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NOVEMBER 1992

INCORPORATING ELECTRONICS MONTHLY

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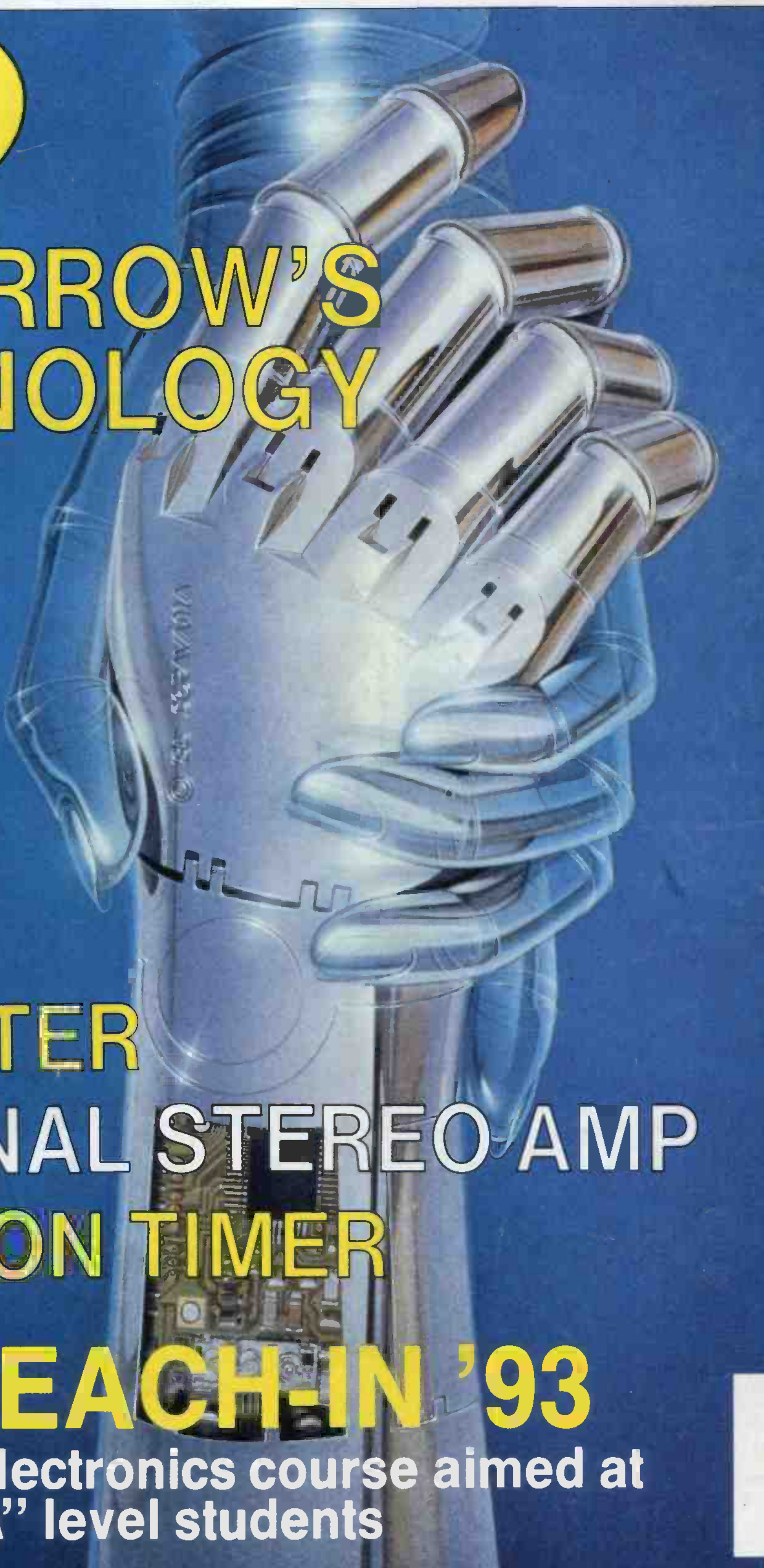
21ST Anniversary Issue



TOMORROW'S TECHNOLOGY

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THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS

AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00 Order ref 30P7R.

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.**

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

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

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 override facility. Complete with wall brackets, 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

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

MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases. £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 **NOW ONLY £19.00!! REF 19P14R.**

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 WALIKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R

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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

TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. Latest edition £20.00 ref 20P32R.

CABLE TIES. 142mm x 3.2mm white nylon pack of 100 £3.00 ref 3P104R. Bumper pack of 1,000 ties £14.00 ref 14P6R

GOT A CARAVAN OR BOAT?

NEW 80 PAGE FULL COLOUR LEISURE CATALOGUE

2,500 NEW LINES FREE WITH ORDER ON REQUEST

OR SEND £1.00

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

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

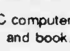
COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

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

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

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.

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



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 5 tapes **New low price £8.00 ref 8P161**

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 15w at 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**

HIGH RESOLUTION 12" AMBER MONITOR 12v 1.5A Hercules compatible (TTL input) new and cased £22.00 ref 22P2R

VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4R

25 WATT STEREO AMPLIFIER c. 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 but otherwise ok. Our price £20.00

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 £25.00 ref B25P1 additional detectors £11.00 ref B11P1

IBM AT KEYBOARDS Brand new 86 key keyboards £15.00 ref 15P612

AMSTRAD MP3

UHF/VHF TV RECEIVER/CONVERTER

CONVERTS COLOUR MONITOR INTO A TV!

£9.00

286 MOTHER BOARDS. Brand new and tested complete with technical manual. £49.00 ref A49P1

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.

CAPACITOR PACK 1. 100 assorted non electrolytic capacitors £2.00 ref 2P286R.

CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287R.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R.

LED PACK. 50 red leds, 50 green leds and 50 yellow leds all 5mm £8.00 ref 8P52R

AMSTRAD 1640DD BASE UNITS

BRAND NEW AND CASED

TWO BUILT IN 5 1/4" DRIVES

MOTHER BOARD WITH 640K MEMORY

KEYBOARD AND MOUSE

MANUAL

OUR PRICE JUST

£79!!!!

BM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R

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.

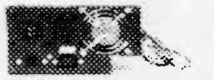
STRIP BOARD CUTTING TOOL. £2.00 ref 2P352R.

50 METRES OF MAINS CABLE £3.00 2 core black precut in convenient 2 m lengths. Ideal for repairs and projects. ref 3P91R

4 CORE SCREENED AUDIO CABLE 24 METRES £2.00 Precut into convenient 1.2 m lengths. Ref 2P365R

6 1/2" 20 WATT SPEAKER Built in tweeter 4 ohm £5.00 ref 5P205R

WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries complete with hand charger and solar panel 14P200R



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

ALARM PIR SENSORS Standard 12v alarm type sensor will interface to most alarm panels. £16.00 ref 16P200

MODEMS FOR THREE POUNDS!! Fully cased UK modems designed for dial up system (PSTN) no data or info but only £3.00 ref 3P145R

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

DATA RECORDERS Customer returned mains battery units built in mic ideal for Computer or general purpose audio use. Price is £4.00 ref 4P100R

SPECTRUM JOYSTICK INTERFACE Plugs into 48K Spectrum to provide a standard Atari type joystick port. Our price £4.00 ref 4P101R

ATARI JOYSTICKS Ok for use with the above interface, our price £4.00 ref 4P102R

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

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 23077

VISA

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

720K 3 1/2" DISC DRIVE Brand new units made by JVC complete with tech info just £19.00!! ref J19P2

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

HEX KEYBOARDS Brand new units approx 5" x 3" only £1.00 each ref CD42R

PROJECT BOX 51/2" x 31/2" x 1" black ABS with screw on lid. £1.00 ref CD43R

SCART TO SCART LEADS Bargain price leads at 2 for £3.00 ref 3P147R

SCART TO D TYPE LEADS Standard Scart on one end, Hi density D type 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

QUICK SHOTS Standard Atari compatible hand controller (same as joysticks) our price is 2 for £2.00 ref 2P380R

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

AC STEPDOWN CONVERTOR Cased units that convert 240v to 110v 3" x 2" with mains input lead and 2 pin American output socket (suitable for resistive loads only) our price £2.00 ref 2P381R

CURLY CABLE Extends from 8" to 6 feet! D connector on one end, spade connectors on the other ideal for joysticks etc (6 core) £1.00 each ref CD44R

COMPUTER JOYSTICK BARGAIN Pack of 2 joysticks only £2.00 ref 2P382R

BUGGING TAPE RECORDER Small hand held cassette recorders that only operate when there is sound then turn off 6 seconds after so you could leave it in a room all day and just record any thing that was said. Price is £20.00 ref 20P3R

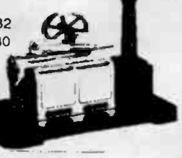
NEW SOLAR ENERGY KIT Contains 8 solar cells, motor, tools, fan etc plus educational booklet. Ideal for the budding enthusiast! Price is £12.00 ref 12P2R

286 AT PC

286 MOTHER BOARD WITH 640K RAM FULL SIZE METAL CASE, TECHNICAL MANUAL, KEYBOARD AND POWER SUPPLY £139 REF 139P1 (no i/o cards or drives included) Some metal work req'd phone for details.

35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200

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.

VIDEO TAPES E180 FIFTY TAPES FOR £70.00 REF F70P1

360K 5 1/4" Brand new drives white front. £20.00 Ref F20P1

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.

IN SUSSEX? CALL IN AND SEE US!

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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EVERYDAY WITH PRACTICAL ELECTRONICS
INCORPORATING ELECTRONICS MONTHLY

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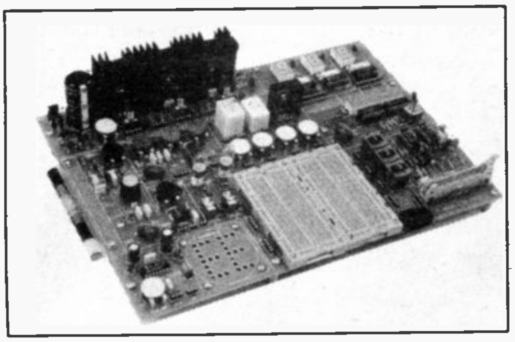
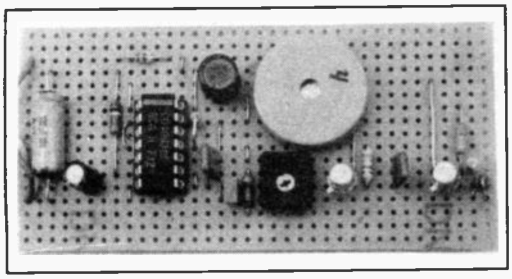
PROJECTS ... THEORY ... NEWS ...
COMMENT ... POPULAR FEATURES ...





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Our December '92 issue will be published on Friday, 6 November 1992. See page 683 for details.

Projects

Series

Features

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THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

COMPUTER *SCOOPS*

PC-AT 386 20-DX FULLY LOADED FOR £499!

- 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............ **£499** (F)

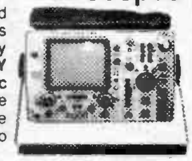
A COMPLETE IBM PC COMPAT SYSTEM FOR ONLY £99!!

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, 128K 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 motherboard. In very good used condition with 90 day guarantee. At the unique price of:

Optional FITTED extras: 256K RAM £15; 640K RAM £39. 12" CGA colour monitor with card £89. 2nd 5-1/4" 720K floppy (or 360K if preferred) £29.95. 20 mbyte hard drive £99.

£99 (E)

HP Double Beam 100mhz Scopes



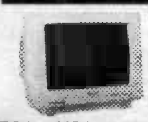
A Major purchase from a liquidated company enables us to offer you this superb **Hewlett Packard quality HP1740A** oscilloscope in **HARDLY USED CONDITION** at a fantastic price! Although exceptionally simple to use the full spec. of this scope would take up the whole page, so briefly here are a few of its features:

- **5 mV/div to 20v/div in 12 ranges**
- **Large 8 x 10cm CRT with scale illuminated**
- **50ns/div to 2s/div 24 ranges (timebase)**
- **Third channel trigger view**
- **Dual input impedance 50Ω/1 megΩ**
- **TV sync trigger**
- **Full delayed time base facilities**
- **Light weight fully portable, dual voltage**

Fully guaranteed with full user manual.

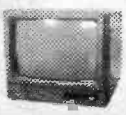
Only **£435.00** (F)

COLOUR MONITORS



SAVE £59 - ONLY £100 WHEN BOUGHT WITH THE 386 ABOVE!

14" Philips Model CM8873 VGA multi-sync all the way up to 34Khz with 640 x 480 resolution. This one has everything! Two switches enable you to select CGA, EGA or VGA and digital/analog. Sound is also provided, with a volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with virtually all computers including IBM PC's, Amiga, Atari, BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only............£159(E)



KME 12" high definition colour monitors.0.28" dot pitch for superb clarity and modern two tone plastic styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality TV with our RGB Telebox. Excellent used condition with 90 day guarantee. Beige and brown case. Only...... £149 (E)

Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case.Full 90 day guarantee. Only .... £129 (E)

NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15"L x 13"W x 12"H. The front cosmetic bezel has been removed for contractual reasons. Only.......... **£79** (E)

20", 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools,Shops,Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

CALL FOR PRICING ON NTSC VERSIONS!

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** JU364 720K*	£21.95(B)
3.5" **Mitsubishi** MF353C-L. 1.4 Meg. Laptops only*	£29.95(B)
3.5" **Mitsubishi** MF353C-D. 1.4 Meg. Non laptop*	£29.95(B)
5.25" **Teac** FD-55(36). 360K half height.	£22.95(B)
5.25" **Teac** FD-55(72). 720K half height.	£24.95(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)

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)

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)

SPECIAL INTEREST

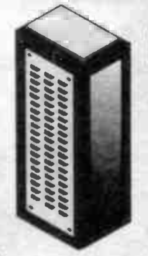
Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Pillar 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
ADDS 2020 VDU terminals - brand new	£ 225
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)
Qume LetterPro 20 daisy. Qume QS-3 interface.	£39.95 (D)
Centronics 152-2 9 x 7 dot matrix. Full width.	£149 (D)
Centronics 159-4 9 x 7 dot matrix.Serial. 9-1/2" width	£ 99 (D)

Superb Quality 6 foot 40u

19" Rack Cabinets



Massive Reductions

Virtually New, Ultra Smart!

Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:

Rack 1	Complete with removable side panels	£275.00 (G)
Rack 2	Less side panels	£145.00 (G)

COOLING FANS

3 Inch	AC. 1½" thick	£ 8.50(B)
92 mm	AC 230 v. 18mm thick	£12.95(B)
3½ Inch	AC ETRI slimline.Only 1" thick.	£ 9.95(B)
3½ Inch	AC 230 v 8 watts. Only 3/4" thick	£12.95(A)
4 Inch	AC 110/240v 1½" thick.	£10.95(B)
10 Inch	AC round. 3½ thick. Rotron 110v	£10.95(B)
10 Inch	As above but 230 volts	£24.95(B)
60 mm	DC 1" thick.No.812 for 6/12v.814 24v.	£15.95(A)
80 mm	DC 5 v. Papst 8105G 4w. 38mm. RFE.	£19.95(A)
92 mm	DC 12v. 18 mm thick.	£14.95(A)
4 Inch	DC 12v. 12w 1½" thick	£12.50(B)
4 Inch	DC 24v 8w. 1" thick.	£14.50(B)

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NEXT MONTH

VERSATILE INFRA-RED REMOTE CONTROL

There are many applications for which constructors would like remote control. This versatile unit has been designed for application in a diverse range of equipment. Everything from one button operation of garage doors to 32 codes for three different receivers in one room, a total of 96 combinations.

The entire system, transmitter and receiver, uses just three i.c.s is compact and easy to build. Various output decoding and switching options are discussed and full detail of interfacing to our Mains Appliance Remote Control (MARC) system, published in 1990, are given. If you want remote control for almost anything this article should meet your needs.

FREE

BULL ELECTRICAL CATALOGUE

MIDI LEAD TESTER

This unit enables MIDI connecting leads to be quickly checked, and it will show up broken wires/connections or short circuits from one lead to another. In use it is much quicker and easier than using a multimeter or continuity checker. Checking leads with ordinary test equipment is easy enough provided you have four hands (two for the test leads and two for the plugs!) It should be possible to build the tester for less than the cost of ready made units, some of which seem to be rather crude in comparison to this device. It can help to greatly speed-up checks on a faulty MIDI system.

COMBINATION SWITCH

The Combination Switch or Combination Lock is a versatile project which may be used to unlock a door or switch off an alarm etc. The user's password is held in memory, which is protected by a back-up battery in case of power cuts. The password may be re-programmed by the user at any time, and up to 12 digits can be stored. If the wrong password is entered more than three times, a siren output is activated for a minute or so. There is also provision for a switch input so that the siren sounds if the switch is closed before the correct password has been entered. This may be used to detect a door or window being forced. The project may be fully integrated with an alarm system if required.

EVERYDAY WITH PRACTICAL ELECTRONICS

DECEMBER ISSUE PUBLISHED FRIDAY 6TH NOVEMBER.

SURVEILLANCE
PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all of our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the word! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range.......£16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range.......£13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range.......£15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range.......£16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range.......£19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range.......£22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range.......£23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation.......£22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line.......£13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits).......£50.95
Individual Transmitter DLTX.......£19.95
Individual Receiver DLRX.......£37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range.......£20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use. All conversation transmitted. Powered from line. 500m range.......£15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.......£13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm. 1500m range.......£16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation.......£22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation.......£30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation.......£50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catlogue). Size 20mm x 67mm. 9V operation. 1000m range.......£40.95

QLX180 Crystal Cointrolled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range.......£40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m.......£35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation.......£60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

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SPARKOMATIC 4 x 150 watt CAR AMPLIFIER

The SA3200 is our top of the line 4 Channel Amplifier which is extremely well specified. It is very powerful and versatile and features separate bass and treble controls which gives the user the possibility of reducing bass response to the front speakers and adding treble for better stereo imaging. The bass response can then be increased to the rear speakers which are usually larger and capable of offering better reproduction. The SA3200 features a bridge operation switch which offers the possiblity of using the amplifier in 4, 3 or 2 channel mode. The 3 channel mode is ideal for installations where rear deck speakers are used in combination with a separate subwoofer.

● 4 x 150 Watts max ● 4 x 80 Watts into 4 Ohms at less than 0.5% THD ● 2 x 80 Watts plus 1 x 160 Watts at less than 0.5% THD ● 2 x 160 Watts into 4 Ohms at less than 0.5% THD ● Separate bass and treble controls for front and rear channels ● Separate sensitivity controls for front and rear channels ● 2, 3 or 4 channel operation ● Heavy duty power wires ● Glass blasted aluminium heatsink ● High current capacility

£251.65 plus £7 p&p

SPARKOMATIC 2 x 150 watt CAR AMPLIFIER

The SA1500 is a very highly specified 2 Channel Amplifier with built-in sub bass crossover. The SA 1500, which is ideal for powering medium sized subwoofers, will also operate in bridge mode as a 150 Watt mono amplifier.

● 2 x 150 Watts max. into 4 Ohms ● 2 x 70 Watts per channel at 0.5% THD ● Bridge mode operation ● Sensitivity adjustment ranging from 100mV to 1V ● Heavy duty power wires ● Built-in sub bass crossover ● Glass blasted aluminium heatsink ● High current capacity

£117.65 plus £6.50 p&p

SPARKOMATIC 80 watt CAR POWER AMPLIFIER

The AMP 7000 produces high power at low distortion. The amplifier accommodates low level, high level and high power radio speaker inputs. The response is linear and extends beyond the capability of all music sources. This compact unit mounts easily and its quick connect terminals accept RCA or straight wire input terminals. Power rating 2 x 40 watt per channel. MMP 2 x 20 watt at 10%. THD response 20Hz-20kHz. Size 160mm x 130mm x 45mm.

£32.95 plus £3.50 p&p

11 BAND COMPONENT GRAPHIC EQUALIZER FOR CARS

This neat unit connects between the line output of your car stereo and your power amplifiers so that you are able to adjust the sound as in a studio compensating for soft furnishing and sound reflections from glass, also it has a sub-woofer output to drive a separate amplifier for that extra deep bass sound. FEATURES: 2 channel inputs 4 channel outputs via phono sockets, CD input via 3.5mm jack 11 band graphic. SPECIFICATION RANGE 20Hz-60kHz THD 0.05%, S/N RATIO 85dB. EQ FREQUENCIES 60Hz, 120Hz, 250Hz, 380Hz, 500Hz, 750Hz, 1kHz, 2kHz, 4kHz, 8kHz, 16kHz (boost cut of ±12dB) SIZE 178mm x 25mm x 140mm.

£32.70 postage £1.80

EMINENCE 4Ω PROFESSIONAL USA MADE IN CAR CHASSIS SPEAKERS

All units are fitted with big magents "Nomex" Voice coils NOT ALUMINIUM. "Nomex" is very light and can stand extremely high temperatures, this mixture makes for high efficiency and long lasting quality of sound.

V6 6½" 200W Max	Range 50Hz-3kHz £34.40
V6 8" 300W Max	Range 45Hz-3kHz £39.35
V10 10" 400W Max	Range 33Hz-4kHz £44.45
V12 12" 400W Max	Range 35Hz-3kHz £45.95
BOSS 15" 800W Max	Range 35Hz-4kHz £79.90
KING 18" 1200W Max	Range 20Hz-1kHz P.O.A.

Postage £3.85per speaker.

Build your own Bazooka sub woofer tube to suit Eminence car speakers. 10mm thick fibre supplied with grille and clamp terminals finished in black vinyl.

Eminence U10, Size 270mm x 700mm **£25.95** £3.50 p&p

Eminence U12 Size 320mm x 710mm **£29.95** £3.50 p&p

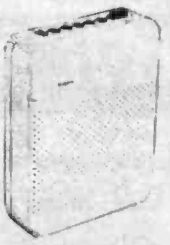
R T-V C MAIL ORDER BARGAIN PACKS

No. Qty. per pack

MO20 1 30W dome tweeter by *Eagle/Japan Made* size 90mm x 66mm £1
MO21 1 60W Hifi tweeter made for *Jamo UK* size 90mm sq. £1
MO22 2 30 watt 8 ohm Hifi chassis speakers. *Made for Hitachi UK* midi systems, size 125mm sq. with large 70mm magnet £9.00 + £2.00 p&p
MO23 2 Pod Car Speakers. Moulded in black plastic with 15 watt 10cm *Goodmans* unit fitted £4.95 + £2.50 p&p
MO23A 1pr 40 watt Car Speakers made for Roadstar of Switzerland. Fitted with dual polypropylene cone and foam rubber surround. Big 70mm magent for good base response. Supplied with grills fixing screws and cable. Size 13cm, weight 1.5Kg £11.70 pair + £3.65 p&p or TWO pairs for £25.00 UK post paid
MO24 2 Audax JBL 40-100watt dome tweeters. High performance 10mm Ferrofluid cooled horn loaded unit for load distortion and high output. Supplied with 1st order crossover, spec. 40 watts at 3kHz, 100 watt at 8kHz; size 51mm x 51mm x 16.5mm. Ideal for car use £7.50 + £1 p&p
MO25 2 33000µF 10V d.c. can type computer grade quality electrolytic *UK made* £1
MO25A 1 47µF 385V d.c. can type electrolytic. Size 350mm x 250mm. *UK made by Phillips* £1.75
MO26 2 680µF 100V d.c. can type electrolytic size 45mm x 25mm £1
MO27 3 2200µF 25V d.c. can type electrolytic size 45mm x 25mm £1
MO28 1 15000µF 40V d.c. can type 23A electrolytic size 113mm x 50mm £1
MO29 1 33000µF 16V 27A can type electrolytic size 113mm x 50mm £1
MO30 20 Assorted Variable trimmers £1
MO31 4 Tuning capacitors 2-gang dielectric type £1
MO32 2 10k + 10k wirewound precision potentiometer £1
MO33 8 Rotary potentiometers £1
MO34 5 100k multitum Varicap type tuning potentiometer with knob size 45mm x 5mm £1
MO35 200 Carbon resistors £1
MO36 2 Large VU meters. *Japan Made* £1
MO37 1 Large Tuning meter 125µA-0-125µA size 55mm x 47mm £1.75
MO38 1 Dual VU meter 280µA f.s.d., size 80mm x 42mm x 15mm £1.50
MO39 5 Coaxial Aerial Plugs, all metal type £1
MO40 6 Fuseholders, chassis mounting for 20mm size fuses £1
MO41 4 Fuseholders, in-line type for 20mm size fuses £1
MO42 20 5 Pin Din 180°chassis mount sockets £1
MO43 6 Double phono sockets £1
MO44 5 6.35mm (¼") Stereo Jack sockets £1
MO45 4 6.35 (¼") Mono Jack Plugs £1
MO46 12 Coax Sockets chassis mount £1
MO47 2 Case handles plated U-shape, size 97mm x 50mm £1
MO48 30 Mixed control knobs £1
MO49 1 Cassette tape transport mechanism, belt-drive, top loading, six piano key operation with knobs, stereo record/replay erase heads, heavy fly-wheel £5.50 + £2.65 p&p
MO50 1 Hifi stereo pre-amp. module. Input for CD Tuner record player with diagram. *Made by Mullard* £1
MO51 2 AM/FM tuner head modules'. *Made by Mullard* £1
MO52 3 AM I.F. modules'. *Made by Mullard* £1
MO53 1 FM stereo decoder module with diagram. *Made by Mullard* £1
MO54 3 UHF Varicap tuned tuner heads unboxed, untested but complete. *Made by Mullard* £1
MO55 1 25V d.c. 150mA Mains adaptor in neat plastic box, size 80mm x 55mm x 47mm £1
MO55A 1 *ETRI* Brand new 80mm Cooling Fan. Five bladed A.C. impedance corrected motor on a cast aluminium chassis. Size 80mm x 40mm. Voltage 115V a.c. working, 130mA. *Japanese made.* £5.95 + £1.40 p&p, TWO for £11.20 UK post paid
MO56 2 6V-0V-6V 4VA p.c.b. mount mains transformer 240V input, size 42mm x 33mm x 35mm. *UK Made* £1
MO57 25 4 Volt miniature wire-ended bulbs £1
MO57A 1 SRBP Copper Clad Printed Circuit Board. Size 410mm x 360mm x2mm £3.65 + 75 p&p
MO58 2 Mono cassette tape heads. *Japan Made* £1
MO59 2 Sonotone stereo cartridge with 78 and LP Styl. *Japan Made* £1
MO60 8 Bridge rectifiers 1amp 24Volt £1
MO61 10 OC44 transistors. Remove paint from top and it becomes a photo electric cell (ORP12) £1
MO63 6 14 watt output transistors. Three complimentary pairs in T066 case (replacement for AD161 + 162) £1
MO64 5 5 watt Audio i.c. No. TBA800 £1
MO65 5 Motor Speed Control i.c. £1
MO66 1 Digital DVM Meter i.c. *Made by Plessey*, with diagram £1
MO67 4 7-Segment 0.3in l.e.d. display (red) £1
MO68 1 Tape Deck i.c., with record replay switching. No. LM1818, with diagram £1
MO69 2 Ferrite Rod. High grade with LW, SW & MW coils, size 140mm x 10mm £1
MO70 1 Moving coil dynamic, handheld, ball microphone. *Ross Electronics* customers returns (*no warrantee*) £1

No. Qty. per pack

MO71A 1 Analogue Multimeter. *Ross Electronics* customers retums (*no warrantee*) £3.90 + 90p p&p
MO72 1 WW II EX WD headphone, A BIT OF NOSTALGIA, low impedance £3.50 + £1.20 p&p
MO73 1 Koss Stereo Headphones on ear. Lightweight design, vari-fitting ear-cups with contour cushions, 36in. cord. 3.5mm + 6.35mm Jack plug adaptor £3.50 + £1 p&p
MO74 2 Tone dialling keypad, use services that require DTMF tone signals for a rotary dial pulse phone, size 90mm x 55mm 12mm £11.00 + 70p p&p
MO75 1 100 yard roll of single screened quick splice cable, good quality *British Made* £4.50 + £2 p&p
MO76 1 100 yard 3-core 3 amp cable, coded brown, blue and green/yellow £4.20 + £2 p&p
MO80 2 Solar Powered Wooden Kits. Easy to build aeroplane, with revolving propeller, and an old time gramophone with music chip. Supplied with glue, solar cells, electronics and pre-cut panels. One of each for £12.00 + £1.50 p&p
MO81 1 Bump and Go Space Ship Kit with motor, wheels, p.c.b. wire and diagram. An ideal introduction for youngsters into the world of electronics and mechanics; goes all the way to the moon on two AA batteries £8.95 + £1 p&p
MO82 1 Filofax Personal Organiser Radio/Calculator. This neat little unit simply fits inside your filofax so you can listen to AM Radio with earphone or use it as a solar powered 8-digit calculator. Punched with six holes to fit all personal organisers. *UK Made* under ½ price £8.95 + £1 p&p
MO83 ★ 1 Video Sender. With this handy unit you can transmit output of your home video, wideo camcorder or satelite equipment over the air to a receiving television within a range of 100ft. Simply connect the video and audio output of your equipment into this unit, and a 10-13.8V d.c. power supply – extra £3.75 £11.75 + £2 p&p
MO84 1 Multiband radio. Listen to air traffic control, aircraft, radar, public utilities VHF 54-176MHz + CB 1-80 with built in squelch control £17.95 + £2 p&p
MO85 2 AM, FM. LW Ross Pushbutton Radio. With this neat unit you can easily tune in to five pre-set stations of your choice without fiddling or fuss, runs off six C-cell batteries or 240V mains. Output 400mW, volume and tone control. Size 230mm x 150mm x 65mm £23.00 + £3.65 p&p



MO86 1 (As above) £15.00 + £2.80 p&p
MO87 1 Amplifier Kit 30 + 30 Watt. An easy to build amplifier with a good specification. All components mount on single p.c.b. punched and back-printed for ease, case ready drilled finished in black vynil with matching scale and knobs. Inputs for: CD/AUX tape 1; tape II; tuner and MC phono. Controls: bass; treble; volume; balance; mode and power switch. Featured project in *Everyday Electronics*, April 1989 issue; reprint with kit £40.00 + £3.65 p&p

All items prefixed with MO number MAIL ORDER only or can only be collected by prior appointment from address below. Where p&p not stated please add £3.65 per order for postage and carton charge.

★ VHF RADIO TRANSMITTERS

2 Watt transmitter kit, supplied with fibre glass pcb, all components, diagrams, ready for you to build. 12-24V d.c. **£8.50** + £0.70 pp

★ *We are only able to supply these devices if customers provide a written and signed disclaimer that they will not be used in the UK. Please include this with your order as they are not licensable in the UK.*

R T-V C

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electronize electronic kits

NEW! MOTOR SPEED CONTROL (FOR RADIO CONTROLLED MODELS)

- ☆ Standard radio control input - no servo required.
- ☆ Smooth forward and reverse P.W.M. speed control.
- ☆ Runs any motor up to 10 amp. continuous current.
- ☆ 35 amp. short term stall rating.
- ☆ Low loss Power MOSFET switching.
- ☆ Neutral and span adjustment.
- ☆ Optional voltage regulator for single battery operation. (Type 43VR)

Type 43X (2 to 24 v motors)	parts kit £17.75	Assembled £25.95
Type 43VR (7 to 24 v motors)	parts kit £19.45	Assembled £27.95

MICRO-PRESSURE CAR ALARM

This new type of alarm is triggered by a unique pressure sensing system. As any vehicle door is opened air is drawn out, causing a minute drop in air pressure. A sensor detects this sudden pressure change and sets off the alarm. A sophisticated arrangement of electronic filters and timers provide features to match more expensive ultra-sonic systems.

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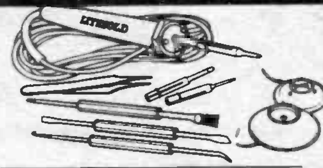

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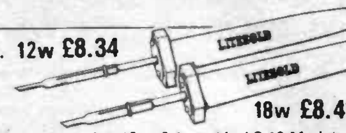

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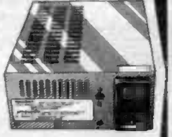

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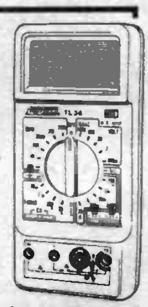

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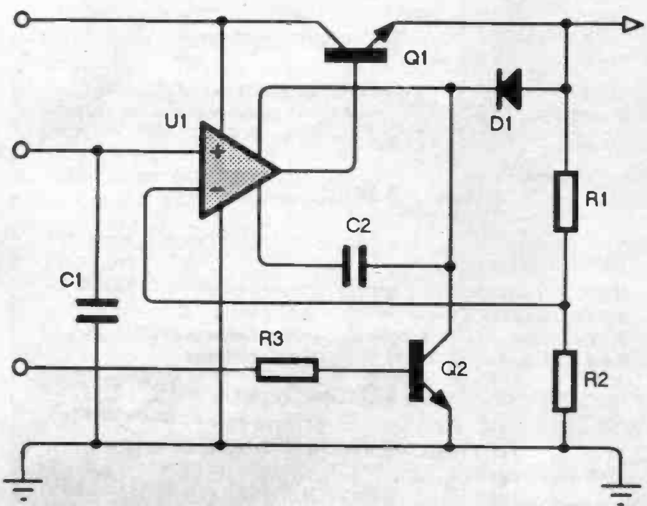

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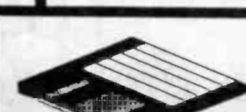

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A versatile thermostat using a thermistor probe and having an l.c.d. display. MIN/MAX memories, -10 to 110 degrees celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO relay output. Punched and printed case.

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4 CHANNEL LIGHT CHASER

A 1000W per channel chaser with Zero Volt Switching, Hard Drive, and full inductive load capability. Built-in mic. and sophisticated 'Beat Seeker' circuit - chase steps to music, or auto when silent. Variable speed and mic. sensitivity control, l.e.d. mimic on front panel. Switchable for 3 or 4 channels. P552 output socket. Suits Rope Lights, Pin Spots, Disco, and Display lighting.

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

KIT 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

DIGITAL CAPACITANCE METER KIT 493

This has been one of Magenta's best ever kits. It provides clear readings of capacitance values from a few pF up to thousands of µF. It is ideal for beginners as there is no confusion over the placing of the decimal point, and it allows obscurely marked components to be identified quickly and easily. Quartz controlled accuracy of 1%, large clear 5 digit display and high speed operation make it a very useful instrument for production and testing departments. The kit is now supplied with a punched and printed front panel as well as the case, all components and top quality printed circuit board. When assembled it looks a really professional job. For a limited time this kit is offered at a new low price.

SPECIAL KIT PRICE £34.95
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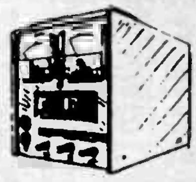
MOSFET VARIABLE BENCH POWER SUPPLY 25V 2.5A



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.

KIT 769..£56.82

8 CHANNEL LIGHT SHOW PROGRAMMABLE SEQUENCER

A superbly finished kit with pre-drilled case and screen printed front panel. this kit uses a microcontroller IC to generate over 100 light sequences. Programs include 3 and 4 channel versions so thet existing light units can be used as well as 8 channel arrangements. NEW output design provides foolproof operation with pinspots and other difficult loads. Space in memory for 10 user programs up to 16 steps long. Keypad

KIT 838..£57.17

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

IONISER

A highly efficient mains powered Negative Ion Generator that clears the air by neutralising excess positive ions. Many claimed health benefits due to the ioniser removing dust and pollen from the air and clearing smoke particles. Costs virtually nothing to run and is completely safe in operation. Uses five point emitters.

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A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790........................£28.51

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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.

KIT 815........................£45.95

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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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Covers 1.6 to 30MHz in three bands using modern miniature plug-in coils. Audio output is via a built-in loudspeaker. Advanced stable design gives excellent stability, sensitivity and selectivity. Simple to build battery powered circuit. Receives a vast number of stations at all times of the day.

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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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A six channel light driver that scans from left to right and back continuously. Variable speed control. Up to 500 watts per channel. Housed in a plastic box-for complete safety. Built on a single printed circuit board.

KIT 560........................£22.41

LIGHT RIDER 9-12V CHASER LIGHTS

A low voltage DC powered end-to-end type chaser that can be set for any number of lights between 3 and 16. The kit is supplied with 16 l.e.d.s but by adding power transistors it is possible to drive filament bulbs for a larger brighter display. Very popular with car customisers and modellers. L.e.d.s can be randomly positioned and paired to give twinkling effects.

KIT 559........................£15.58

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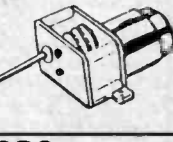

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BC549C	£0.10
BC550C	£0.08
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BC558C	£0.08
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BC639	£0.21
BC640	£0.21
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BD203	£0.40
BD204	£0.40
BD222	£0.40
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BD442	£0.41
BD534	£0.47
BD535	£0.48
BD536	£0.65
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BD648	£0.52
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BF195	£0.19
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BF259	£0.33
BF337	£0.36
BF355	£0.38
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BF451	£0.19
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BFX29	£0.29
BFX84	£0.31
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BFY51	£0.26
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VOL. 21 No. 11 NOVEMBER '92

HISTORIC

As regular readers will know this is a historic issue which not only represents 21 years of *Everyday Electronics* but also sees the merger of *Practical Electronics* with *Everyday Electronics*. We have tried to expand the magazine to meet the needs of both sets of readers and we hope and believe that this issue represents the best possible electronics magazine for hobbyists, students and technicians alike.

Never before have we encompassed such a wide spread of articles with plenty to read on new technology and general developments, plus a good range of constructional projects. However we do not intend to rest there, please let us know what you think of the magazine; especially if we are failing to cover something which interests you. We cannot promise to meet every requirement but we can try.

DEMAND

We are anticipating a very heavy demand for this issue and have printed 43,000 copies in an effort to make sure everybody who wants one gets one. However we do want to make sure you can also get your copy next month. So why not take out a subscription (see page 738), or fill in the blue "Shop Save" card stitched into this issue. This card will also get you into our free draw for one of two Maplin multimeters, each worth £30 (UK readers only). Just fill in the card and hand it to your newsagent, there is no obligation to buy but he will keep an issue for you to look at – what have you got to loose?

There has been so much pressure on space this month that we have had to leave out one or two items. These include our *Readout* (EE) or *Wavelengths* (PE) readers letters page. We hope to fit this in next month so keep those letters coming, we should have room for a lively selection.

Mike Kenward

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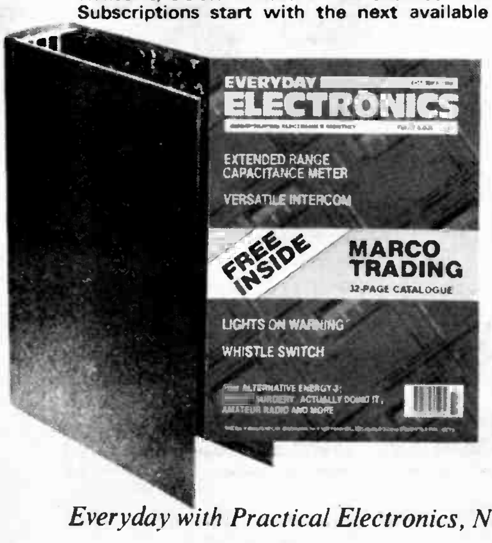

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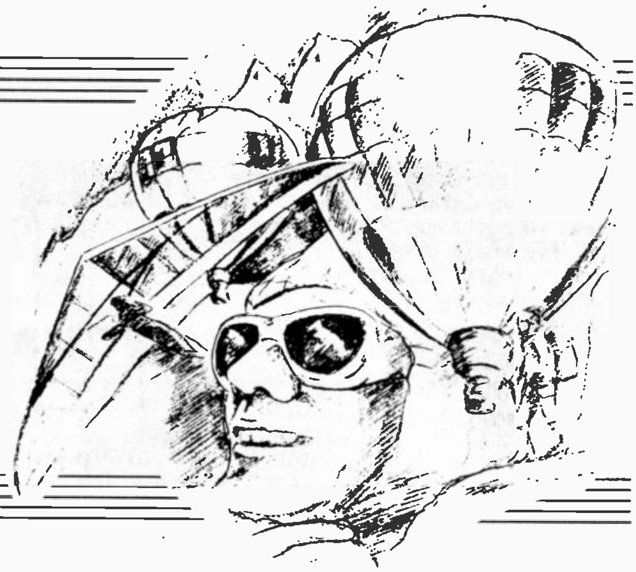
EPE ALTIMET



JOHN BECKER

Measure up to the outdoor high-life with this handy pocket altimeter

ANYONE with an interest in the ups and downs of outdoor activities, walkers, climbers, cyclists, balloonists, hang-gliders, pot-holers and so on, will find their curiosity further satisfied through using the EPE Altimet. It is a handheld unit which uses two sensors, a DPM (digital panel meter) chip and an l.c.d. (liquid crystal display) to monitor and display data about altitude in metres and feet, barometric pressure in millibars, and temperature in Fahrenheit or Celsius.

The maximum readout range is +/− 1999 metres relative to sea level. To facilitate setting-up, access to a digital multimeter, a good thermometer and a nearby hill is recommended!

PRESSING FACTS

The earth is surrounded by an envelope of air extending to around 500 miles above its surface and having an estimated total weight of 5,000 billion tons. At sea level, the pressure exerted by this mass of air is on average 14·72 pounds per square inch (PSI), or 1kg per square centimetre. This average is also defined as a pressure of one atmosphere, or one bar, although meteorologists more commonly regard it as 1013·25 millibars (mb).

As one rises higher into the atmosphere, so the air pressure decreases, reducing to about one half (500mb) at 5,000 metres – see Fig. 1. At 16,000 metres the pressure has dropped to 100mb, while at 100,000 metres it is barely 0.001mb.

Although the pressure versus height relationship is not linear, for some purposes it may be regarded as such within the range of 0 to 5000 metres. It can thus be stated that up to a height of 5000 metres a change of 1mb represents a change of 10 metres.

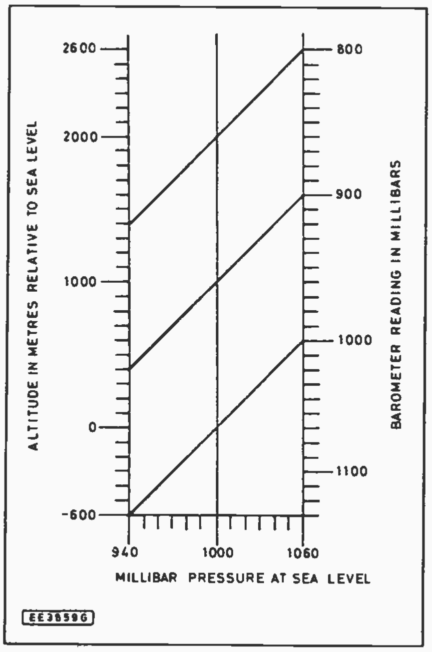


Fig. 2. Altitude to variable atmospheric pressure conversion graph.

However, the atmosphere is in a constant state of turmoil and the total weight of air above a given location can vary considerably. Under extreme conditions the pressure can range from about 940mb to 1060mb, as indicated by the scale on a standard aneroid barometer. Obviously, therefore, an altimeter using the barometric principle must have a separate control to adjust for natural changes in atmospheric pressure.

Variations in height plotted against millibars across the range of 940mb to 1060mb is shown in the conversion graph Fig. 2. If the pressure at sea level is 1000mb (horizontal axis) and a barometer shows a reading of 900mb (right hand column) the barometer is at a height of 1000 metres (left hand column). If the pressure at sea level is 1060mb and the barometer's altitude is 1000 metres it should show a reading of 960mb.

PRESSURE SENSOR

A piezo-resistive device, the Motorola MPX100A, is used as the pressure sensor in the EPE Altimet. Its schematic functional details are shown in Fig. 3.

In manufacture, a transverse voltage strain gauge is diffused on a thin silicon diaphragm which is mounted across an evacuated cavity. In the presence of an excitation voltage across the strain gauge, when pressure is applied to the diaphragm the resistance of the gauge changes, causing a change in the output voltage directly proportional to the pressure applied.

The MPX100A produces a voltage change of between 45mV and 90mV,

Fig. 1. Basic altitude to millibar graph.

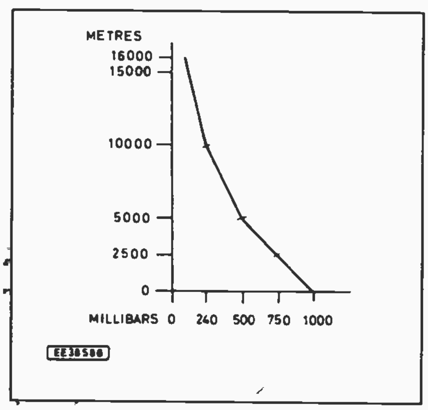
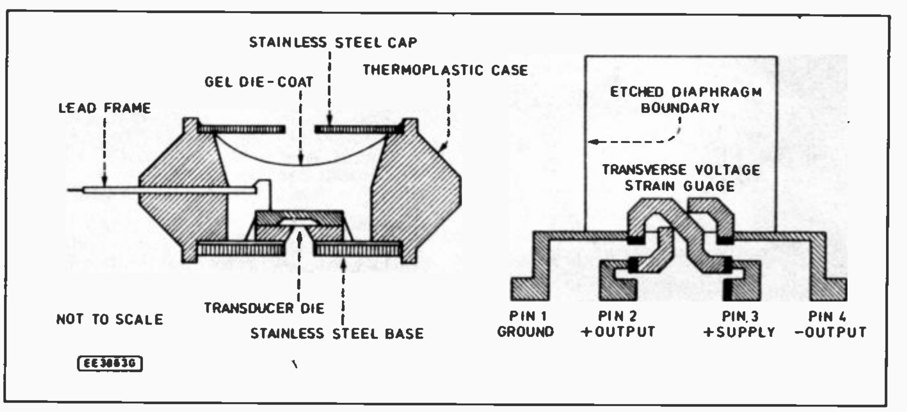


Fig. 3. The MPX100A pressure transducer internal structure and function details.



the guaranteed minimum to maximum manufacturing tolerance range, for a pressure change of 100 kiloPascals (kPa). 100kPa equals 14·5 PSI, which is approximately equal to one bar.

Taking the typical output as 60mV per 100kPa, a 1mb pressure change will produce a voltage change of approximately 0·06mV. Likewise, a change in altitude of one metre (below an altitude of 5,000 metres) produces a change of 0·006mV.

Consequently, the interface between the sensor and the l.c.d. readout must convert the voltage changes by a factor which will cause each 0·006mV step to result in a barometric display change of one unit per millibar. This factor then has to be multiplied by 10 for the metres display, and by a further 3·28 for the feet display (1 metre = 3·280839 feet).

In the practical circuit, whose block diagram is shown in Fig. 4, the sensor output is in fact multiplied by a factor related to unitary changes on the feet scale, and then separately divided for the metres and millibar scales.

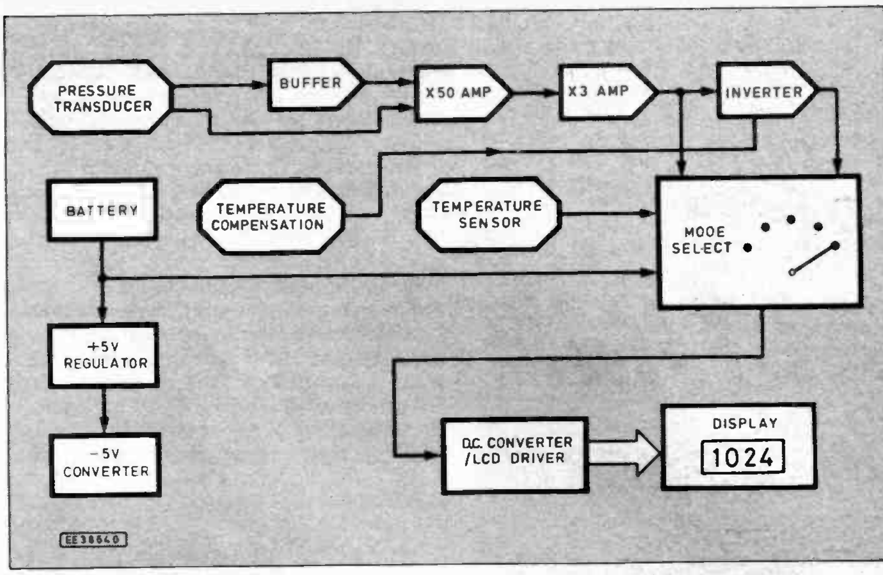


Fig. 4. Full block diagram for the EPE Altimet.

SENSOR CIRCUIT

In order to ease the understanding of the EPE Altimet circuit, it has been divided in to three sections: pressure sensor and psu; temperature and battery level; an l.c.d. display and controller.

The details of the sensor amplification and division scaling circuit diagram is shown in Fig. 5. It also shows the power supply details.

TX1 is the pressure sensing transducer. Its internal resistance is predetermined in manufacture within the range of 400 to 550 ohms. The value of the resistor R5 in series with TX1 is selected to suit the resistance of the transducer at 25°C.

Several of the transducer parameters are temperature dependent and the value of resistor R5 is instrumental in minimising part of the effect of their changes. This will be discussed later.

The transducer TX1 has two differential outputs, pins 2 and 4. The voltage span across them decreases as atmospheric pressure falls. Both are fed to the non-inverting inputs of op.amps IC2a and IC2b, which are configured respectively as a unity gain buffer and differential amplifier with a gain of about 50 set by the values of resistors R10 and R11.

From IC2b, the signal is inverted and is given an additional gain of around 3·3 by IC2c. Preset control VR2 in series with resistors R13 and R14 varies the bias at IC2c pin 12 so enabling the basic output voltage at IC2c pin 14 to be preset.

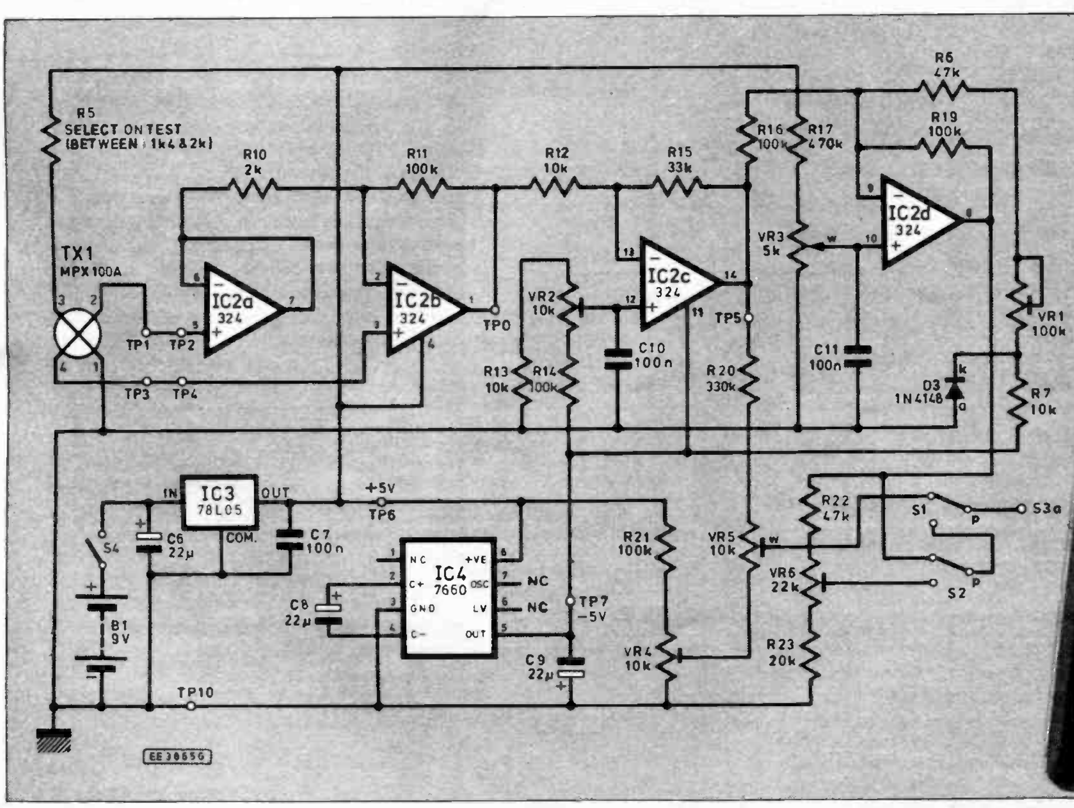
Before being further processed by IC2d, the voltage at IC2c pin 14 is tapped to provide barometric pressure data. Preset VR5 in series with resistor R20 divides the voltage by 32·8 presetting the span range required by the l.c.d. readout circuit. The inclusion of preset VR4 in series with resistor R21 is used to impose a bias voltage on one side of VR5 to increase the barometer readout by approximately 1000mb.

Whereas a barometer shows a decrease in reading with a decrease in pressure, an altimeter has to show an increase. Consequently, IC2d is used to invert the voltage change direction but, within the tolerances of resistors R16 and R19, does not change the amplification.

A panel-mounted control VR3 provides IC2d with a variable bias voltage, allowing the altitude readout to be set to compensate for normal meteorological changes in atmospheric pressure. The range controlled by VR3 is about 300 metres. This may be increased by increasing the value of VR3 or by reducing the value of R17.

The output of IC2d directly provides the voltage data for an altitude readout in feet. For the metres scale, the output of IC2d is tapped by preset VR6 in series with resistors R22 and R23, dividing the voltage by 3·28. Switch S2 selects between

Fig. 5. Circuit diagram for the EPE Altimet sensor amplifier, division scaling and regulated power supply.



the Feet and Metres modes and feeds to switch S1 which selects between Height and Barometric modes.

TEMPERATURE COMPENSATION

In any d.c. amplification circuit there is a tendency for voltage levels to change as temperature changes. The component which causes most drift in the EPE Altimet is the transducer TX1.

Even with resistor R5 chosen correctly, the transducer's offset voltage typically changes with temperature by about +/−15 microvolts per degree Celsius. In the test model, the offset drift after amplification was 63mV per 40°F (22·2°C).

Compensation for this and other minor drifts is effected by the temperature-related change in voltage across the forward biased diode D3. The voltage at the junction of D3 and resistor R7 increases by about 1mV with each 1°F increase (1·8mV°C).

A proportion of the change, as controlled by the values of resistor R6 and preset VR1, is fed into IC2d to counterbalance the majority of the circuit drift from the altitude readouts. The barometer output is left uncompensated since the attenuation by VR5 reduces the effect to only about 2mV per 40°F (22·2°C).

TEMPERATURE AND BATTERY MONITORING

Another diode is used as the temperature sensing element, shown in Fig.6 as D4. Resistor R24 and preset VR9 form a potential divider across the +5V and 0V power lines providing a bias voltage to D4. The voltage across D4 changes at a similar rate to that across D3 (Fig. 5).

Preset VR9 adjusts the displayed temperature value and VR7 presets the voltage/temperature output span. The choice of whether temperatures are shown in Fahrenheit or Celsius is made when setting up the unit, and simply entails adjusting VR7 for the desired ratio. S3a selects between temperature display and the modes routed via switch S1 as shown in Fig. 5.

Whereas height and barometric readings are shown as integer values, temperature is displayed to within one tenth of a degree. The decimal point control being switched in by S3b.

In height and barometric modes, the decimal point is pulsed in phase with the l.c.d. backplane clock, so rendering the point inactive. In temperature mode, the point is activated by connecting it via the OR gate around diodes D1, D2 and resistor R18 to two segments of the l.c.d. hundreds digit, one or other of which will always be active irrespective of the number displayed.

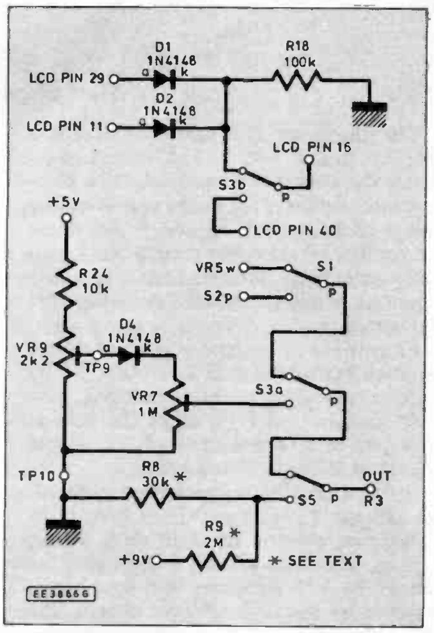


Fig. 6. Circuit diagram of the temperature and battery level section.

Also shown in Fig.6 is a battery check facility. Resistors R8 and R9 form a potential divider across the battery input lines. The tapped voltage is switched to the l.c.d. circuit (Fig. 7) via switch S5, an action which switches the previous mode selectors out of circuit.

The R8/R9 ratio causes an l.c.d. readout of approximately 900 for a battery voltage of 9·0V. There was insufficient room in the case to fit a d.p.c.o. switch to activate a decimal point in a similar way to S3.

L.C.D. READOUT

The circuit diagram which converts the monitored voltages levels into an equivalent l.c.d. display is shown in Fig. 7. The DPM chip IC1 is the heart of the circuit. It assesses the input voltage level and relates it to the reference voltage set by VR8 in series with resistor R2, timing the rate at which capacitor C4 charges and discharges.

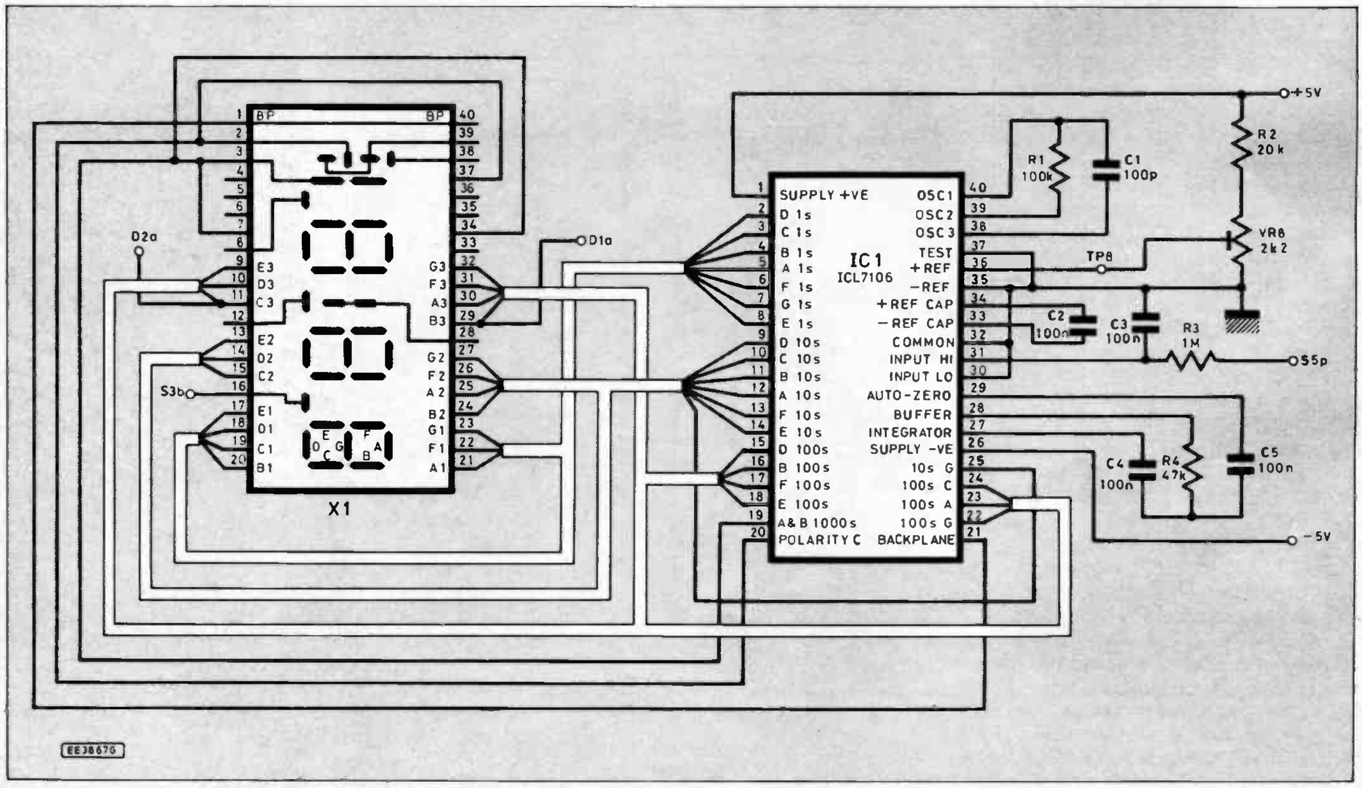
The timing is clock controlled at a rate set by resistor R1 and capacitor C1 and an internal counter counts the number of pulses required to discharge capacitor C4. The counter outputs are internally decoded to control the four l.c.d. digits and a negative polarity symbol.

The backplane pulsing and phasing necessary for controlling l.c.d.s is automatically generated by IC1 and is internally set at a sub-multiple of the main clock frequency. (Note that l.c.d. segments should *NOT* be controlled by a d.c. voltage since this steady state could damage them.)

Irrespective of the reference voltage set, the full scale range for that voltage is represented by 1999 steps. Input voltages outside the reference range cause the l.c.d. to blank the three right-hand digits and turn on the left-hand digit.

Preset VR8 is used to vary the reference voltage to suit the output voltage span produced by the transducer's amplifier stages. In effect, VR8 serves as an additional gain controller. This means that

Fig. 7. Circuit diagram of the display section and interconnection details between the display driver IC1 and the l.c.d.



when VR5 and VR6 have been set to the relative span ranges for their mode scales, a common increase or decrease to the altitude and barometer mode gains can be effected by adjusting VR8.

It will be seen that the lines controlling the polarity symbol and the thousand's digit are apparently connected to unused pins of the l.c.d. These connections correspond with the equivalent 1000 and polarity segments of a 4-digit l.c.d. module which may be used in place of the 3·5 digit version.

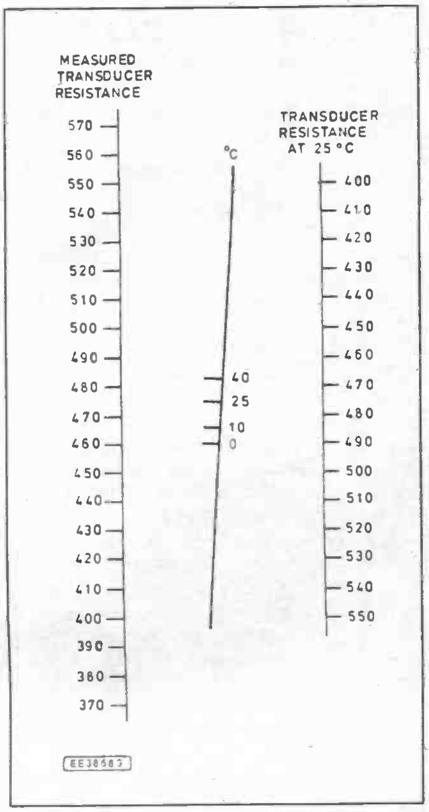


Fig. 8. Pressure transducer MPX100A resistance/temperature nomogram.

POWER SUPPLY

A regulated +/−5V supply is generated from a single 9V battery. Referring back to Fig. 5, the battery voltage is switched on by S4 and is regulated down to +5V by IC3.

Using an internal pulsed inverter, IC4 generates an almost equivalent *negative* voltage from the +5V supply. The load driven by IC4, though, will slightly reduce the voltage from the nominal −5V to around −4·7V.

Capacitor C8 is associated with the chip's internal switching and C9 is the output reservoir capacitor. There is inherently a very slight residual ripple of IC4's clock frequency left on the negative line, though the final effect of this upon the signal input to IC1 is nulled by the inclusion of resistor R3 and capacitor C3 in Fig. 7.

The current drawn by the circuit is around 13·5mA. If, as intended, the unit is used intermittently throughout a journey, a PP3-sized battery could last for weeks or even months.

Under continuous switched-on use, a PP3 battery life of around eight hours seems a reasonable expectation. The battery may be run down to about 7·3V before IC1 fails to regulate satisfactorily. A NiCad battery may be used.

COMPONENT TOLERANCES

Standard carbon-track miniature skeleton preset potentiometers and 5 per cent 0·25W carbon film resistors were used in the prototype, providing accuracy and stability well within the author's own requirements. A more tightly controlled performance can be obtained by using cermet presets and one per cent 0·25W metal film resistors. The main advantage of cermet over carbon presets in this application is the smooth linearity of their tracking, allowing more precise adjustment of their settings.

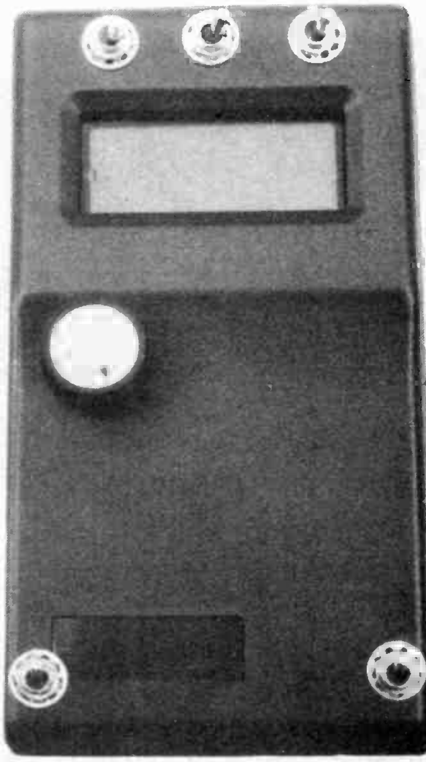
Metal film resistors have a better temperature stability than the standard carbon film variety. Typical temperature coefficients for the latter are −150 to −800 parts per million (ppm) per °C, whereas for metal film they are typically +/−50 ppm per °C. Even though temperature compensation is provided, the use of metal film resistors could still be beneficial.

RESISTANCE MATCHING

Since the correct value for resistor R5 is related to TX1 transducer's resistance at 25°C (77°F), it is preferable to take into account the transducer's temperature at the time that the measurement is made. The Nomogram in Fig. 8 shows how the resistance at a known temperature can be converted to its equivalent at 25°C (77°F).

Clip the leads of a digital multimeter to the transducer pins 1 and 3, and switch the meter to a range suitable for measuring up to about 550 ohms. Place a thermometer alongside the transducer and allow the temperature to stabilise.

Measure the resistance and note the temperature. Place a ruler so that its edge passes through the resistance value in the chart's left hand column and the temperature in the centre column. Read off the value in the right hand column and multiply it by 3·577 (a factor specified by the transducer manufacturer). This is the optimum value for R5.

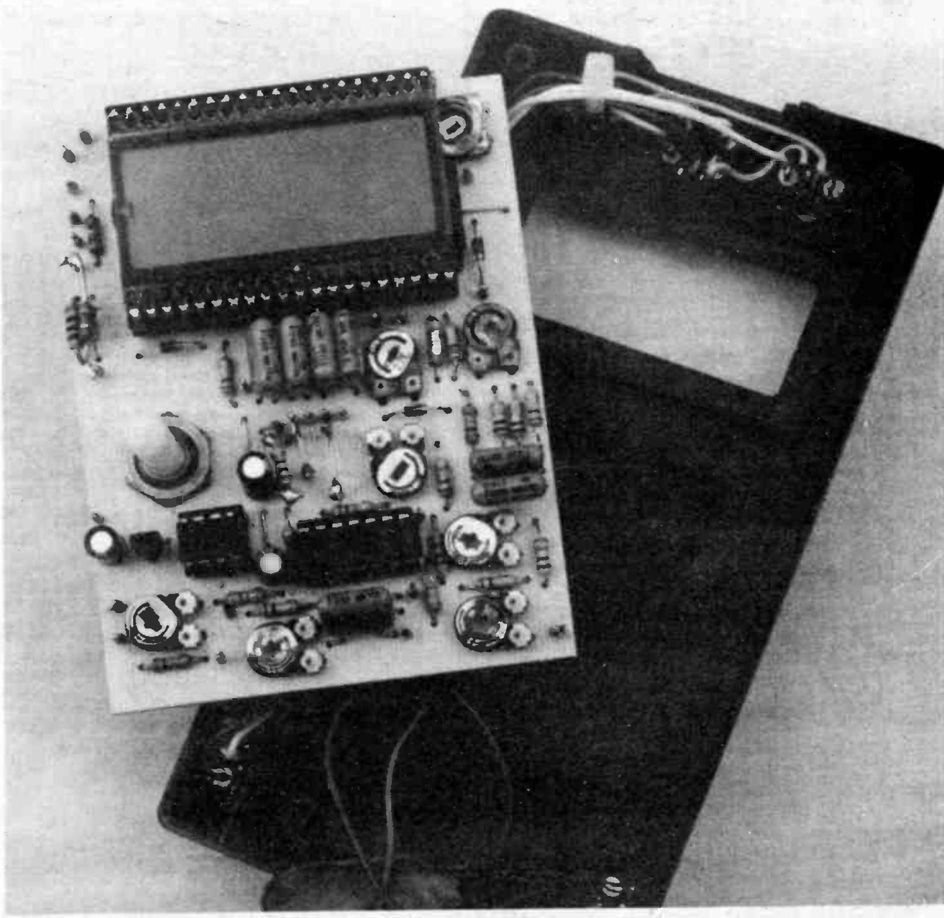


The transducer used in the prototype has a resistance of 433 ohms at 25°C and the value for R5 was calculated as 1548 ohms (1k548). The resistor with the measured value closest to this which was conveniently available was 1567 ohms. Although not the precise calculated value, the tolerance margin has proved to be acceptable.

Two or more resistors in series or parallel may be used to optimise the value. (There was not enough space on the p.c.b. to substitute a preset potentiometer for R5.)

CONSTRUCTION

The topside printed circuit board component layout and full size underside copper foil master pattern is shown in Fig. 9. This board is available from the *EPE PCB Service*, code EE807.



COMPONENTS

Resistors

R1, R11, R14, R16, R18, R19, R21	100k (7 off)
R2, R23	20k (2 off)
R3	1M
R4, R6, R22	47k (3 off)
R5	Between 1k4 and 2k – See Text
R8	30k – See Text
R9	2M – see text
R7, R12, R13, R24	10k (4 off)
R10	2k
R15	33k
R17	470k
R20	330k
R25	10

All 0·25W 5% carbon film or better.

Potentiometers

VR1	100k min. skeleton preset, horiz.
VR2, VR4, VR5	10k min. skeleton preset, horiz. (3 off)
VR3	5k rotary carbon, linear
VR6	22k min. skeleton preset, horiz.
VR7	1M min skeleton preset, horiz.
VR8, VR9	2k2 min. skeleton preset, horiz. (2 off)

All presets carbon or cermet.

Capacitors

C1	100p polystyrene
C2 to C5, C7, C10, C11	100n polyester (7 off)
C6, C8, C9	22µ radial elect., 16V (3 off)

Semiconductors

D1 to D4	1N4148 signal diode
IC1	ICL7106 ADC/display driver
IC2	LM324 quad op.amp
IC3	78L05 +5V 100mA voltage regulator
IC4	ICL7660 voltage converter

Switches

S1, S2, S4, S5	miniature s.p.c.o. toggle (4 off)
S3	miniature d.p.c.o. toggle

See SHOP TALK Page

Miscellaneous

TX1	MPX100A pressure transducer
X1	3½ digit l.c.d. display

Handheld, calculator style palastic case, size 148mm x 60mm x 36mm (with 50mm x 20mm display window cutout); 8-pin d.i.l. socket, 14-pin d.i.l. socket; 40-pin d.i.l. socket (3-off – see text); PP3 battery and snap connector; knob; p.c.b. stand-off spacer; rubber grommet for VR3 shaft; connecting wire; fixings; solder etc.

Printed circuit board available from EE PCB Service, code EE807 (see PCB page 754).

Approx cost guidance only **£50**

Before mounting the components, check that the board fits the case satisfactorily, trimming off any excess fibre-glass if necessary. It may also, with some models of the case, be necessary to trim down the internal partitions to allow the board to fit lengthwise while still allowing for the battery and switches to be inserted.

The front panel drilling measurements and layout used in the prototype model is shown in Fig. 10. Check that they apply to your case before drilling any holes!

CIRCUIT BOARD

There are several link wires required on the p.c.b., some of which go below i.c. positions (see Fig. 9), and these should be inserted and soldered first, but omit links TP1/TP2 and TP3/TP4 until later. The preset "pots" and d.i.l. sockets for the i.c.s and the l.c.d. should be inserted next.

The board has been designed so that the display is mounted above IC1. This is achieved by first soldering two 20-pin s.i.l. (single-in-line) sockets into the l.c.d. position. If s.i.l. sockets are not available, cut a 40-pin d.i.l. socket in half. Once assembly is complete, a *second* level of s.i.l. sockets to hold the l.c.d. is plugged into the first.

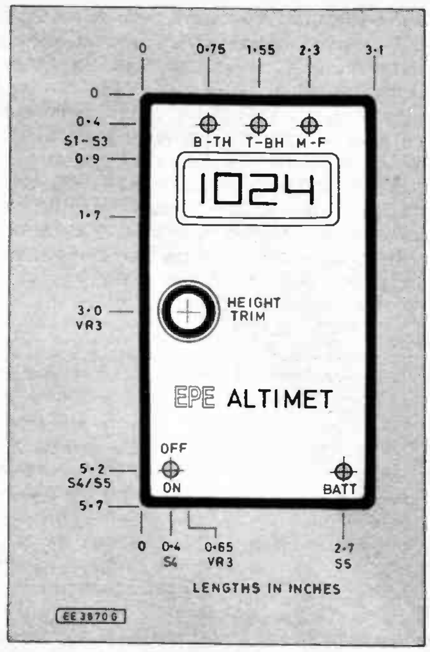


Fig. 10. Case drilling details.

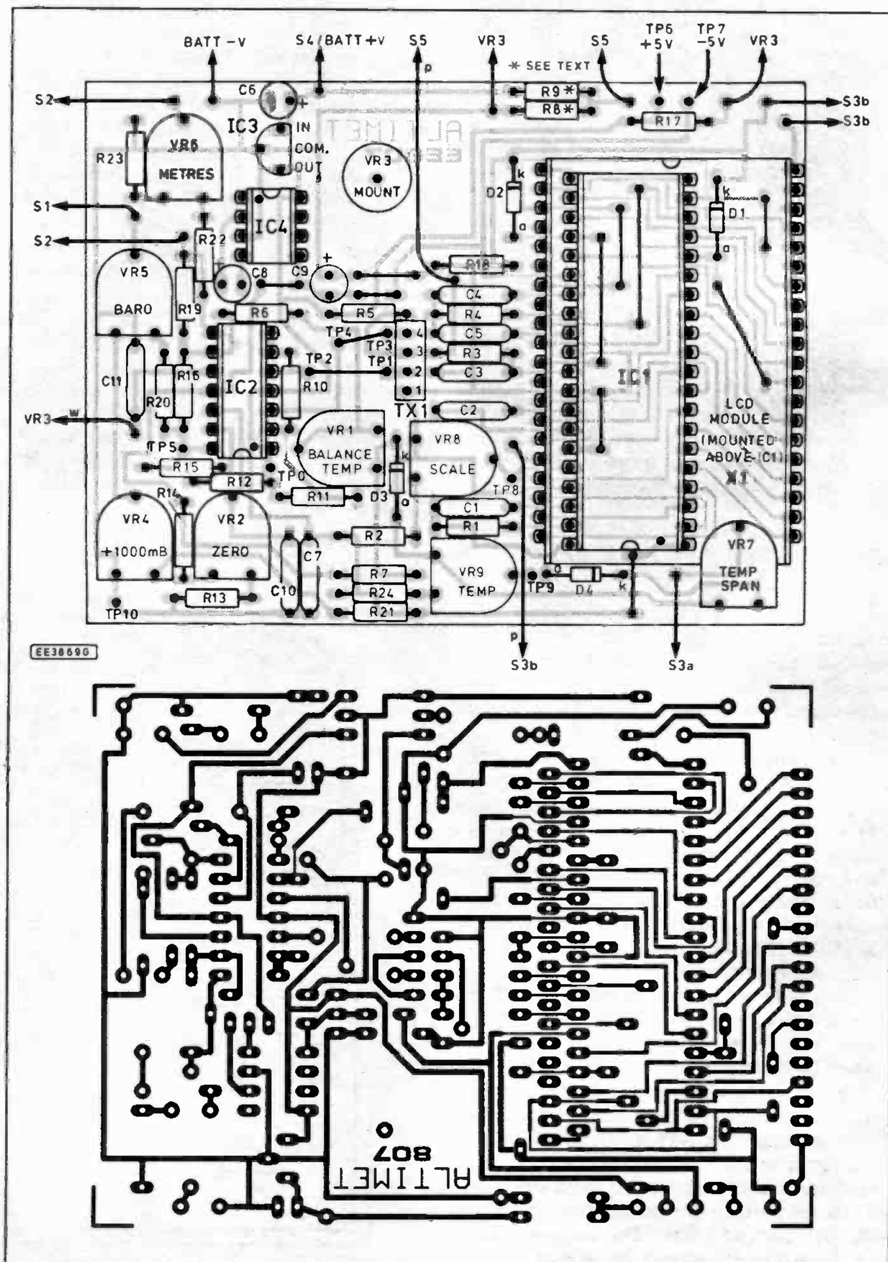
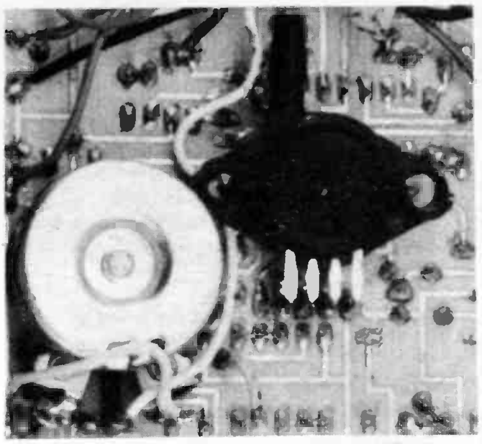


Fig. 9. Printed circuit board component layout and full size foil pattern.

Solder in the components in order of resistors, diodes, capacitors and voltage regulator IC3. Next mount the rotary potentiometer VR3 in its p.c.b. hole, shaft protruding from the component side, using an insulating washer between its body and the back of the board to prevent shorting across soldered joints. The transducer TX1 is also mounted on the trackside of the board, carefully bending its leads through ninety degrees so that its body lies parallel to the p.c.b. in the direction of IC2.

Two versions of the MPX100A may be available (Fig. 12), one enclosed in a plastic case, the other not. Either may be used, but the unenclosed version must have insulating tape placed between its body and the p.c.b. tracks. *Do NOT cover the hole in the transducer's centre, and under no circumstances poke anything into the hole below which is the very delicate pressure diaphragm.*



(above) Transducer TX1 and VR3 mounted on the board track side and (below) the completed circuit board.

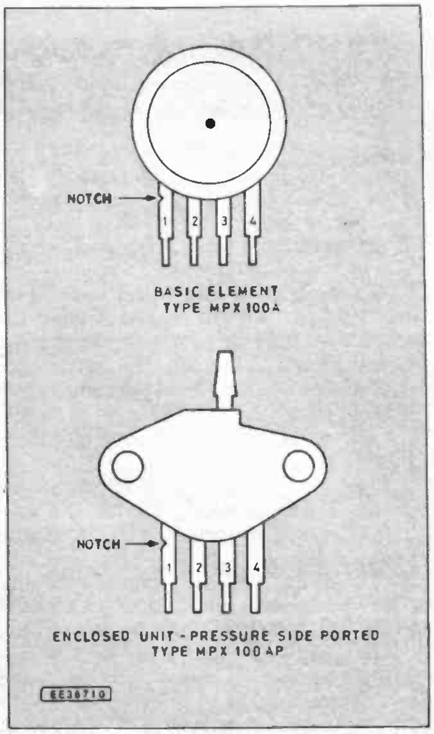


Fig. 12. Pressure transducer pintout details.

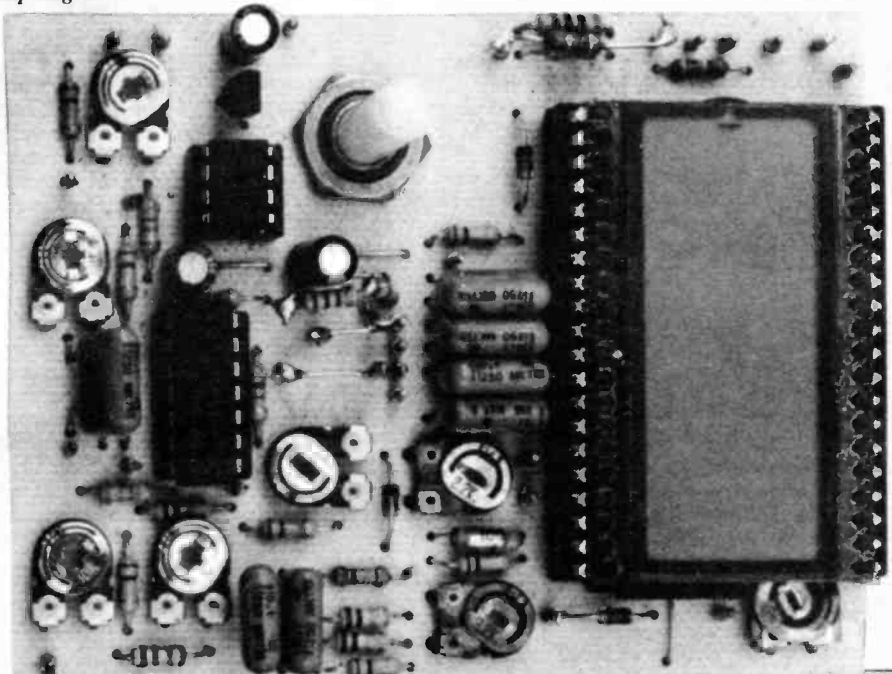


Fig. 11 (right). Interwiring from off-board components to the p.c.b. Note, VR3, TX1 and all wires are connected to trackside.

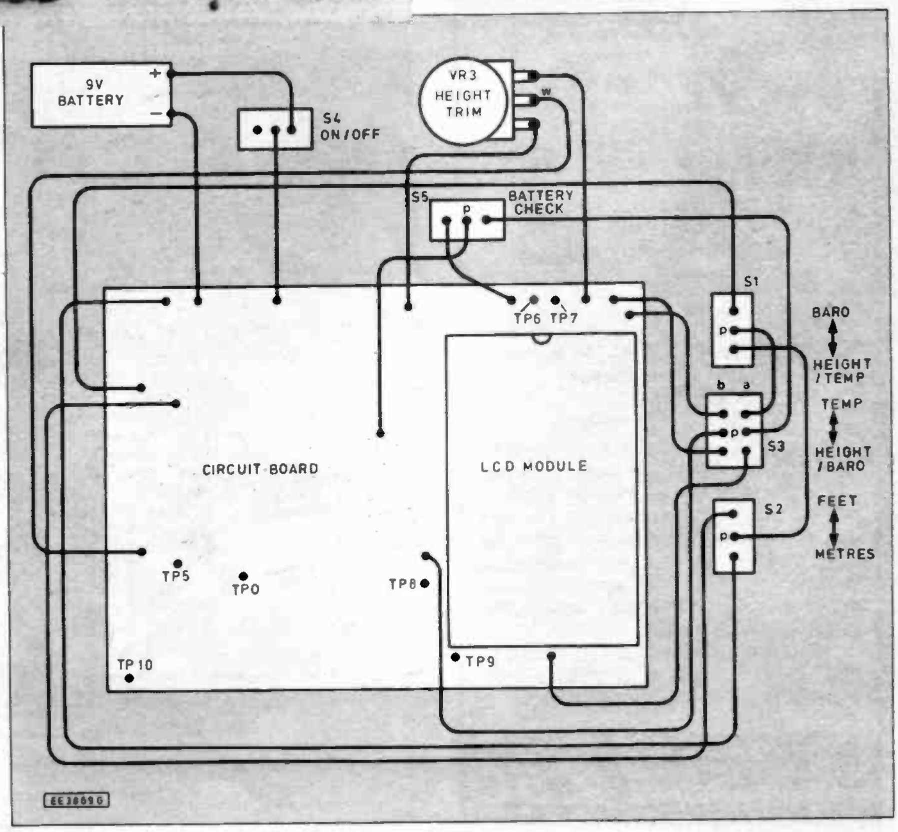
Details of the interwiring from the circuit board to all off-board components is shown in Fig. 11. Wire up all control connections from the trackside of the board and then thoroughly check with a close-up magnifying glass that there are no shorts between joints and adjacent tracks.

INITIAL TESTING

It is suggested that for the setting-up procedures the unit should be powered from a bench power supply delivering 9V, or that a 9V battery of greater size than PP3 be used. A 12V supply, such as a car battery, may be used though to avoid overtaxing IC3, a 390 ohm 0·5W resistor should be connected in series with the *positive* battery lead, so reducing the supply to about 9V when full load is applied.

Several test points (TP) are provided on the p.c.b. For ease of use it is recommended that terminal pins are soldered into these positions. All test measurements are made with respect to the negative terminal of the 9V battery which should be regarded as the 0V or "ground" line. The common lead of the voltmeter should be clipped to test point TP10.

For the first test, with IC3 and IC4 in circuit, but the l.c.d. and other i.c.s omitted, switch on and check that close to +5V is present at TP6 and that about −5V is present at TP7. Check the voltages at TP6 and TP7 again when IC1, IC2 and the display X1 have been inserted, but note that TP7 may now have fallen to about −4·7V. Any large deviation of the supply voltages will indicate a fault condition, such as a wrong component polarity or a track short or break.



BENCH SETTING

Throughout this section of the setting-up, the figures obtained from the model are quoted in square brackets as an example. They will vary slightly for other units.

Setting-up falls into two parts, "workshop alignment" and fine tuning under "field conditions". Since the response of the transducer can vary in manufacture between 45mV and 90mV per 100kPa, the final alignment can only take place after subjecting the unit to known changes in barometric pressure, such as those experienced when using it at the top and bottom of a hill of known height.

However, the millibars and metres presets VR4 to VR6 are aligned without the transducer fully in circuit, using the test circuit shown in Fig. 13. The circuit consists of R24 and VR9 from the temperature readout circuit, with the addition of a resistor R25 across VR9 to temporarily reduce its span range.

Temporarily link the outer terminals of the rotary control VR3 to TP6 and TP7 instead of to their normal designated points in Fig. 9. Set presets VR1, VR2 and VR3 midway, VR4 to ground, VR5 and VR6 to maximum output, and set VR8 for a reference voltage of about 200mV at TP8.

Clip a digital voltmeter across TP9 and TP10 and on its lowest suitable range measure the voltage when the wiper of VR9 is at its maximum resistance [4·9mV]. Link TP2 to TP9 and TP4 to TP10 (as links TP1/TP2 and TP3/TP4 have been left out, the transducer is not presently connected to IC2).

Assume for the moment that the transducer will have a span of 60mV per 100kPa and that 1000 metres = 10kPa. Therefore, 1000 metres represents a 6mV swing from the transducer which equals 3,280 feet (1000 × 3·28). Calculate the number of feet that the measured millivolt span range of VR9 represents: [3,280ft/6mV × 4·9mV = 2,678 feet].

FEET

Set the switches for Feet mode. Set VR9 midway and adjust VR2 and VR3 until the display X1 shows a reading of about zero (within a hundred units or so). Note the total l.c.d. readout range with VR9 at its minimum and maximum settings.

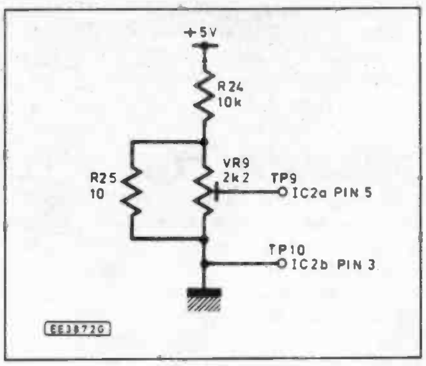


Fig. 13. Alignment and setting-up test circuit diagram.

Adjust VR8 until the full range controlled by VR9 is close to that calculated [−1305 to +1373 = 2678, TP8 = 178·4mV]. Set VR9 to maximum output [l.c.d. = 1373]. (If the feet range span obtained is not exactly that calculated, for the next calculations use the maximum output figure actually obtained.)

METRES

Switch S2 to the Metres range. Divide the maximum feet reading by 3·28 to produce the metres integer equivalent [1373/3·28 = 418·597561 = 419]. Without touching VR8, adjust VR6 until the l.c.d. reads as close as possible to the calculated metres value [419].

Set VR9 to minimum and check that the l.c.d. readout is the metres close equivalent to the minimum feet readout [−1305/3·28 = 397·865854 = 398]. There is likely to be a slight non-linearity between the feet and metres conversion figures within about 10 metres either side of a zero height readout.

Switch S1 to the Millibars range, set VR9 midway and adjust VR4 until an l.c.d. readout of about 1000 is produced. Do not adjust VR8. From the measured swing range of VR9 [4·9mV] calculate the millibar range that this represents:
[60mV = 1000mb therefore 4·9mV = 1000/60 × 4·9 = 81·66mb = 82mb]

Swing VR9 back and forth across its range and adjust VR5 until the total l.c.d. range difference is the calculated millibar value [975 to 1057 = 82].

Layout of function switches on the front panel and position of the p.c.b. inside the case, showing wiring to track side and switches S4, S5 either side of the battery compartment.

TRANSDUCER BALANCING

The next step is to put the transducer fully into circuit and adjust preset VR1 to compensate for l.c.d. readout drift with temperature. Remove "test" resistor R25 from across VR9, disconnect the temporary TP10/TP4 and TP9/TP2 links, link TP1 to TP2 and TP3 to TP4, and correctly reconnect VR3. Switch to the Feet or Metres range, then raise and lower the unit between floor and ceiling and observe that the display registers the height changes, even though accurate altitude setting has not yet been made.

After leaving the unit switched on for a few minutes to allow temperatures to stabilise, note the room temperature (as shown on a good mercury-filled thermometer). Switch to the metres range, set VR1 midway, adjust preset VR3 and/or VR2 for an l.c.d. readout of about zero. Note the l.c.d. readouts with VR1 at *minimum, midway* and *maximum* resistance settings.

Allow the room temperature to rise by as many degrees as is feasible, 20°F or 10°C for example. Note the l.c.d. readings at the three VR1 settings and judge approximately which value of VR1 produces the minimum readout change.

(A hair dryer blowing low heat across both sides of the p.c.b. was used in the original tests, allowing the temperature to rise slowly over about 15 minutes. Cooling to low temperatures was assisted by a fridge!

Beware, though, that rapid temperature changes and uneven p.c.b. heating can produce misleading results. If condensation forms on the unit when removed from the fridge dry it off using the hair dryer.)

Let the room and the unit cool naturally back to the original temperature, set VR1 to two or three positions close to the estimated value noting the l.c.d. readings. Allow the temperature to rise again and note the l.c.d. figures at each chosen VR1 position. Set VR1 to the resistance setting at which the minimum output change occurs.

The transducer TX1 and temperature compensation diode D3 may respond at different rates affecting the apparent stability of the readout during the early minutes of a significant temperature change. Once the transducer and diode reach the same temperature the readout should have returned to its original figures.

HYSTERESIS

It should be recognised that there are component hysteresis factors which affect the maximum practical balance obtainable. Hysteresis applies particularly to the transducer and dictates that at any given pressure or temperature there will be a difference in the output voltages produced depending on whether this pressure or temperature is approached upwards or downwards.

The MPX100A has typical pressure and temperature hysteresis factors of +/−0·05% and +−0·5% of full scale (100kPa) respectively. Without temperature drift correction the l.c.d. output change on the test model was about 15 metres per °F (27 metres °C) the equivalent of around 1·5mV per °F (2·7mV °C). Although impaired by hysteresis, the compensation circuit allowed the drift to be kept down to only 20 metres over a massive 40°F (22.2°C) temperature change.

Hysteresis and drift factors, however, should be seen in context with the scale of potential atmospheric changes. A barometric change of only one millibar will cause an apparent change of 10 metres on the altimeter. At the time of writing, the weather forecast predicts a 15mb change from 1020mb to 1035mb over the next 24 hours. The effects of normal ambient temperature changes become minor by comparison.

TEMPERATURE AND BATTERY READOUTS

The unit may be set for either Celsius or Fahrenheit temperature readout scales, depending on the range set by preset VR7. Set VR9 and VR7 midway, switch to Temperature mode and note the display reading and that of a thermometer alongside the p.c.b.

Allow the room temperature to change across a reasonable range and note the difference in the l.c.d. reading and the difference in temperature. Adjust VR7 up or down as appropriate and again change the room temperature. Repeat until the temperature and l.c.d. spans are the same, and then adjust VR9 so that the l.c.d. reading matches the thermometer reading.

The values for resistors R8 and R9 should be selected after IC1's final reference voltage has been set by VR8. The ratio of R8 to R9 should cause the l.c.d. to show a reading of approximately 900 with a battery voltage of 9·0V. If the reading is low, increase the value of R8 or decrease R9.

FIELD SETTING

Final altitude alignment can only be done by checking the unit's height readout against a known height change. Consult a local Ordnance Survey (OS) map, preferably the large scale Pathfinder (green) series, and find two locations where the heights are known and of several tens of metres apart.

Go to one location and using the rotary control VR3 set the height on the l.c.d., also noting the temperature. If the temperature is changing and the unit's temperature balance is not exact, while still at the same location note the l.c.d. height reading at different temperatures. Go to the other location and repeat.

Take two readings made at the same temperature and calculate the difference between the l.c.d. change and the actual height change. Slightly reduce or increase the setting of preset VR8 as appropriate and repeat the procedure until the actual and displayed height spans correspond. An l.c.d. reading change of 55 metres compared to an actual height change of 60 metres, for example, would require adjustment of VR8 to decrease IC1's reference voltage.

It is preferable for the time between high and low readings to be kept short to minimise the likelihood of atmospheric pressure changes occurring between readings. It is advisable, for the same reason, to choose a day when the *BBC TV* weather forecast maps show the isobars well spaced out.

Once VR8 has been finally set, the current millibar setting for your area (watch *BBC TV* again!) can be set by adjusting VR4. It should be remembered that weather forecast charts give millibar figures referenced to sea level. If you live significantly higher than sea level, the true atmospheric pressure for your location can be calculated from the simple equation +10 metres = −1mb.

USING IT

Since atmospheric pressure is constantly changing throughout the day, the height trimming control VR3 should be adjusted prior to each outing, setting the display to show the correct height in metres for the starting location as established from an OS map. If significant isobar changes are forecast it is advisable to re-trim VR3 in association with an OS map occasionally throughout a prolonged land-bound journey.

It is assumed that balloonists and other leisure-aeronauts will not be aloft long enough for meteorological changes during their flight to have any significance. Try to avoid subjecting the EPE Altimet to rapid or excessive temperature changes. □

LOW COST RANGER1 PCB DESIGN FROM SEETRAX

- Circuit Schematic
- Circuit Capture
- PCB Design
- Host Of Outputs

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What The Press Said About RANGER1

For most small users, Seetrax Ranger1 provides a sophisticated system at an affordable price. It is better than EasyPC or Tsien's Boardmaker since it provides a lot more automation and takes the design all the way from schematic to PCB - other packages separate designs for both, that is, no schematic capture. It is more expensive but the ability to draw in the circuit diagram and quickly turn it into a board design easily makes up for this.

Source JUNE 1991 Practical Electronics

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Innovations

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

Amateur Radio Morse Test

THE Radiocommunications Agency has announced proposed changes to the format of the 12 words per minute *Amateur Radio Morse Test.*

It is claimed that the new format will prepare candidates better for the sort of operating conditions they can expect to encounter "On Air". It follows the same lines as the five words per minute test which was successfully introduced last year.

The new style test will come into operation from January 1, 1993. Candidates who have studied under the old format will still be able to take the old test until March 31, 1993 when the new test will become compulsory.

Simultaneously with the introduction of the new style test, 1 January, 1993 will also see a new procedure for the identification of candidates. Instead of written proof of identity, candidates will have to bring to the test centre two recent passport sized photographs of themselves. – *Shades of code breaking?*

In the new test, the candidate will be required to receive a minimum of 120 letters and 7 figures in the form of a typical exchange between radio amateurs. A manual Morse key will be used to send the message. This portion of the test will last approximately 2½ minutes and a maximum of six uncorrected errors will be permitted.

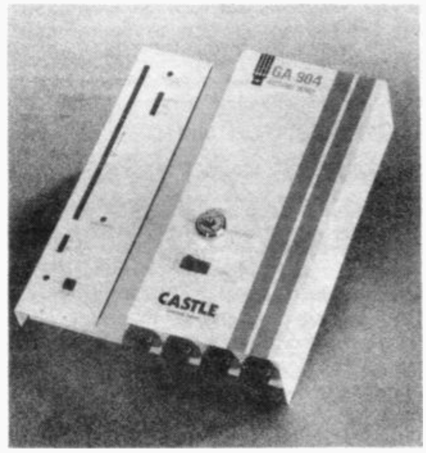
In the sending test, the candidate will be given a text to send by hand on a straight Morse key consisting of not less than 75 letters and five figures, also in the form of a typical exchange. This portion of the test will last approximately 1½ minutes. There must be no uncorrected errors in the sending and not more than four corrected errors.

The Radio Society of Great Britain conducts both the five and 12 w.p.m. Morse tests on behalf of the Agency. Further information on taking the test may be obtained from: **Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE.**

Patent News

The first ever report published by the Patent Office since becoming a Trading Fund on 1 October, 1991, and its accounts, prepared for the first time on a full commercial basis, show a surplus of £603,000 for the six month period to 31 March, 1992.

However, in volume terms, patent applications in 1991 were two per cent down on 1990, while trade mark (including service mark) and design applications were down by 12 per cent respectively. A similar trend was evident in the European Patent Office where a down-turn in activity was recorded for the first time.



Orange Aid

No its not a new fizzy drink but a new approach which may help anyone who has been a victim or does not want to be the perpetrator of excessive noise. Thanks to the Castle "Electronic Orange", the annoying sounds which may be escaping from the local disco may be a thing of the past.

The sound pressure (noise) within the room is picked up by a microphone and when the noise reaches the threshold, which is adjustable, a spherical yellow coloured lamp, "the orange", lights up. If the noise rises further, the device removes the power to the amplifiers. After resetting the electronics, either manually or automatically, the volume must be reduced to prevent another trip condition from occurring.

Further information and prices from **Castle Associates Ltd, Salter Road, Cayton Low Road Industrial Estate, Scarborough, North Yorks YO11 3UZ.**

THE PHILIPS LECTURE

Established in 1980 under the sponsorship of Philips Electrical, the Philips Lecture is given annually on the theme of science in industry. This years lecture is entitled "Thermal Imaging – A New Eye On The World" and is being given by Dr. C. T. Elliott of the Defence Research Agency, Malvern.

A thermal imager produces a visible, television-like image using the infrared radiation that warm objects emit. It sees in complete darkness and through smoke and mist. This enhanced vision capability has given rise to numerous military and civil applications such as a pilot aid for military aircraft flying at low level in the dark, helping firemen to find people in smoke-filled buildings, and possibly, in future, helping to drive cars at night.

The development both of high performance imagers, based on cooled semiconductor detectors, and moderate performance imagers, using uncooled pyroelectric detectors, will be outlined together with illustrations of some of the applications.

The lecture will take place at the following venues and further details can be obtained from **The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG. Tel: 071 839 5561.**

Venues: 7 October, 17.30 at The Royal Society, 6 Carlton House Terrace; 12 October, University of Surrey and the University of Durham on 16 October.

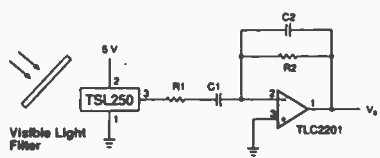
BOOKSHOP

To help make their renowned range of technical publications more readily available to industry and educational establishments alike, Texas have formed a "Technical Bookshop" and issued a catalogue.

The 1992 Technical Bookshop Catalogue contains a brief description of titles available and lists data books, user guides and applications manuals for engineers and students.

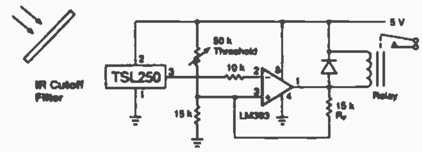
Texas Instruments Ltd, Dept EPE, Manton Lane, Bedford MK41 7AP. Tel 0234 270111.

Typical Applications for the TSL250



IR Remote Control Receiver

The TSL252 and a simple active filter can be used as an IR remote control receiver. A visible light filter is used to reject visible light and pass infrared, thus reducing interference. R1, C1, R2, C2 and the TLC2201 form an active band pass filter. The actual values are chosen based on the data rate of the IR transmitter.



Adjustable Light-Activated Switch

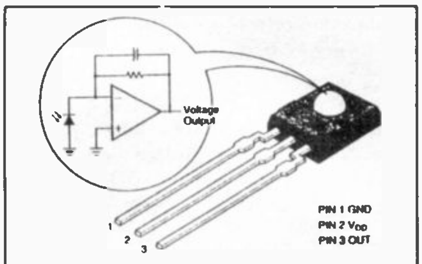
The IR cutoff filter prevents the switch from being activated by infrared. Resistor R_F provides hysteresis to prevent false activation due to noise.

BRIGHT LIGHTS

Changes in light intensity can be used or monitored with high accuracy using one of the new family of light-to-voltage optical sensors (types TSL250/51/52) from Texas Instruments. The devices combine, in a single three-pin package, a large area photodiode, an operational amplifier and feedback components.

The devices operate from a single variable supply voltage (3V to 9V), and each device provides a voltage output proportional to the incident light intensity. Because the output is a voltage level, the devices can be easily interfaced to comparators or A/D converters.

Integrating an amplifier and a photodiode together on the same chip not only simplifies designs, but also enhances the noise immunity of the device. Thus they are particularly useful at low light levels or in noisy environments.



Potential applications for the TSL250/1/2 include light control, IR remote control, security systems and medical chemical testing.

Further details from: **Texas Instruments Ltd, Dept EPE, Manton Lane, Bedford MK41 7AP.**

Cable Gains

The number of homes connected to broadband cable systems rose in July to 330,630, according to the Independent Television Commission's (ITC) latest cable statistics. This was a net increase of 39,000 (13·5%) over the last three months and of 139,000 (72·5%) over the last year.

Because research has shown cable households to be larger than average (3·1 people aged four years and over), it is claimed this means that over one million viewers now receive multichannel television via one of Britain's cable franchises. The take-up rate has increased by 2·25 percentage points over the last year.

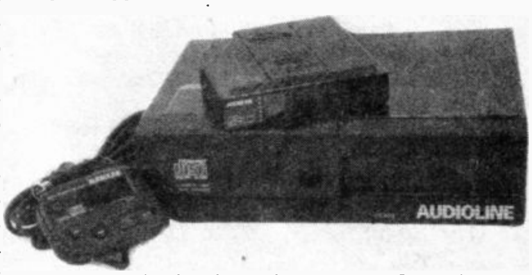
In-Car Stereo CD

The closest thing yet to a sound studio on wheels is one of the claims from Maplin for their new add-on In-Car Stereo 6X CD Autochanger System. – Mind you at £329.95 its only what you'd expect.

The unit takes standard 5 in. discs and also 3 in. types with adaptors (not supplied). A stereo pair of phono sockets are supplied for the audio output, but if the radio cassette does not have spare CD inputs, there is no problem. The CD autochanger includes an ingenious v.h.f. f.m. modulator which can be simply inserted between the plug of the aerial lead and input socket of the radio unit – in principal just like a video recorder between antenna and TV at home.

The f.m. modulator provides an interface between the CD autochanger and the f.m. stereo radio. But please note: The radio unit *must* be f.m. stereo – the unit cannot work with MW and LW receivers.

The main CD autochanger player can be fitted distant from the existing stereo system, and is remotely controlled via a small keypad which can be fitted on the dashboard by means of the self-adhesive Velcro pad supplied.



The Car CD Multiplay (code GK74R) from Maplin.

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THE NEXT 21 YEARS

BARRY FOX

For at least ten years the Japanese electronics companies have been trying to engineer the marriage of audio and video. They have many times promised consumers a single AV centre in the living-room, with TV screen, hifi sound system, video tape and disc and surround-sound speakers, perhaps with a computer keyboard and telephone tagged on. But most consumers – if only for convenience in room layout – still prefer to have a separate TV set and hifi system in different parts of the room, a telephone on the wall or table, and a computer in another room.

The situation is likely to change over the next ten years, because it becomes increasingly hard to draw any dividing line between audio, video and telecommunications. Also consumers are becoming increasingly unhappy with the proliferation of different boxes which serve related functions and all require their own cobweb of wiring. The time will soon, finally be right for a more unified approach to electronics in the home.

DIGITAL RECORDING

No-one can yet predict which of the two competing new digital home recording systems (DCC or Mini Disc) will win the standards battle due this winter, or whether both will fail and let recordable CD fill the gap. Whatever happens, digital sound recording will become a way of life, and with it legislation and technology to restrict cloning but at the same time legitimize some degree of copying – probably with the implementation of a tax on blank media.

Until now, making an audio recording has been a relatively troublesome business, with the need to set gain controls to avoid overload, or rely on automatic gain control circuitry which compresses the sound. With digital recorders, making a copy is as easy as copying computer data from disc to disc.

Once the public gets a feel for this there will be no turning back – just as people who have bought CD players seldom go back to playing vinyl LPs. It is not so much the sound quality which sells CDs, but the glorious convenience of the system.

ARMCHAIR RECORD STORE

From the success of any home digital audio recording format, it will be a logical step to combination units, which hard wire a CD player to a digital recorder. Digital audio broadcasting, whether by terrestrial transmitter or satellite, will open the door to what has been dubbed "the armchair record store". This is a digital recorder which copies broadcast material, for a fee, and with copyright payment, as an alternative to record retailing.

Digital TV, whether conventional or high definition, will provide more channels from available terrestrial and satellite bandwidths. Viewers will need a digital decoder, which will probably double as a de-scrambling device for subscription entertainment and very probably control a VCR to tape and decode only what the viewer has paid to watch.

The advent of digital TV transmission will create the need for a new kind of home video recorder, which works digitally. This will tape the raw broadcast data stream for later decoding. Where several programmes are interleaved into the same stream, the video recorder will tape them all. When the tape is replayed the viewer will be able to decide which one to decode and watch. If some or all of the programmes are scrambled, the viewer will have to pay a fee to decode and watch them.

The broadcasters are already using digital video recorders to originate and edit programmes. The advantage of digital recording is that it allows repeated copying, through many generations, without loss of quality. For special effects work, TV producers may well have to copy through a dozen generations. There are several different digital formats on offer to professionals and as the technology matures it will become cheap enough to spin off into the domestic market.

HOME VIDEOS

Many people already use camcorders to make point and shoot video movies. An increasing number of hobbyists edit their home videos. These people will welcome the chance to use digital technology, and so avoid generation loss.

Recordable discs systems will let editors work much faster than they can from tape. Sony's Mini Disc may well find applications in video, with first generation units recording video as an f.m. analogue signal and later as digital code.

All the new digital audio and video formats will rely heavily on compression, with data rate dratically reduced by real time analysis of the signal by a coder which discards any redundant information.

INTERACTION

The new audio and video transmission technologies will be used with cable systems, and with the added benefit of interaction. Viewers will be able to control the choice of programmes and services sent to them by feeding signals back up the same cable. They will be able to vote too, whether in quiz shows or political ballots.

Although a lot of effort has been made to provide interaction control without a keyboard, this will change. To anyone who uses a keyboard, it is infuriatingly clumsy to have to type text by using a mouse or similar control to select letters from a displayed alphabet. And more and more people are growing up with keyboards. Within a few years it will be commonplace to provide TV viewers with a portable keyboard which connects to the TV set by infra red link.

The growth of cable will be stimulated by growing realisation by the public that the Mercury service already offered or promised by twenty cable franchises gives a hassle-free alternative to British Telecom's practical monopoly to date.

Much of the talk about video phones is ill-informed, because few people need or want to watch who they are talking with by phone. Picture information can most easily be sent by fax. But cable links and/or the new ISDN phone lines should make it easier for video phones to provide security surveillance. This will marry the phone to a domestic TV screen.

CD-I

Although no-one knows how long it will take, interactive CD (almost certainly Philips CD-I format) will become a way of life, with games probably seeding a new revolution in home entertainment and education. Kodak's Photo CD looks likely to be a short lived product, simply because the compatibility bridge between CD-I and Photo CD has already made the Photo CD player little more than a CD-I player with a few microchips or wires removed to justify the lower price.

With full motion video, and Photo CD imaging technology, and the ability to play CD audio discs, the CD-I player could become the CD player of the future. There is likely to be a second standard, which quadruples the amount of information stored on disc, thereby doubling picture quality and playing time. This makes the five inch disc a carrier for movies as well as games, education, audio etc. So although digital FMV picture quality cannot yet match the twelve inch analogue Laser Disc, this will change. Pioneer, currently relaunching Laser Disc in Europe, is researching digital video technology.

STANDARD

The big advantage of digial video disc is not that the programme can be easily copied many times. Indeed this is seen by the movie studios as a very real disadvantage, and they will press for electronic copy controls similar to the Serial Mangement Copy System already adopted as a standard feature for digital audio recorders. The real advantage is that digital video can be made standards-indpendent. One disc or tape will play in any country, regardless of local TV standard.

This will apply both to conventional TV formats, and the new widescreen and high defintion formats that will move into the home over the next decade. It is too early yet to predict which formats will prevail, except to be sure that the long term future must be digital.

The transition from conventional 4:3 TV screens to widescreen 16:9 displays will be governed more by artistic, than technical, considerations. Producers and broadcasters have to decide how to make programmes shot in 16:9 format acceptable to viewers with 4:3 sets, and how best to display 4:3 programmes in widescreen ratio.

All these strands lead to some simplification and rationalization of the mess of equipment now cluttering homes. Quite simply homes of the future will run out of space for separate boxes, and will stop buying unless they are presented with an acceptable alternative.

At the same time there should be a trend towards portable information centres, a Data Discman/CD-I player which sits on the desk or by the telephone, providing information such as telephone numbers from Yellow Pages or the standard telephone directory. But this will only happen when colour l.c.d. screens of reasonable size become affordable – and when British Telecom abandons its policy of charging over £2000 a year for use of directory data on a disc that cost only around £1 to press.

Public concern for the environment may help here. Why spend around 30 million a year on cutting down trees to print paper directories when all the information can be stored on a single piece of plastics, five inches in diameter?

CHOICES

Over the next decades it is clear that the consumer will be asked to make many choices between competing new technologies. It is also clear that legislators will be asked to make choices, for instance on the type of technology to be used for digital audio and TV broadcasting, and on the vexed question of taxing blank media.

The already tangled relationship between consumers' freedom of choice, natural rivalry between manufacturers and the need for governments to keep some kind of control on broadcasting, will become increasingly difficult to unravel.

Only one factor will remain constant. While the hardware industry struggles to keep prices down, the software industry will struggle to keep prices up. This, of course, is why the cash-rich Japanese electronics compaines are already buying Western music, film and TV archives – and why they will continue to do so until the West has nothing left to sell.

HISTORY FORETELLS THE FUTURE

Here history foretells the future. Just look in your local electronics store and see how much of last year's hardware is still on sale. Then look in your local record and video shop and see how much old software is still being repackaged at a healthy price.

Special Feature

TOMORROWS TECHNOLOGY

IAN POOLE

TECHNOLOGY is advancing at an ever increasing rate. The necessity to stay ahead of the competition feeds companies with the incentive to spend many millions of pounds each year on research and development. This brings many advantages to the electronics enthusiast.

New components which are much better than anything previously available are constantly being launched onto the market. It does not normally take long after they are launched for them to fall in price quite dramatically and become normal every day devices.

BRIEF HISTORY

To illustrate this fact it is worth looking back over technological advances of the past 21 years. Some of the components we take for granted today were very much at the forefront of technology, if they were even available, at that time. The one which stands out above all the others must be the introduction of the microprocessor.

The first processor was in fact launched 21 years ago in 1971. Designed by the Intel Corporation, microprocessors arose out of the first calculators which were beginning to hit the market.

The first microprocessor was the 4004. It contained about 2500 transistors – a very large number for a single i.c. at the time, and it used a 4-bit word.

Along with the processor itself Intel launched a number of other companion i.c.s. These included a RAM i.c., memory control, and an I/O expansion chip.

A year later Intel announced their first 8-bit processor, the 8008. Then in 1974 this was followed by the 8080. This processor was a great improvement on the previous chips. It used NMOS technology for increased speed and it soon became an industry standard.

Intel was not the only company in the microprocessor race, many other manufacturers started to produce them. These included many famous names. One was Motorola who launched their 6800, also in 1974.

MICRO-PROCESSOR DEVELOPMENT

The introduction of the microprocessor was a revolution in itself. It reflected many of the advances which were taking place particularly in i.c. manufacture. However, developments within the whole field of electronics were involved. If these had not been made then the idea of a microprocessor would not have been possible.

One of the major advances which enabled the very large scale integration used in microprocessors to become possible was the development of MOS technology. Bipolar i.c.s were limited in the number of transistors which could be placed on a single chip. This was because of the current they consumed and the resulting heat which had to be dissipated.

The foundations for MOS technology were laid in 1959 when the first f.e.t.s were produced. They caught on only slowly because they were expensive and unreliable. However development continued and improvements came. By 1970 MOS technology was well established and it was widely used. Suitably refined silicon was available. In addition to this complementary MOS (CMOS) was becoming a standard because it enabled less power to be used than ordinary bipolar technologies.

The development which lead to all of this was the integrated circuit itself. Two people are credited with its discovery. One was Jack Kilby who worked for a small company called Texas Instruments. The other was Bob Noyce of Fairchild (who later co-founded Intel). They were both investigating ways of making electronics equipment smaller. By the end of 1961 their work had lead to both their companies producing small quantities of i.c.s.

During the 1960s and 1970s a tremendous amount of effort was placed into research of i.c. technology. The American defence and space industries gave impetus to these developments and gradually their cost fell and they became far more widely used.

In fact, today much of the research and development in the electronics industry is devoted towards i.c. technology. Some of it may not bear any fruit, but some of it may be just as revolutionary as the i.c. or the microprocessor.

CURRENT EXAMPLES

Today a very large amount of research is allied to improvements in computer related technologies. This is not to say that other areas of electronics are not seeing major developments. However computer sales represent one of the major electronics sales areas.

Within the computer related developments there are a number of main areas of research. Size is obviously one major concern. Although today's personal computers represent a considerable achievement in terms of miniaturisation there is still a need to make the basic elements within i.c.s smaller. If this can be done then operating speeds can be increased

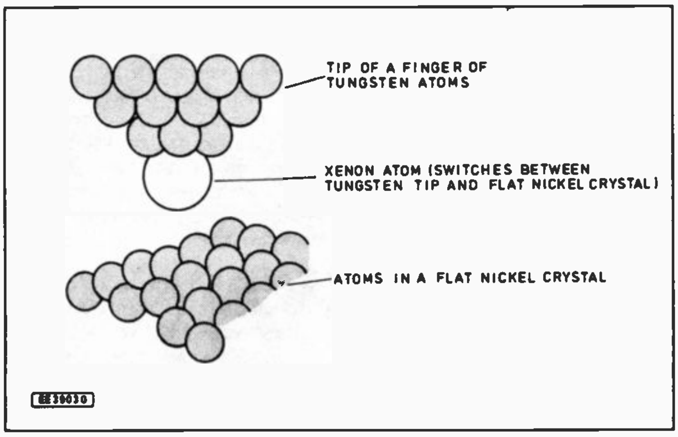

Fig. 1. Structure of the atom sized switch.

and production costs for the final units can be reduced.

One interesting development is being undertaken at IBM's Research Centre in California. It is aimed at enabling much more to be packed into integrated circuits. Currently the dimensions of the smallest transistors are around 0.5µm. It is expected that this will be reduced to about half by the end of the century. This naturally limits the ultimate size of any i.c. which is made.

To make any major reductions in the size of basic i.c. components a complete review in thinking is needed. This is exactly what the IBM researchers have been doing. They have performed some experiments which have shown how the movement of a single atom can act as a switch.

In these experiments a single atom was successfully moved between two electrodes spaced apart by a few atom diameters (Fig. 1). The effect was monitored by looking at the change in tunnelling current as the atom changed its position. The two different values of current can then be equated to the different logic levels.

Unfortunately it is not easy to demonstrate the effect. A temperature of −269 degrees C is required together with some very specialised equipment. It is hardly surprising that the effect is not in a state where it can be used commercially. However it is likely to have an impact on future generations of miniaturised devices. Also if a method is found whereby it can be incorporated into an i.c. then it could help solve many of the problems facing i.c. designers today.

SUPER-CONDUCTING I.C.s

Another interesting idea which is more likely to bring some direct results in the near future uses superconducting technology in i.c.s. The advantage of it is that it enables i.c.s to operate at very fast speeds whilst dissipating only minute amounts of power. This is a great advantage because today's fast i.c.s are power hungry. This is a problem because the heat generated by the i.c. has to be removed otherwise the chip will overheat.

Using this superconducting technology, a company in the USA. called Hypress Inc. has made a shift register. It can operate at frequencies up to 4GHz whilst only dissipating 40µW. In fact it is estimated that i.c.s using these techniques could be able to operate at 25GHz and more.

Another advantage of these devices is that the fabrication process uses temperatures of only 150 degrees C. This means that it is ideal for making i.c.s with both silicon and gallium arsenide on the same chip.

The first superconducting i.c.s are likely to find uses in military equipment, particularly in radar systems where very high speed signal processing is required. Another use is in radio communications equipment where very high speed analogue to digital converters could be made and used with high speed processors for advanced digital signal processors.

Longer term aims are very exciting. It is hoped to build a complete computer processor with them. Current estimates indicate that it should be possible to make a computer processor out of 16 chips. It would have 1000 times the processing power of a VAX11/780 and it would consume less than one watt in power.

GALLIUM ARSENIDE RISES TO THE FRONT

Gallium arsenide has long been thought of as the answer to many problems. It has many advantages over silicon, especially in terms of speed, but until recently it has only been used in applications where current consumption is not of major importance. Accordingly its uses tend to be confined to high performance r.f. circuits and very high speed logic. In none of these applications can it compare with the low power used by fairly standard silicon technologies like CMOS.

The high current consumption and power dissipation of gallium arsenide i.c.s has also limited the scale of integration of any i.c.s made from it. Honeywell have been looking at ways of reducing this power requirement. It has long been accepted that complementary circuits like those used in CMOS are the key to low power consumption. However until now it has not been possible to make this type of structure in gallium arsenide. By generating a new type of structure called a complementary HFET (C-HFET) Honeywell have been able to create complementary structures.

The first departure from the normal is that these chips do not consist of straight gallium arsenide. Instead they use a structure containing aluminium gallium arsenide and indium gallium arsenide to achieve much better results. Like CMOS this new structure only draws current when it changes state. This means that power consumption is considerably reduced and integration levels can rise.

To produce the new structures required for this process it has been necessary to use a process called molecular beam epitaxial deposition. This enables the very precis structures required for the C-HFETs to be made (Fig. 2).

Although the development of these devices is still in its very early stages, a 4K bit static RAM has been produced. In tests this had an access time of only 4nS and it dissipated only 100mW. This is about one fifth of that used by a standard gallium arsenide memory of the same size. These new devices are not available yet because there is still plenty of work to do. However they are likely to be very much in demand when they hit the market place.

3-D STORAGE

Memory development is one area of electronics which is also receiving plenty of attention. Whatever the capacity of disc drives people always want more. This has fuelled development of various storage media for many years. It is only about 15 years since disk drives for anything apart from a personal computer were housed in 19 inch rack mounting units. Now with much smaller disk drives available, development is still progressing quickly.

One of the major problems with disk storage is that it is relatively inefficient in terms of space because it can only use the surfaces of the discs. When the two sides of the disc are insufficient then several disks can be stacked to increase the capacity. Unfortunately this does not really overcome the root of the problem.

To overcome this a new idea of using 3-D storage blocks is being developed. Data can be stored in all positions in the cube and this means that the storage capacity can be dramatically increased.

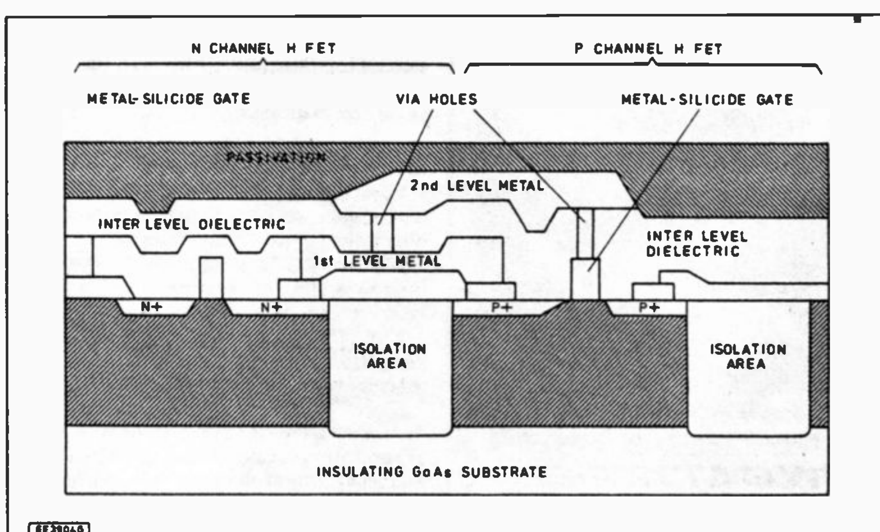

Fig. 2. C-HFET structure. In view of the complicated nature of the C-HFET it can be seen that it was not easy to develop.

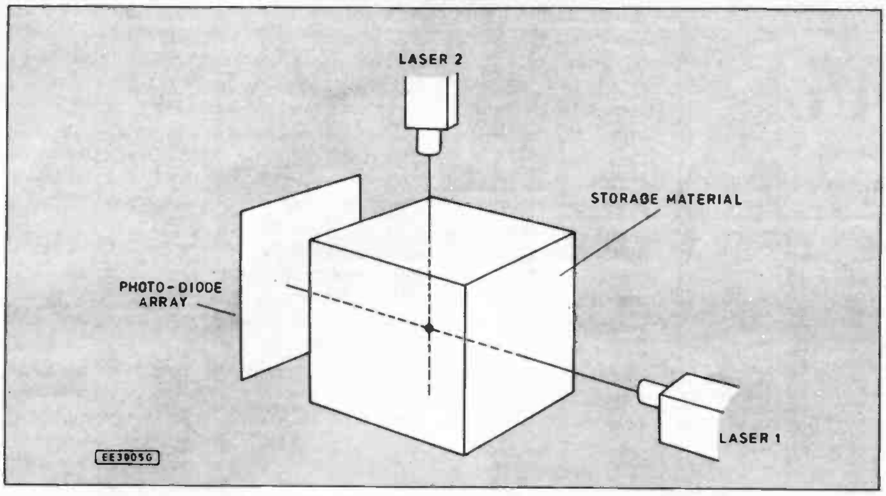

Fig. 3. 3-D storage medium.

NEW MATERIALS

To achieve this, radically new techniques and materials are needed. The basic idea involves the use of a specialised organic material which changes state when it is energised by two intersecting light beams. It is very fast and its storage density is very high. In fact the density is limited by the definition and registration of the light beams and not the material, which works at the atomic level.

The system is based around the fact that the material is normally absorbent to UV light and clear to wavelengths in the visible section of the spectrum. However when it is excited by two intersecting beams of light, its absorbency changes (Fig. 3). It then starts to absorb light in the red/green part of the spectrum. These two states of absorbency can be used to represent the two digital states.

To read data from the material an equivalent process is used. Two intersecting UV beams detect the absorbency of the material. The resulting light can then be detected by an array of photodiodes which convert the information into electrical signals.

Although the write process is fast, it can be speeded up even further by projecting an array or pattern of data onto the material. The second light beam is then used to fix the data in the correct plane in the cube. Using the process in this way large amounts of data can be stored exceedingly quickly.

Work on this idea is still very much in its experimental stages and there are many problems to be overcome. One is that the storage material which is used at the moment is only stable at low temperatures. If the process is to be widely used then it must be able to operate at room temperature. To achieve this other substances are being investigated.

The possibilities of this new technology are very exciting. Its size and speed mean that it could very quickly out-perform any other type of storage for many years to come. There are even further possibilities. Being an optical form of storage it could be ideal in linking into optical computers which are being discussed as the next revolution for the future. Not surprisingly many companies are taking a keen interest in this work.

NEW BATTERIES

Not all the developments which are taking place in electronics are associated with computers. Some are equally important and likely to have a large impact on the electronics world. One interesting area for research is in batteries.

Existing technologies have many drawbacks. Non-rechargeable or primary cells are expensive. They have to be discarded once they are used despite the fact that they remain basically intact after use. Their disposal also poses problems in this age when people are rightly conscious about the environment.

Rechargeable cells offer a very attractive alternative. Of the technologies which are available NiCads hold a virtual monopoly despite a number of difficulties. Firstly they only produce 1·2 volts instead of the 1·5 produced by a primary cell. They also have a finite number of charge/discharge cycles. Under ideal conditions this can be as many as several thousand, but under normal use it is somewhat less. One major mode of failure occurs as a result of the mechanical stresses which are set up in the cathode as a result of even normal use.

A new battery technology which is emerging could overcome these problems. The batteries use a form of ceramic called a ternary oxide. There is a wide variety of these ceramics and by choosing the correct types voltages over a relatively wide range can be generated. This means that it is possible to make batteries using this technology which will give a voltage of 1·5 volts.

The other advantage of these ceramic batteries is that they can endure an almost unlimited number of charge/discharge cycles. This results from the fact that there are almost no internal stresses set up during normal use: a fact which has been verified using X-rays.

Work is progressing quite rapidly on developing these cells. Although the results look very promising it will still be a few years before they are available.

SILICON LIGHT

Light emitting diodes are now a standard component, used in a wide variety of applications. However they have always been made from gallium arsenide. Whilst gallium arsenide performs very well it is difficult to handle and more expensive than silicon. If a process could be devised to use silicon then enormous savings could be made in view of the extensive use of l.e.d.s.

Some progress is now being made towards this goal. The key to it is based around a process being developed by Siemens. It involves an electrochemical process which creates minute pores in the silicon about 1nm in diameter.

These holes have the effect of restricting the movement of the charge carriers i.e. holes or electrons. In turn this causes the silicon to exhibit properties more like that of gallium arsenide where light emission and absorption are concerned.

Work is still in its early stages. Experiments using the treated silicon have shown that it can be stimulated into generating red or yellow light when exposed to a blue laser. The actual colour of the light which is generated is dependent upon the size of the pores. Now it remains to generate light using an electric current.

FOR THE FUTURE

It is very difficult to gaze into the future and predict how the electronics world is likely to be in 21 years time. A few people have managed to produce predictions which have come true. For example Isaac Asimov talked about a man using a small hand-held calculating machine with its red numerals. This was many years before the calculator with either l.e.d. or l.c.d. displays was available.

To have an idea of what technology may be like in a few years time it is possible to look at today's research and see where it could lead. Alternatively one can look at today's needs and see how this could stimulate research and development.

SMALLER AND FASTER

Much of today's research seems to be associated with faster, more powerful and smaller computers with more memory. The need for this seems to have been amply demonstrated by the fact that whenever a more powerful computer comes on the market then it can be used immediately. The same can also be demonstrated with even the comparatively humble PC. Ever larger programs are being written which require more memory and higher speeds.

The original 8080 or 8086 machines cannot cope with most programs on the market today. Even the 286 machines are becoming obsolete and the 386 is being overtaken by the 486.

Storage is another area where there will be major advances. PCs today now have the disc storage capacity which only a large machine would have had ten or fifteen years ago. With this in mind it is quite possible that ideas like the 3-D storage system could become a reality relatively soon.

However one area which desperately needs to be addressed is that of the user friendliness of computers and computer related products. Even video recorders and similar items can be far too complicated for the non-technical man in the street. Far more research needs to be put into the man-machine interface. Currently this is the most difficult area of any computer product.

Apart from computer products there will be major advances in personal communications. Cellular phone technology has proved to be a great success and has shown that there is a need for flexible mobile communications. In the years to come this form of communications will become cheaper and more reliable. However whether there is a real need for a global system remains to be seen. After all most people really only want to speak regularly to someone less than 30 miles away.

Like all technology, the developments we see in the next 21 years will vary. Some will be good and others may seem like a retrograde step. What is certain is that the developments will be exciting. With what currently appears to be on the horizon the next 21 years will be just as exciting as the last 21 if not more so! □

VIEWCOM

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DIGITAL INTEGRATED CIRCUIT SPECIALIST

4000 SERIES

40008	0.10
4000UB	0.11
4001A	0.11
4001B	0.10
4001UB	0.12
4002B	0.11
4006B	0.30
4007UB	0.11
4008B	0.31
4009AE	0.18
4009UB	0.18
4010B	0.18
4011B	0.11
4011UB	0.12
4012AE	0.11
4012B	0.11
4013B	0.17
4014B	0.28
4015B	0.31
4016B	0.18
4017B	0.25
4018B	0.26
4019B	0.22
4020AE	0.29
4020B	0.29
4021B	0.31
4022B	0.32
4023B	0.11
4023UB	0.17
4024AE	0.21
4024B	0.21
4025B	0.11
4026B	0.38
4027B	0.16
4028B	0.25
4029B	0.30
4030B	0.15
4031B	0.65
4032B	0.48
4033B	0.38
4034B	0.72
4035B	0.27
4036B	1.75
4037B	0.71
4038B	0.42
4039B	1.75
4040B	0.26
4041B	0.32
4042B	0.24
4043B	0.29
4044B	0.26
4045B	0.68
4046B	0.32
4047B	0.27
4048B	0.23
4049B	0.16
4049UB	0.17
4050B	0.18
4051B	0.27
4052B	0.27
4053B	0.27
4054B	0.49
4055B	0.48
4056B	0.31
4059B	3.43
4060B	0.34
4063B	0.27
4066B	0.16
4067B	1.15
4068B	0.11
4069UB	0.12
4070B	0.11
4071B	0.11
4072B	0.11
4073B	0.11
4075B	0.11
4076B	0.32
4077B	0.11
4078B	0.11
4081B	0.10
4082B	0.11
4085B	0.32
4086B	0.29
4089B	0.71
4093B	0.16
4094B	0.32
4095B	0.54
4096B	0.85
4097B	1.22
4098B	0.31
4099B	0.38
4104B	0.74
4106B	0.58
4160B	0.65
4161B	0.65
4163B	0.98
4174B	0.98
4175B	0.88
4194B	1.10
4409P	8.50
4410P	12.65
4411P	16.60
4412FP	26.90
4412FL	26.90
4412VP	14.60
4416P	16.25
4419P	8.20
4429PB	5.60
4433P	15.85
4443P	8.90
4447P1	9.78
4469P	24.10
4490P	3.90
4490L	7.80
4495P	4.82
4497P	10.45
4499P	4.80
4500B	6.40
4501UB	0.27
4502B	0.27
4503B	0.32
4504B	1.37
4505B	3.40
4506UB	0.88
4508B	0.72
4510B	0.29
4511B	0.36
4512B	0.27
4513B	2.60
4514B	0.84
4515B	0.68
4516B	0.33
4517B	0.96
4518B	0.29
4519B	0.28
4520B	0.32
4521B	0.82
4522B	0.72
4526B	0.46
4527B	0.46
4528B	0.46
4529B	0.62
4530B	1.48
4531B	0.88
4532B	0.30
4534B	3.98
4536B	1.98
4538B	0.57
4539B	0.62
4541B	0.32
4543B	0.62
4544B	1.48
4547B	1.78
4549B	4.24
4551B	1.06
4553B	1.82
4554B	4.62
4555B	0.32
4556B	0.44
4557B	1.98
4558B	1.68
4560B	1.52
4561B	1.80
4562B	3.96
4566B	2.52
4568B	3.98
4569B	2.34
4572B	0.30
4572UB	0.94
4580B	6.80
4581B	2.96
4582B	1.68
4583B	0.57
4584B	0.44
4585B	0.68
4597B	4.40
4598B	4.40
4599B	3.42
4720B	9.90
4720V	8.87
4723B	2.98
4724B	1.30
4731VP	7.20
4737VP	17.12
4738VP	16.70
4750VD	30.20
4752VP	31.71
4753VP	9.98
4754VP	18.48
40085	0.62
40097	0.45
40098	0.48
40100	1.14
40101	0.76
40102	0.92
40103	0.41
40105	0.64
40106	0.24
40107	0.27
40108	2.58
40109	1.09
40110	0.64
40114	1.48
40116	8.10
40117	1.66
40147	1.66
40160	0.52
40161	0.52
40162	0.52
40163	0.52
40174	0.32
40175	0.54
40181	2.54
40192	0.48
40193	0.48
40194	0.78
40195	0.78
40240	1.36
40244	1.36
40245	1.36
40257	1.32
40373	1.10
40374	1.10
45000P	11.50
45026	3.40
45027	4.81
45028	3.45
45040	7.44
45041	7.88
45100	1.63
45106	5.40
45109	3.08
45138	1.48
45145	9.25
45146	10.44
45151	15.00
45152	16.50
45156	13.50
45157	11.06
45158	11.94
45159	18.90
45406	2.10
45407	4.98
45411	6.44?
45414	10.55
45428	9.25?
45433	18.46?
45440	12.75?
45441	11.31?
45453	6.94?

74 SERIES

7400	0.18
7402	0.18
7403	0.18
7404	0.23
7405	0.23
7406	0.30
7406A	0.33
7407	0.30
7407A	0.32
7412	0.40
7408	0.23
7410	0.15
7413	0.27
7414	0.28
7416	0.33
7417	0.30
7420	0.20
7425	0.15
7426	0.20
7427	0.18
7430	0.22
7432	0.27
7437	0.24
7438	0.38
7440	0.48
7442	0.38
7445	0.70
7446	0.84
7447	0.84
7447A	0.90
7451	0.25
7454	0.40
7470	0.27
7472	0.18
7473	0.23
7474	0.35
7475	0.25
7476	0.23
7480	0.79
7483	0.60
7485	0.28
7486	0.26
7490	0.39
7490A	0.72
7491	1.60
7492	0.42
7492A	0.70
7493	0.54
7493A	0.61
7495A	0.69
74104	0.42
74107	0.30
74110	4.16
74116	3.10
74119	1.98
74121	0.48
74123	0.32
74125	0.37
74126	0.54
74128	0.80
74132	0.51
74150	1.36
74151	0.42
74151A	0.62
74154	1.56
74155	0.78
74157	0.43
74158	0.98
74159	3.20
74160	0.47
74161A	1.60
74163	0.80
74164	0.56
74165	0.98
74166	0.66
74174	0.68
74175	0.53
74185	1.10
74192	0.72
74193	1.03
74203	P.O.A
74221	1.42
74259	2.45
74265	0.80
74273	2.40
74276	2.40
74279	0.73
74283	0.68
74298	2.60
74365	0.44
74367	0.66
74393	2.05
74403	P.O.A
74423	P.O.A

74LS SERIES

74LS00	0.10
74LS01	0.10
74LS02	0.10
74LS03	0.10
74LS04	0.10
74LS05	0.10
74LS06	0.39
74LS07	0.39
74LS08	0.10
74LS09	0.10
74LS10	0.10
74LS11	0.10
74LS12	0.10
74LS13	0.18
74LS14	0.22
74LS15	0.12
74LS20	0.12
74LS21	0.12
74LS22	0.12
74LS24	0.33
74LS26	0.12
74LS27	0.12
74LS28	0.12
74LS30	0.12
74LS32	0.13
74LS33	0.13
74LS37	0.14
74LS38	0.13
74LS40	0.13
74LS42	0.23
74LS44	1.62
74LS47	0.48
74LS48	0.46
74LS49	0.62
74LS51	0.11
74LS54	0.11
74LS55	0.13
74LS73	0.20
74LS73A	0.26
74LS74	0.16
74LS74A	0.18
74LS75	0.21
74LS76	0.22
74LS76A	0.24
74LS77	0.42
74LS78	0.00
74LS78A	0.22
74LS83	0.34
74LS83A	0.37
74LS85	0.34
74LS86	0.22
74LS90	0.24
74LS91	0.50
74LS92	0.29
74LS93	0.24
74LS95	0.38
74LS96	0.46
74LS107	0.25
74LS107A	0.28
74LS109	0.25
74LS109A	0.28
74LS112	0.25
74LS112A	0.27
74LS113	0.25
74LS113A	0.27
74LS114	0.25
74LS114A	0.27
74LS122	0.33
74LS123	0.33
74LS125	0.28
74LS125A	0.30
74LS126	0.28
74LS126A	0.28
74LS132	0.28
74LS133	0.28
74LS136	0.28
74LS137	0.62
74LS138	0.26
74LS139	0.26
74LS145	0.55
74LS147	0.86
74LS148	0.72
74LS151	0.25
74LS153	0.28
74LS154	0.73
74LS155	0.34
74LS156	0.34
74LS157	0.20
74LS158	0.25
74LS160	0.36
74LS160A	0.40
74LS161	0.36
74LS161A	0.40
74LS162	0.36
74LS162A	0.40
74LS163	0.34
74LS163A	0.38
74LS164	0.34
74LS165	0.48
74LS166	0.53
74LS168	0.58
74LS169	0.53
74LS170	0.66
74LS173	0.41
74LS173A	0.60
74LS174	0.28
74LS175	0.30
74LS181	1.40
74LS182	1.58
74LS183	1.58
74LS189A	1.88
74LS190	0.44
74LS191	0.41
74LS192	0.39
74LS193	0.39
74LS194	0.38
74LS194A	0.43
74LS195A	0.42
74LS196	0.43
74LS197	0.40
74LS221	0.41
74LS240	0.43
74LS241	0.40
74LS242	0.41
74LS243	0.48
74LS244	0.38
74LS245	0.38
74LS247	0.38
74LS248	0.38
74LS249	0.68
74LS251	0.22
74LS253	0.34
74LS256	0.50
74LS257	0.30
74LS257A	0.34
74LS258	0.33
74LS258A	0.36
74LS259	0.48
74LS260	0.20
74LS266	0.20
74LS273	0.42
74LS275	6.10
74LS279	0.31
74LS280	0.86
74LS283	0.44
74LS290	0.24
74LS293	0.24
74LS295	0.58
74LS295A	0.64
74LS298	0.63
74LS299	1.18
74LS321	5.62
74LS322	1.58
74LS322A	1.62
74LS323	1.78
74LS347	0.90
74LS348	1.18
74LS352	0.78
74LS353	0.88
74LS363	1.38
74LS364	1.38
74LS365	0.24
74LS365A	0.26
74LS366	0.28
74LS366A	0.32
74LS367	0.26
74LS367A	0.30
74LS368	0.28
74LS368A	1.32
74LS373	0.38
74LS374	0.42
74LS375	0.44
74LS377	0.58
74LS378	0.62
74LS379	0.86
74LS381A	3.05
74LS385	2.22
74LS386	0.46
74LS390	0.39
74LS393	0.34
74LS395	0.66
74LS395A	0.68
74LS396	1.68
74LS398	1.22
74LS399	0.66
74LS445	1.50
74LS450	5.00
74LS461A	4.97
74LS465	2.78
74LS467	2.78
74LS468	2.78
74LS469	4.88
74LS490	0.90
74LS491A	5.98
74LS502	2.60
74LS540	0.93
74LS541	0.76
74LS546	4.43
74LS548	4.18
74LS549	4.18
74LS568	1.62
74LS569	1.14
74LS573	1.34
74LS574	1.34
74LS590	4.53
74LS591	6.58
74LS592	5.28
74LS593	6.25
74LS595	3.76
74LS597	4.64
74LS604	4.46
74LS605	4.46
74LS606	4.46
74LS610	9.95
74LS611	11.94
74LS612	6.68
74LS620	1.38
74LS621	1.76
74LS622	1.66
74LS623	1.28
74LS624	2.10
74LS625	2.28
74LS626	2.18
74LS627	2.33
74LS628	2.18
74LS629	0.93
74LS631	42.20
74LS640	0.84
74LS641	0.86
74LS641-1	1.28
74LS642	0.82
74LS642-1	2.48
74LS643	0.84
74LS643-1	2.48
74LS644	0.84
74LS644-1	2.48
74LS645	0.86
74LS645-1	1.28
74LS646	5.58
74LS647	5.58
74LS648	5.58
74LS649	5.58
74LS651	6.30
74LS652	5.58
74LS653	5.58
74LS654	5.58
74LS668	0.83
74LS669	0.56
74LS670	0.60
74LS673	2.50
74LS674	2.50
74LS682	1.71
74LS683	1.71
74LS684	1.58
74LS685	1.71
74LS686	2.70
74LS687	2.42
74LS688	1.58
74LS689	1.70
74LS690	3.98
74LS716	6.58?
74LS718	6.58?
74LS724	1.24
74LS748	1.15
74LS794	8.65
74LS795	1.22
74LS796	1.22
74LS797	1.22

74HC SERIES

74HC00	0.13
74HC02	0.13
74HC03	0.13
74HC04	0.15
74HCU04	0.19
74HC05	0.14
74HC08	0.17
74HC10	0.19
74HC11	0.13
74HC14	0.24
74HC14A	0.28
74HC20	0.18
74HC21	0.19
74HC27	0.19
74HC30	0.19
74HC32	0.19
74HC42	0.29
74HC51	0.19
74HC58	0.28
74HC73	0.23
74HC74	0.23
74HC75	0.27
74HC76	0.27
74HC77	0.34
74HC85	0.32
74HC86	0.24
74HC107	0.26
74HC109	0.24
74HC112	0.27
74HC113	0.27
74HC123	0.34
74HC125	0.31
74HC126	0.32
74HC131	0.35
74HC132	0.27
74HC133	0.31
74HC137	0.44
74HC138	0.32
74HC139	0.21
74HC141	0.41
74HC147	0.41
74HC148	0.37
74HC151	0.31
74HC153	0.31
74HC154	0.89
74HC155	0.47
74HC157	0.33
74HC158	0.32
74HC160	0.43
74HC161	0.38
74HC162	0.43
74HC163	0.43
74HC164	0.38
74HC165	0.55
74HC166	0.59
74HC173	0.51
74HC174	0.32
74HC175	0.32
74HC181	1.30
74HC182	0.40
74HC190	0.45
74HC191	0.48
74HC192	0.52
74HC193	0.40
74HC194	0.45
74HC195	0.32
74HC221	0.41
74HC237	0.49
74HC238	0.50
74HC240	0.44
74HC241	0.44
74HC242	0.54
74HC243	0.59
74HC244	0.43
74HC245	0.44
74HC251	0.24
74HC253	0.35
74HC257	0.32
74HC258	0.49
74HC259	0.44
74HC266	0.32
74HC273	0.41
74HC279	0.34
74HC280	0.60
74HC283	0.38
74HC298	0.49
74HC299	1.04
74HC323	1.07
74HC354	0.37
74HC356	0.44
74HC365	0.33
74HC366	0.35
74HC367	0.32
74HC368	0.35
74HC373	0.41
74HC374	0.38
74HC375	0.51
74HC377	0.51
74HC386	0.19
74HC390	0.36
74HC393	0.41
74HC423	0.64
74HC521	0.64
74HC533	0.64
74HC534	0.60
74HC540	0.69
74HC541	0.58
74HC563	0.59
74HC564	0.59
74HC573	0.64
74HC573A	0.68
74HC574	0.64
74HC589	1.10
74HC590	0.80
74HC592	0.80
74HC593	1.12
74HC595	0.84
74HC597	0.79
74HC620	1.09
74HC623	1.09
74HC633	1.09
74HC640	0.89
74HC643	0.89
74HC645	0.94
74HC646	1.19
74HC648	1.19
74HC651	0.99
74HC652	0.99
74HC658	3.02
74HC659	3.02
74HC664	3.02
74HC665	3.02
74HC670	0.74
74HC677	2.55
74HC678	3.98
74HC680	2.58
74HC682	4.64
74HC684	2.54
74HC688	0.79
74HC690	1.09
74HC691	1.09
74HC692	1.16
74HC693	1.16
74HC697	1.06
74HC698	1.06
74HC699	1.06
74HC4002	0.24
74HC4015	0.72
74HC4016	0.43
74HC4017	0.30
74HC4020	0.49
74HC4022	0.38
74HC4024	0.33
74HC4028	0.39
74HC4040	0.33
74HC4046	1.30
74HC4049	0.37
74HC4050	0.36
74HC4051	0.64
74HC4052A	0.74
74HC4053	0.68
74HC4053A	0.74
74HC4060	0.32
74HC4061	1.70
74HC4066	0.31
74HC4066A	0.36
74HC4072	0.30
74HC4075	0.25
74HC4078	0.31
74HC4094	0.49
74HC4316	0.68
74HC4351	0.89
74HC4511	0.55
74HC4514	1.19
74HC4515	1.19
74HC4518	0.54
74HC4520	0.59
74HC4538	0.74
74HC4543	0.55
74HC7001	0.68
74HC7002	0.68
74HC7032	0.68
74HC7266	0.56
74HC7074	1.34
74HC7292	0.77
74HC7294	0.77
74HC40102	0.84
74HC40103	0.84
74HC40105	1.40

74HCT SERIES

74HCT00	0.22
74HCT02	0.22
74HCT03	0.22
74HCT04	0.22
74HCT08	0.22
74HCT10	0.22
74HCT11	0.22
74HCT14	0.26
74HCT20	0.26
74HCT21	0.26
74HCT27	0.22
74HCT30	0.22
74HCT32	0.22
74HCT42	0.46
74HCT73	0.36
74HCT74	0.26
74HCT75	0.36
74HCT85	0.60
74HCT86	0.36
74HCT93	0.58
74HCT107	0.40
74HCT109	0.42
74HCT112	0.42
74HCT123	0.64
74HCT125	0.56
74HCT126	0.56
74HCT132	0.50
74HCT137	0.52
74HCT138	0.32
74HCT139	0.45
74HCT147	0.54
74HCT151	0.52
74HCT153	0.44
74HCT154	1.18
74HCT157	0.44
74HCT158	0.44
74HCT160	0.56
74HCT161	0.56
74HCT182	0.56
74HCT163	0.56
74HCT164	0.52
74HCT165	0.52
74HCT166	0.52
74HCT173	0.52
74HCT174	0.52
74HCT175	0.52
74HCT181	2.48
74HCT182	0.96
74HCT190	0.64
74HCT191	0.64
74HCT192	0.64
74HCT193	0.64
74HCT194	0.76
74HCT195	0.78
74HCT221	0.98
74HCT237	0.94
74HCT238	0.51
74HCT240	0.44
74HCT241	0.44
74HCT242	0.76
74HCT243	0.64
74HCT244	0.44
74HCT245	0.44
74HCT251	0.58
74HCT253	0.34
74HCT257	0.48
74HCT258	0.48
74HCT259	0.78
74HCT273	0.68
74HCT280	0.98
74HCT283	0.96
74HCT299	1.64
74HCT354	0.86
74HCT356	0.88
74HCT365	0.54
74HCT366	0.54
74HCT367	0.54
74HCT368	0.54
74HCT373	0.44
74HCT374	0.44
74HCT377	0.64
74HCT390	0.68
74HCT393	0.68
74HCT521	0.98
74HCT521A	1.10
74HCT533	0.68
74HCT534	0.64
74HCT540	0.64
74HCT541	0.64
74HCT563	0.66
74HCT564	0.66
74HCT573	0.64
74HCT574	0.64
74HCT583	1.28
74HCT640	0.90
74HCT643	0.90
74HCT645	0.75
74HCT646	1.28
74HCT648	1.28
74HCT651	1.10
74HCT652	1.10
74HCT670	1.10
74HCT673	1.10
74HCT688	1.10
74HCT4002	0.26
74HCT4015	0.76
74HCT4016	0.52
74HCT4017	0.68
74HCT4020	0.74
74HCT4024	0.68
74HCT4040	0.70
74HCT4046	1.60
74HCT4046A	2.10
74HCT4051	0.84
74HCT4052	0.84
74HCT4053	0.84
74HCT4060	0.84
74HCT4066	0.66
74HCT4067	3.32
74HCT4075	0.38
74HCT4094	0.84
74HCT4316	0.68
74HCT4351	1.04
74HCT4510	1.04
74HCT4511	0.94
74HCT4514	1.64
74HCT4515	1.68
74HCT4516	1.08
74HCT4520	0.90
74HCT4538	1.02
74HCT7007A	0.26
74HCT7046A	2.80
74HCT40102	1.64
74HCT40103	1.48
74HCT40104	1.82
74HCT40105	1.40

74AC SERIES

74AC00	0.38
74AC02	0.49
74AC04	0.49
74AC08	0.49
74AC10	0.49
74AC11	0.49
74AC14	0.49
74AC20	0.49
74AC32	0.49
74AC74	0.49
74AC109	0.61
74AC138	0.68
74AC139	0.65
74AC151	0.68
74AC153	0.65
74AC157	0.65
74AC158	0.65
74AC163	0.72
74AC169	1.71
74AC174	0.65
74AC175	0.80
74AC191	1.12
74AC240	0.86
74AC241	0.88
74AC244	0.88
74AC245	1.10
74AC251	0.60
74AC253	0.60
74AC258	0.60
74AC273	1.10
74AC299	2.06
74AC373	0.88
74AC374	0.88
74AC377	0.84
74AC540	0.98
74AC541	0.98
74AC573	1.26
74AC646SP	3.86
74AC648SP	3.86

74ACT SERIES

74ACT00	0.49
74ACT02	0.49
74ACT04	0.49
74ACT05	0.49
74ACT08	0.49
74ACT10	0.49
74ACT14	0.69
74ACT20	0.49
74ACT32	0.49
74ACT74	0.61
74ACT86	0.67
74ACT109	0.61
74ACT112	0.82
74ACT138	0.66
74ACT151	0.95
74ACT153	0.95
74ACT156	0.95
74ACT157	0.95
74ACT158	0.66
74ACT161	1.87
74ACT163	1.87
74ACT164	1.87
74ACT174	0.66
74ACT175	0.95
74ACT191	3.67
74ACT193	3.67
74ACT238	1.00
74ACT240	0.84
74ACT241	0.84
74ACT244	0.84
74ACT245	1.10
74ACT251	0.95
74ACT257	0.95
74ACT258	0.95
74ACT273	1.79
74ACT280	0.95
74ACT283	2.56
74ACT373	0.84
74ACT374	0.84
74ACT540	1.79
74ACT541	1.79
74ACT563	1.68
74ACT573	0.88
74ACT574	1.77
74ACT640	2.32
74ACT643	2.32
74ACT645	2.32
74ACT646	6.18
74ACT648	7.10
74ACT651	7.10
74ACT652	6.18
74ACT708D	79.20
74ACT793	3.28
74ACT794	3.28
74ACT821	3.90
74ACT841	6.90
74ACT874	5.60
74ACT1010	64.30

74C SERIES

74C00	0.56
74C02	0.56
74C08	0.56
74C10	0.56
74C14	0.56
74C20	0.98
74C30	0.98
74C32	0.68
74C42	0.98
74C48	1.98
74C73	1.15
74C74	0.68
74C76	1.15
74C85	1.52
74C90	1.25
74C93	2.10
74C95	1.60
74C150	6.10
74C151	4.16
74C154	2.98
74C157	2.48
74C164	1.52
74C165	1.23
74C221	1.54
74C240	2.08
74C244	2.08
74C373	2.08
74C374	2.08
74C901	0.86
74C902	0.86
74C903	1.52
74C906	0.86
74C907	1.52
74C908	2.80
74C911	14.42
74C912	8.30
74C914	1.16
74C915	2.74
74C922	4.35
74C923	4.35
74C925	9.30
74C926	9.30
74C929	9.30

74F SERIES

74F00	0.28
74F02	0.28
74F04	0.28
74F06	0.74
74F07	0.74
74F08	0.28
74F10	0.28
74F11	0.28
74F13	0.62
74F14	0.41
74F20	0.28
74F27	0.28
74F30	0.28
74F32	0.28
74F37	0.41
74F38	0.44
74F40	0.66
74F51	0.44
74F64	0.32
74F74	0.30
74F85	2.36
74F86	0.41
74F109	0.42
74F112	0.72
74F113	1.12
74F114	1.12
74F125	0.60
74F126	0.88
74F132	0.52
74F138	0.58
74F139	0.52
74F148	0.90
74F151	0.52
74F153	0.62
74F157	0.54
74F158	0.54
74F160	1.28
74F160A	1.29
74F161	1.28
74F162	1.28
74F163	1.28
74F164	1.28
74F166	4.32
74F168	3.40
74F169	3.40
74F174	0.76
74F175	0.76
74F181	3.36
74F182	1.22
74F189	4.36
74F190	2.92
74F191	2.92
74F192	2.92??
74F193	2.92
74F194	1.31
74F195	2.90
74F219	4.38
74F224	1.92
74F240	0.62
74F241	0.62
74F244	0.62
74F245	0.72
74F251	0.62
74F251A	0.66
74F253	0.62
74F257	0.62
74F257A	0.66
74F258	0.62
74F259	3.72
74F260	0.80
74F269	8.28
74F273	2.20
74F280	0.62
74F283	0.78
74F299	3.36
74F323	4.48
74F350	1.50
74F352	0.64
74F353	1.14
74F365	1.28
74F366	1.30
74F367	1.38
74F368	1.30
74F373	0.62
74F374	0.62
74F378	1.56
74F381	3.68
74F385	11.18
74F395	3.28
74F399	0.98
74F412	5.02
74F413	19.66
74F432	4.48
74F521	1.20
74F524	7.26
74F533	1.20
74F534	1.20
74F537	1.60
74F538	1.60
74F539	1.60
74F540	1.78
74F541	1.76
74F543SP	4.92
74F544	4.92
74F545	3.36
74F547	6.04
74F563	2.24
74F564	2.24
74F573	1.60
74F574	1.60
74F579	6.64
74F604	5.08
74F620	3.98
74F621	3.52
74F623	3.98
74F646N	5.35
74F646SP	5.15
74F676SP	10.60
74F821SP	3.98
74F823SP	3.98
74F825SP	3.98
74F827SP	3.98
74F828SP	4.48
74F841SP	4.48
74F843SP	4.30
74F845SP	4.30
74F1242	2.41
74F1243	2.41
74F1244	2.12

74FCT SERIES

74FCT299	3.32
74FCT299A	4.85
74FCT521A	3.60
74FCT821B	5.80

74ALS SERIES

74ALS00	0.46
74ALS00A	0.46
74ALS04	0.66
74ALS09	0.46
74ALS21	0.46
74ALS86	0.59
74ALS112	0.59
74ALS244A	1.46
74ALS573	1.33
74ALS576A	1.79
74ALS640	1.79
74ALS645	1.79
74ALS645A	3.80
74ALS645A1	3.99
74ALS808	1.62
74ALS874NT	2.40
74ALS1000	0.46
74ALS1008	0.98
74ALS1010	1.44
74ALS1032	0.46

74S SERIES

74S00	0.44
74S02	0.44
74S03	0.51
74S04	0.42
74S08	0.42
74S09	0.48
74S10	0.98
74S11	0.48
74S20	0.48
74S32	0.78
74S40	0.25
74S51	0.36
74S64	0.36
74S74	0.98
74S86	1.12
74S112	1.08
74S124	2.42
74S132	0.98
74S133	0.73
74S134	1.95
74S138	0.88
74S139	0.88
74S140	0.78
74S153	1.26
74S157	1.72
74S163	2.60
74S174	0.92
74S175	1.35
74S182	3.29
74S189	2.14
74S195	2.40
74S240	1.00
74S241	1.12
74S244	1.77
74S257	1.22
74S258	1.22
74S260	0.70
74S273	2.44
74S274	2.42
74S280	0.96
74S283	1.90
74S374	2.18
74S394	2.10
74S412	2.10
74S436	2.62
74S437	2.62
74S472	2.32
74S734	2.62

74 & 54 MISC

74AS163	4.99
74AS574	4.66
74AS645	5.32
74AS805	3.11
74H21	3.30
74H73	3.30
74H103	3.30
74H104	3.30
74L04	1.20
54LS138FH	1.98

4000 SERIES SURFACE MOUNT

4001BT	0.25
4002BT	0.25
4011BT	0.25
4011UBT	0.25
4012BT	0.25
4013BT	0.36
4015BT	0.67
4016BT	0.34
4017BT	0.56
4018BT	0.56
4020BT	0.76
4021BT	0.52
4023BT	0.25
4024BT	0.61
4025BT	0.25
4027BT	0.36
4028BT	0.45
4029BT	0.79
4040BT	0.65
4042BT	0.59
4046BT	1.13
4047BT	0.85
4049BT	0.85
4050BT	0.38
4051BT	0.87
4052BT	0.79
4053BT	0.86
4060BT	0.67
4066BT	0.47
4068BT	0.25
4069UBT	0.25
4070BT	0.25
4071BT	0.25
4075BT	0.25
4077BT	0.25
4078BT	0.25
4081BT	0.25
4093BT	0.32
4094BT	0.76
4508BT	1.64
4510BT	0.81
4511BT	1.08
4512BT	0.52
4514BT	1.76
4516BT	0.81
4518BT	0.94
4520BT	0.94
4521BT	0.86
4522BT	0.90
4534BD	3.42
4528BT	0.70
4538BT	1.37
4541BT	0.70
4543BT	0.68
4555BT	0.70
4556BT	0.70
4585BT	0.63
40106BT	0.38
40244BT	1.06
40373BT	1.82

74HC SERIES SURFACE MOUNT

74HC00M	0.21
74HC02M	0.21
74HC03M	0.21
74HC04M	0.21
74HCU04M	0.21
74HC08M	0.21
74HC10M	0.21
74HC14M	0.34
74HC20M	0.21
74HC30M	0.21
74HC32M	0.21
74HC74AM	0.27
74HC75M	0.29
74HC85WM	0.65
74HC86M	0.34
74HC123AM	0.42
74HC125M	0.46
74HC132M	0.42
74HC138M	0.34
74HC139M	0.34
74HC154WM	0.48
74HC157M	0.34
74HC161M	0.42
74HC164M	0.46
74HC165M	0.57
74HC173M	0.44
74HC174M	0.38
74HC221AM	0.65
74HC240WM	0.55
74HC244WM	0.55
74HC245AWM	0.61
74HC251M	0.34
74HC259M	0.69
74HC273WM	0.55
74HC367WM	0.53
74HC373WM	0.55
74HC374WM	0.55
74HC390M	0.57
74HC393M	0.53
74HC540WM	0.76
74HC541WM	0.76
74HC573WM	1.09
74HC574WM	0.84
74HC688WM	0.84
74HC4017M	0.44
74HC4020M	0.44
74HC4040M	0.44
74HC4046M	1.68
74HC4060M	0.46
74HC4066WM	0.84
74HC4538M	0.76

74HCT SERIES SURFACE MOUNT

74HCT00M	0.21
74HCT04M	0.21
74HCT05M	0.21
74HCT32M	0.21
74HCT74M	0.27
74HCT138M	0.34
74HCT166M	0.65
74HCT193WM	0.48
74HCT244WM	0.55
74HCT245WM	0.61
74HCT251M	0.34
74HCT257M	0.32
74HCT273WM	0.55
74HCT373WM	0.55
74HCT374WM	0.55
74HCT540WM	0.76
74HCT541WM	0.76
74HCT574WM	0.84

74FCT SERIES SURFACE MOUNT

74FCT244M	3.19
74FCT245M	4.69
74FCT273M	3.19
74FCT373M	3.19
74FCT374M	3.19
74FCT541M	6.95
74FCT573M	3.56
74FCT574M	3.56

VOLTAGE REGULATORS

78008AP	1.15
7805	0.28
7805A	0.32
7805FA	0.45
7806	0.28
7808	0.28
7809	0.32
7812	0.28
7812A	0.32
7812CTC	0.32
7815	0.28
7818	0.28
7824	0.28
78L05	0.24
78L05A	0.28
78L05ACLP	0.40
78L05ACZ	0.28
78L12	0.28
78L12A	0.28
78L12ACZ	0.30
78L15	0.28
78L24	0.28
78L56	1.10
78M05	0.32
78M05A	0.36
78M12	0.32
78M12A	0.36
78M13A	0.65
78M15	0.32
78S05	0.48
78S12	0.48
78S15	0.55
7905	0.28
7905A	0.32
7905FA	0.60
7909	0.55
7912	0.30
7912A	0.36
7912FA	0.78
7915	0.30
7918	0.30
7924	0.30
79L12A	0.35
79L12ACP	0.35
79M05	0.42
79M05A	0.42
79M05FA	0.65
79M12	0.50
79M12A	0.60
LM317T	0.50
LM317MP	1.06
LM317LZ	0.55
LM338K	4.45
UA78GU1C	1.02
UA79GU1C	1.02
RC4195N	1.80

CRYSTALS

CAN TYPE HC49(HC18/U)

Freq.MHz	
1.843200	1.60
2.000000	1.66
2.457600	1.49
3.276800	0.98
3.579545	1.10
3.686400	1.02
4.000000	1.02
4.096000	1.10
4.194304	1.10
4.433619	1.10
4.608000	1.10
4.915200	1.20
5.000000	1.02
5.068800	1.10
5.242880	1.20
5.888200	1.80
6.000000	1.02
6.144000	1.02
6.400000	1.64
6.552000	1.40
6.553600	1.21
7.372800	0.78
8.000000	1.00
8.867230	1.34
9.830000	1.20
10.00000	1.10
10.69500	1.90
11.00000	1.10
12.00000	0.92
13.87500	2.40
14.00000	1.64
14.31818	0.85
14.74560	1.10
15.00000	1.10
16.00000	1.02
18.43200	1.10
19.66080	1.20
20.00000	1.60
22.11840	1.68
24.00000	1.82
27.64800	1.20
30.00000	6.99
32.00000	1.40
48.00000	1.68

HC33/U

0.204800	8.23
0.307200	6.99
1.000000	3.95
1.843200	3.71
2.000000	4.65
2.097152	3.71
2.457600	1.92
2.500000	1.92
3.000000	2.25

HC49/U4H

3.276800	1.66
5.068800	2.25
7.864320	1.49
8.000000	1.14
10.00000	2.25
11.05920	2.40
12.00000	1.14
14.00000	2.25
16.00000	1.14
20.00000	1.52
24.00000	1.90

UM-1

8.000000	2.25
8.192000	2.02
10.00000	2.25
11.00000	2.25
12.28800	2.66
15.00000	2.25
18.00000	2.50
20.00000	2.25
21.00000	2.25
24.00000	2.80
17.73447	2.80

CRYSTALS MISC.

HC34/U	
0.100000	12.87
HC43/T	
1.000000	6.99
MINI CYLINDER	
0.032768	0.88
WATCH	
0.032768	0.82
CTV	
3.579545	2.21
HC13/U	
0.100000	12.87

CRYSTAL OSCILLATORS

SPG8640AN	9.25
SPG8640BN	9.25
SPG8650BN	9.25

We stock Surface Mount & Standard ICs, Capacitors, Resistors, Diodes, Transistors, DIL & TTL Xtal Osc. Headers and Connectors

MICROPROCESSOR & SUPPORT ICs

6321P	4.20
63485CP32/SMD	32.50
63B03XP	11.95
6502	3.40
6502A	3.90
6520P	3.89
6522	3.60
6522A	7.95
6551	3.10
6551A	3.60
65C02P2	6.90
65C02P3	6.90
65C102P2	8.40
65C22P2	5.67
65C51E1	3.65
65C51E2	4.45
68000CP10	6.02
68000CP12	7.72
68000CP16	12.67
68000CP8	4.95
68008CP10	7.70
68008CP8	5.95
6802P	2.47
6803P	4.98
6805E2P	9.18
6810P	2.98
6821P	1.52
6840P	3.90
6844P	17.20
6845L	8.60
6845P	5.40
6845SP	6.92
68A00P	7.02
68A09P	7.63
68A21P	3.03
68A40P	4.83
68A50P	2.82
68B03P	15.25
68B09P	9.25
68B21P	4.29
68B21P	3.14
68B40P	5.22
68B45P	9.92
8085AP-2	3.60
8086	3.40
8086-2	3.90
80C85A	3.60
80C85A-2	3.85
80C286-12/PGA	38.50
AM9050CDC	4.95
AM9050CPC	4.60
C8253	2.85
CA80C85B	4.80
CD82C85	9.62
CD82C86H-5	9.74
CG80C286-12	38.50
CG80C286-16	48.60
D8086	3.40
D8086-2	3.90
D8254-2	6.42
D8282	4.20
D8284A	3.90
D8288	6.48
D82C288-8	9.36
D8748H	9.95
DP8311N	6.54
DS5000-32-12	47.50
EF6803P	4.98
EF6821P	1.30
F6821P	1.30
HD6321P	4.20
HD63485PS32	32.50
HD63B03XP	11.95
HD6845SP	6.92
HD68B21P	4.29
M5M82C54P-6	5.40
MAB8032AH12P	5.19
MAB8035HL-6P	3.50
MAB8035HP-6P	3.50
MAB8039HL-11P	5.09
MC146805E2P	9.18
MC6802P	2.47
MC6821P	1.30
MC68000P8/10	P.O.A
MC68000P12	P.O.A.
MC68000P16	P.O.A
MC68010P8/10	P.O.A.
MSM80C35RS	4.90
MSM80C85A	3.60
MSM80C85A-2	3.85
MSM80C86	7.80
MSM81C55	4.80
MSM82C51A	3.58
MSM82C53-2	3.98
MSM82C53-5	3.58
MSM82C54-2	4.20
MSM82C59A-2	3.98
MSM82C84A	3.30
MSM82C84A-2	3.60
MSM82C88	12.80
NS16550AFN	18.90
P80C32	7.00
P8032AH	4.29
P8051AH	11.20
P8052AH/BASIC	23.45
P8080A	3.90
P8085A-2	3.00
P8085AH-2	3.30
P8088	4.80
P80C86AL-2	14.60
P8155H	3.50
P8185	18.10
P8205	2.00
P8212	2.40
P8226	2.40
P8228	3.86
P8251	2.45
P8251A	2.85
P8253	2.20
P8255A-5	2.40
P8259	2.80
P8259A	2.70
P8274	9.98
P8275	21.20
P8279-5	2.80
P8282	2.84
P8286	3.60
P8287	4.55
P82C54	4.10
P82C54-2	4.80
PCD8584P	7.30
PCF8566P	6.76
PCF8566T	6.76
PCF8570P	4.93
PCF8573P	5.81
PCF8574P	5.90
PCF8574T	5.90
PCF8577T	7.70
PCF8591P	9.35
R6502AP	5.95
R6520P	3.89
R6522	3.20
R6522AP	7.95
R65C02P2	5.84
R65C02P3	6.90
R65C22P2	5.67
R65C102P2	7.34
SAB80C32P	6.75
TMP8085AP-2	3.60
TMS3477NL	12.10
TMS77C01NL	2.85
TMS9900NL	24.40
TMS9901NL	7.22
TMS9902ANL	7.98
TMS9902NL	7.34
TMS9914ANL	18.94
TMS9926ANL	4.70
TMS9995JDL	69.85
UM6845B	4.95
UPB8282C	3.60
UPB8284AD	3.60
UPB8286C	3.80
UPD70108C-8	6.95
UPD70108C-10	9.10
UPD70116C-8	9.20
UPD70116C-10	12.90
UPD7201AC	6.60
UPD7201C	6.60
UPD765AC	5.42
UPD8085AC-2	4.98
UPD80C39HC	8.42
UPD80C40HC	13.84
UPD8243HC	2.60
UPD8251AFC	5.78
UPD8253C-2	3.32
UPD8253C-5	3.32
UPD8255AC-2	3.20
UPD8255AC-5	3.20
UPD8259AC	3.34
UPD8259AC-2	3.60
UPD8279C-5	5.40
UPD8741AD	12.52
UPD8749HC	13.98
V20-8MHz	6.95
V20-10MHz	9.10
V30-8MHz	9.20
V30-10MHz	12.90
Z80-DMA	4.45
Z80-PIO	1.88
Z80A-CPU	1.25
Z80A-CTC	1.52
Z80A-DART	3.15
Z80A-PIO	1.25
Z80A-SIO/O	3.40
Z80B-CPU	1.52
Z80B-CTC	3.00
Z80B-DART	5.80
Z80B-PIO	2.20
Z80B-SIO	4.50
Z8001B-CPU	11.98
Z8018006VSC	8.25
Z80C00AB6	2.98

MATHS CO-PROCESSORS

AM9511-4DC	48.85
AM9511A-4DC	58.30
D80287-10/INTEL	44.00
D80287-8/INTEL	40.00
80287XL/INTEL	48.00
BOX287XL/INTEL	52.00
80387-16/20/25	P.O.A
80387DX-33	P.O.A.

MEMORIES DYNAMIC RAM

4164-10	1.20
4164-12	1.00
4164-15	1.00
41256-8	1.60
41256-10	1.50
41256-12	1.40
41464-12	4.45
41464-10	4.45
4464-10	2.80
414256A-70	3.90
44C256AZ-10	6.95
44C256-8	5.00
511000-85	8.45
HM48416AP-15	4.60
HM48416AP-20	4.25
HY53C256LS-80	1.80
HY53C464LS-80	3.95
HYB511000-85	8.45
KM44C256AZ10	6.95
M5M4464P-15	4.60
MK4116N-54	2.80
MK4564N-15	1.00
NMC3764N-15	1.00
UPD41464C-12	4.20
UPD41464C-15	4.20
UPD416C-2	3.40
UPD416C-3	3.65
UPD4460-1	2.60

STATIC RAM

2114-3L	3.40
6264LP-10	2.20
6264LP-12	2.40
62256LP-12	4.95
62256LP-10	4.95
CDM6116AE3	5.30
CDM6117AE3	5.85
HM1-6116-5	4.38
HM3-6116-5	3.60
HM6116LP-2	2.60
HM6116LP-3	2.60
HM6117LP-3	5.75
HM62256LP-10	7.93
HM6264ALP-12	3.95
HM6264ASP-20	3.95
HM6267P-35	5.07
HM628128LP-80	18.55
HM66204L-12	15.80
KM62256ALP-10	4.95
LH5164D-10L	2.40
P2114AL-2	3.40
P2114AL-4	3.40
PCD5101P	3.30
UPD43256AGU10L	8.33
UPD43256C-12	5.60
UPD4364C-15	4.70

UVPROMS

27C128-25	2.95
27C64A-15	2.74
27C256-15	3.95
27C256-25	3.95
D27256	5.40
HM27C101G-20	9.80
HN27C1024HG10	18.63
HN27C64FP-20T	3.40
HN27C64G-15	4.20
HN27C64G-20	4.20
HN462532P	4.50
HN4827128G-25	4.55
HN482764G	3.60
HY6264LP-10	2.40
M2716-1F1	3.50
M5L2732K	4.40
M5L2764K	3.30
MBM27C64-20/21V	4.90
MBM27C128-30	4.20
MBM27C256-30	5.10
NMC27C256Q-25	4.95
NMC27C64Q-25	3.66
TMS2516JL-45	4.58
TMS27128JL-25	4.60
TMS2716JL-45	4.60
UPD27256D/21V	5.60
UPD2732A/21V	4.95
UPD27C256D-15	5.80
UPD27C512D-15	6.96
UPD27C64D-25	4.95

EEPROMS

AT28C256-15DC	28.50
AT28C64-25	9.80
AT28C64-15	10.95
KM28C256-20	25.84
KM28C256-15	27.50
KM28C64-25	9.20
X2816AD	5.10
X2816AP-25	5.10
X2864AP-35	12.20

MISC. MEMORIES

6341-1J	4.56
AM2148-45DC	5.44
AM27S281PC	3.98
IDT7130LA-100P	10.43
IDT7132LA-100P	11.19
MB8414E	4.95
MCM4027AC3	2.80
N82S126AN	2.49
N82S153N	5.60
N82S181AN	6.09
NMC6504J-9	3.40
NMC9306N	1.45
P5101L-1	3.90
TBP18S030N	1.74
TBP24S10N	2.90
TBP24SA10N	3.15
TC5501P	3.50
TC5504AP-2	3.40
TC5516PL-15	4.20
TC5517AP-2	4.20
TC5565PL-15	3.80
TMS4014JDL	3.40

LINEAR & MISC

3630BM	3.40
3660K	3.70
4N33	0.80
5541BJG	2.80
555	0.20
723-14Pin	0.48
741-8Pin	0.18
747-14Pin	0.56
748-8Pin	0.39
6N136	1.60
6N139	1.75
AD524AD	16.30
AD536AJD	25.75
AD648JN	1.53
AD558JN	20.98
AD574AKD	P.O.A
AD574JD	24.20
AD581JH	5.40
AD585AQ	23.64
AD590KH	9.92
AD592CN	14.68
AD594AD	2.68
AD595AD	4.60
AD7248JN	19.87
AD741KN	0.82
AD7523KN	6.80
AD7537JN	21.69
AD7541KN	11.98
AD7547JN	24.17
AD7569JN	12.20
AD7576JN	9.68
AD7578KN	35.89
AD7628KN	21.86
AD7640JN	21.01
AD7645JN	15.91
ADC0801LCJ	32.60
ADC0820CCN	23.40
ADC0832CCN	6.26
ADC0834CCN	6.67
ADC0838CCN	11.04
ADC0803LCN	13.30
ADC0841CCN	7.54
ADC0804LCN	7.08
ADC0804LCWM	7.54
ADC0809CCN	9.87
ADC0817CCN	23.96
ADC0819CCV	6.81
ADC0844CCN	12.69
ADC84KG-10	12.60
ADD3501CCN	23.67
ADG201AKN	3.60
ADOP07CN	1.60
AH0015CD	17.20
AY-3-1270	3.60
AY-5-1013	3.20
AY-5-1013A	5.24
AY-5-8136	6.45
BA6109	1.68
BA6208	1.40
BA6251	2.80
BAA1505	1.80
CA1458P	0.52
CA3028AE	1.76
CA3045	8.30
CA3046	0.51
CA3053	1.57
CA3054	0.94
CA3059	1.20
CA3078AT	2.42
CA3079	0.88
CA3080E	0.70
CA3081	0.96
CA3082	1.32
CA3083	1.32
CA3086	0.60
CA3089E	1.10
CA3094AE	2.01
CA3096AE	2.16
CA3097E	2.45
CA3100E	1.59
CA3130BT	13.20
CA3130E	0.78
CA3140E	0.47
CA3141E	1.42
CA3146E	1.16
CA3160E	1.25
CA3161E	1.41
CA3162E	5.29
CA3183E	1.39
CA3189E	1.20
CA3240E	0.95
CA324E	0.44
CA3260E	1.68
CA3290E	0.91
CA3306CE	6.98
CA556CE	0.20
CA741CE	0.18
CNX36	0.40
DAC08EP	2.78
DAC08CP	2.60
DAC0800LCN	3.60
DAC0801LCN	3.00
DAC0808LCN	3.10
DAC0830LCN	12.26
DAC0832LCN	7.13
DAC1000LCN	19.99
DAC1006LCN	19.99
DAC1008LCN	11.85
DAC1020LCN	18.67
DAC1201KPV	14.38
DG200CJ	4.16
DG201ABK	4.37
DG201ACJ	3.73
DG201CJ	5.70
DG211	1.56
DG212CJ	2.25
DG303ACJ	6.85
DG308CJ	4.45
DG509ACJ	6.30
DP8212N	2.56
DP8304BN	2.40
DS1221	6.44
DS1231	4.44
DS1231-20	4.44
DS1232	3.78
DS1488N	0.30
DS1489N	0.30
DS14C88M	1.20
DS14C88N	1.25
DS14C89N	1.56
DS3486N	1.92
DS3487N	1.92
DS34C86N	2.80
DS34C87N	2.80
DS75150N	1.21
DS75154N	1.21
DS75160AN	5.86
DS75161AN	6.14
DS75176BN	1.82
DS75361N	2.51
DS75451N	0.62
DS75452N	0.62
DS75453N	0.62
DS75491N	0.85
DS75492N	1.09
DS7494	2.38
DS8640N	0.98
DS8836N	1.05
DS8837N	2.10
DS8838N	2.10
DS88C20N	5.72
HA12017	1.44
HA13426	11.98
HCPL-2231	10.28
HCPL-2602	6.89
HCPL-2630	4.80
HCPL-2730	3.90
HCPL-2731	3.80
HCPL-4200	6.15
HCPL-2200	6.38
HEF4754VP	12.40
HI1-0201-5	3.30
HI1-0509-5	6.84
HI1-0509A-5	9.79
HI1-574AKD-5	42.50
HS574AK	19.90
ICL232CPE	4.93
ICL7106CPL	6.75
ICL7109CPL	6.80
ICL7116CPL	5.35
ICL7135CPI	8.32
ICL7611DCPA	1.32
ICL7612DCPA	1.71
ICL7621BCPA	5.79
ICL7621DCPA	1.98
ICL7642ECPD	3.24
ICL7650SCPD	4.48
ICL7652BCPD	5.82
ICL7660CPA	1.40
ICL7662CPA	3.24
ICL7663BCPA	3.12
ICL7664CPA	3.95
ICL7665BCPA	4.42
ICL7667CPA	2.66
ICL7660CPA	2.74
ICL7673CPA	1.60
ICL8038CCPD	4.70
ICL8052ACPD	12.85
ICL8068ACJD	13.40
ICL8069CCSQ	2.59
ICL8069DCSQ	2.68
ICL8069DCZR	1.61
ICL8211CPA	2.28
ICL8212CPA	1.33
ICM7170IPG	7.66
ICM7207IPD	7.16
ICM7211AMIPL	4.98
ICM7212AMIPL	4.60
ICM7216AIJI	27.72
ICM7217AIPI	9.85
ICM7217BIJI	10.42
ICM7218DIJI	6.41
ICM7218EIJL	16.88
ICM7224IPL	9.24
ICM7226BIPL	25.04
ICM7227AIPI	12.60
ICM7232CRIPL	7.72
ICM7555IPA	0.64
ICM7556IPD	1.30
ICL7104-16CPL	26.08
ICL7106CPL	6.75
ICL7107CPL	6.95
ICL7109CPL	6.80
ICL7116CPL	5.25
ICL7126CPL	5.35
ICL7611DCPA	1.32
ICL7621DCPA	1.98
ICL7660CPA	1.40
ICL7662CPA	3.24
ICL7673CPA	1.26
ICL8069CCSQ	2.59
ICL8069DCSO	2.86
ICL8069DCZR	1.61
ICL8211CPA	2.28
ICL8212CPA	1.10
ICM7170IPG	7.66
ICM7207IPD	5.76
ICM7211AIPL	4.98
ICM7211AMIPL	4.98
ICM7212AMIPL	4.60
ICM7216AIJI	21.23
ICM7217AIPI	6.92
ICM7217IJI	10.42
ICM7218AIJI	6.85
ICM7218CIJI	6.85
ICM7218DIJI	6.85
ICM7218EIJL	15.90
ICM7224IPL	7.16
ICM7226BIPL	25.04
ICM7555IPA	0.64
ICM7556IPD	0.95
ILD74	0.99
INA101HP	9.65
INS8250N	13.36
ISQ74	0.99
L293E	4.56
L297	5.31
L297A	4.69
L4805CV	2.20
L487	3.15
L723	0.79
L7806CV	0.48
LF13201N	7.80
LF13202N	7.80
LF13333N	7.80
LF13508D	18.20
LF13741N	0.65
LF347BN	6.74
LF347N	0.64
LF353N	0.38
LF355N	1.08
LF356BN	3.36
LF356H	3.05
LF356N	1.40
LF357BN	0.90
LF357N	1.60
LF398H	7.05
LF398N	2.75
LF411CN	0.72
LF412CN	1.20
LF441CN	0.72
LF442CN	0.96
LF444CN	2.40
LH0002CH	21.17
LH0002CN	10.80
LH0021CK	43.68
LH0022CH	18.20
LM101AH	4.43
LM101AJ	5.84
LM10CH	11.09
LM10CN	9.24
LM1035N	4.90
LM110H	8.78
LM111H	6.74
LM117H	20.70
LM118H	20.28
LM119H	17.05
LM119J	22.93
LM124J	24.99
LM124J	3.83
LM12CLK	29.25
LM131H	20.14
LM134H	10.81
LM135H	12.03
LM13600N	2.44
LM13700N	1.43
LM139J	3.31
LM1458M	1.05
LM1458N	0.45
LM1496N	2.39
LM158H	6.88
LM161H	14.33
LM1881N	3.60
LM193H	11.51
LM201AH	4.81
LM208H	8.75
LM218H	15.75
LM224N	2.01
LM231N	9.01
LM239N	1.28
LM248J	7.72
LM2575T-12	6.26
LM2575T-15	6.26
LM2575T-5.0	6.26
LM2575T-ADJ	7.16
LM2577T-12	7.07
LM2577T-15	7.07
LM2577T-ADJ	7.76
LM2578H	8.29
LM2578N	3.97
LM2579T	12.91
LM2901N	1.16
LM2902N	0.80
LM2903N	0.60
LM2904N	0.80
LM2907N	5.41
LM2917N	5.20
LM2917N-8	3.65
LM2925T	4.33
LM2940CT-5.0	1.20
LM2941CT	3.40
LM2984CT	3.84
LM301AN	0.36
LM3046N	2.69
LM305AH	6.39
LM306H	2.39
LM307N	0.80
LM3080N	2.03
LM3086N	1.59
LM308N	0.48
LM308AN	2.38
LM308H	2.38
LM310H	4.81
LM310N	2.39
LM311H	2.22
LM311J-8	3.76
LM311N	0.27
LM311N-14	2.15
LM317KC	5.05
LM317T	0.50
LM318H	3.84
LM318N	1.25
LM319H	6.26
LM319J	7.32
LM319N	1.10
LM324N	0.35
LM325N	4.80
LM3302N	1.64
LM331AN	11.66
LM331N	5.06
LM334Z	1.46
LM335Z	2.16
LM3361AN	3.32
LM336Z-2.5	1.26
LM336Z-5.0	1.20
LM337J	3.28
LM338K	4.45
LM338K-STEEL	7.98
LM339AN	1.00
LM339N	0.24
LM340AT-12	1.68
LM343H	7.63
LM346N	3.10
LM348N	0.48
LM34DZ	4.34
LM350K/STEEL	11.50
LM350T	2.66
LM3524N	1.71
LM3578N	3.06
LM358N	0.32
LM359N	3.44
LM35CZ	5.13
LM35DH	5.63
LM35DZ	2.98
LM360H	7.72
LM360N	9.83
LM361N	5.66
LM363H-100	4.65
LM376N	1.35
LM377N	3.53
LM380N-14	2.12
LM380N-8	1.10
LM384N	4.17
LM385LP-1.2	2.08
LM385LP-2.5	2.06
LM385M-1.2	2.40
LM386M-1/SMD	1.65
LM386N	1.10
LM386N-1	1.12
LM386N-4	2.16
LM387N	1.64
LM388N-1	2.46
LM3900N	0.68
LM3909N	1.48
LM3911N	1.84
LM392N	1.02
LM393N	0.24
LM394CH	6.47
LM394CN	4.98
LM3999Z	2.77
LM4250CN	2.22
LM4250J	6.35
LM431ACZ	0.99
LM555CM	0.40
LM555CN	0.28
LM556CN	1.16
LM556J	6.36
LM567CN	0.68
LM604CN	4.16
LM607CN	2.98
LM611CN	2.67
LM6125H	14.99
LM613N	2.88
LM614CN	4.03
LM6213N	6.95
LM6221N	7.98
LM6225N	9.55
LM6265N	6.38
LM6361N	2.90
LM6364N	2.95
LM709CH	2.70
LM709CN	1.85
LM710CH	1.68
LM710CN	1.64
LM715CH	6.29
LM723CN	0.85
LM723H	6.90
LM725CN	9.39
LM733CH	2.93
LM733CN	1.93
LM741CH	1.56
LM741CN	0.28
LM741H	4.40
LM741J	3.96
LM747CN	0.56
LM748CN	2.29
LM748CN	0.78
LM77000CP	2.98
LM78GCP	1.52
LM78L05ACZ	0.30
LM78MGCP	1.57
LM7912CT	0.38
LM7915CT	0.40
LM833N	1.48
LM837N	2.01
LMC555CN	0.60
LMC660CN	1.79
LS204CB	1.34
LS285AB	3.55
LS286B	3.60
LS404CB	2.38
LS7210	3.98
LT1004CLP-1.2	2.79
LT1004CLP-2.5	2.79
LT1006CN8	2.68
LT1007CP	4.07
LT1009CP	2.79
LT1014CJ	9.60
LT1028C	7.02
LT1030CN	3.28
LT1032CN	2.98
LT1037CP	4.07
LT1054CP	4.34
LT1070CT	9.14
LT1071CK	10.54
LT1084CT	6.36
LT1084CK	10.54
LTC485CN8	1.92
M706B1	1.40
MAX232CPE	2.80
MAX232ACPE	4.95
MAX232EWE/SMD	6.86
MAX359CPE	6.99
MAX452CPA	5.38
MC10103P	1.24
MC1350P	3.10
MC1377P	4.93
MC1413P	0.74
MC1455P	0.40
MC1458P	0.32
MC1488N	0.22
MC1488L	1.46
MC1489N	0.22
MC1489A	0.60
MC3301P	0.88
MC3302P	0.60
MC3479P	7.92
MC3486N	2.45
MCT2	0.64
MCT61	1.18
ML924	4.90
MM53200N	2.98
MM58167AN	13.32
MM58174AN	14.52
MM58274BN	6.30
MM58274CN	6.30
MN3004	4.84
MN3011	20.38
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MPOP07CP	2.02
MUX08-EP	6.52
MV601DP	3.31
N8264N	3.68
NE531	1.69
NE5020N	8.24
NE5532N	0.72
NE5534P	0.83
NE555N	0.20
NE556N	0.38
NE565N	2.00
NE566N	1.14
NE567N	0.65
NE568N	3.86
NE570N	2.51
NE589N	3.25
NE592N14	0.92
NJM4556D	0.86
NJM4556S	0.86
NJM4558DX	0.86
NJM4558S	0.60
NS16450N	10.42
OP07-CP	2.36
OP11-GP	4.26
OP227-GY	10.04
OP27-GP	2.89
PBD352302	6.60
PBD352303	6.60
PBL3726/6	7.20
PCB80C39-11P	7.84
PCD3311P	4.82
PCD3312P	4.73
PCF8583P	7.98
RC4136N	0.90
RC4207GN	2.24
RC4558C	0.62
RC4558M/SMD	0.60
REF01CP	1.92
REF01HP	2.93
REF02CP	2.30
REF02GP	3.20
REF03GP	1.95
REF25Z	1.12
SAA1027	2.65
SAA1043P	7.98
SAA3049P	6.23
SAA5025D	6.40
SAA6002A	10.60
SAS560S	3.40
SAS570S	1.60
SFC2741DC	0.18
SL1451DP	12.44
SL1452	21.18
SL1454DP	11.10
SL1455DP	12.44
SL1612CDP	5.03
SL1613CDP	3.69
SL1640CDP	7.64
SL1641CDP	7.09
SL2363CCM	12.73
SL2364CDP	4.28
SL301LCM	13.19
SL3127CDP	2.78
SL3145CDP	3.78
SL360GCM	13.91
SL486DP	2.98
SL490B	2.51
SL6700CDP	5.47
SL952DP	7.26
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SN75114N	4.57
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SN75138N	4.41
SN75140P	3.11
SN75150P	1.62
SN75151N	5.02
SN75152N	6.36
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SN75162BN	11.78
SN75172N	4.56
SN75173N	4.56
SN75174N	3.25
SN75175N	5.28
SN75176AP	1.80
SN75176BP	2.28
SN75177BP	2.74
SN75179BP	2.46
SN75182N	2.90
SN75183N	2.90
SN75188N	0.40
SN75189AN	0.85
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SN75437ANE	3.26
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SN75462P	1.52
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SN75468	4.33
SN75469N	4.33
SN75472P	1.89
SN75477	2.10
SN75C1168N	4.78
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SN75C189CN	1.43
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STK4152II	7.75
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TA8410K	4.20
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TIL113	0.66
TIL117	0.66
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TL026CP	1.22
TL064CDP	0.48
TL081CP	0.31
TL082CP	0.36
TL084CN	0.49
TL331CP	1.23
TL430CLP	0.98
TL431CLP	0.84
TLC272CP	1.30
TLC555CP	0.44
TLC556CN	1.14
TLP521	0.80
TSC7126CPL	3.80
TSC7135CPI	5.98
TSC7660CPA	1.20
U1096B	4.92
U2066B	2.64
UA2240CN/CP	1.40
UA709CP	0.68
UA723CN	0.48
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UA748TC	0.52
UA9636ACP	1.86
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UDN6118A	1.65
ULA1R8029E1	4.96
ULN2001AN	0.93
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ULN2004AN	1.40
ULN2801A	0.84
ULN2803A	0.84
ULN2804A	1.35
UM5100	2.28
UM6101	3.80
XR2206CP	3.95
ZN425E-8	4.47
ZN426E-8	2.51
ZN427E-8	9.32
ZN428E-8	4.89
ZN429E-8	2.59
ZN435E	4.89
ZN439E8	7.44
ZN447E	10.88
ZN448E	7.02
ZN449E	4.76
ZN459CP	4.07
ZNA234E	11.98

TRANSISTORS THYRISTORS & TRIACS

2N2219A	0.28
2N2222	0.28
2N2222A	0.22
2N2369	0.24
2N2369A	0.24
2N2484	0.32
2N2894	0.76
2N2905	0.32
2N2905A	0.32
2N2907	0.30
2N2907A	0.30
2N2923	0.30
2N2243	0.78
2N3053	0.34
2N3055	0.68
2N3441	1.20
2N3553	0.98
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2N3789	2.16
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2N3866	1.24
2N3904	0.11
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2N4062	0.32
2N4091	0.78
2N4123	0.10
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2N4221A	2.96
2N4236	3.72
2N4401	0.18
2N4403	0.18
2N4921	1.40
2N5401	0.16
2N5415	0.72
2N5449	0.88
2N5459	0.53
2N5485	0.48
2N5876	1.32
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2N6037	0.72
2N6050	3.12
2N6051	3.49
2N6054	2.20
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2N6057	2.24
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2N6388	0.98
2N6517	0.34
2N6519	0.34
2N6668	1.40
2N696	0.26
2N706A	0.48
2SA1015	0.10
2SA1048/O	0.14
2SA1048Y	0.14
2SA1096R	0.74
2SA1100	0.52
2SA1102	2.10
2SA1104	2.10
2SA1111	1.18
2SA1115	0.80
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2SA1263N	1.70
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2SA1283	0.24
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2SA156	1.40
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2SC1775	0.30
2SC1845	0.20
2SC2009	0.38
2SC2180N	8.96
2SC2235	0.58
2SC2238/O	0.76
2SC2238B	0.68
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2SC2705	0.68
2SC2928	4.82
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2SC458	0.15
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2SC826	0.82
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2SC945	0.20
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2SD1266	1.78
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2SD1762	0.30
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2SD880/GR	0.40
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2SK246Y	0.30
3SK45	1.85
3SK88	0.84
40406	1.60
40673	2.40
BC140-16	0.48
BC146/01	0.58
BC149	0.40
BC157	0.34
BC158	0.34
BC169C	0.14
BC179	0.34
BC182	0.06
BC182A	0.06
BC182B	0.06
BC182L	0.06
BC182LB	0.07
BC183	0.07
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BC184	0.07
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BC184LC	0.08
BC212-18	0.08
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BC212B	0.07
BC212L	0.07
BC212LB	0.08
BC213	0.07
BC213L	0.07
BC214	0.07
BC214L	0.10
BC237	0.08
BC307	0.08
BC327	0.07
BC328	0.07
BC337	0.07
BC337-25	0.08
BC489	0.24
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BC516	0.22
BC517	0.20
BC546	0.05
BC546A	0.05
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BC547	0.07
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BC547C	0.07
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BC550B	0.07
BC550C	0.08
BC556	0.05
BC556A	0.05
BC556B	0.05
BC557	0.07
BC557B	0.07
BC558	0.07
BC558A	0.07
BC558B	0.07
BC559A	0.07
BC559B	0.07
BC560A	0.07

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Constructional Project

REACTION TIMER

T. R. de VAUX-BALBIRNIE

Just how fast do you think you are?

THIS Reaction Timer project was originally designed for fun at a party. However, it could have other more serious applications – in school science lessons, for example.

Reaction time is the time taken for a person to detect something (a stimulus) and for the brain to process it and make something happen. For example, when a child runs out in front of a car, the motorist applies the brakes as quickly as possible. The time elapsing between seeing the child (stimulus) and producing an action (pressing the brake pedal) is the reaction time.

The *Highway Code* uses the term *thinking distance* since here the reaction time is translated into the distance travelled at various speeds. This is more easily understood by motorists. For example, if a car is travelling at 30mph, the Highway Code tells us that the thinking distance is 30ft. A simple calculation can turn this into a reaction time:

30mph = 44ft/second.
So 30ft. is covered in
30/44 second = 0·7s approx.

THINKING TIMES

Thinking distance or reaction time depends on several factors. Firstly, the person concerned – some people have faster reaction times than others and, to some extent, this depends on the person's age. Secondly the state of alertness. The time will be greatly increased if the subject is tired or not concentrating.

Finally, the *type* of stimulus – the reaction time for a *visual* stimulus may not be the same as that for an *aural* one. Also, the effect of alcohol and some medicines (such as cough mixtures and so-called "cold cures" containing certain antihistamines) – these will increase the reaction time.

IMPORTANT WARNING: Under no circumstances must this reaction timer be used to indicate the ability to drive safely or to judge any impairment on driving due to the effects of alcohol.

The Reaction Timer is a battery-powered circuit housed in two interconnected units each built in a small plastic box. The main section has an on-off switch, a row of nine l.e.d.s (light emitting diodes) and a pushbutton (Freeze) switch. It also contains the circuit panel and battery. The remote section has a Start/Reset pushbutton switch mounted on top.

TESTING TIMES

Two people are needed to perform the test. The person performing it (the tester) sits with the remote section in such a way that the person being tested (the subject) cannot see the Start/Reset switch and possibly anticipate the start. The subject sits in front of the main unit with his or her finger ready on the Freeze button.

The unit is switched on and the tester presses the Start/Reset button whereupon the first l.e.d. in the display lights up. After some random time the button is released.

At this point, the l.e.d.s in the display operate one by one in rapid succession. As soon as the subject sees the first l.e.d. go off, he or she presses the Freeze button and keeps it pressed. This stops the display and the l.e.d. which remains lit indicates the reaction time against a scale of values marked alongside.

The button is now released ready for another try. Normally, several trials will be performed on the subject and an average time taken.

The prototype unit measurers the reaction time in 0·1 second (100ms) increments up to 0·8s (800ms). If there is a delay of more than 0·8s between observing the display and pressing the button, the unit "locks out" automatically and all l.e.d.s go off. The circuit could be adjusted at the setting-up stage to go up in larger steps, say, 150ms giving a maximum display readout of 120ms (1·2s).

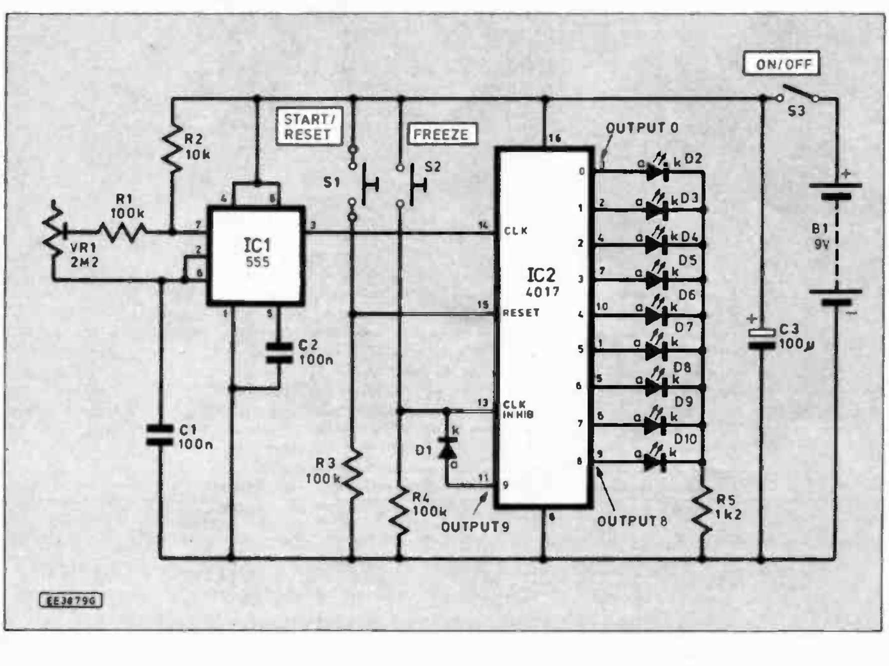
In the prototype model, the first three l.e.d.s are *green*, the next three *yellow* and the last three *red*. These could be used to indicate *Good*, *Fair* and *Poor* reaction times.

CIRCUIT DESCRIPTION

The full circuit diagram for the Reaction Timer is shown in Fig. 1. IC1 is a 555 timer i.c. which is connected as an *astable multivibrator*. Thus, while a supply exists – that is, with On-Off switch S3, *on*, pulses are produced continuously from the output, pin 3, at a nominal rate of 10 per second (10Hz).

The exact frequency depends on the values of fixed resistors, R1 and R2, preset potentiometer VR1 and capacitor, C1. To allow for component tolerances, and to enable different rates of operation, VR1 forms the adjustment for the pulse repetition frequency. The setting-up procedure for getting this right is described at the end.

Fig. 1. Complete circuit diagram for the Reaction Timer.



The pulses supplied by IC1 are applied direct to the clock input pin 14 of IC2, a CMOS decade counter. This device has ten outputs, 0-9, each one (apart from number nine) being responsible for lighting one l.e.d. in the display, D2 to D10.

As each pulse is received, successive outputs 0-9 (pins 3, 2, 4, 7, 10, 1, 5, 6, 9 and 11 respectively go high (supply positive voltage) and each l.e.d. lights in sequence. Since only one l.e.d. is on at a given time, they can all share the same common current-limiting resistor, R5.

Normally, on the tenth pulse, IC2 would self-reset and begin a further cycle. To prevent this happening, so that timings above 0·8s are invalid, output 9 (pin 11), which has no l.e.d. connected to it, disables the i.c. by applying a high state to *clock inhibit* pin 13 through diode, D1.

Thus, output nine remains high continuously, further clock pulses then have no effect and all l.e.d.s are *off*. In use, the subject will try to press the Freeze button, S2, before the display reaches the last l.e.d. – this action also inhibits the clock by making pin 13 high.

The Start/Reset switch, S1, on the remote section resets the display by applying a high state to IC2 reset input (pin 15). In the reset state, output 0 goes high and the first l.e.d., D2, lights.

When S1 is released, pin 15 goes low via resistor R3 which enables the clock. The test then proceeds in the manner already described.

Since IC2 cannot supply a large output current, *low current* l.e.d.s were used in the prototype unit coupled with a relatively high value of current-limiting resistor, R5. Standard l.e.d.s could probably be used but they would not be very bright.

COMPONENTS

Resistors
R1, R3, R4 — 100k (3 off)
R2 — 10k
R5 — 1k2
All 0.25W 5% carbon film

See SHOP TALK Page

Potentiometer
VR1 — 2M2 skeleton preset, horiz.

Capacitors
C1, C2 — 100n ceramic (2 off)
C3 — 100µ p.c.b. mounting elect., 10V

Semiconductors
D1 — 1N4148 signal diode
D2 to D10 — Low current l.e.d.s: red (3 off); yellow (3 off); green (3 off)
IC1 — 555 bipolar timer
IC2 — 4017 decade counter

Miscellaneous
S1, S2 — Miniature push-to-make switch (2 off)
S3 — Miniature toggle switch
B1 — PP3 battery and connector

Stripboard, 0·1in. matrix, size 15 strips by 27 holes; plastic boxes, size 114mm x 76mm x 38mm and 50mm x 37mm x 24mm; 8-pin d.i.l. socket; 16-pin d.i.l. socket; 10-way "rainbow" ribbon cable; stranded connecting wire; twin multi-strand connecting cable; stand-off insulator; fixings; solder etc.

Approx cost guidance only **£12** *excl. Batt*

CIRCUIT BOARD

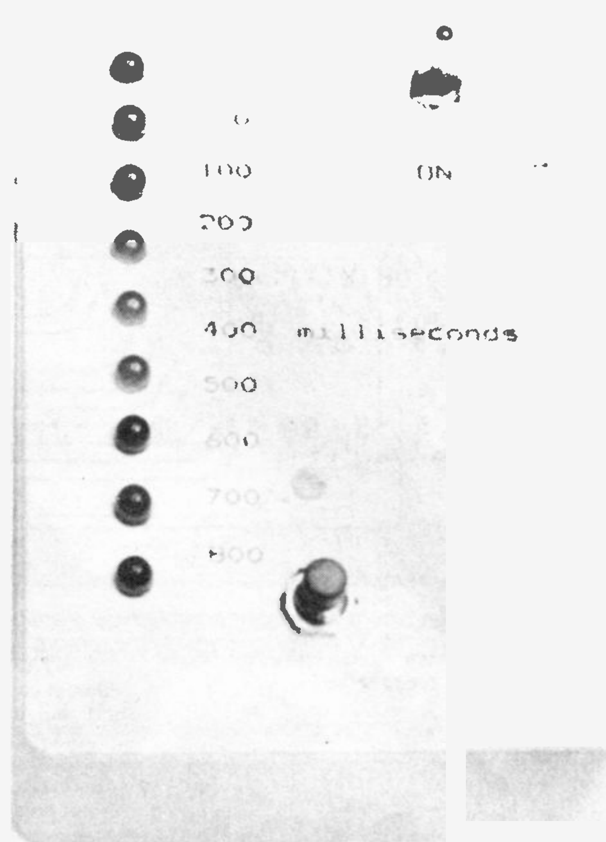
Construction of the Reaction Timer is based on a circuit panel made from a piece of 0·1in. matrix stripboard, size 15 strips x 27 holes. Fig. 2 shows full top-side component layout and the track breaks required on the copper strip side.

Begin by cutting the material to size, drilling the single fixing hole and making all track breaks and inter-strip links as indicated. Follow with the soldered on-board components but do not insert the i.c.s into their sockets until the end of construction. Note that diode D1 and capacitor C3 are polarity-sensitive components and must be connected the correct way round.

Leave the anode (a) end of diode D1 unconnected for the moment. Solder a short stalk (clipped-off resistor end) to board matrix position *H*19. At the end of construction D1 anode end lead will be soldered to this stalk so completing the connection. The reason for doing this is to help in the setting-up procedure at the end.

It will help construction if 10-way "rainbow" ribbon cable is used for the edge connections to strips *D, E, G, H, I, J, K, L, M* and *O* on the right-hand side of the circuit panel. This will keep the wiring neat and help in avoiding wiring errors later.

Solder a 10cm piece of *red* light-duty stranded wire to strip *C* and solder the black battery connector "negative" wire to strip *N* as shown in Fig. 3. Solder a similar piece of wire to strip *J* on the left-hand side. Leave VR1 adjusted to approximately mid-track position.



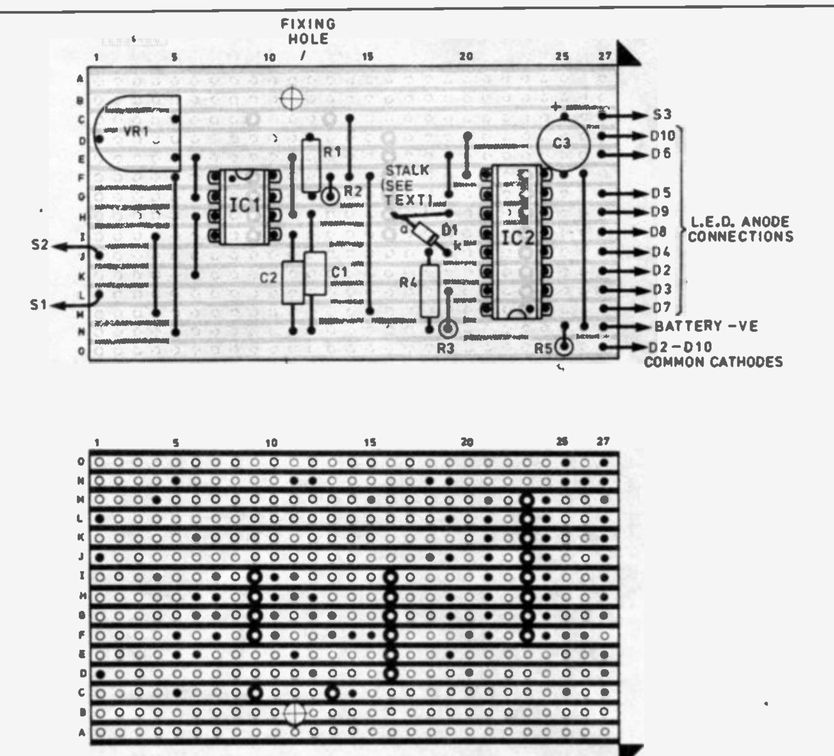


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks. Do not connect the diode D1 anode to the short lead from hole H19 *at this stage, wait until after the setting-up has been completed.*

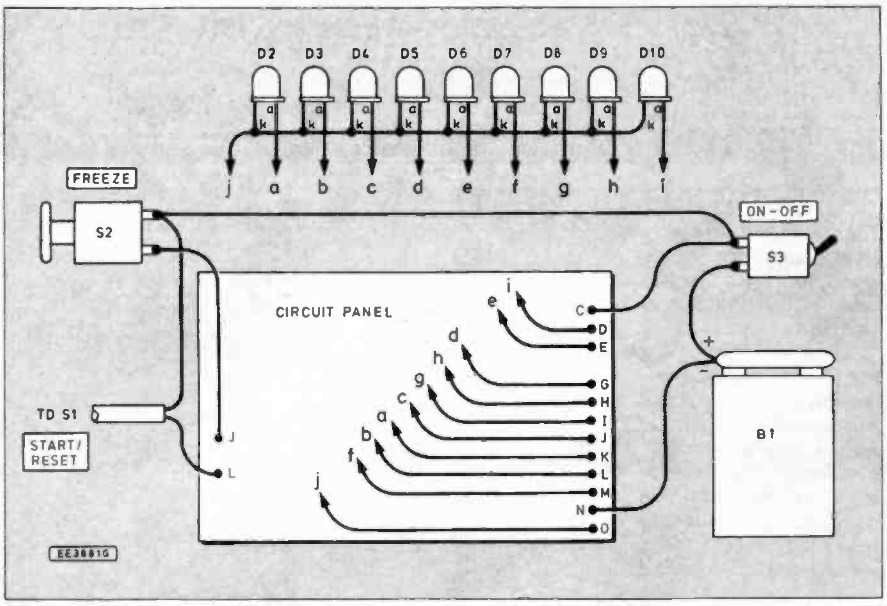


Fig. 3. Interwiring from the circuit board to the display l.e.d.s and other off-board components. Switch S1 is mounted inside the remote "tester" box.

MAIN UNIT

Refering to Fig. 3 and photographs, prepare the main unit box by drilling holes for S2 (Freeze) and S3 (On-Off) also a small hole in the side for the interconnecting wire to pass through. Drill holes for the nine l.e.d.s – it is worth measuring the positions of these carefully since the appearance of the finished project depends largely on the display being neat.

The holes should be of such a diameter that the l.e.d.s are a tight push-fit. They may then be secured with a little glue. Alternatively, l.e.d. mounting clips could be used.

Mount all remaining components. Note that everything is secured in the *main section* of the box with nothing on the lid – this avoids strain on the interconnecting wires.

Complete the internal wiring – note particularly the common connection for all l.e.d. cathode (k) ends. Follow the colours of the ribbon cable carefully so that the l.e.d.s end up lighting in the correct sequence.

Do not cut the end leads of the l.e.d.s too short and take care when bending them not to break them off. Solder the l.e.d. connections quickly to avoid heat damage. Note that l.e.d.s are polarity-sensitive and will not work if connected the wrong way round.

To avoid a lot of inconvenience later, try to get the polarity of the l.e.d.s right first time. Note the "flat" on the body and the shorter end lead – both these denote the cathode (k) end.

Cut off a suitable length of light-duty twin wire to use as the interconnecting lead between boxes and solder the two wires at one end to strip *L* on the left-hand side of the circuit panel and the other to switch S2. Tie a knot in the wire to provide strain relief and pass it through the hole in the side of the case from the inside. (Note: Never tie a knot in a *mains* carrying lead to act as a strain relief).

Attach the circuit panel above the l.e.d. display in the position shown in the photograph. Use a plastic stand-off insulator long enough for the copper strip side to be held clear of the l.e.d. connections. A long 6BA nylon bolt with three nuts was used for the purpose in the prototype – one nut to secure the bolt and two to sandwich the circuit panel.

Use a piece of thin plastic p.v.c. tape to provide some insulation for the copper strips if necessary. Secure the battery to the base of the case using an adhesive fixing pad.

REMOTE UNIT

Drill holes in the remote box for Start/Reset switch, S1, and for the interconnecting lead to pass through. A keyboard-type switch was used in the prototype but any small push-to-make switch will do.

Mount switch S1, pass the twin wire interconnecting cable through the hole and tie a knot in it to provide strain relief. Solder the two end wires to S1 terminals leaving some slack in the wire so that it cannot pull free in service.

Back to the main unit. After a check for errors, insert the i.c.s with the correct orientation – note that IC2 is "upside down" compared with IC1. In theory at least, as IC2 is a CMOS device it can be damaged by any static charge which may exist. To be safe, touch a water tap or other earthed object before removing it from its packaging. Alternatively, avoid touching the pins when inserting it into its socket. Switch S3 *off* before proceeding.

TESTING AND ADJUSTMENT

Commence the testing and setting-up by connecting the battery and switching S3 *on*. The l.e.d.s should light rapidly one by one in sequence then start again (the cycle keeps repeating because one end of diode D1 has been left *disconnected*).

If any l.e.d. fails to light, suspect that it has been connected the wrong way round in the circuit. If any l.e.d.s operate out of sequence, they have been connected to the wrong IC2 outputs.

By timing ten complete cycles and adjusting preset VR1 to make this exactly 10 seconds (since it cycles through ten outputs), you will know that the time taken for the display to advance by one l.e.d. is 0·1s (100ms). This rate was found to be satisfactory in practice but it could be speeded up or slowed down as required by suitable adjustment to VR1.

Once this operation has been carried out, the wire stalk at board matrix position *H*19 may be soldered to diode D1 anode. When tested, the unit should behave as before except that *all* l.e.d.s will go off after the first cycle.

It only remains to label the switches and l.e.d. display – this may be done in *milliseconds* i.e. 0, 100, 200 so on – see photograph. Use dry print lettering to give a professional appearance.

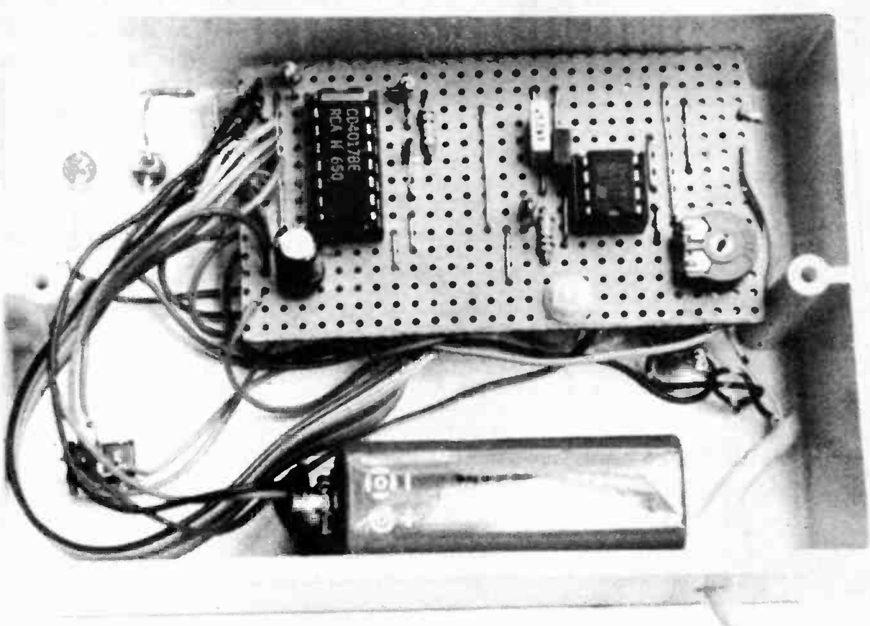
REACTION

It is interesting to note that most people have a reaction time shorter than the *Highway Code* seems to suggest. This is probably because the situation in driving is not the same as here.

In these tests, the level of concentration is greater since it only needs to be kept up for a relatively short time. In driving, it would be impossible to maintain this degree of concentration.

This could be investigated by allowing a long time before releasing the Start/Reset switch. This will usually be found to increase the reaction time of the subject. □

Layout of components inside the completed main unit. The remote case is similar but only houses the Start/Reset switch S1.



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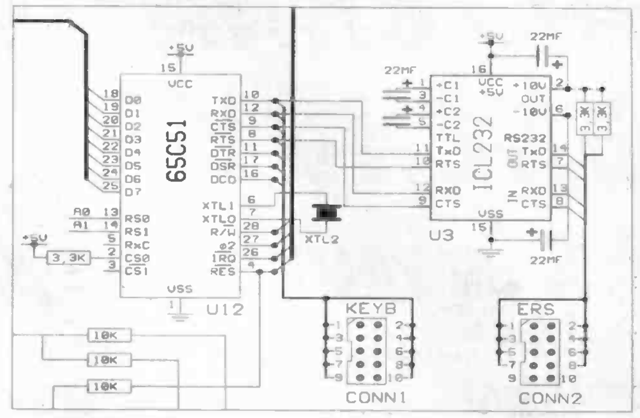

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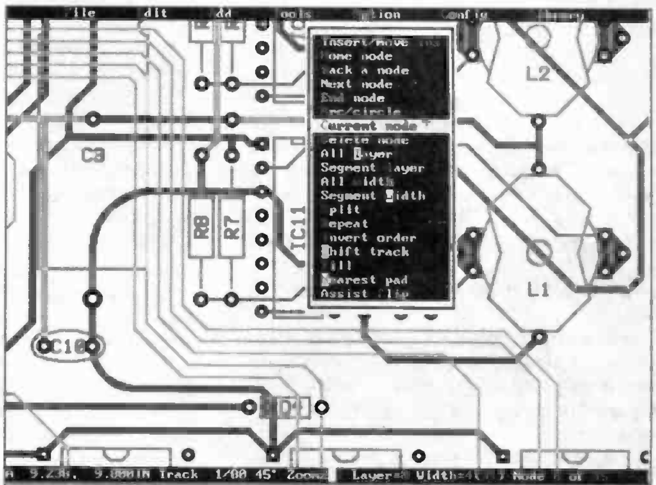

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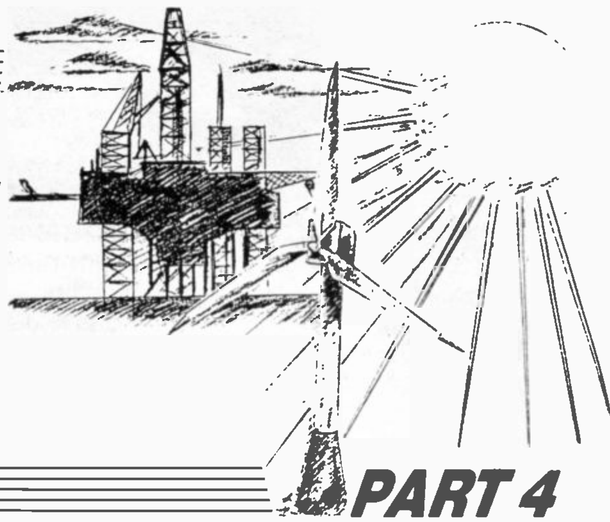


ALTERNATIVE ENERGY

T. R. de VAUX BALBIRNIE — PART 4

Developments using renewable energy sources. Energy from water.

THIS is the fourth article in a short series about renewable energy – that is, sources of power which will last for ever unlike those derived from the fossil fuels – coal, oil and natural gas – which will eventually run out. This month we shall examine various ways of using *water power.*

The Department of Energy has funded a programme of research and development into alternative energy methods since 1974. Some ideas turn out to be economically and technically attractive, some could be promising in the medium term and others are long shots and unlikely to be used in the foreseeable future.

The Government is working towards an electrical generating capacity of 1000MW from renewable energy sources by the end of the century – equivalent to the output of one large coal-fired power station. Technically, renewable energy sources could furnish *all* our needs but they are *diffuse* – that is, the power is spread out over a large area and this often makes exploitation difficult and therefore expensive.

WATER, WATER EVERYWHERE

Water power in its various forms, together with on-shore wind energy, geothermal energy and schemes producing energy from waste material (of which more will be said next month), are likely to make a significant contribution to Britain's total energy needs in the 21st century. This, together with nuclear power and a smaller contribution from the dwindling supplies of fossil fuels, should maintain our increasing energy needs.

Water power in some form is an ancient technology – water wheels have been used for milling corn and other purposes for centuries. There is a reference to water power having been used in Greece during the First Century A.D. and in the Middle Ages the water wheel was in widespread use in several countries.

The traditional *overshot* and *undershot* types of water wheel are shown in Fig. 1. Today, the water wheel would be described as a *turbine* where the water turns blades on a shaft which can then provide useful work.

There are several ways of obtaining energy from water and hence to generate electricity – from the tides, from waves and from the power of falling water – that is, *hydroelectric power* schemes. It is also possible to use naturally-occuring hot water – springs and geysers – and this method will be discussed in more detail next month. Unlike tides, springs and geysers, both wave energy and hydroelectric schemes actually use indirect solar power.

Waves are caused by the wind blowing across the surface of the sea and it is the sun which causes the differences in temperature which cause the wind to blow. As well as causing horizontal currents, the water is made to move up and down. It is this movement which carries vast amounts of energy and which may be exploited to generate electricity.

Hydroelectric power is also derived indirectly from the sun since it is the heat of the sun (solar radiation) which evaporates the water in the first place and carries it up as vapour to the high ground where it falls as rain. The energy held by the water on the high ground is called *potential energy* (energy due to position). As it falls, the power may be transferred to a turbine which rotates the shaft of a generator and produces electricity.

We saw in a previous article that approximately 20 per cent of solar energy falling on the earth causes evaporation of water but much of it happens very diffusely with small amounts of flowing water spread out over a very large area. It would be uneconomic to extract the energy from such small amounts of slow-moving water.

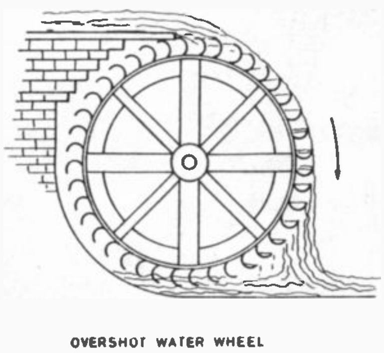


Fig. 1. Types of traditional waterwheel.

EBB AND FLOW

Tidal energy is an "odd man out" because here the power has not come from the sun. Tides are caused chiefly by the gravitational pull of the moon and, to some extent, the sun on the mass of water which makes up the oceans of the world. Although the sun is massive in comparison to the moon, it is also much further away so it is the moon which has the greater influence. The gravitational force causes the water to pile up and it moves as the earth turns on its axis.

Most parts of the world experience two tides each *tidal day* – that is, every 25 hours and 5 minutes. When the sun aligns with the moon there is a larger than normal gravitational force and a particularly high tide results. This occurs twice a month and is called a *spring tide*.

When the sun and the moon are in opposition, a smaller gravitational force results and this gives rise to a lower tide than usual called a *neap tide*. Even so, tides are very complex and far removed from the pattern suggested by simple theory. The size of a tide is influenced by the shape of the coastline with funnelling effects tending to increase the tidal range.

Advisors to The Department of Energy believe that tidal energy and wind power (which has been discussed in previous parts of this series), have a promising future and together have the potential to generate a

Potential sites for tidal barrage schemes.

significant fraction of the total electricity needs of the U.K. We may draw on the experience of the French, Americans and Canadians who have had large-scale tidal power schemes in operation for several years.

In Britain, we are fortunate in having some of the highest tides in Europe and these are ideal for economic exploitation. It is thought that the tidal range needs to exceed about five metres to make this method commercially worthwhile and many such sites are to be found around the west coast and elsewhere – see the map of potential barrage scheme sites.

In the Severn Estuary, funnelling and other effects combine to provide one of the largest tidal ranges in the world – over 11 metres in the region between Barry and Weston-Super-Mare (see Fig. 2). The flow of water carries a vast amount of energy and using this to generate electricity is a very attractive and economically viable proposition.

By maximum commercial exploitation, we could generate at least 20 per cent of Britain's total electricity needs by tidal power alone – rather more if we did not look too coldly at the commercial aspects but weighed them up against the indirect benefits. Even if we abstracted energy only from the largest tides – those of the Severn, the Mersey and a few more, 10 per cent of our total energy needs could be realized. The eight largest schemes used together could save Britain about 25 million tonnes of coal per year.

We presume that by drawing energy out of the tidal system, we are slowing down the rate at which the earth spins on its axis. However, this effect is so small as to be imperceptible and is happening all the time anyway.

TIDAL BARRIERS

To exploit tidal energy, a *barrage* or dam needs to be built to control the flow. A river basin is thus formed. The barrage has a number of turbines set into it and as water flows in and out of the basin with each change of the tide, the turbines rotate, turn generators and make electricity (see Fig. 3).

The proposed Severn Tidal Barrage scheme is, at the moment, undergoing extensive study. The Severn Tidal Power Group has completed a programme of investigations and has confirmed that a suitable barrage could be constructed using existing technology. It is further believed that, once built, the scheme would be capable of delivering electricity to the public supply network for more than a century.

The Severn Barrage project, if put into operation, would be the largest tidal power scheme in the world. The barrage itself would be enormous – some 16km (10 miles) in length stretching between Lavernock Point (between Barry and Cardiff) to a point near Weston-Super-Mare (see Fig. 2). The basin would enclose an area of 480 square kilometres.

Into the barrage would be set 216 turbines each with a diameter of 9m and each having a generating capacity of 40MW giving a total power output of 8640MW – that is, it would exceed the output of eight large coal-fired power stations. This would provide seven per cent of the total electrical energy requirement of England and Wales.

Despite the great capital cost – some £8 billion (at 1988 prices) – the potential for saving fossil fuels would be vast – some 8 million tonnes per year. The reduction in carbon dioxide emission would be almost 18 million tonnes per year with consequent relief from the greenhouse effect.

Construction of the Severn Barrage would probably involve floating large hollow concrete sections to the site. Each section – called a *caisson* – would carry one of the turbines. It would be necessary to provide locks to allow the largest ships to pass to the ports along the river and some means of allowing fish through without harm. The construction time scale would be approximately 14 years – about five years for preparation, a further seven for construction and first power production and a further two years for full-stream operation.

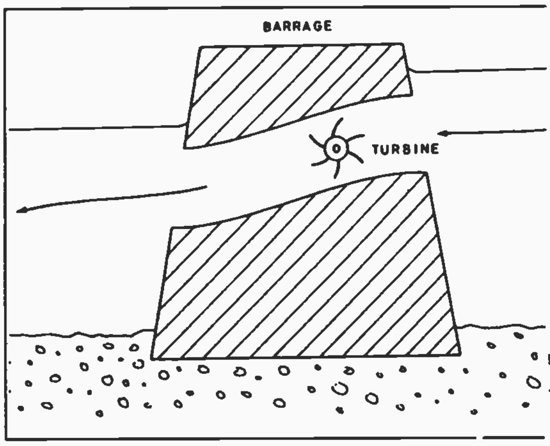


Fig. 3. Principle of the tidal barrage.

ACROSS THE MERSEY

A similar but much smaller *Mersey Barrage project* would use a dam 2km in length with a basin enclosing 61 square kilometres. There would be 28 turbines set into it, each having a diameter of 8m and each with a generating capacity of 25MW. This would provide a total peak output of 700MW. The Mersey is well suited to such a scheme with spring tides reaching a range of 8m.

The preferred siting for the barrage is between the Liverpool Garden Festival site near the city centre and a point close to New Ferry on the Wirral – see Fig. 4. As in the Severn project, a system of locks would be required to allow the passage of ships to the Manchester Ship Canal.

The Mersey Barrage scheme would save some 700,000 tonnes of coal per year. Constructional cost is estimated at £880M (at 1989 prices). If the scheme were approved by Parliament, the project could be complete and generating power within two years.

In addition to the two largest projects outlined above, Britain has the potential for several less ambitious schemes each making a small but significant contribution. A study made in 1986 identified 34 such sites each with the potential to generate between 30 and 150MW.

A feasability study on a possible Conway (North Wales) Barrage shows the potential to generate 33MW while a Wyre Barrage (near Fleetwood in Lancashire) could

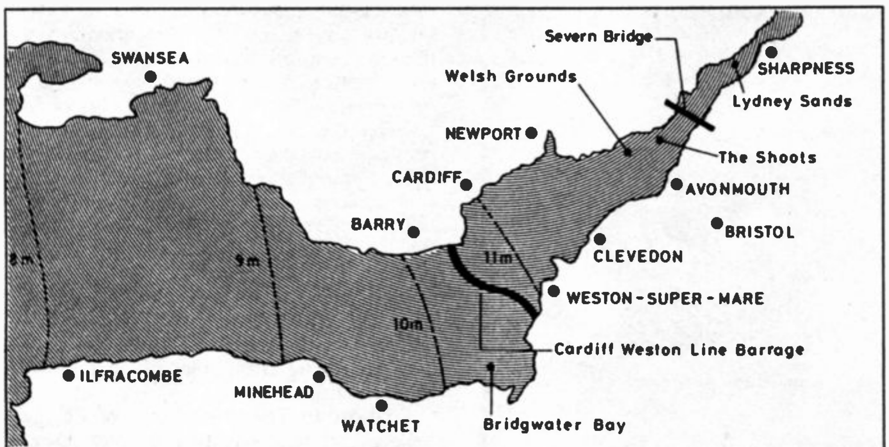


Fig. 2. Possible location of a Severn barrage.

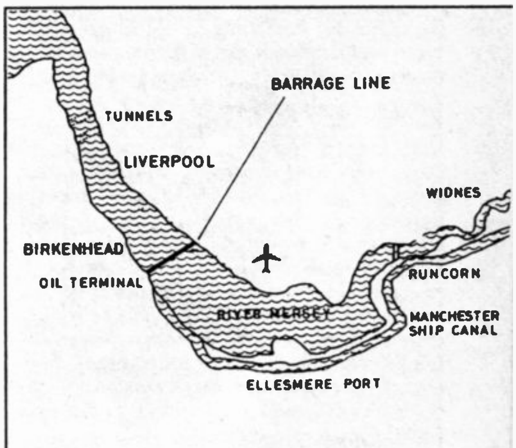


Fig. 4. Possible location of a Mersey barrage.

produce 47MW of electricity. Scotland tends to have lower tides so there are fewer commercially attractive sites there. However, Scotland has a greater potential for hydroelectric schemes than England and Wales.

EFFECTS ON THE ENVIRONMENT

Tidal energy has the advantage of being less diffuse than many other forms of renewable energy. Also, the energy in moving water is easily turned into electricity by well-known and relatively inexpensive technology. However, the use of tidal energy is not without some cost to the environment.

Abstraction of tidal power alters the pattern of water movement and lessens the speed of the currents. This can cause sediment build-up and lower turbidity with possible effects on wildlife. Within the river basin, the tidal range would be reduced and the low-water level raised.

It is thought that lower turbidity could increase the availability of food for fish and birds but, on the negative side, there would be a reduced mudflat area for feeding wading birds. However, taking everything into account, tidal power is thought to rank with the wind in being among the most environmentally-friendly sources of power.

Because a tidal energy scheme controls the flow of water, it prevents flooding along large stretches of the river during extreme high tides. Other methods of flood prevention would therefore not be required and the savings made here offset some of the constructional costs of the barrage itself.

WAVE ENERGY

It is well known that waves carry an enormous amount of energy. Our coast has a history of broken seawalls and seaside piers having being destroyed during violent storms. Research into abstraction of wave energy has been carried out since the mid-1970's and extensive studies have been made to find the best types of device for the job – some 300 ideas in all.

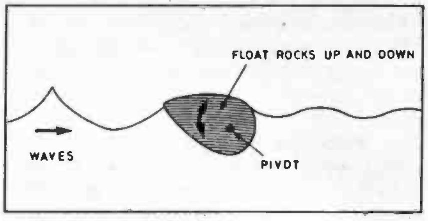
The best places for large-scale wave energy exploitation lie between latitude 40 and 60 degrees and many parts of Britain have a near-ideal situation. Off the West Coast, in the NW approaches, there is said to be available some 70MW of power per km of coastline – that is to say, over a stretch of approximately 15km (about 10 miles) there is available the equivalent energy of a large coal-fired power station.

In fact, the waves around our coast carry all the energy we need but its abstraction would prove very expensive and difficult. Also, the power of the waves is notoriously unpredictable depending as it does on wind speed and the exact way and time for which the wind blows across the water surface.

OFFSHORE

There are basically two wave energy extraction technologies – *offshore* and *shoreline*. Large off-shore wave energy projects are exciting and once seemed attractive on account of the vast amounts of energy available. The up and down wave energy could be extracted by transferring the motion to floating *nodding ducks* in the manner developed by Professor Salter of Edinburgh University (see illustration). The motion would then be transferred to an electrical generator. However, off-shore wave technology is difficult.

The mighty 2000MW off-shore proposals originally investigated by the Department of Energy now seem far too expensive to imple-



Salter's Ducks, method of operation.

ment. The technique of bringing the energy ashore and difficulties in maintenance of the equipment would also raise problems. It appears that the economic viability of using off-shore waves as a source of energy would depend on other methods rising in price.

SHORELINE

On the other hand, due to the relatively low cost involved, small-scale *shoreline* projects seem to hold much promise. These would be of value as local power sources in remote regions where it is expensive to lay on a supply of electricity – perhaps by using diesel generators.

One such scheme under investigation is the Shoreline Rock Gully System developed by Queen's University, Belfast and funded by the Department of Energy. This is presently undergoing trials on Islay in the Inner Hebrides (see below). In this scheme, the energy is extracted from waves in a natural gully so greatly reducing construction costs.

The waves force water into a large chamber (a *capture chamber*). This rises like a piston and forces the air through a turbine which then operates an electrical generator. As the water retreats, the air ren-enters the chamber and the turbine is operated once again.

A special air turbine developed by Professor Alan Wells – the *Wells Turbine* – can operate without reversing whichever way the air is moving through it and this is a great advantage. The output from the generator varies from a peak of some 100kW during a storm to some 75kW during normal working conditions. Work began on the project in 1985 with construction commencing in 1987. The output was connected to the National Grid in 1991.

One advantage of wave energy which is not always true of other alternative energy sources is that production tends to track demand – in winter, when more electricity is needed, the waves are generally larger and so more electricity is produced.

HYDROELECTRIC POWER

The technique of producing energy from falling water has been well established in Britain – as in many other parts of the world – for many years. Unfortunately, there is little room for expansion since all the major resources are already in use.

Currently, about two per cent of U.K. electricity needs are supplied in this way – mainly in Scotland which holds 90 per cent of the total resource. Really large amounts of energy are only available where the head (height of fall) exceeds 50m and these provide 85 per cent of the total energy produced by H.E.P. technology.

Britain is not as fortunate as certain other countries (Canada and Sweden, for example) in having large masses of falling water. Perhaps the future lies in developing many small-scale projects which would nevertheless, provide a useful contribution to our total energy needs.

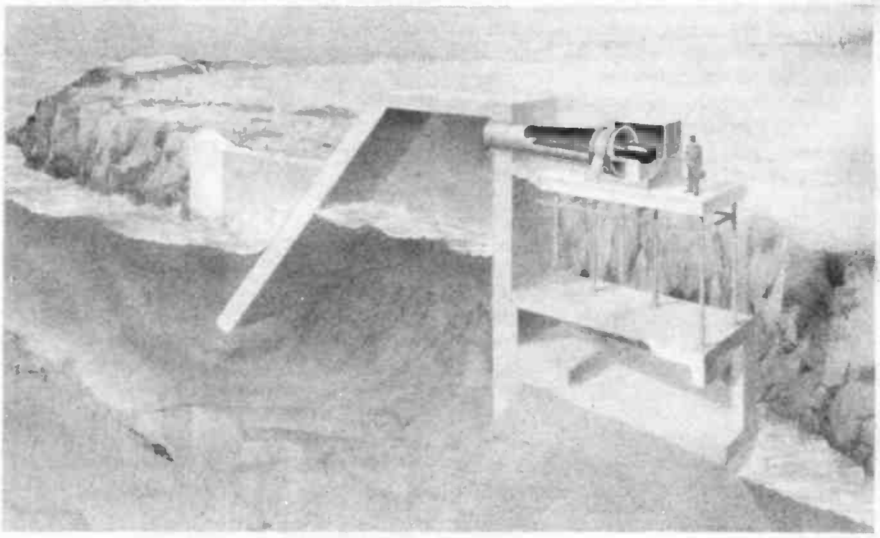
Work by the University of Salford has shown that some 300MW of power is available where the head is little more than three metres. It could be argued that 300MW is too small to be worthwhile – it is, after all, only one-third of the output of a large conventional power station, but the energy is available using well-established technology and at a reasonable price.

Many such schemes could provide up to one per cent of our total requirements in the future. This would be helpful to island communities too remote from the nearest conventional electricity supply.

PUMPED STORAGE

Although not a source of alternative energy as such, this month's work would not be complete without a brief mention of *pumped storage* power stations because these schemes provide an indirect saving in the use of fossil fuels and a consequent reduction in carbon dioxide emission.

To understand the principle of pumped storage power generation, we need to know that the public demand for electricity varies throughout the 24 hour cycle. During the night, the requirement both by private



The shoreline generation system, this cutway artists diagram shows the principle of operation.

homes and industry falls off considerably. The generating companies wish to boost demand in the off-peak period to provide a better balance between off-peak and on-peak usage since this makes for more efficient operation of the network.

Schemes such as *Economy-7* help to do this by offering electricity to the consumer at a discounted price between certain hours of the night and early morning. In this way, storage heaters and other pieces of equipment may be used to take advantage of the lower price.

On a much larger scale, off-peak power may be used to pump water from a lake at the bottom of a mountain to a reservoir at the top. At times of peak demand or perhaps when there is a sudden unexpected need for power such as during a spell of cold weather, the water is allowed to flow downhill again, turn the turbines, and generate electricity just as in a conventional hydroelectric scheme.

At Dinorwig in North Wales, this method is used to provide full generating capacity within ten seconds. The turbines which generate the electricity when the water flows downhill may be operated in reversing as pumps to drive the water up again. It is true that some energy is lost in the process – that is, some is turned into heat in the water and therefore unavailable for use. In modern systems this amounts to 10 per cent approximately.

A pumped storage system does not make much use of a renewable energy resource since mainly fossil fuel energy is used to raise the water to the higher level in the first place. However, by providing a more even demand, the overall efficiency of the distribution system is increased. Even taking into account the "lost" 10 per cent, this means an ultimate saving in the use of fossil fuels.

HYDROGEN AS A FUEL

A further way of obtaining energy from water – this time a *chemical* one – is to use *hydrogen gas* as a fuel. Water consists of only two basic materials (elements) – the gases *hydrogen* and *oxygen*. If hydrogen is removed from water, it may then be used to power a car. A conventional petrol-burning engine may be adapted to use hyrdogen. However, as every schoolboy chemist knows, hydrogen must be treated with respect since it forms a highly explosive mixture with air.

To remove the hydrogen (and the oxygen) from water involves passing an electric current through it – that is, to perform *electrolysis*. Obviously, in order to do this, the electricity has to come from somewhere and this may be derived from fossil fuels, nuclear energy or some renewable energy source.

When the hydrogen burns and delivers power to the engine, we are simply regaining the energy which generated the electricity in the first place. However, there are some advantage in doing this. Firstly, the relatively inexpensive and well-known technology of the internal combustion engine may continue to be used. Also, hydrogen is a perfectly *clean* fuel.

The only product of combustion is water – that is, regaining the water which was electrolysed. This means that the exhaust is totally harmless and non-polluting. There is no carbon dioxide produced and therefore no contribution to the greenhouse effect.

GAS CAR

Since the early 80's, the German car manufacturer, BMW, has been carrying out a research programme to examine the use of hydrogen as a fuel for motor vehicles. The idea is to use solar cells to generate electricity which is then used to electrolyse water and produce hydrogen gas.

In the BMW system, the hydrogen is *liquefied* and so stores much more energy in a given space than the gas. This method brings certain problems, however, The greatest of these is that liquid hydrogen only exists at a temperature of −253°C.

In practice this means that the storage tank must be very well insulated to prevent the fuel from boiling off rapidly into the atmosphere. The fuel tank specially developed for the purpose is double-walled with very sophisticated insulation. This is capable of holding 93 litres (20.5 gallons) of liquid hydrogen which provides a range of 300km (190 miles approximately).

The tank is fitted in the 6-cylinder 3.5 litre long-wheelbase 735iL model across the luggage compartment. This avoids problems with the rear seating which is unaffected.

Developing engines to produce maximum power using hydrogen fuel demands difficult and expensive technology. BMW see one possible way forward in not trying to develop maximum power but to reduce it by some 30 per cent compared with using petrol. A lean mixture is then used and this simplifies the procedure and reduces costs.

HAZARD

Even with the high degree of insulation used on the fuel tank, liquid hydrogen does boil off and is released through safety valves – a maximum of two per cent of the fuel is lost to the atmosphere this way each day. There are concerns about the safety aspects associated with this free hydrogen and also the possibility of damage to the fuel tank in an accident leading to large-scale release of gas into the atmosphere.

It is impossible to remove all risk but this must be compared with the hazard due to the storage of petrol. At least, unlike petrol, hydrogen is non-toxic and when released into the air is quickly diluted, and rapidly becomes harmless.

An interesting feature prevents accidental build-up of hydrogen in the passenger compartment. If a predetermined concentration of gas is exceeded, a sensor detects it and an electronic circuit causes the sliding roof, windows and boot lid to open so preventing an ignitable mixture accumulating.

In the event of an accident, the doors unlock, the windows and boot lid open and the sun roof slides back. Taking everything into account, it is doubtful if a car burning hydrogen as a fuel involves any more risk than a conventionally-powered car.

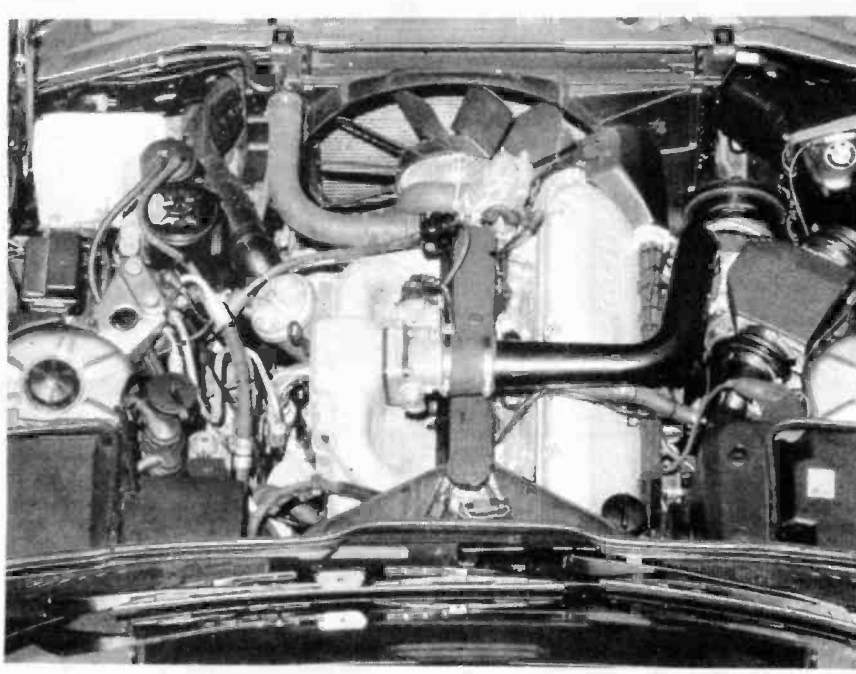
BMW are taking their Hydrogen Drive research project very seriously. To improve the development of hydrogen-burning engines they started to use the world's first purpose built test bed in March, 1989. This uses a complete data processing system with results being recorded electronically in a measuring and control room. Data is then analysed and optimum working conditions determined.

VIABLE

Research into hydrogen-powered cars suggests that this fuel could make a viable alternative to petrol. At the moment costs are still too high, however, and problems still remain. Experimental cars have been built using hydrogen compressed into cylinders but the quantity of gas is not sufficient to provide a satisfactory range. A further idea is to absorb the gas into various materials but this method has not been altogether successful either.

A variation of the method is to use *fuel cells*. Here, instead of burning the hydrogen in an engine, the hydrogen and oxygen obtained by electroysis are passed over special porous plates. The two gases re-combine to provide water and in the process a voltage is formed between the plates. Thus, electrical energy is produced *direct* from the fuel. This may then be used to operate an electric motor to power the car. At the moment fuel cells are rather bulky but further research could possibly bring them down to a manageable size.

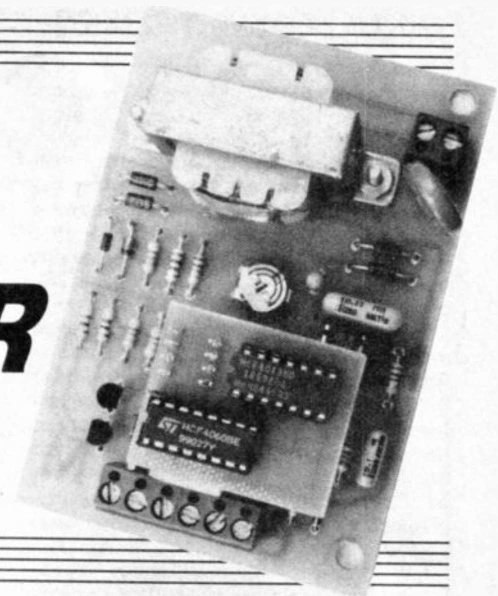
Next month we shall look at some further examples of renewable energy sources – those using household waste, biomass and geothermal energy. We shall also look at some aspects of nuclear power to see how this fits into the complete *Alternative Energy* picture.



The BMW hydrogen drive engine in a 735iL.

Project Update

BATTERY TO MAINS INVERTER DAUGHTER BOARD



MARK DANIELS

An add-on board for a past project.

THE *Battery to Mains Inverter* project which appeared in the March 1991 issue of *Everyday Electronics* used an M706B1 timebase i.c. to generate the accurate 50Hz timing signals required for its correct operation. Unfortunately, it would appear that this device is no longer readily available and no direct replacement or substitute for it is known to be in existence. To help readers already constructing this project or contemplating its construction an add-on daughter board has been designed to take the place of the now elusive M706B1. *(The March '91 issue is available as a back number from the Editorial office – see the Editorial page for details – Ed.*

CIRCUIT REQUIREMENTS

The M706B1 i.c. which was specified for IC1 in the original design was supplied in a standard 8-pin d.i.l. package and provided complementary 50Hz square wave outputs from a 3·2768MHz crystal reference.

Ideally the circuit which replaces this device should make use of the existing components and i.c. socket for its connections. To enable us to mount extra components in place of the original device a small daughter board carrying the substitute parts is mounted above the main p.c.b. and connections between the two boards are made using tinned copper wire.

CIRCUIT DESCRIPTION

The circuit shown in Fig. 1, comprises two standard low power CMOS i.c.s., IC1(1) and IC1(2). IC1(1) is a 14 stage binary counter with an on board crystal oscillator section designed for connection to an external crystal. A number of the stages are made available on the device pins, but in this application the largest division ratio is chosen, giving an output of 200Hz at pin 3, using the original crystal, X1 (see original article).

The counter/oscillator IC1(1) has only a single output and a division ratio which is insufficient for our requirements, so extra stages in the form of a dual bistable, IC1(2) are added at its output.

The two bistables in IC1(2) are cascaded to provide a further division by four thus reducing the 200Hz at its input to the required 50Hz complementary outputs. Reference to Fig. 1 will show how the replacement components connect to the pins of the original IC1 position, using all other existing components on the parent board in their original positions and with no changes in their values.

CONSTRUCTION

The full size foil pattern and component overlay for the small daughter board are given in Fig. 2. For ease of construction it is recommended that sockets are used for the two i.c.s.

Eight lengths of 20 s.w.g. tinned copper wire (30 amp fuse wire) approximately 30mm long are soldered to the remaining pads on the reverse of the p.c.b. to make the connections to the parent board.

If the parent board is already assembled IC1 and its socket (if fitted) will need removing before the daughter board can be offered up.

Feed the tinned wires into IC1 holes in the parent board allowing sufficient clearance above the parent board components to preclude the possibility of short circuits in the future. Check that the board is correctly aligned; the figures on the daughter board corresponding to the original IC1 connections, before soldering the connections. Reference to the photograph should clarify any obscurities.

Before fitting the two new i.c.s. it may be sensible to check that the power rails are all present and correct. 0V on IC1(1) pins 8 and 12 and IC1(2) pins 4, 6, 7, 8 and 10. Twelve volts should be present on IC1(1) pin 16 and IC1(2) pin 14.

TESTING

Fit the two i.c.s, observing CMOS handling precautions and polarity requirements and switch on.

The inverter should start immediately if the parent board was working prior to modification. If not, fault finding is pretty much the same as in the original design, with the possibility of a check for 200Hz at pin 3 of IC1(1). Use Fig. 1 of this article in conjunction with the main schematic of the original article if fault finding should become necessary.

CONNECTION CLARIFICATION

The small transformer T2 in the original article appears to have caused confusion among some readers, as its secondary is incorrectly labelled in the main circuit diagram, Fig. 2. It should be labelled 12V-0V-12V, *not* 0V-12V as shown. The p.c.b. layout of Fig. 3 is also incorrectly labelled, and should be marked 12V-0V-12V, the centre-tap lead being cut off as it is not required in this application.

Editorial Note: *The author is presently working on a 250W inverter design together with an uninterruptable power supply add-on, which we hope to publish in a few months time.* □

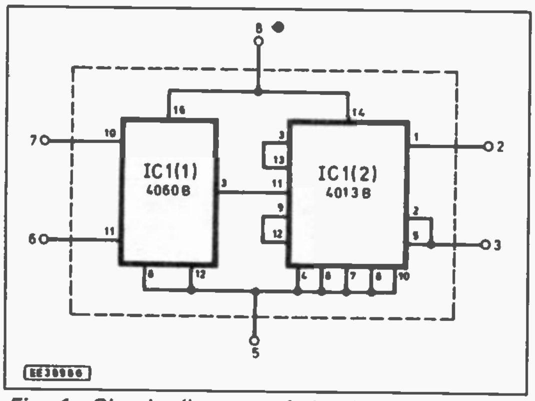


Fig. 1. Circuit diagram of the Daughter Board. Numbers outside the dotted line correspond to the original pin numbers.

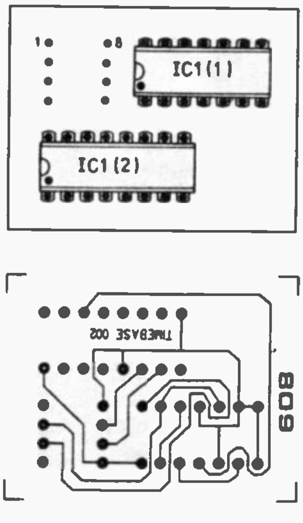


Fig 2. (right) P.C.B. construction.

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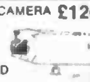

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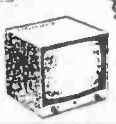

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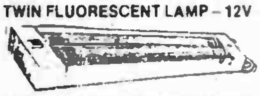

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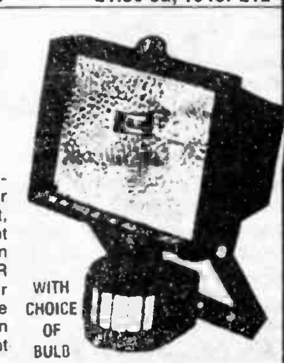

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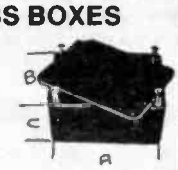

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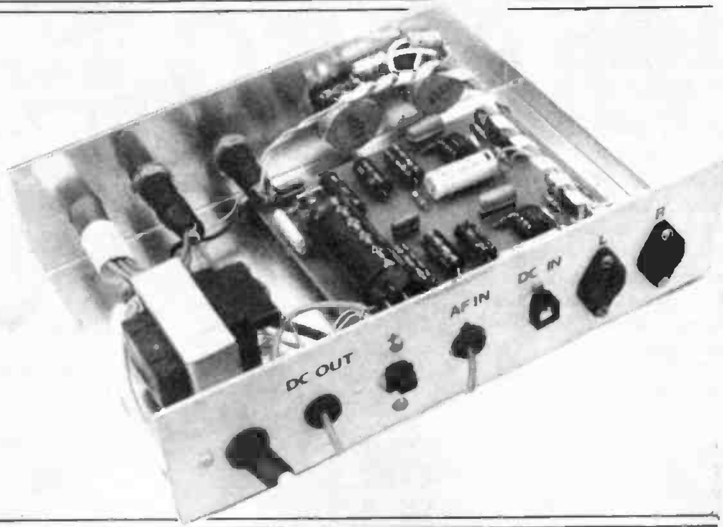
Constructional Project

PERSONAL STEREO AMPLIFIER



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A versatile, low cost, add-on stereo amplifier (approx. one watt) for your personal stereo.
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PERSONAL stereos (Walkmans) are excellent for the purpose they were designed, i.e. personal listening. If a wider listening audience is envisaged, then the output power is hardly adequate for the purpose.

This unit may be used directly from the mains supply or, as will probably be the case, from the personal stereo's own a.c./d.c. adapter. The output power has been chosen to be deliberately small for two reasons:

Cost – It is hardly worthwhile designing a larger more powerful amplifier as they already exist in the form of the home music centre etc.

Flexibility – The amplifier will work into a variety of loudspeaker impedances, and accept a wide range of inputs. Finally the amplifier may be varied to suit the users' individual requirements and pocket!

CIRCUIT DESCRIPTION

The complete circuit diagram for the audio stages of the Personal Stereo Amplifier is shown in Fig. 1. It is based upon the very popular audio amplifier i.c., the TBA820. This is capable of delivering a maximum of 1·6W, although in this design it is slightly lower than this.

The incoming stereo signal is applied, via plug PL1, to the individual volume controls VR1/VR101 and hence to the input, pin 3 of IC1 (left) and IC101 (right channel). Resistor R1, (the remainder of the description applies equally to the right hand channel – prefixed with one hundred), sets the input impedance and R2 the gain. The open loop gain is 70dB but is reduced substantially in this design.

Capacitor C4 provides for ripple rejection of the power supply. Capacitor C6 provides for a degree of "bootstrap" feedback and C5 adjusts the frequency response. Components R4 and C7 form a Zobel network.

The output signal is passed to the speaker via the electrolytic capacitor C8. This is a non-standard value and some constructors might wish to insert a 470μ type. This will not affect the performance.

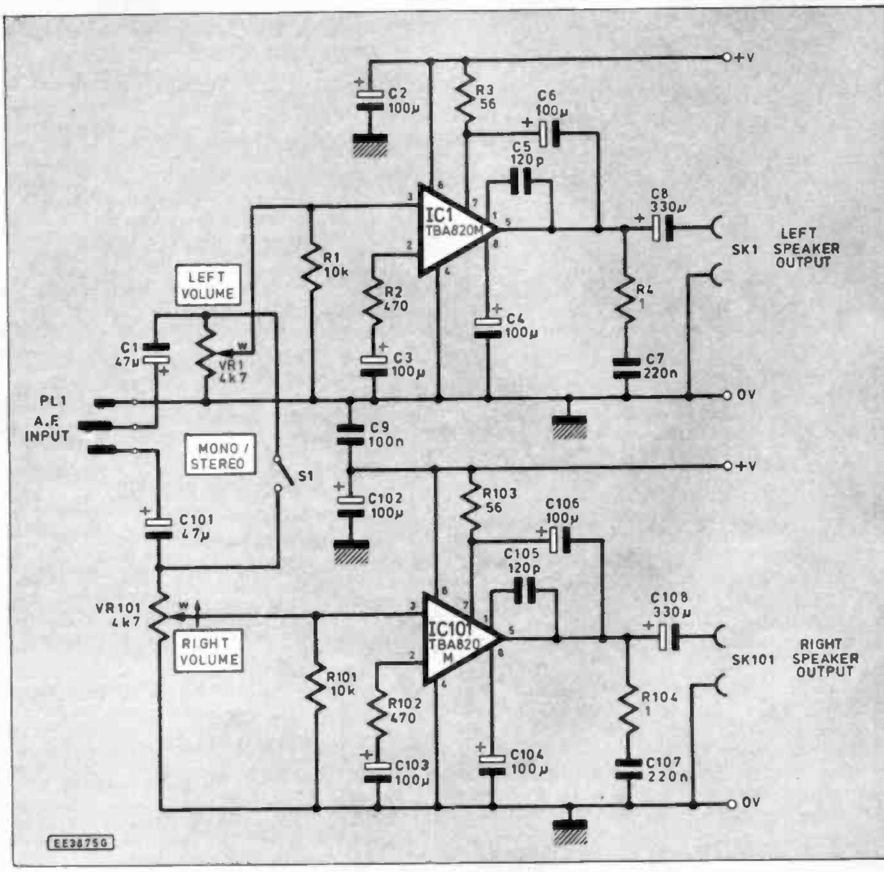
No tone controls are provided as it is assumed that the personal stereo will already possess these, even if it is in the form of a simple tone control rather than combined bass/treble controls.

POWER SUPPLY

The power supply (Fig. 1a) is a conventional full-wave one and consists of a 6VA transformer T1, "bridge" diodes D1 to D4 and smoothing capacitor C10 and provides a basic 14V to the main amplifier. The voltage regulator IC2, enables a variable stabilised voltage to be produced, which can be used to power most personal stereos.

The output voltage from IC2 may be varied, using preset-potentiometer VR2, from 5V (the regulator voltage) up to around 12V, thus making it fairly universal for most applications. A changeover switch S3 is provided to change the polarity of the d.c. applied to the personal stereo's d.c. input.

Fig. 1. Full circuit diagram of the audio section of the Personal Stereo Amplifier. The "preset" power supply circuit is shown opposite, output voltage is set by VR2.



Socket SK2 allows for the user to use an already existing a.c.-d.c. adapter instead of the internal mains supply. A changeover switch is not necessary here as the bridge rectifier formed by D1 to D4 protects the circuit from any reverse voltages.

DESIGN OPTIONS

One or two features of the present design could be omitted or changed if desired. For example, the internal mains supply could be omitted – saving the cost of the transformer and associated components – and utilising the existing a.c./d.c. adapter. Note that the main amplifier will work off a variety of voltages and does not need the voltage to be especially stable.

The design used two separate volume controls as this is the writers' preference although it is probably more convenient to use a "ganged" stereo variable potentiometer. Note that whichever method is used, the control(s) must be of *LOG* law type.

A bridge rectifier in a single encapsulation could be substituted for the four separate diodes if this is more convenient. The author also preferred push switches for S1 and S2, (mainly because these were already to hand!) as they look more attractive than toggle switches. The constructor may wish to change these, in which case the mains neon could be omitted as the toggle switch will show if the unit is switched on or off.

The Mono/Stereo switch could also be omitted as most cassette tapes and radio programmes are in stereo, but was considered to be useful for a.m. medium wave broadcasts.

CONSTRUCTION

The amplifier is built on a single-sided printed circuit board (p.c.b.), the topside component layout and full size underside copper foil master pattern being shown in Fig. 2. This board is available from the *EE PCB Service*, code EE808.

Some readers may note that the p.c.b. is reasonably spacious, not using in its construction any vertical mounting components (except the regulator). This allows a degree of flexibility in the size of components, particularly that of the capacitors. If desired (not part of the PCB Service) the p.c.b. could be scaled down to fit whatever case you may have.

If desired the circuit could also be constructed on *plain* perforated board following a similar layout as in the p.c.b. design. Stripboard is NOT recommended due to the capacitive effects of the unwanted tracks.

Before continuing with construction decide carefully on the options described earlier and vary the construction as you go.

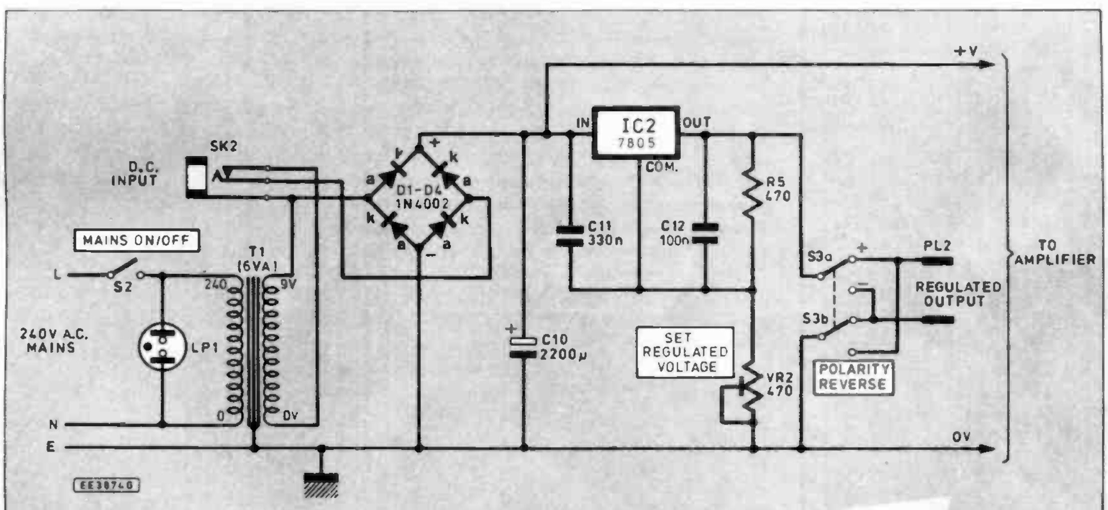
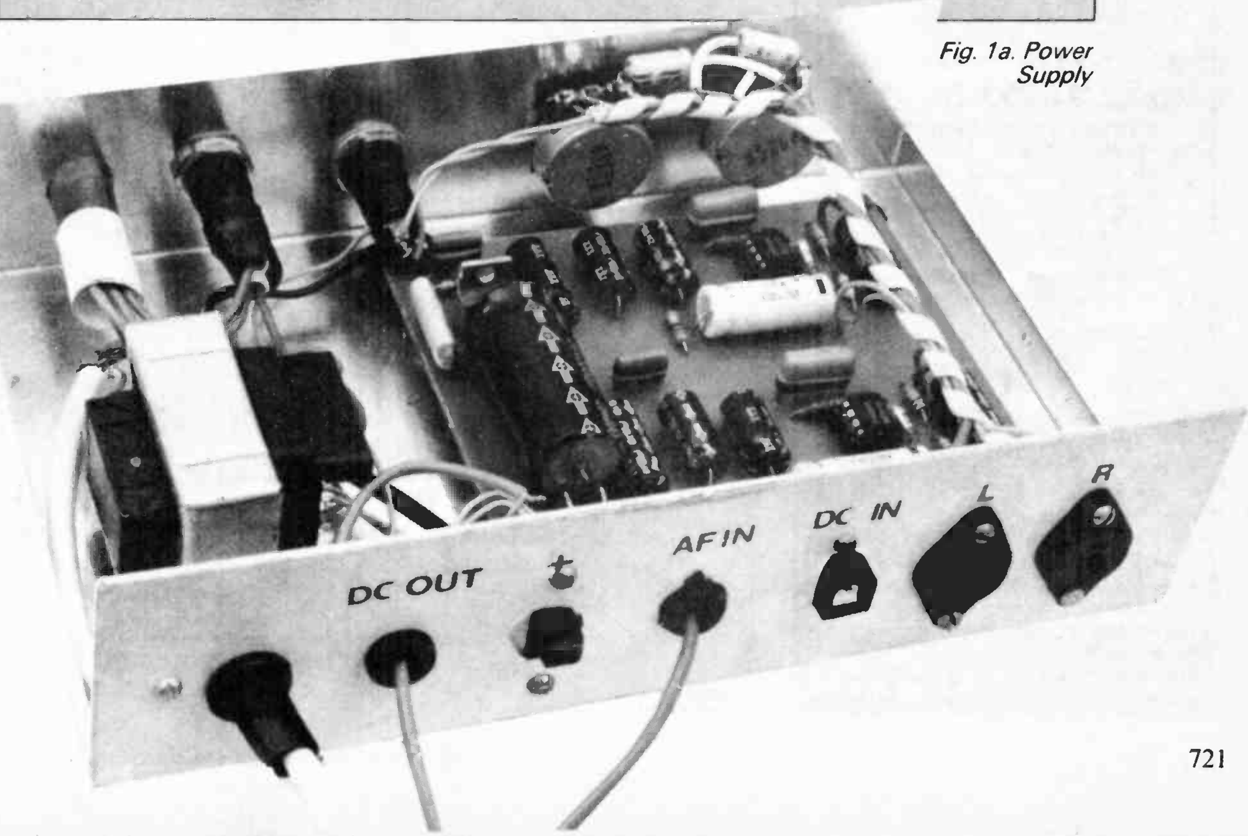


Fig. 1a. Power Supply



COMPONENTS

Resistors

R1, R101 10k (2 off)
R2, R5,
R102 470 (3 0ff)
R3, R103 56 (2 off)
R4, R104 1 (2 off)
All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1, VR101 *4k7 min. rotary carbon, log (2 off)
VR2 1k horizontal p.c.b. mounting preset, lin.

Capacitors

C1, C101 47µ axial elect., 25V (2 off)
C2, C3, C4, C6, C102, C103, C104, C106 100µ axial elect. 25V (8 off)
C5, C105 120p polystyrene (2 off)
C7, C107 220n polyester (2 off)
C8, C108 *330µ axial elect. 25V (2 off)
C9, C12 100n polyester (2 off)
C10 2200µ axial elect, 25V
C11 330n polyester

Semiconductors

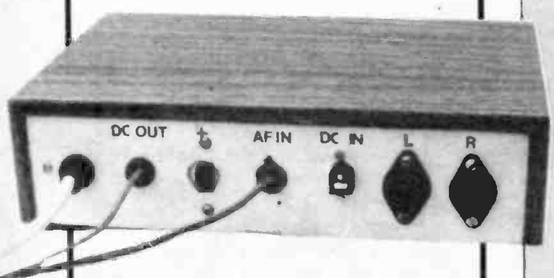
D1, D2, D3, D4 *1N4002 1A 100V rectifier (4 off)
IC1, IC101 TBA820M audio amplifier (2 off)
IC2 7805 5V 1A positive regulator

Miscellaneous

PL1 *Stereo jack plug 2·1mm or 2·5mm
PL2 *Mono line jack socket 2·1mm or 2·5mm
SK1, SK101 Loudspeaker chassis socket (2 off)
SK2 *Chassis mounting jack socket 2·1mm or 2·5mm
S1, S2 *Single pole push or toggle switch
S3 Standard d.p.d.t. slide switch
LP1 Mains neon 240V
T1 Mains 6VA transformer, mains primary; two secondaries 0-9V at 300mA or one secondary 0-9V at 600mA

Printed circuit board available from *EE PCB Service*, code EE808; metal case, leather-grain finish, size 200mm x 125mm x 50mm; two control knobs; 8-pin d.i.l. socket (2 off); stereo screened cable; mono screened cable; 3-core mains cable; connecting wire; solder; hardware etc.

Items marked * – See text



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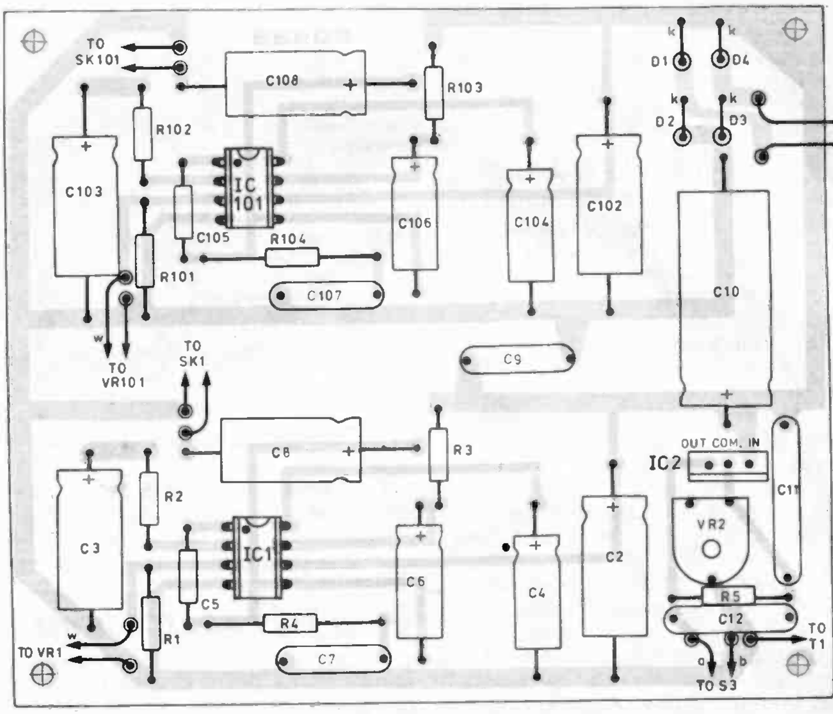

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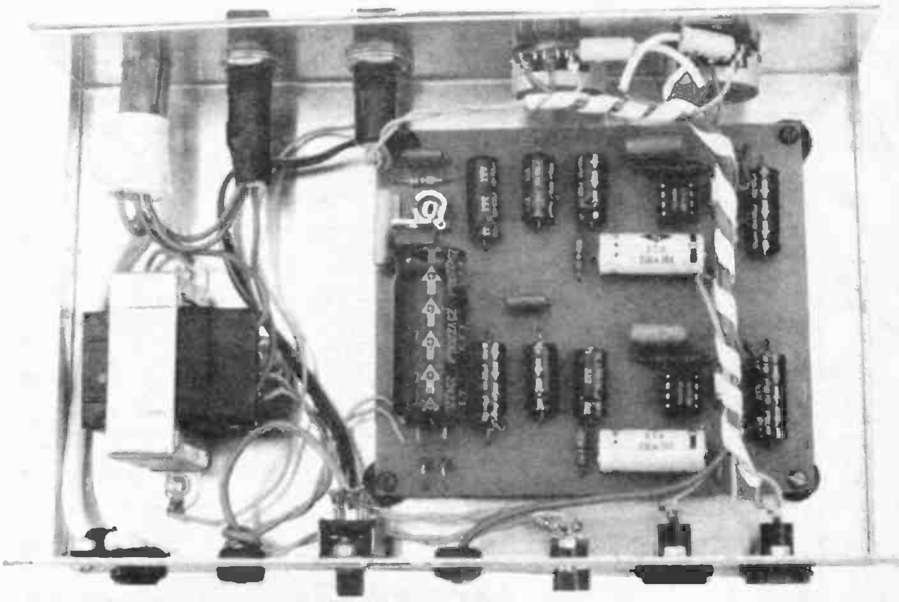
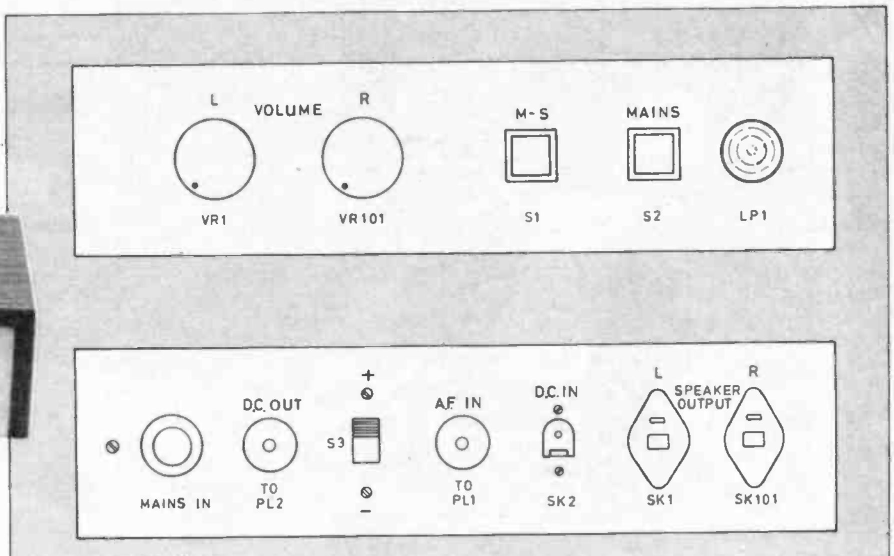




EE38770

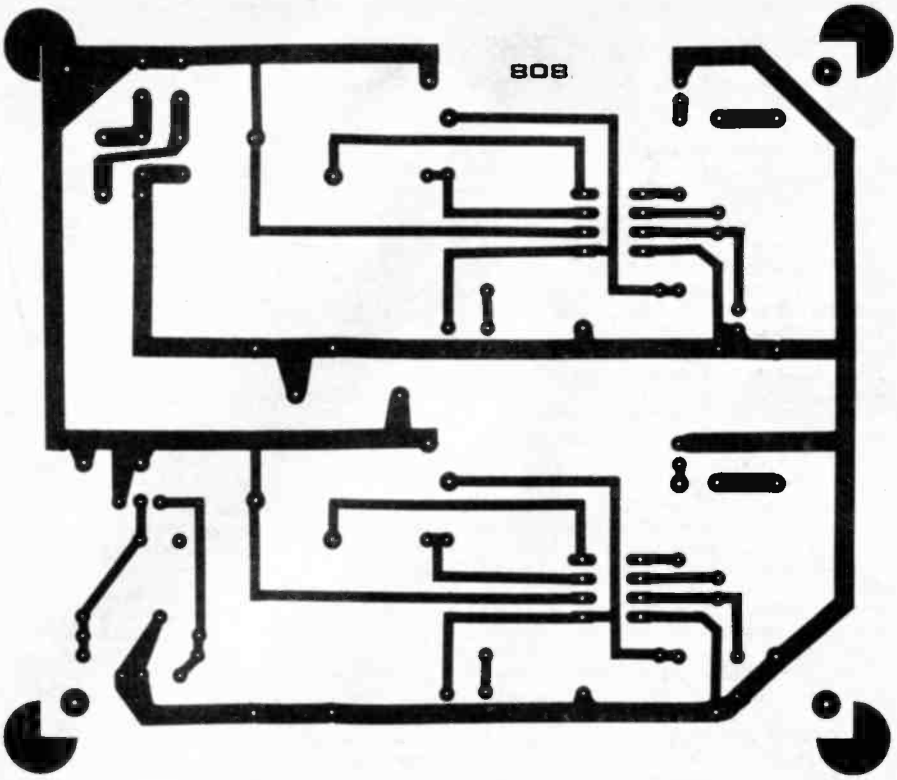
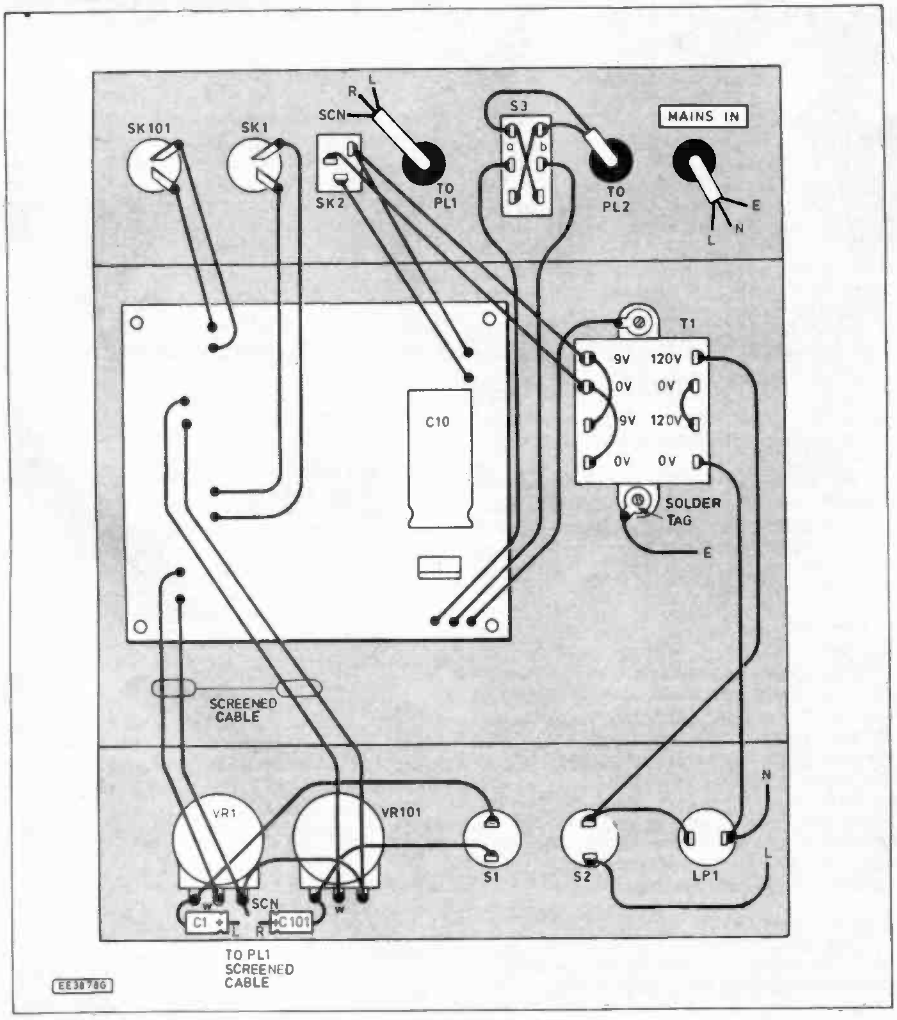


Fig. 2. The printed circuit board component layout (above left) and the full size underside copper foil master pattern (above).

Fig. 3. (bottom left). Suggested front and rear panel component layout.

Fig. 4. Interwiring details from the circuit board and front and rear panel mounted components. Layout of components inside the completed unit is shown in the photograph left centre.



First though, examine your personal stereo and ascertain the diameter of the d.c. input socket and the headphone output socket. They will either be 2·1mm or 2·5mm, choose the correct type and fit them where shown.

The recommended layouts of the front and rear panels are shown in Fig. 3 and could, of course, be varied as desired. it is important though to use a *metal* case to provide a certain amount of screening.

INTERWIRING

The final wiring details are shown in Fig. 4. Check carefully the connections to the transformer as those shown may not correspond exactly to the type you are using. *It is most important to insulate ALL mains wiring using either sleeving or insulating tape.*

It is very important that the p.c.b. "earth" be connected to the metal case chassis, by means of a solder tag under the transformer mounting. Also, if you are using the mains supply connect the Earth lead of the mains input to a similar tag.

Remember to use *screened* cable when wiring from the potentiometer(s) to the p.c.b. and input plug to the potentiometers. The left-hand channel is normally the "tip" connection on the jack plug, but do check first.

If you are going to use the amplifier with just one type of stereo, then switch S3 may be omitted and the d.c. output cable can be connected permanently in whatever polarity is required. Use screened cable for this.

Some readers may note the lack of heatsinking on the amplifier i.c.s. and regulator. In the prototype version this was not a problem, although the regulator did operate slightly warm.

If needed then small squares of aluminium may be Superglued to the amplifier i.c.s and bolted to the regulator. No more than one square centimetre will be needed for the i.c.s, and perhaps slightly larger for the regulator.

Finally, remember to fit a 3A fuse in the mains plug, as the unit is not itself fused.

IN USE

Using the Personal Stereo Amplifier is quite straightforward. Simply plug the "A.F. In." lead into the Headphone output socket of the personal stereo, and the "D.C. Out." lead into the D.C. In socket of the stereo. If you are not using the internal mains supply then you will need to plug the stereo's a.c./d.c. adapter into the "DC In" socket on the amplifier.

Remember to adjust preset VR2 for the voltage required for the type of personal stereo you are using. Set the volume control of the stereo to three-quarters of maximum output – absolutely no more – if you do so distortion will be introduced and will overload the amplifier. It will be wise to experiment with the setting of the stereo's volume control to achieve a correct balance.

ON NO ACCOUNT connect the output from the amplifier to headphones of any type. Even with just over one watt output damage to the ears could result.

Remember that resistor R2 sets the gain, the smaller the value the larger the gain and hence larger the output. Conversely, increasing the value reduces the output and this may be a consideration if the output of the personal stereo overloads the amplifier even if the volume is well turned down. □

SHOP TALK

with David Barrington

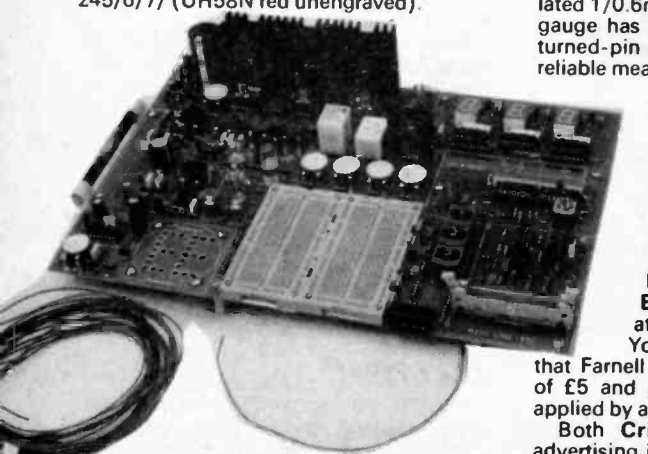
Mini Lab

It is important when buying components for the *Teach-In '93* series *Mini Lab* project that the items will fit on the p.c.b. and are suitable for use with the series. These restraints mean that a number of components **must** be of the correct type and manufacture and therefore we have provided the following detailed information.

The variable resistors are PIHER fully enclosed types with the optional clip-on thumbwheel, available in various colours, these come from **Cricklewood Electronics**. Toggle switches are from the C&K Z101 range available from **Farnell**, 148-705, or **Maplin**, FH00A. Although designed for panel mounting, they fit the p.c.b. without adpation.

The current rating is important because this switch later turns the 5V rail on/off, and 1A+ rating is required. Other types either will not fit the p.c.b. or have low ratings. ElectroValue also sell C&K toggle switches but they haven't been tried. We think they will also fit.

The push switches are from the MEC range available from **Farnell** as follows (a limited range is listed by **Maplin** – part no's. in brackets): switch body 148-464 (FP51F); red bezel 148-474 (FP53H – black); buttons engraved 1, 2 or 3 149-245/6/7/ (UH58N red unengraved).



It is important that the correct turned-pin s.i.l. sockets are used. We recommend beginning with two 32-way strips: Farnell 170-715 or Cricklewood Electronics also supply. The RS 402-642 (available from Electromail – see note below) is the more expensive wire-wrap version. These are repeatedly used in future parts, so buy in a small stock. No other types are suitable.

The buzzer or audible warning device is the RS 245-017 only. Very cheap, others won't fit the board. Otherwise, stick a wire-ended type onto the board and solder the leads to the p.c.b.

Relay, recommended RS 346-637 or Farnell 103-080. Again very cheap. 6V 0.1A M.E.S. bulb and holders, the p.c.b. was designed to fit the Maplin JX87U. The 6V 0.6W M.E.S. bulbs are commonplace.

P.C.B. mounting "Jacks", Farnell 149-318/9 or RS 434-712 will fit directly. Farnell 149-319 is recommended because it's gold plated. P.C.B. 0.5in. insulated shorting link plug, Farnell 149-315/6/7 (black/red/blue) is the only source we know for this part. The RS version won't fit. These components are used in future projects as on-board selector switches for frequency, l.e.d. voltmeter f.s.d. selection, etc.; in total the Mini Lab needs 17 "jacks" and four shorting plugs.

P.C.B. mounted "pluggable" screw terminals, The Pluggable types permit the terminal blocks to be unhooked without having to screw/unscrew terminals, thus reducing strain on the p.c.b. track. The screw terminal mates with a board-mounted pin header. Extremely convenient to use. RS 426-142 (2-way) and 426-143 (4-way) plus 24-way pin header 426-165.

Trouble is, RS only sell in packs of five. Therefore, choose the identical Farnell 105-499 (2-way), 152-007 (4-way) and one pack of 25 loose pins 105-503, all available singly. Alternatively, use normal screw terminal blocks but you need a screwdriver to unhook wires all the time.

Breadboard (solderless prototyping board) – Veroblock; check the prices carefully before buying! Maplin YL11M; Greenweld Hobbiblock looks suspiciously similar; ElectroValue or Cirkit Hobby Bloc.

P.C.B. mounting pillars and screws: 20mm length or more. Fully insulated nylon types are O.K. – they are needed to keep the p.c.b. clear of any working surfaces where the tracks might be shorted out.

In later parts, a loudspeaker is mounted under the board so it has to be stood off anyway. The central stand-offs also impart mechanical strength to the board and stop it from flexing when you press down on it.

Interconnecting wire – single core insulated 1/0.6mm (0.28mm²) as required. This gauge has been proven to work with the turned-pin sockets to provide a quick and reliable means of connection.

All RS items are available to anyone with an RS account directly from RS Components or via mail order from **Electromail**, PO Box 33, Corby, Northants NN17 9WZ (☎ *0536 204555*) (many schools and colleges keep either an RS or an Electromail catalogue) **Farnell Electronic Components** are at Canal Road, Leeds, West Yorkshire LS12 2TU. Please note that Farnell have a minimum order charge of £5 and post and packing charges are applied by all the companies.

Both **Cricklewood** and **Maplin** are advertising in this issue. **Electrovalue** are at 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB. (☎ *0784 433603*). The **Greenweld** catalogue supplied free with this issue should also prove very helpful.

The Mini Lab p.c.b. is only available through the **EPE PCB Service** see page 754,. Please remember that in consideration of the effort by both Authors which went into the Mini Lab design, the copper track layout remains Copyright Dytronics 1992.

We think the design of the Mini Lab is the most ambitious and versatile educational system undertaken in recent years by any magazine, and will be a credit to *Everyday with Practical Electronics*: we're justifiably proud of the system and hope it will capture the imagination of young readers and more mature students alike.

Since it contains everything needed for even quite advanced circuit development, the convenience of the Mini Lab might even appeal to experienced electronics technicians and enthusiasts.

EPE Altimet

The special pressure transducer type MPX100 called for in the *EE Altimet* project comes in two versions, plastic cased and uncased.

Either type can be used, but it is preferable to use the cased version and this one carries the type prefix MPX100AP. The MPX100AP version is stocked by **Maplin**, code UH37S

The uncased one is marked MPX100A and if this is to be used it must be insulated from the p.c.b. copper tracks. If any readers have difficulty in locating the voltage converter, ICL7660, or the display driver, ICL7106, they are listed by **Viewcom** and **Electromail**. The handheld case is also listed by Electromail (507-983) but it can now be obtained from most of our components advertisers.

The altimeter printed circuit board is available from the EPE PCB Service, code 807.

Personal Stereo Amplifier

We do not expect too many problems when shopping around for parts for the *Personal Stereo Amplifier*. The plugs and sockets used in the model were purchased from Cricklewood but they also appear in many of our advertisers listings. When ordering the volume control potentiometer, be sure to ask for a "Log" type.

The TBA820M 2W power amp i.c. seems to be fairly widely stocked and most suppliers should also be able to offer a suitable 6VA mains transformer. The ones used in the prototype came from Maplin.

The woodgrain finish aluminum case used in the model no longer seems to be in existance. However, one of the "leather-grain", p.v.c. covered aluminium boxes from Marco Trading (☎ *0939 232763*) seem ideally suited for this unit: Marco code Box/J9. You could opt for the "black" vinyl-cover type, available generally.

Vibration Alarm

Some readers may experience local difficulties sourcing the p.c.b. mounting choke for the **Vibration Alarm**. Looking through the **Circkit** (☎ *0992 4444111*) catalogue, their range of inductors, including chokes, is probably one of the largest in our market today and one of their RB series should fit the bill.

Although the photograph of the prototype model shows the use of a toggle switch, the slider version seemed to be more readily available and was used in the final version, hence its inclusion on the working diagram. It may seem strange to include the switch in the battery negative lead, but it ensures that capacitor C2 in fully discharged each time the unit is switched off.

Reaction Timer

We cannot see that there will be any component buying problems for those wishing to build the *Reaction Timer* project.

Be sure to make it clear that you require "*low current*" types when ordering the l.e.d.s. The multi-colour ribbon cable is now stocked by nearly all component advertisers.

Battery/Mains Inverter – Daughter Board

This time around, the i.c. used in the *Battery/Mains Inverter – Daughter Board* are from the ever popular 4000 series of i.c.s. and should be widely stocked. They are certainly listed in the current **Viewcom** (☎ *081 471 9338*) advertisement and in the latest **Greenweld**, **Cricklewood** and **Maplin** catalogues.

The small printed circuit board is available from the *EE PCB Service*, code EE809.

As a footnote and at the time of going to press, we understand that although the original M706B1 50Hz timebase i.c. is still being listed in the very latest Maplin catalogue they are only carrying stocks in the region of "tens" not hundreds; their quote!

PLEASE TAKE NOTE

Quicktest (Sept '92)

The op.amp (IC2) used in the *Quicktest* project is, of course, the ubiquitous *741*.

Quite how the error escaped three checks we do not know, but please be assured we do try very hard.

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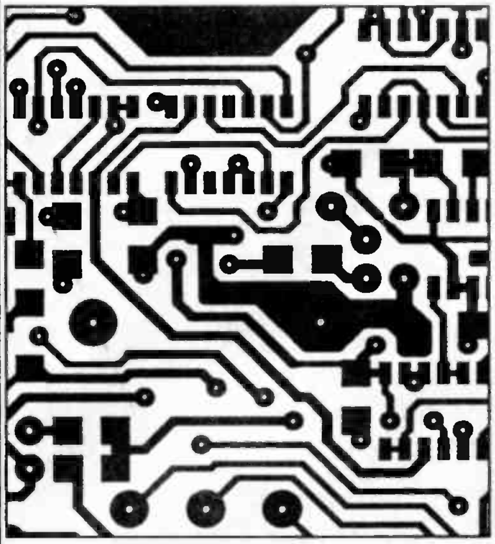

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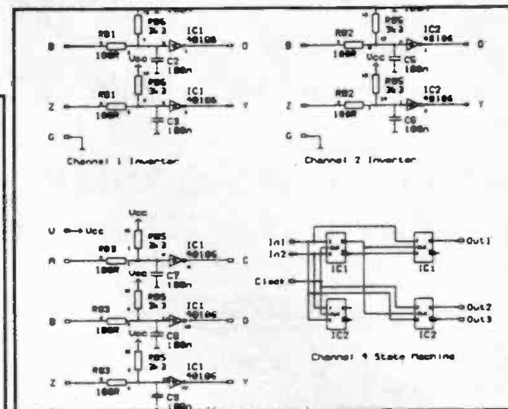

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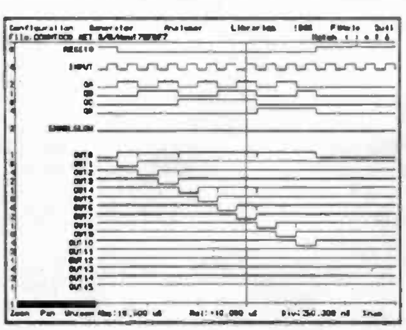

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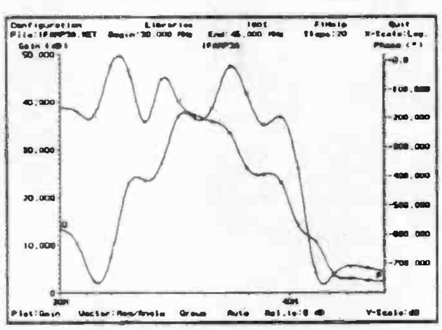

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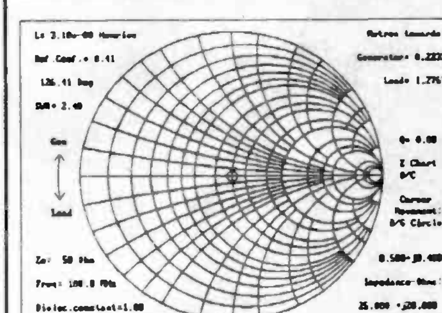

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Teach-In '93

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

Part 1

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, and starts with fundamental principles to give the student a solid foundation before proceeding onto further topics.

IN ACCORDANCE with the recommendations contained in the various GCSE Electronics Syllabuses, which themselves comply with the National Criteria for Science, no attempt is made to explain the "physics" behind any electronic components. Instead, we are much more interested in what they look like and *how to use them*, rather than what makes them work in the way they do. Many text books on electronics start with the very dry theory of atoms, electrons and semiconductor physics, much of which in our opinion may deter the less able candidate: apart from being of academic interest only, it can also be a bit boring!

We invited a highly-qualified and experienced Moderator and GCE A Level Examiner to join us and the text incorporates his very valuable suggestions to enable *Teach In* to have maximum appeal to those candidates undertaking GCSE or GCE examinations and coursework. *Teach In* we hope will also appeal to the experienced *Everyday with Practical Electronics* reader who might like to brush up on his or her theory.

INTRODUCING THE MINI LAB

As a means of helping to demonstrate various topics, the authors have designed a unique electronics "Mini Lab" which should be of great assistance to the novice or student following the series. Once the series has been completed, the Mini Lab will be of on-going use to help readers develop ideas of their own, no doubt utilising many principles gleaned from *Teach In*.

The Mini Lab consists of a single printed circuit board (p.c.b.) which is divided into various areas. As we proceed through the *Teach In* course, the areas will gradually fill with a variety of interesting and economical circuits which demonstrates a topic and forms a useful piece of equipment to aid the student.

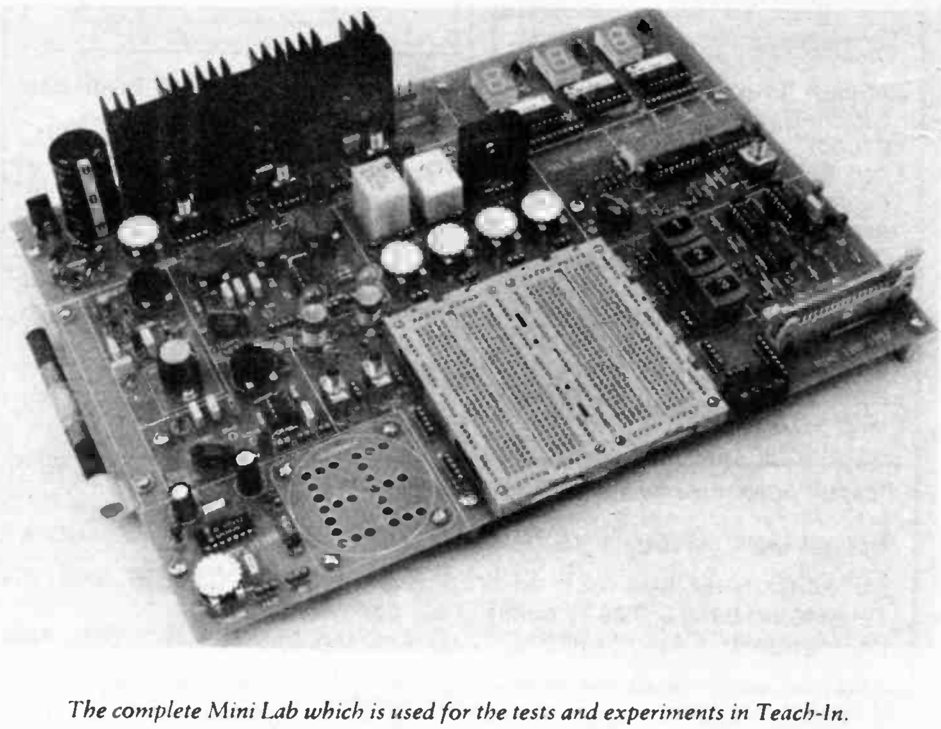
Although it is necessary to solder components to the board, the use of a p.c.b. helps to ensure a high success rate for candidates, with less chance of any disappointing failures. The component count is spread over many months, and the use of plastic boxes and enclosures is avoided, helping to keep construction costs down. A solderless plug-in prototyping board is incorporated which is regularly used to connect up reusable electronic components to form a circuit.

The Mini Lab develops from basic principles, working all the way through from switches, batteries and bulbs to a microprocessor development system – the "Micro Lab" – which is connected to the Mini Lab through an expansion unit. Constructional details relating to the Mini and Micro Labs are given separately, as and when required.

BREADBOARD

We'll shortly be using the plug-in "breadboard" area of the Mini Lab. This is essentially a set of spring contacts interconnected to form a pattern of conducting rows. You can simply push components into them and connect parts together, without the need for soldering. Obviously you can remove and re-use the parts too. The breadboard we have chosen is the popular "Veroblock" type, and several blocks can be joined together to form larger units for more ambitious designs.

Take care of your new breadboard: the wires of components should slide in and out easily. Don't force unduly large wires into the socket strips, and avoid bent or deformed wire ends which might damage individual



The complete Mini Lab which is used for the tests and experiments in Teach-In.

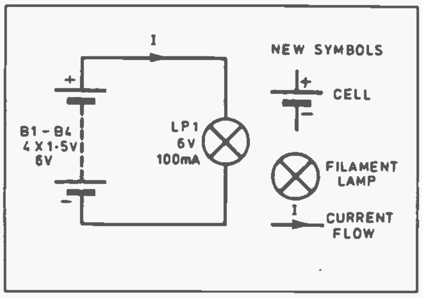


Fig. 1.1(a). Basic electrical circuit.

sockets. A pair of fine-nose pliers might help when inserting or removing wires. Used with care, your breadboard will last many years. In the meantime, welcome aboard to *Teach In*!

Our analysis of electricity starts with some simple battery and bulb experiments, and the Mini Lab is immediately pressed into service to help demonstrate a few basic principles. We won't let you proceed until the foundations are firmly laid!

ELECTRICITY – WHAT IS IT?

For the first two parts of *Teach In* the Mini Lab is operated by a battery at a safe low voltage. Later, as the Mini Lab grows, a mains power supply is described which you will be able to build with complete confidence. Take a look at Fig. 1.1(a), which shows a very simple electrical circuit consisting of nothing more than four 1.5 VOLT (V) *"dry cells"*, labelled B1 to B4, and a bulb (LP1).

Don't worry too much about any symbols which may be unfamiliar, because soon you will be able to read a circuit diagram as easily as reading this text (we hope!). We will always introduce new symbols by highlighting them separately next to the circuit diagram. The symbols which you see represent the cells and bulb: B1 to B4 are four 1.5V cells, and the circle with a cross is a simple indicator bulb, like a torch bulb.

All four cells are connected together one after the other to make a six volt battery – just like you might need in a radio or cassette recorder for example. It's important that they are all connected the right way round with respect to each other or the circuit simply won't work.

As you will doubtless know, cells have two terminals marked "+" and "–" and the negative terminal of one is connected to the positive of the next. The diagram shows you which terminal is which. Often designers don't bother showing all four cells in the circuit diagram, just the "first" and "last".

The bulb is labelled "LP1" for "Lamp 1" and the supplier's catalogue says that it's rated at "6V 100mA". What do these ratings mean? To find out, let's build the circuit shown in Fig. 1.1(a).

BATTERY PACK

As we have said in the initial stages of this series, your Mini Lab is powered by an external battery pack. In Part Three it becomes mains-operated via a versatile power supply unit. For now, you must select the "EXT BATT" option as your source of power by inserting a selector shorting plug between the appropriate sockets of the "Power Supply" section: this is clearly marked on the board. You *must* do this, otherwise your battery pack will remain disconnected.

An on-off switch is also fitted to the Mini Lab, so that you can easily turn the 6V battery supply on or off when required. It's best to switch off before making any modifications to your experiment.

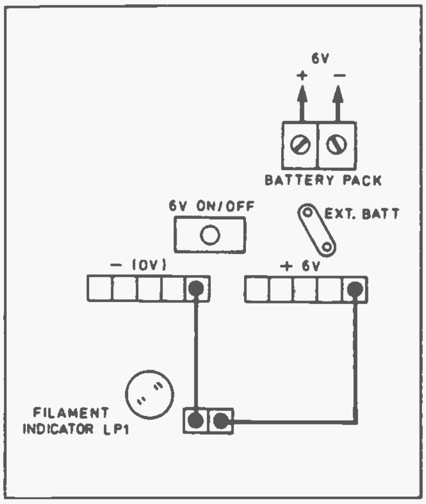


Fig. 1.1(b). The electrical circuit built on the Mini Lab. The 6V Battery Pack is connected externally by screw terminals. Use the ON/OFF switch as needed, and ensure the "EXT BATT" option is selected with a shorting plug. See the Mini Lab constructional details. The "6V ON/OFF" switch is not shown in any demonstration circuit diagrams.

Refer to the constructional details of the Mini Lab which describes the assembly and connection of the 6V battery pack. The positive and negative terminals of the 6V supply are available on distribution socket strips mounted on the Mini Lab board, and you can now build the circuit as shown in Fig. 1.1(b). Insert solid-core jumper wires as shown, to connect the battery to either one of the filament indicators clearly marked on your board.

The bulb should illuminate. (If not, check the bulb is screwed fully home, and the cells are the right way round.) So far so good! What is happening is that electric current is flowing out of the positive terminal of the 6 volt battery pack, through the bulb which lights up, and back into the negative terminal. (Take care not to "short out" the battery or a very high current will flow, which could ultimately damage it.) So what's the difference between voltage and current?

VOLTAGE

Batteries are a source of electrical energy. We call this the "electromotive force" or e.m.f. for short. The energy is still there in the battery even if you disconnect it from the circuit (unless the battery is flat).

Across the terminals of each individual 1.5V cell exists a **potential difference** of 1.5 volts. Fitting B1 to B4 together in the holder connects the cells **in series** to make an overall potential difference of 6 volts. So a potential difference (p.d.) can exist **between two points in a circuit**, compared with an electric current which flows **through** the circuit. This is the most fundamental of all rules in electronics.

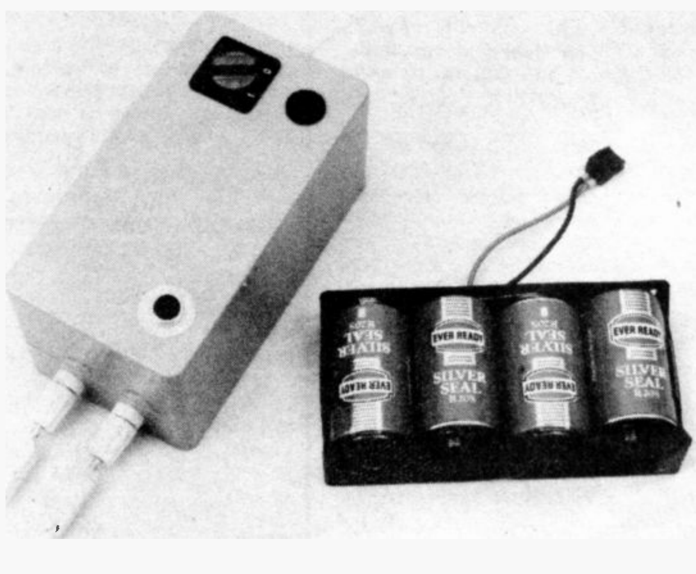
Strictly speaking it's wrong to talk of "+6 volts and –6 volts" because this implies that the p.d. is actually 12 volts. More accurately we should say "+6 volts with reference to 0V", the p.d. is then 6 volts. This becomes important when we talk later about *split power rails*, which have both positive and negative voltage supplies *with reference to 0V*.

If no p.d. exists between two points, then no electromotive force is present and so no current can flow if you try to make a circuit. A voltage needs to exist before current can flow, and the current always flows from the higher voltage (the most positive one) to the lower voltage (the least positive/ most negative one) in the circuit.

Because the current only flows one way in this instance, it's called **direct current** or "d.c." for short. In other areas of electronics, we will be looking at currents which flow forwards then backwards – *alternating current* or "a.c." for short. You might see "240V a.c." marked on an electrical appliance designed to be plugged into the mains. When you're dealing with batteries, the voltages are always understood to be d.c.

CURRENT

The electric current which flows through the circuit is actually a measure of the rate of flow of **electric charge past any given point**. Electric charge is the fundamental "raw material" of electric current, which in simple terms consists of nothing more than a flow of electrons. More electric charge on



The mains supply unit (detailed in a later issue) and battery pack used with the Mini Lab.

the move implies a greater rate of flowing electrons – this means that a "faster" or higher current is flowing.

By convention it's easiest to think of current flowing from the most positive to the most negative potential: this theory dates back to the days of the earliest discoveries of the principles of electricity. The trouble is, we now know that the theory isn't true!

Scientists have since discovered that electrons have a negative charge and are attracted to a more positive charge (just like dissimilar poles of a magnet are attracted to each other), so in real life electrons actually flow from the most negative to the most positive potential and not the other way round.

There's no need to worry: mercifully everyone still talks in conventional current terms, where current is deemed to flow from positive to negative potentials. This doesn't affect circuit design or our understanding of electronics whatsoever. Those studying atomic physics, for instance, might talk in terms of what's happening in real life at sub-atomic level – but in electronics, we don't need to.

Some substances are very good at letting current flow through them. Copper is commonly used as the conductor in electric wire because it lets current flow through it extremely easily – it has plenty of loose electrons available which can carry lots of electric current. Other conductors include aluminium, steel, lead, gold, silver and tin. Gold is a particularly useful element which is often used to plate electrical contacts, so that they don't corrode with age and become unreliable.

INSULATORS

An **insulator** contains hardly any free electrons and so is very poor at letting current flow. For example, an electrical cable supplying your TV will have copper cores carrying "live" electric current, each core being insulated with a plastic such as P.V.C. The insulator will not allow current to flow through, so it protects you from electric shock. Other examples of insulators are glass, wood, ceramic and rubber.

Current is given the symbol I and is measured in **Amperes**, or often "Amps" (A) for short. Voltage is given the symbol V and, not surprisingly, is measured in **Volts**.

Sometimes the units of volts and amperes can be too large to be of use in electronics. Designers often have to use prefixes when talking about volts and amps to make them more manageable units. Common prefixes which we will use a lot when describing current and voltage are:-

SYMBOL	PREFIX	FRACTION
m	milli	1/1000
µ	micro	1/1000,000

Example:
1mV = 1 millivolt = 0.001 volts.
so 100mV = 100 millivolts = 0.1 volts.
1 µA = 1 microamp = 0.000001 amps.

To answer our question posed earlier, LP1 is rated at 6V (the bulb's maximum reliable operating voltage), at which voltage a current of 100mA (0.1 amperes) will flow through the bulb. We'll talk about milliamps, microamps, and also millivolts, as necessary from now on – it saves having to write lots of zeros. There are other prefixes which we use in other areas of electronics, which we'll introduce when appropriate.

SWITCHES

On its own, our circuit of Fig. 1.1(a) isn't much practical use (except as a torch!) but we can add some useful functions if we introduce some **switches**. The simplest of all switches is a basic push switch, see Fig. 1.2(a), which also shows the circuit symbol for this component (S1). This can be demonstrated with the Mini Lab as shown in Fig. 1.2(b), which places a normally-open (n.o.) push switch **in series with** LP1. Pressing S1 completes the circuit and the bulb lights – releasing it extinguishes the bulb.

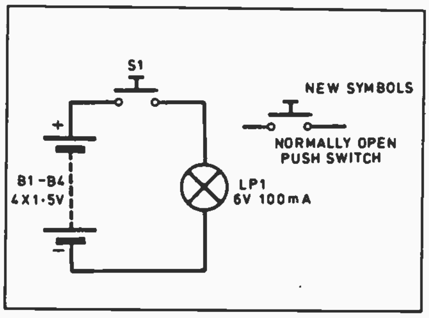


Fig. 1.2(a). Circuit with push switch.

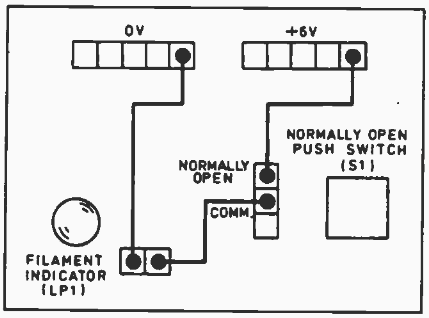


Fig. 1.2(b). Interwiring diagram – be sure to use the correct pins of the switch.

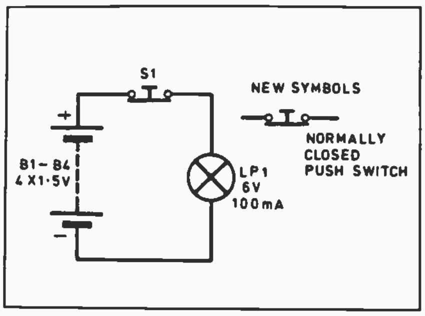


Fig. 1.3(a). Circuit with normally-closed switch

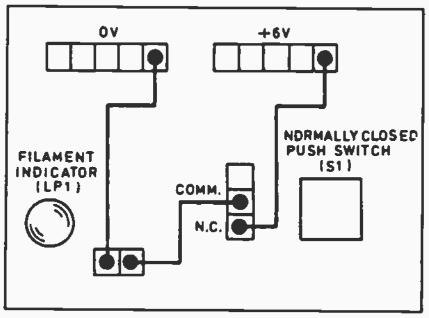


Fig. 1.3(b). Using the normally-closed contacts of a push switch.

A reverse effect can be achieved with a normally-closed (n.c.) switch, as shown in the circuit diagram of Fig. 1.3(a), which is wired up on the Mini Lab as shown in Fig. 1.3(b). Make sure you connect to the correct socket strips adjacent to the switch.

Here, pressing the switch actually **breaks** the circuit, interrupting the supply to the bulb. Releasing it restores power once more. Normally-closed circuits like this are used a lot in burglar alarms, for instance, where deliberately cutting a security wire or releasing a n.c. switch causes an alarm to sound.

Toggle switches are very widely used on equipment as on-off or control switches, and their circuit schematic symbol is shown in Fig. 1.4(a). S1 is a "changeover" toggle switch which can be switched between two circuits. Here, the two circuits are LP1 and a buzzer (audible warning device) labelled WD1. The moving contact (or "wiper") of S1 can be moved by operating the toggle (or "tang") between two positions.

Build this circuit on your Mini Lab by referring to Fig. 1.4(b), and compare your wiring with the circuit diagram so that you can see how we wired the circuit up. Now by operating S1, you can apply power alternately between the Mini Lab buzzer and the bulb. This type of switch is known as a **single pole double throw** switch or s.p.d.t. for short.

An interesting variation of this circuit is shown in Fig. 1.5(a) which utilises two s.p.d.t. toggle switches and a bulb. Connect up this circuit on your Mini Lab as shown in Fig. 1.5(b). What happens every time you

RESISTOR COLOUR CODE

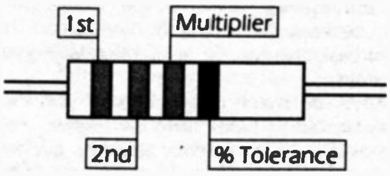
Most resistors you see have four coloured stripes to indicate their *resistance and tolerance*. How do you know which way round to read the resistor? The gold or silver stripe features last in the code.

COLOUR	NUMERAL 1st & 2nd	MULTIPLIER	TOLERANCE %
Black	0	x 1R	
Brown	1	x 10R	
Red	2	x 100R	
Orange	3	x 1k	
Yellow	4	x 10k	
Green	5	x 100k	
Blue	6	x 1M	
Violet	7	x 10M	
Grey	8		
White	9		
Gold			5%
Silver			10%

EXAMPLES

Red/Red/Red/Gold =
2 2 x 100R = 2,200 ohms or 2k2 5%
Yellow/Violet/Orange/Gold =
4 7 x 1k = 47k 5%
Grey/Red/Green/Silver =
8 2 x 100k = 8,200,000 ohms or 8M2 10%

We nervously offer the following mnemonic which might help you to remember the order of the colours: "**B**ad **B**oys **R**ape **O**ur **Y**oung **G**irls **B**ut **V**iolet **G**ives **W**illingly"! (Don't blame the authors.)



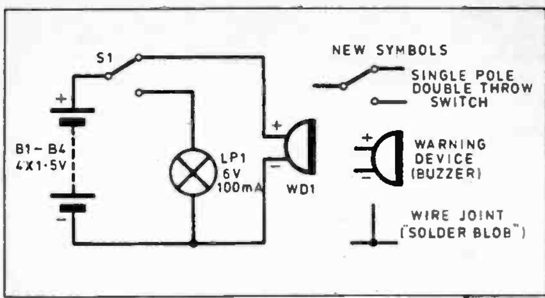


Fig. 1.4(a). Introducing a changeover switch to control a buzzer and bulb.

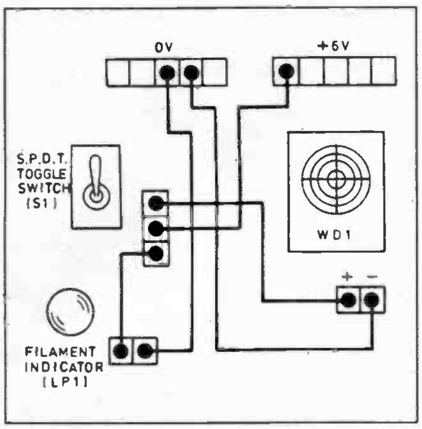


Fig. 1.4(b). Connecting diagram for a changeover circuit. The buzzer must be correctly polarised or it won't work. Use S1 to switch between the buzzer and bulb.

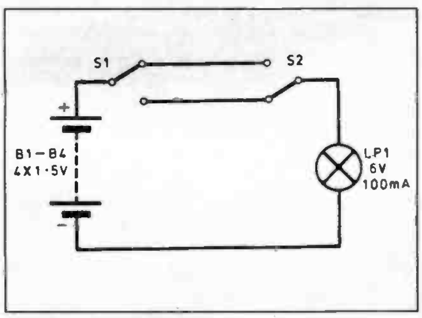


Fig. 1.5(a). Electrician's staircase lighting circuit.

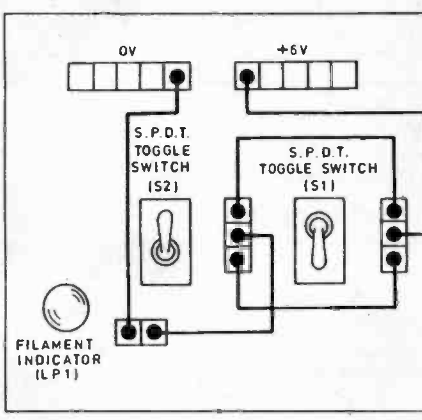
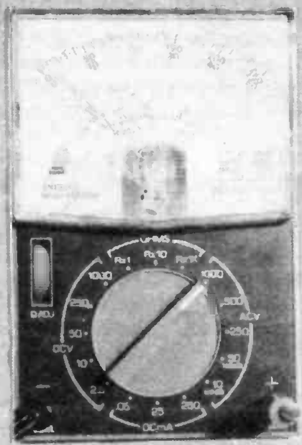


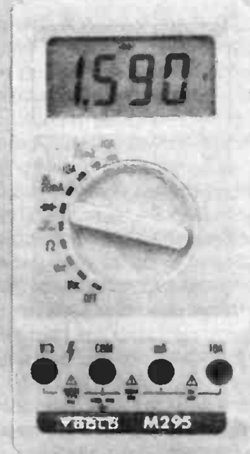
Fig. 1.5(b). Using both s.p.d.t. toggle switches to control a lamp.

operate a switch? You might find this sort of circuit in everyday use as a lighting circuit in a house – switches at the top and bottom of a staircase can control the light at the top of the stairs.

There are many other types of switches available. Some types have two wipers, and can switch two completely separate circuits at the same time. These **double pole** (d.p.) switches, and some more switches besides,



An analogue multimeter.



A digital multimeter.

USING YOUR MULTIMETER

Multimeters are available in two types: *analogue* which uses a standard moving-coil meter movement, and *digital* which is much easier to read and generally more precise. They can measure current, voltage and resistance. Some can also measure other additional parameters like frequency or capacitance or even test transistors.

Multimeters, especially moving-coil types, are not perfect. When used to measure voltages, meters "look like" resistors in a circuit and can affect the circuit under test (see "Potential Dividers" for an explanation of loading effects). Typically, an analogue meter will be described as "20,000 o.p.v." (ohms per volt), which means that on, say, a 2V d.c. range, the meter acts like a 40k resistor. The higher the o.p.v. specification, the more accurate your voltage readings will be. In GCSE Electronics, "perfect" meters are always assumed so you need not worry about accuracy.

VOLTAGE MEASUREMENTS

When reading voltages, you need to make sure that your multimeter doesn't load your test circuit too much or you will obtain misleading results. Try to use a voltmeter on the highest range setting possible, so that the resistance of the meter is as large as practical. However, it's pointless trying to read a voltage of 500mV on a 50V f.s.d. (full scale deflection) scale, so you will have to compromise somewhere.

Voltmeters are of course used to measure potential differences *across* components such as resistors. It's wise to ensure that the resistance of your voltmeter (calculated from its o.p.v. rating) is at least ten times greater than any resistor across which you are measuring a voltage – see the "Ten Per Cent Rule". This way, you will not load the circuit excessively and will obtain acceptable accuracy.

CURRENT MEASUREMENT

Current flows from the most positive potential to the most negative, so connect the positive and negative test leads from your meter the right way round – see the section on "Resistance and Ohm's Law" where we measure current through a resistor.

Always de-energise the circuit first, then insert the ammeter before powering up again. Start with a high current range, so that you avoid damaging the meter by overloading it. You can always switch to a lower range afterwards, but you should disconnect the power from the circuit in between switching ranges – unless you have an autoranging digital multimeter, which will take care of itself.

An ammeter "looks like" a short-circuit (almost) between its terminals. Never treat an ammeter as a load in itself – don't put it across a battery or power supply to see what happens, because any high short-circuit current which flows (several amps, in the case of an alkaline battery) may damage your meter and the battery.

RESISTANCE

If you have an analogue meter, you will notice that zero ohms is on the extreme *right* of the scale. Higher resistances are on the left, but the scale is *non-linear* and the calibrations tend to become cramped on the left. You should always "zero" your meter before testing resistance: do this by shorting the leads together and adjust the meter's zeroing control accordingly. You have to repeat this every time you change the resistance range.

Testing resistors etc. *in situ* in a circuit can often give strange results: this is generally because there might be other components actually in parallel with the component, which affects the resistor value – see "Resistors In Parallel" and "Potential Dividers" in the text.

Ohmmeters use an *internal battery* to enable them to measure resistance. You must **always** ensure that the circuit under test is **fully de-energised** when the meter is set to any resistance range, or damage may result.

RESISTOR COLOUR CODE

Most resistors you see have four coloured stripes to indicate their *resistance* and *tolerance*. How do you know which way round to read the resistor? The gold or silver stripe features last in the code.

are summarised in Fig. 1.6. We also show a one pole 3-way rotary switch.

Some switches are **biased** which means that they are spring-loaded in one direction. Press them to operate them, and release them to return to the previous state. An electric lawnmower uses this sort of switch – why?

Alternatively, some push switches are **latching**, which means that you press them once to operate them, and they stay like that when you release the actuator. Press them again to return to the previous state. A table lamp might use such a switch. Have a look through some catalogues to see if you can recognize different sorts of switches yourself.

In fact, we cheated a little when we designed the Mini Lab; you will have noted that both the n.o. and n.c. push switches (Figs. 1.2(b) and 1.3(b)) are both one and the same switch. It's actually a s.p.d.t. push switch which can form either a n.o. or n.c. function by selecting the relevant socket strip on your Mini Lab. Check it out by using the battery pack and bulb to confirm how it works.

Switches have **electrical ratings** which are indications of how large a voltage they can be allowed to switch without being damaged, and how much current their

is like squeezing the hosepipe to slow the water down.

We can examine the operation of the resistor by taking some measurements with a **multimeter**. We show you separately how to use your test meter – if necessary, read that section in conjunction with this part.

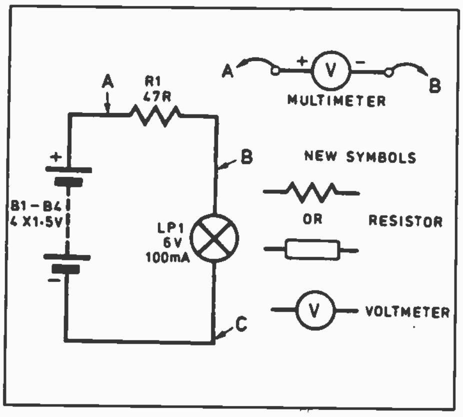


Fig. 1.7(a). A resistor in a circuit with the bulb. Also shown is the basic connection for using your multimeter when set to its voltage range. Connect the right way round!

voltmeter is represented by a circle containing the letter "V" and because voltmeters are **polarised**, you must connect them the right way round.

MULTIMETER

Connect the + terminal of your multimeter to location "A", and the – terminal to location "B" and read the voltage from the scale, noting it down as "Result 1" in the table below. Then repeat, with the + terminal to "B" and the – terminal to "C" (Result 2), and finally read the voltage at "A" (+) and C (–) to obtain Result 3.

OUR READING	TEST RESULTS:
Result 1 3.15V (Voltage across the resistor)	
Result 2 3.08V (Voltage across the bulb)	
Result 3 6.3V (Voltage across the battery)	

What has happened is that the potential difference (p.d.) across the battery pack has been split up between the resistor R1 and the bulb. The 6.3 volts of the battery is no longer placed solely across the bulb – some

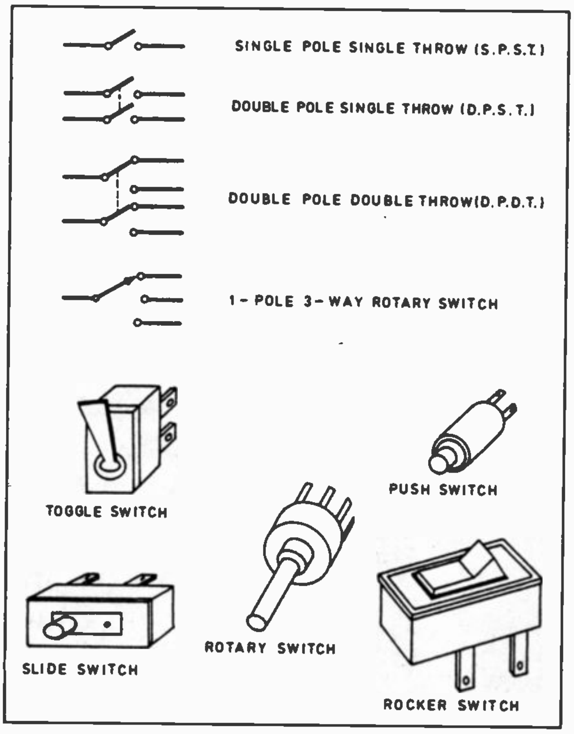


Fig. 1.6. A selection of switch types and styles.

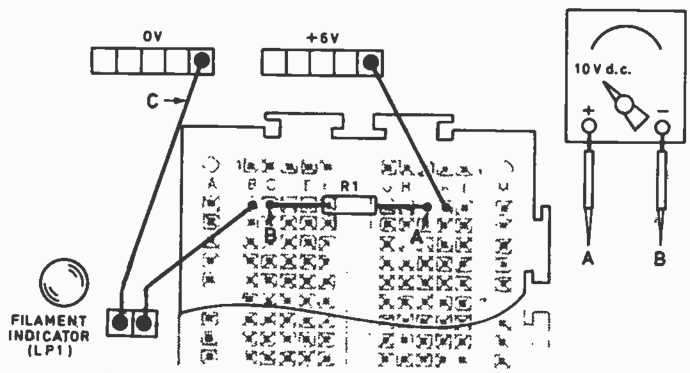


Fig. 1.7(b). Interwiring diagram. The locations "A" and "B" are connected to the positive and negative terminals respectively of your multimeter, set to a suitable voltage range. Repeat for BC and AC

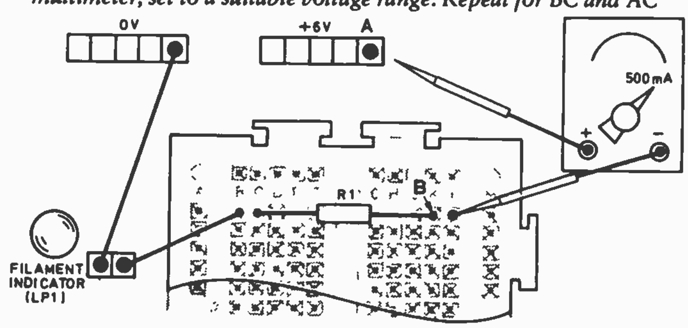


Fig. 1.7(d). Measuring current through the resistor and bulb.

contacts can carry. Exceeding these ratings could be dangerous. This is of particular importance when we examine how to safely switch mains electricity supplies, which is discussed in Part Three of *Teach In*.

RESISTANCE AND OHM'S LAW

Take a look at the circuit diagram of Fig. 1.7(a) – it's just like the battery and bulb of earlier experiments but included in series with the bulb is a zig-zag symbol, R1. (Many Examining Boards use an equally acceptable rectangle symbol instead of the traditional zig zag.) This new component is a **Resistor** and not surprisingly, its job is to introduce **resistance** to electric current. If you imagine electric current as water flowing through a hosepipe, introducing a resistor

Resistors all look the same, though they have different sizes and can be made of different materials. We measure resistance in **ohms**. The value of their resistance is shown in a series of coloured stripes printed on the body of the resistor. For now, you need to acquire a **47 ohm resistor**. The coloured stripes to look for are yellow/ violet/ black/ gold. Buy a "quarter watt carbon film" type. (We'll explain the jargon later.)

Using the breadboard area of the Mini Lab, construct the circuit as shown in Fig. 1.7(b), connecting the battery pack and indicator bulb using jumper wires. (The bulb will glow when the circuit is completed.) Select the **voltmeter** function of your multimeter by choosing the "**d.c. voltage**" range, say 10V full-scale deflection (f.s.d.), which is safe for our circuit where the maximum voltage anywhere will be 6 volts. A

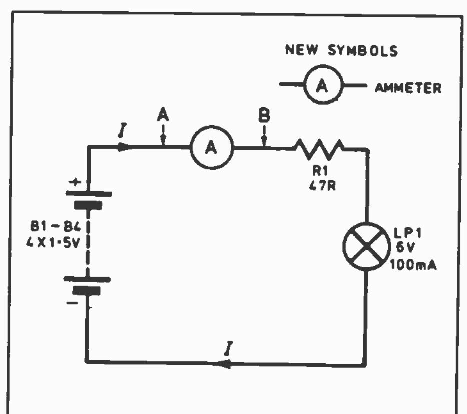


Fig. 1.7(c). Measuring current with an ammeter (Amps range of your multimeter).

of it appears across the resistor. In our own results, a small voltage (0.07V) actually appeared across the meter, which proves that meters aren't perfect, or all the battery voltage would be split between the bulb and resistor.

CURRENT MEASUREMENT

Now we are going to use the multimeter for another function, to measure the current flowing through the circuit. The symbol for an **Ammeter** is depicted in Fig. 1.7(c). To measure current, we have to break the circuit and insert the meter so that the current in the circuit flows through the meter to produce a reading. This is different to reading a voltage, where we simply take a measurement *between two points in a circuit.* **Don't attempt to measure the current "across" the battery,** because you will short out the battery pack and probably *damage your meter.*

Construct the circuit on the Mini Lab as in Fig. 1.7(d). Set your multimeter to "d.c. current" and select a high full scale deflection (f.s.d.) to be on the safe side, say 500mA (0.5 amps), and simply touch the + meter probe to point "A" (battery + terminal), and the – probe to "B" (resistor R1). This will complete the circuit, current will flow through the meter and the bulb will glow. Note the reading on the current range of your multimeter. We took a reading of 62mA. Call this Result 4, and note it here:

OUR READING **TEST RESULTS:**
Result 4 62mA
(Current flowing through the circuit)

In this simple circuit, the current flows through the ammeter, resistor and the bulb, and the current will be the same wherever you measure it. Putting the ammeter in the circuit say between the bulb and the battery negative terminal instead, will produce the same result. Try it.

Now short out the resistor with a jumper wire and repeat the experiment. What happens to the bulb? This is in effect exactly the same as the very first circuit we saw in Fig. 1.1(a), because the resistor is now bypassed and no longer has any effect. What is the current reading on your multimeter now? We measured 97mA. Call this Result 5, and note it here:

OUR READING **TEST RESULTS:**
Result 5 97mA
(Current flowing through the bulb, resistor shorted out)

OHM'S LAW

The Ohm's Law Equation states that:

R = V / I

where V is the voltage appearing across the resistor,

I is the current flowing through the resistor and R is *the value of the resistance measured in Ohms.*

From Fig. 1.7(a) V = Result 1 = 3.15V
From Fig. 1.7(c) I = Result 4 = 62mA (0.062 Amps)

Using our actual measurements and Ohm's Law, the resistance of R1 works out as 50 ohms (3.15 / 0.062). Looking at our various test results, we can also state that by adding a resistor into a circuit, two things happen:-

1 *It reduces the current flowing through the circuit.* Compare Result 4 (resistor in circuit) with Result 5 (resistor shorted out with a wire). More resistance causes less current to flow. Current always takes the path of least resistance.
2 *A voltage appears across the resistor.* Not all the voltage of the battery now appears across the bulb. Some of it is wasted by the resistor. We say that the resistor has produced a "voltage drop".

But wait! We reckoned we had put a 47 ohm resistor into our circuit (identified by its colour code), but our calculation using Ohm's Law showed it to be actually 50 ohms! (You might get slightly different results from ours.) Don't worry, here's why:

Manufacturers of resistors have a **tolerance** to work to. This means that the resistor values might not be exact, but will be within a certain range. The *gold* band of the colour code tells us that the tolerance is ±5 per cent, so in fact our 47 ohm resistor could be anywhere between roughly 44 to 50 ohms. Rarely do you need a "tighter" tolerance, though sometimes you might see precision one per cent or two per cent types for critical circuits.

COLOUR CODE

We show separately the **RESISTOR COLOUR CODE** which enables us to identify the ohmic value of any common resistor. Rather than have an infinite number of different resistances, manufacturers also produce resistors in a range of *preferred values.* The so-called **E12** values you will commonly use are:–

10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their multiples of ten. Larger resistor values are abbreviated and simplified by using prefixes to describe their value. We say *kilohm* (or letter "k") to mean thousands of ohms, and *megohms* (letter "M") for millions. The letter is a multiplier abbreviation which is often used in place of the decimal point to indicate the resistance value. You might see the letter "R" used instead of the Omega symbol (or nothing at all) just for ohms. Here are some examples:

47R = 47 ohms.
820 = 820 ohms.
1k = 1 kilohm = 1,000 ohms.
2k2 = 2.2 kilohms = 2,200 ohms.
10k = 10 kilohms = 10,000 ohms.
390k = 390 kilohms = 390,000 ohms.
1M = 1 megohm = 1,000,000 ohms.
4M7 = 4.7 megohms = 4,700,000 ohms.

When current flows through a resistor, the electrical energy is turned into heat. The temperature of the resistor will increase though you might not notice. We say that the resistor is **dissipating power.**

An electric fire element is an example of a large resistor which is deliberately allowed

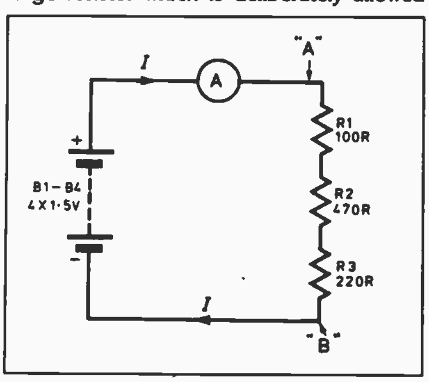


Fig. 1.8(a). Three resistors in series.

to dissipate so much power that it becomes red hot and warms the room. The filament of a light bulb is actually a resistor which dissipates so much power that it becomes white hot. (They are actually much more efficient sources of heat than light!)

The power dissipation, or rate at which the resistor converts electrical energy into heat, is determined by the simple formula:

P = I × V

where P = Power dissipation (Watts, symbol "W")

I is the current flowing through the resistor (Amps)

and V is the voltage across the resistor (volts.)

In our earlier experiment of Fig. 1.7(b) the power dissipated by the 47 ohm resistor will be 0.062 × 3.15 = 0.19 Watts. The 47R resistor is rated at 0.25 Watts which is satisfactory. Exceeding the power dissipation rating of a resistor may damage it.

Substituting Ohm's Law into the above formula, we obtain two further formulae which can be very useful:

$P = I \times I \times R = I^2R.$
Alternatively,
$P = V / R \times V = V^2/R.$

Different materials are utilised by manufacturers when making resistors but the most common type you will use will be cheap and cheerful *carbon film.* Larger resistors can dissipate more power; for instance the electric fire element is actually a large *wirewound* resistor. Have a look through some supplier's catalogues to see if you can now recognise other types. What values are available? What tolerance (%) do they have? How much power can they dissipate? Lastly, how do they compare for cost?

RESISTORS IN SERIES

Three resistors in series are shown in Fig. 1.8(a), values 100R, 470R and 220R, connected across the 6V battery pack. Obtain suitable 0.25 watt carbon film five per cent resistors and build this circuit on the breadboard of the Mini Lab as per Fig. 1.8(b).

Firstly measure the voltage across the resistor chain at points "A" and "B", using your multimeter set to a d.c. voltage range of 10V f.s.d. Also record the voltages across each resistor. Then break into the circuit and measure the current I with your multimeter set to its "d.c. current" range, say 10mA f.s.d., recording all your readings below. Again, we show you what we obtained when we ran the experiment.

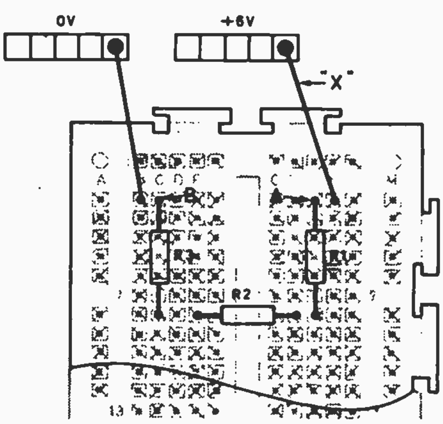


Fig. 1.8(b). Resistors R1 to R3 in series on the breadboard. Measure the current by placing your multimeter (set to 10mA) at the location "X". Then substitute with a jumper wire and measure the voltages as per the text.

OUR READING	TEST RESULTS:
Voltage "AB" 6.2V	
V across R1 0.8V	
V across R2 3.7V	
V across R3 1.7V	
Current I 7.9mA	

The voltage A-B represents the voltage across the ends of the resistor chain. Of course, it's the same as the voltage across the battery in this example. Using Ohm's Law, we can calculate the actual value in real life of the *overall* resistance chain:

R_{total} = V/I	YOUR CALCULATION:
= 6.2 / 0.0079	
= 784 ohms.	

Don't worry if your results are a little different to ours. Remember that resistors have a tolerance, so results are likely to vary somewhat in practice.

The formula for any number of resistors in series is simply:

R_{total} = R1 + R2 + R3 . . . etc.

Thus in our circuit of Fig. 1.8(a) we could simply replace all three resistors with a single component of 100 + 470 + 220 ohms = 790 ohms, if one existed.

Having calculated the overall value of the resistance chain, a practical alternative approach is to measure the resistance with a multimeter set to its Ohms range. Try this:

Disconnect the breadboard from the battery pack. Choose a low resistance range (say 1k f.s.d.), adjust your meter for zero ohms if required, and measure the resistance between points "A" and "B" in Fig. 1.8(b). We noted an overall resistance of 780 ohms using our digital multimeter, which compares favourably with the value of 784 ohms we calculated using Ohm's Law. Your own multimeter reading should be almost exactly the same as the value you calculated yourself with Ohm's Law.

In actual fact, if each resistor in the chain has a tolerance of five per cent, then the tolerance on the *overall* value of the resistors in series will also be five per cent. So our own actual reading of 784 ohms falls within the expected resistance range for the resistors in series, namely 750 to 829 ohms (790 ohms ± 5%).

The other aspect to note is that by connecting several resistors in series, *the potential difference applied across the chain (voltage AB) is split up across the resistors.* Total up the voltages across R1, R2 and R3 and compare against the p.d. across the chain: they should be the same. We promise we didn't fix our results!

RESISTORS IN PARALLEL

Two resistors, both connected to our 6V battery pack are shown in Fig. 1.9(a). We also show a current *I* which is flowing *into* the resistor network. At the junction where R1 and R2 are joined, *I* divides into two currents *Ia* and *Ib*, which themselves are determined by the values of the associated resistors.

Assemble the two resistors onto the Mini Lab breadboard using 0.25W types, and measure the three currents with your multimeter. Set it to a "d.c. current" range of about 100mA, and break into the circuit at locations A, B and C in succession, as shown in Fig. 1.9(b). Simply unhook one end of the resistor and link it back into circuit via the test leads of your ammeter, to measure the current flowing through the component.

Then fill in the results in the table below, and compare against our results.

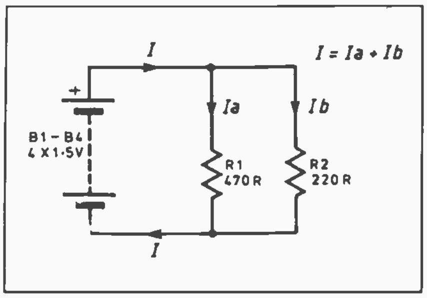


Fig. 1.9(a). Two resistors R1 and R2 in parallel across the 6V battery pack.

OUR READING	TEST RESULTS:
A: Current *I* 42mA	
B: Current *Ia* 13mA	
C: Current *Ib* 29mA	

Clearly what happens is that current I splits into two components *Ia* and *Ib*. This leads us to Kirchhoff's First Law (or Current Law) which states that *the amount of current flowing into the junction of the resistors is the same as the sum of the currents flowing out of it* – because 42mA flows into the junction which divides into two currents coming out of 13mA and 29mA. The same is true if you have three or more currents coming out of a junction: they all add up to the value of the single current going in.

In Fig. 1.9 the two resistors are said to be connected in parallel. The formula for calculating the overall resistance of two resistors in parallel connection is:

R_{total} = R1 × R2/(R1 + R2)

An alternative formula yielding the same result is:

1/R_{total} = 1/R1 + 1/R2.... + 1/Rx etc.

(Take the reciprocal of 1/R_{total} to reveal the answer.)

Our 470R and 100R resistors could thus be replaced by a single resistor of 150R. It's useful to remember that by placing two resistors in parallel, the overall resistance will always be smaller than either of the two individual resistors. It's impossible to make a resistance larger by placing another resistor in parallel with it.

Additionally, when you have two or more resistors in parallel with each other, *the potential difference or "voltage drop" across each of the resistors is bound to be the same.* In our example, the p.d. across both resistors happens to be that of the battery voltage.

POTENTIAL DIVIDERS

Earlier we saw how a potential difference placed across a chain of resistors in series, is divided up amongst those resistors. A p.d. appears across each resistor and when added together, they equal the p.d. across the extreme ends of the resistor chain.

A simple network consisting of two resistors is shown in Fig. 1.10. V_{in} is the voltage from the 6V battery pack and V_{out} is the output voltage from the potential divider.

Three different sets of values are shown in the table for R_a and R_b: construct this simple network on your breadboard using 1k, 2k2 and 4k7 0.25W five per cent carbon film resistors, then measure the voltage V_{out} – the p.d. across R_b – with your multimeter and record this in the table. Our results are shown too. If you are uncertain of the resistors' colour codes, double-check their values using your multimeter set to an ohms range.

This type of circuit is called a **potential divider** and is very useful in electronics for reducing the level of an input or output voltage. The output voltage from the divider depends on the ratio of the values of the two

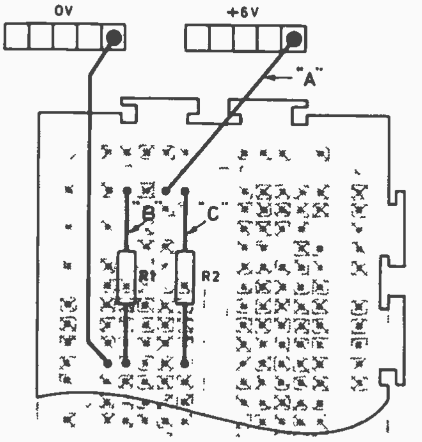


Fig. 1.9(b). Measure the currents using your multimeter at locations "A", "B" and "C".

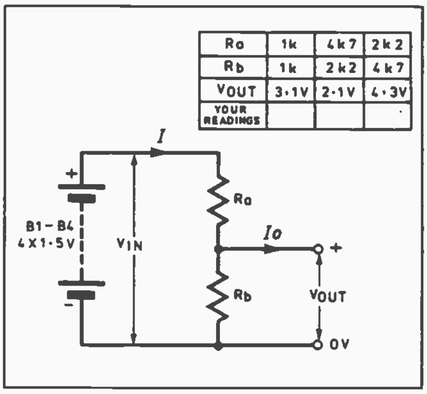
resistors. In fact it's possible to calculate the output from a simple formula:

$V_{out} = V_{in} \times R_b/(R_a + R_b)$

Now try calculating the values of V_{out} and compare it against your actual test readings just recorded.

Our formula assumes that there is *no current* (I_o) drawn by anything connected to the output. By adding a "load" as shown in Fig. 1.11, in effect you reduce the resistance of the bottom half of the potential divider, by adding R_l in parallel with R_b. This has the effect of lowering the output voltage of the divider as it is "pulled down" towards 0V.

There comes a point when the potential divider formula may give misleading results, because it does not take into account the "shunting effect" – if any – which a load connected to the divider may have on R_b. How much effect the load has depends on its resistance – a lower resistance will pull down the output even more. We'll see in future parts of *Teach In*, how the load could be something more complex than a resistor,



Ra	1k	4k7	2k2
Rb	1k	2k2	4k7
VOUT	3·1V	2·1V	4·3V
YOUR READINGS			

Fig. 1.10. The Potential Divider. Build this on the Veroblock yourself, and measure V_{out} (the voltage across R_b) – fill in your results in the table.

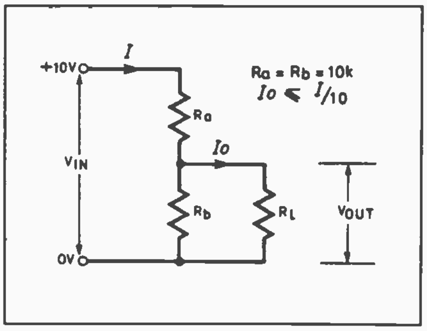


Fig 1.11. The Ten Per Cent Rule. The output current should be no more than 1/10th the current I flowing into the divider.

GCSE QUESTION

MIDLAND EXAMINING GROUP **1751/1**
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PAPER 1 *(reproduced with their permission)*

2

1 Fig. 1 shows a buzzer in series with a pair of resistors.

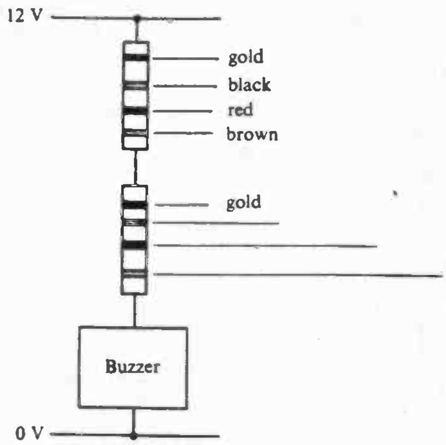


Fig. 1

(*a*) The coloured bands on one of the resistors are labelled. Use the colour code to find the resistance of that resistor. [2]

.... Ω

(*b*) The buzzer is rated at 6 V. When connected to a 12 V supply, it must have a resistance of 60 Ω in series. What is the value of the unlabelled resistor of Fig. 1? [1]

.... Ω

(*c*) Select a suitable value for the unlabelled resistor from this table of preferred values. Draw a circle round your choice. [1]

10	11	12	13	15
16	18	20	22	24
27	30	33	36	39
43	47	51	56	62
68	75	82	91	100

(*d*) Write in the colours of the bands on the unlabelled resistor. [3]

(*e*) Draw on Fig. 1 a voltmeter which measures the potential difference across the buzzer. [2]

MEG 704

like the input of an amplifier section, where a.c. signals may be involved.

THE TEN PER CENT RULE

It's best to ensure that the output current from the divider is no more than 10 per cent of the current flowing through the divider itself, so that you don't unduly load the divider. Firstly work out the current I flowing through both R_a and R_b *with no load attached*. This is calculated very simply with Ohm's Law: $I = V_{in} / (Ra + Rb)$.

We know that the current I into the divider will equal the current through the two resistors plus the output current, refer to Fig. 1.11. Ignoring the load current I_o, and with the values for R_a and R_b set at 10k for example, utilising a 10V supply the current through the divider is 0.0005 amps or 0.5mA.

The output current should be no more than 10 per cent of this, i.e. 50 microamps. This means that the load resistor should preferably be the equivalent of 100k or more, i.e. 5 volts (= V_o) / 50 microamps.

The circuit of Fig. 1.12 shows a 4k7 resistor and a normally-open push switch connected between the 6V and 0V rails of the battery pack. Build this circuit on the Mini Lab yourself, and measure the d.c. voltage output using the multimeter, recording the result both when the switch is open and closed.

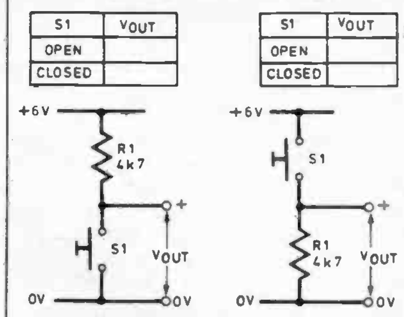


Fig. 1.12 (left). Switching System with Pull Up Resistor. Build this on the Mini Lab and record your voltage measurements in the table.

Fig. 1.13 (right). Switching System with Pull Down Resistor.

Resistor R1 serves as a *pull up* resistor because it "biases" the output towards the +6V rail when the switch is open. Pressing the switch shunts the output to 0V. This is one way of obtaining a signal which is normally at 6V (or whatever the supply rail happens to be) and which is sent to 0V as a result of an operation.

A similar circuit is shown in Fig. 1.13 but this time a *pull-down* resistor R1 biases the output to 0V. Thus the output will be at zero potential when the switch is open, but a "high" signal of +6V is generated when the switch is closed. Prove it by building it on your Mini Lab.

These simple "input systems" enable us to obtain a suitable electrical signal – normally high or normally low, whichever we need – as a result of performing a mechanical operation. Both these functions are of great importance when we come to look at the world of *digital systems*. These only have two states – on and off, or high and low. It's even more relevant when we introduce the Micro Lab, an optional microprocessor expansion unit for the Mini Lab, later on.

VARIABLE RESISTORS

The simple switching systems just introduced enable one of two states – "high" or "low" – to be obtained from simply pushing a button. There will be many times when you will want to *vary* a voltage. A very common method of doing this is based on a variable potential divider. Fig. 1.14(a) introduces the **potentiometer** (pronounced "po-ten-she-oh-meter") which is a three terminal variable resistor. It has a moving contact B which forms a *wiper* on a resistance material.

By connecting the potentiometer as a voltage divider to an input voltage V_{in}, it's easy to change the output voltage V_o by rotating the shaft of the potentiometer. The varying voltage output is available at the wiper of the pot. Thus by performing a mechanical operation (rotating the spindle), an electrical function is carried out.

A very common application of this arrangement is a **volume control** of a radio or a hi-fi. Sometimes you need to adjust a voltage just once, in order to set up a signal, perhaps on a television circuit board. Small "trimmer resistors" or "preset potentiometers" are available, and these are generally fitted to a circuit board so that they

GCSE QUESTION (see previous page)

The *Teach In* Reader would have no problems with this straightforward question which concerned resistors in series. The following answer would have earned you full marks.

(a) Simply use the resistor colour code. The brown and red bands mean that the numerals of the code are 12. The black band means that the multiplier is 1R (x 1). *Answer* **12 ohms (12R).**

(b) Use the formula for resistors in series. We are told that the total resistance in series with the buzzer must be 60 ohms. We have shown one of the resistors to be 12 ohms – the unlabelled component must therefore be **48 ohms**

(c) The nearest preferred values to 48 ohms in the table are **47** or **51** ohms. Either was marked as correct.

(d) Resistor Colour Code again. 47R is **yellow/violet/black.** 51R is **green/brown/black.**

(e) The voltmeter is drawn in *parallel with* the buzzer. Voltmeters measure the voltages (p.d.) *across* components, i.e. between two points in a circuit.

N.B. *No extra marks* would have been awarded by mentioning the resistor tolerance. Also, the Resistor Colour Code was shown on the Exam Paper for reference.

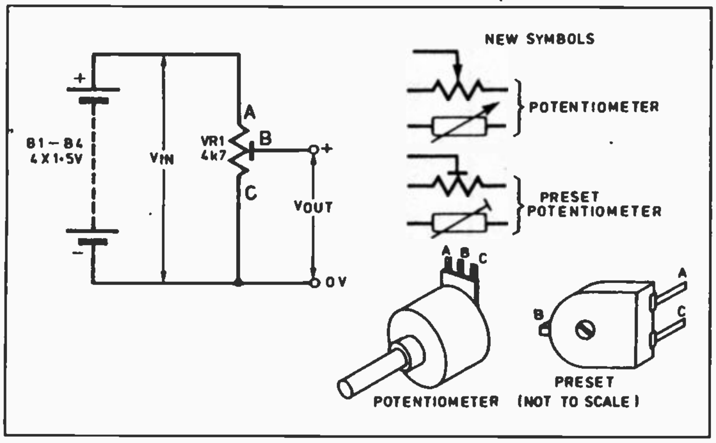


Fig. 1.14(a). A preset variable resistor. Physical forms are also shown.

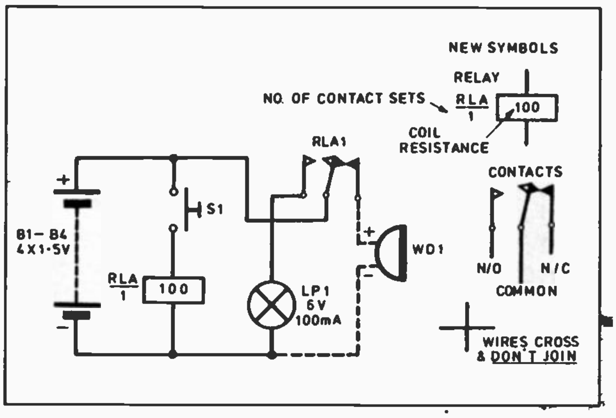


Fig. 1.14(b) (below). Connecting one of the preset potentiometers mounted on your Mini Lab. Measure the voltage between "B" and 0V, when you rotate the control.

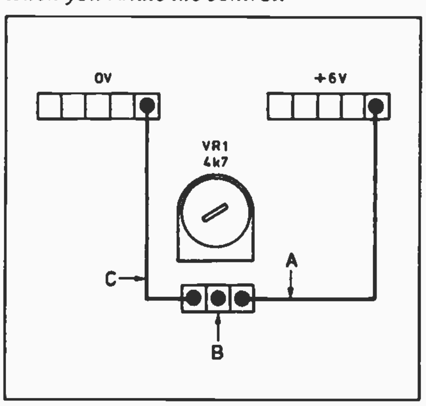
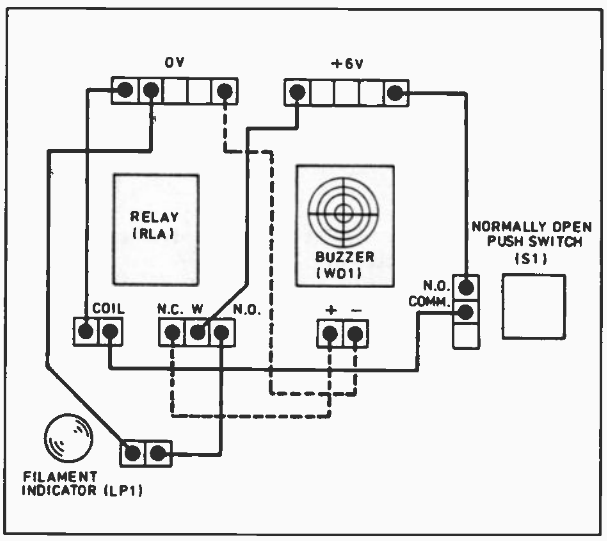


Fig. 1.15(a) (above right). The Relay, used here to switch between a bulb and the buzzer. Add the buzzer (WD1) after building and testing the rest of the circuit.

Fig. 1.15(b) (right). Operating the buzzer and bulb with the changeover contacts of the relay. Connect WD1 the right way round.



can be adjusted with a screwdriver. The symbol for a preset (or trimmer) is also shown in Fig. 1.14.

Potentiometers and trimmers are specified by the ohmic value of their tracks. Anything between 100R to 1M is common. Additionally, the power dissipation of the track, in watts, is also generally given. Small presets might only be 0.15 watts, but large "wirewound" potentiometers could dissipate up to 25 watts of power. Look through a catalogue to check out some other variable resistors, comparing specifications and prices.

The Mini Lab incorporates a selection of preset resistors which can be used as volume or level controls in future experiments. Fig. 1.14(b) shows how to try out a 4k7 preset mounted on the Mini Lab, by connecting it to the 6V battery pack. Measure the voltage between "B" (positive) and "C" (0V) with your multimeter set to a d.c. voltage range. See what effect rotating the control has on the meter reading.

RELAYS

The simple switching systems we have looked at so far are limited by the current they can carry and the voltage they can switch. The smallest switches available can only carry a few tens of milliamps and switch up to 20V d.c. or so. In some applications, this could be far too restricting when we want to switch a heavy load such as a motor.

A relay is an *output device* in which a small current can be used to control a much larger current. They take advantage of the *electromagnetic effect* where a potential applied to a small coil turns it into an electromagnet. This magnetically operates some contacts to form a switch.

Only a small current is needed in the coil to enable the switch contacts to join together. The contacts themselves may be capable of switching very heavy currents, in the order of several amps or more. Fig. 1.15(a) is a demonstration circuit of a relay RLA, the coil of which is activated by pressing S1. The relay actually has *changeover contacts* (RLA1) so that a load can either be switched on or off when the coil operates. Here, a bulb LP1 is connected as the load. The whole circuit is powered by the 6V battery pack.

Build this on your Mini Lab as shown in Fig. 1.15(b). When you press S1, you will hear the relay click and the bulb will illuminate. Now add the audible warning device (correctly polarised) between the n.c. terminal (buzzer +) of RLA and 0V (buzzer –). What happens now when you press the switch?

The relay used on the Mini Lab has the following specification:

Coil Resistance: 100 ohms
Coil Voltage: 6 volts
Contact Current: 3 amps maximum
Contact Voltage: 24V d.c./120V a.c. maximum
Contact Configuration: single pole changeover

What will be the current flowing through the coil when 6 volts is applied? Use Ohm's Law ($I = V / R$) and compare your answer (60mA) against the much higher contact current which the relay can safely switch.

We need to take certain precautions when using relays in transistorised circuits. Next month we see how relay coils can generate some unbelievably high voltages when they are switched *off*. This can ruin certain electronic components unless precautionary measures are taken. We also introduce more electronic devices.

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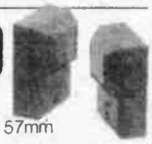

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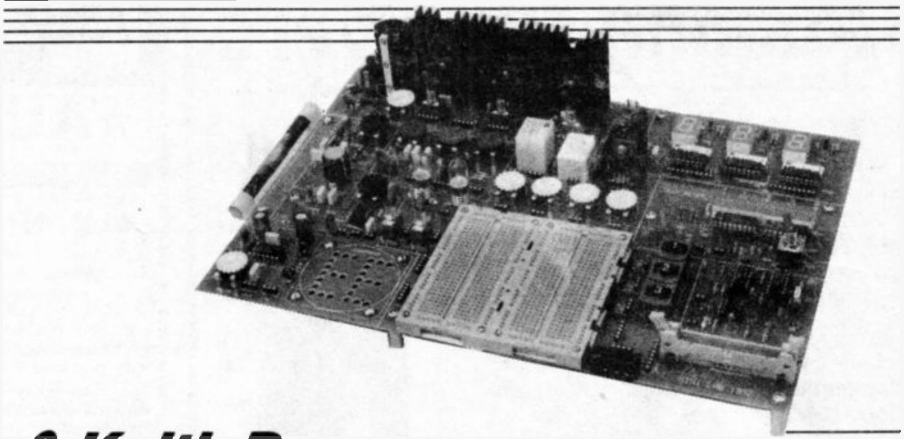


MINI LAB

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. The Mini Lab is an exciting learning aid which brings electronics to life in an enjoyable and interesting way: you will both see, and hear, the electron in action.

A SPECIALLY-DESIGNED printed circuit board (p.c.b.) forms the heart of the Mini Lab which includes a "breadboard" area or plug-in contact block with which basic circuits can be tested. One Veroblock breadboard is required initially and the Mini Lab has room for another.

Ancillary components such as presets, switches and buzzers etc. which cannot be plugged directly into the breadboard are also permanently fitted to the Mini Lab board, and are easily connected to the Veroblock through breadboard-type sockets which are conveniently located nearby.

All the areas are interconnected to a common power supply and the Mini Lab becomes mains-operated in due course. However, only low voltages are ever present on the Mini Lab, so the unit is completely safe to use at all times. A microprocessor expansion port facilitates connection to our Micro Lab microprocessor add-on system which is introduced later in the series for GCE A Level.

When the Mini Lab is finished, you will possess an excellent self-contained development unit complete with a range of test and demonstration items which will help you to widen your knowledge and produce your own designs. We hope that you will enjoy building and using your Mini Lab, and find it of continued use when *Teach In '93* draws to a close. Thereafter, we hope to follow up with occasional articles which will utilise the Mini and Micro Labs in some interesting applications.

Should you have any particular queries or problems, please *write* to us c/o The Editor – we'll be only too glad to help. We also welcome any comments and constructive criticism from both teachers and students alike, so do get in touch with a progress report: we'll be delighted to hear from you!

Alan Winstanley and Keith Dye.

The printed circuit board designs of the Mini and Micro Labs are © Copyright Dytronics 1992.

FIRST STEPS IN CONSTRUCTION

The *Teach In* Mini Lab is constructed on a p.c.b. measuring approximately 295mm × 210mm (the size of a page of EPE) and is divided into distinct sections. Every month *Teach In* discusses a particular topic and accompanying the text will be a brief constructional article describing a relevant circuit which fills one of the sections on the Mini Lab board. There is, however, the requirement to solder a number of components to the board each month, so a little practice with a soldering iron will be useful. Space precludes us from exploring the circuits in any depth: the main thing is to *build them!*

For Part One of *Teach In*, it is necessary to assemble the "general-purpose" central area of the Mini Lab which contains the plug-in breadboard and other components. The breadboard readily copes with most of the electronic components used in *Teach In*, but cannot directly handle certain parts like switches, bulbs or preset potentiometers. These components are instead soldered directly to the Mini Lab p.c.b., then the components' terminals connect via the p.c.b. to adjacent groups of contact strips which form breadboard-style connection points for these parts.

It therefore becomes very easy to connect switches, pots etc. to the breadboard with **standard solid core 0.28mm² insulated wire**, see Fig. 1. Simply cut some wire to length, strip about 5mm of insulation from each end and push the jumper wire into the relevant sockets on the Mini Lab and connect over to the Veroblock. You might often find it easier to use a pair of fine-nose pliers to grip and locate the wires into the sockets. The system works perfectly but *it's important that you use both the correct socket strips and also the right gauge of wire so that a reliable connection can be made each time.*

COMPONENTS

The Components List gives all those parts which you can solder to the Mini Lab board for Part One. It **does not** list the extra parts required to fill the other sections of the board: these will be gradually introduced as required in each month's article which makes the Mini Lab extremely cost-effective. Also, rest assured that we have chosen the most economical components wherever

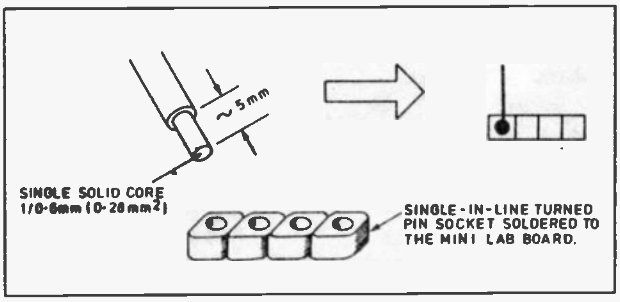


Fig. 1. Using a jumper wire to connect a s.i.l. socket on the Mini Lab printed circuit board.

Mini Lab Components

Variable Resistors

VR1	4k7
VR2	47k
VR3	100k
VR4	2M2

See SHOP TALK Page

Switches

S1 to S3 S.P.D.T. sub-miniature toggle switch (3 off)

S4 to S6 2-pole n/o + 2 pole n/c mom. action push switch, p.c.b. mounted with bezel and button (3 off)

Miscellaneous

WD1 6V p.c.b. mounted audio warning device

RLA 6V 100ohm s.p.c.o. p.c.b. mounting relay

LP1, LP2 6V 100mA M.E.S. bulbs with skeleton holders (2 off)

Mini Lab Printed Circuit Board 295mm × 210mm approx. (available from the *EPE PCB Service* – order code MINI LAB); p.c.b. mounting "jacks" (3 off); 0·5 inch shorting selector plug; single-in-line turned-pin sockets, 2 × 32-way; "pluggable" p.c.b. mounting screw terminals, 1 each 2-way, 4-way; Veroblock breadboard; M2·5 × 12·5mm screws and nuts to mount breadboard (4 off); 20mm p.c.b. stand-offs with screws (8 off); wire – single core insulated 1/0·6mm (0.28mm²) as required.

A detailed Buyers Guide is given in *Shop Talk* which shows all part numbers, alternative sources and additional information.

Price £38 Approx

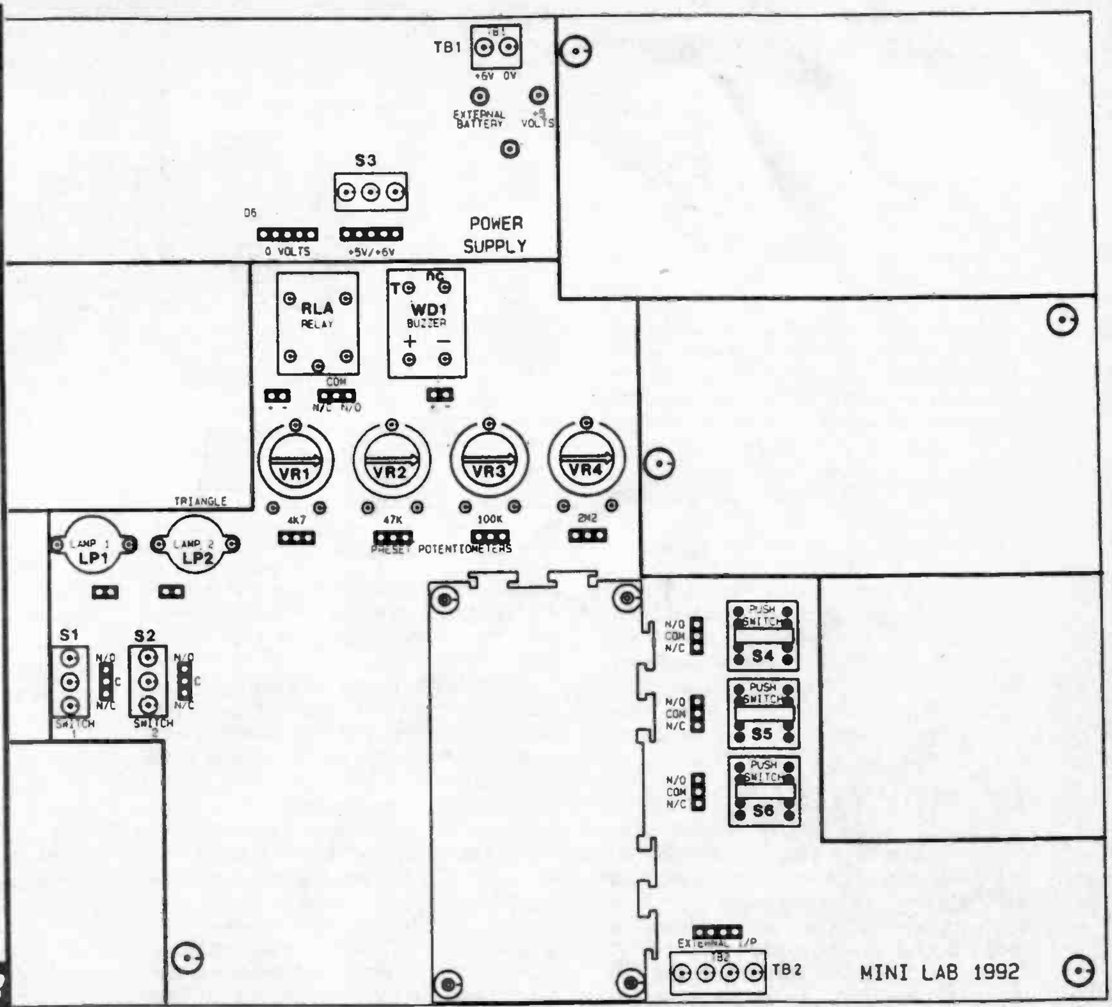
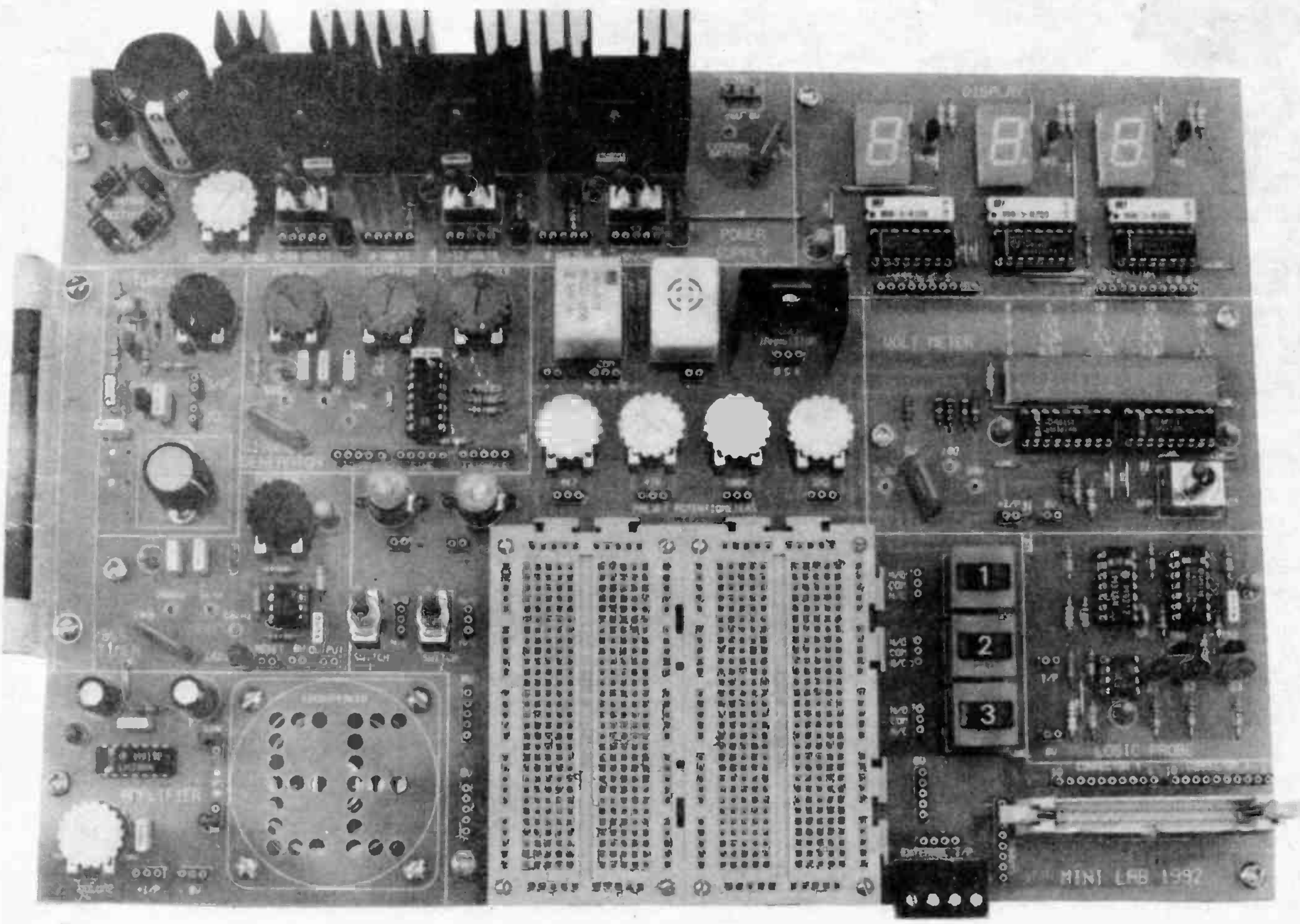


Fig. 2. Construction of the central part of the Mini Lab as required for Part 1 of Teach-In. The photograph below shows the complete Mini Lab.



possible. We also give a list of other requirements for tools, etc. which the newcomer might find useful.

The top side of the Mini Lab p.c.b. is fully silk screen printed with the descriptions and locations of the various components, and you should find the initial assembly very straightforward. Fig. 2 shows the arrangement of the central part of the Mini Lab which can now be constructed.

BATTERY PACK

Also assemble the battery pack (B1 to B4); use four 1.5V cells such as R20S types and connect them the right way round into a suitable holder to make 6 volts. It is connected to the Mini Lab through screw terminals on the printed circuit board, see Fig. 3. We recommend "pluggable" terminals, so that the relatively bulky battery can be conveniently unhitched when desired, without straining the printed circuit board.

The battery *must* be selected for use by inserting a shorting plug (see Parts List) between two small sockets marked "EXT BATT", and also a d.c. on-off switch is fitted, so that you can readily disconnect the battery. Later, this switch serves a different purpose: it turns a 5V supply on and off for digital circuits, once the battery has been replaced with a very comprehensive Mains Power Supply.

I.C. MOUNTING

The s.i.l. ("single in line") socket strips are designed to carry integrated circuits and mainly come in lengths of 32 terminals, and these are snapped off as required to form small groups which can then be soldered to the p.c.b., perhaps using sticky tape to hold them down while you solder the pins. Because they are central to the whole design, we again emphasise that *only* "turned pin" s.i.l. sockets should be used: other types will not work in this application. Invariably, some terminals will break, so allow for a little wastage.

Many parts have to be be pin-compatible with the hole layout in the p.c.b. or they will not fit, so consider the Components List and *Shop Talk* carefully. The recommended parts should solder directly to the board without any problems. A 4-way screw terminal is fitted at the bottom of the board so that later on, components with long wire leads can be made to connect to the Mini Lab.

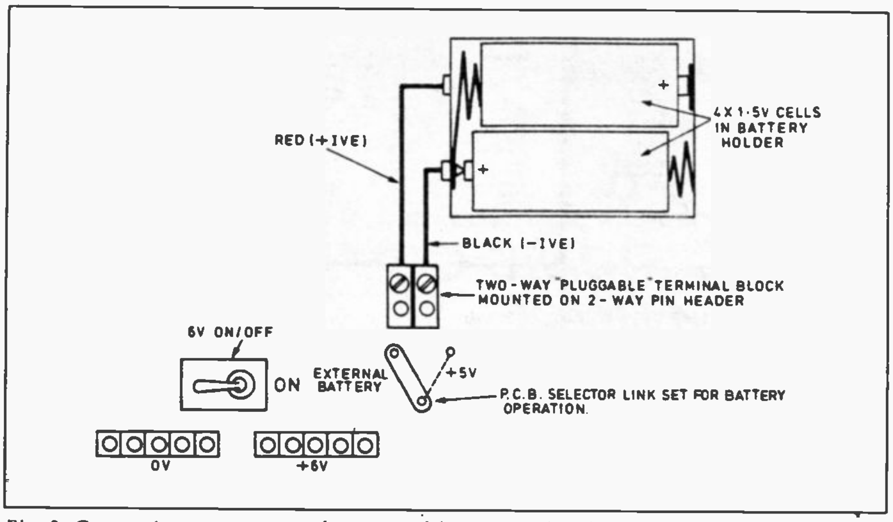


Fig. 3. Connection arrangement for external battery pack. The connection link for selecting "External Battery" is shown.

The bulbholders can be mounted by soldering their tags to a couple of solder pins fitted to the board. The push switches must be the approved type or they will not fit the board: those used on the prototypes used a bezel with engraved buttons marked 1 to 3 as a nice touch. They are, incidentally, the only p.c.b. switches we know of which have an acceptable current rating for our purposes.

Finally, to finish off, the board requires quite a number of 20mm stand-off pillars as shown so that the board can stand on a desk or table top. They stop the whole p.c.b. from flexing unduly when engaged in frenzied experiments!

To avoid confusion, it's important to note that the component designations (VR1, VR2, S1 etc.) shown both in the Components List and Fig. 2 are only used here for the purpose of helping you to assemble this part of the Mini Lab. In the main tutorial of *Teach In*, you will find that the components are given different designations in various circuit and interwiring diagrams.

TOOLS

The following is a list of basic requirements for tools and equipment, and is given as guidance to those approaching the subject for the first time:

Fine-pointed long nose pliers with serrated jaws.
Wire stripper, variable gauge, with built-in wire cutter.
Round-jaw pliers (luxury, useful for bending leads neatly).
Screwdrivers, small flat-bladed and cross-head No. 0 and No. 1 types.
Soldering iron, 15 Watt mains operated pencil type with fine tip, preferably with bench stand.
Soldering Iron Tip Cleaner and Tinner (Multicore TCC1).
Solder 60/40 22 s.w.g.
Suction Desoldering Tool (luxury but useful to have).
Small Freezer aerosol (handy)
Multimeter, 20,000 ohms per volt or higher: reading 250V d.c./500mA d.c. minimum plus resistance range. Or Digital Pocket Multimeter, same readings or better. A modest multimeter will be quite adequate for following *Teach-In*

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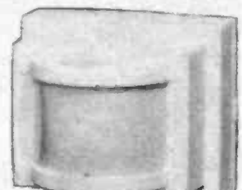

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Techniques

ACTUALLY DOING IT!

by Robert Penfold

LAST MONTH the topic of customising projects was discussed. This is something that the majority of constructors indulge in, and it adds to the interest and enjoyment obtained from the hobby. You do need to be slightly careful when doing your own thing though, and in particular, you need to be careful when using substitute or equivalent components.

SUBSTITUTION

There are several possible reasons for using substitutes. One is simply that you cannot find exactly the right component listed in any of the component catalogues.

Another is that you have almost the right component in your spares box, and that you would prefer to use this rather than buy the right component. A third possibility is that the project under construction is an old design, and that some of the components used in the original unit are no longer available.

It is clear from readers' letters that many constructors are simply not sure if certain components are the right ones or not. A fair percentage of queries from readers who are having difficulty getting projects to work include inquiries about the suitability of one or more components. In most cases the components in question seem to be perfectly suitable, but in a few cases a misunderstanding has resulted in a totally unsuitable component being used.

For complete beginners at electronic construction the best advice is to only build projects using what you are certain are the correct components. When building a project from *"Everyday with Practical Electronics"* remember to consult the *Shoptalk* feature.

If for one reason or another you cannot obtain all the right parts, then it is best not to go ahead with the project. Once you have gained a small amount of experience it is probably safe to start making some simple substitutions.

SWITCHES

In theory, provided a switch has the right number of ways (contacts) and a sufficient number of poles ("moving contact"), it will do the job. It does not matter whether you use a pushbutton, slider, rotary, or rocker type.

In reality you need to be very careful that the switch contacts have suitable current and voltage ratings. The most important point to watch is that you do not use an unsuitable switch on the mains supply. This could be lethal for the switch and anyone who uses it!

Generally speaking, miniature switches are *not* intended for operation on the 240V a.c. mains supply. Most of those that are intended for use on mains supplies are only suitable for continental and US supplies of around 110V to 120V. For mains operation use the larger switches that are intended for on/off switching of the 240V UK mains supply.

Sometimes a components list specifies that a switch should be a *make-before-break* or a *break-before-make* type. These terms only apply to changeover and multi-way switches, not simple on/off types.

With a "make-before-break" switch, as the moving contact is shifted from one terminal to the next it momentarily short circuits the two terminals together.

With "break-before-make" switches the moving contact (pole) becomes briefly isolated from both terminals as it is switched from one to the other.

In most cases it does not matter which of these switch types is used. However, where one type or the other is *specifically* called for in a components list it is essential to use the right kind. Otherwise you might, for example, find that the power supply is short circuited each time you operate the switch. At best the switch would be short lived, and at worst expensive damage would be caused to other components in the circuit.

CAPACITORS

If you look in one of the larger electronic component catalogues there will almost certainly be more than a dozen different types of capacitor on offer. Capacitors that operate well in some respects tend to be less impressive in others.

Circuit designers therefore have to look at the important requirements for each capacitor, and choose a type which measures-up to these requirements. Using a capacitor having the right value, voltage rating, etc., but having the wrong type of construction, may not be a safe substitute.

Ceramic capacitors provide good performance at high frequencies. They are often used for supply decoupling and signal coupling in radio frequency circuits. In other respects the performance of ceramic capacitors tends to be poor.

The tolerance figures are mostly quite high, and the values drift significantly with changes in temperature and the passage of time. They can also give problems with microphony in audio circuits (i.e. they act like crude microphones). It is unwise to substitute another type of capacitor for a ceramic type, or to use a ceramic capacitor where some other kind has been specified.

The various plastic foil capacitors, such as Mylar, polyester, polystyrene, and polycarbonate types have broadly similar characteristics. In fact components list sometimes just specify "plastic foil" capacitors rather than a particular type within this category.

Provided the electrical ratings are suitable it is unlikely that there will be any problem if one kind of plastic foil capacitor is substituted for a different type. Bear in mind though that there are substantial variations in the sizes and shapes of plastic foil capacitors. A substitute capacitor might have suitable electrical characteristics, but can it be fitted onto the circuit board?

POLARISED

Higher value capacitors are mostly of the electrolytic and tantalum types. The latter are physically very small, and have superior electrical characteristics. Accordingly, a tantalum type can be used instead of an electrolytic type. A substitution in the opposite direction is unlikely to give good results though. In a timing circuit for instance, the higher leakage of an electrolytic capacitor could result in greatly extended times, with the times possibly carrying on indefinitely.

Tantalum and electrolytic capacitors are polarised components which must be connected the right way round if they are to function properly. It is not a good idea to use a polarised capacitor in place of a non-polarised type. The signal across a polarised capacitor must include a d.c. component if the component is to function reliably.

If a large non-polarised capacitor is called for, it is likely that this d.c. component is not present, or that the application is a critical one where the quality of a polarised component would simply not be good enough anyway.

Silvered mica capacitors are sometimes specified for radio frequency circuits. These are very high quality components with price-tags to match.

Mica capacitors are still available, but are becoming increasingly difficult to track down. A good quality polystyrene capacitor is about the only reasonable substitute for a mica type.

LOUDSPEAKERS

The main ratings of loudspeakers are the physical size, the power rating, and the impedance. Using a slightly smaller or larger loudspeaker than that specified is fine, but only if the substitute component has a high enough power rating. Be especially careful about using a loudspeaker that is smaller than the specified size.

In general, the larger the physical size of a loudspeaker, the higher its power rating. Some miniature loudspeakers have very low power ratings. Bear in mind that seriously overloading a loudspeaker can burn out the coil, or (more probably) result in it literally ripping itself apart.

If an eight ohm impedance loudspeaker is required there should be no difficulty in obtaining a suitable component, since virtually all loudspeakers have this impedance. The main exceptions are the high impedance types, where there is a definite lack of standardisation.

A variety of impedances from about 50 to 80 ohms are used. Using a loudspeaker of not quite the right impedance should not cause any difficulties. A 64 ohm component should work perfectly well in place of (say) a 50 ohm or 80 ohm loudspeaker.

Never use an eight ohm loudspeaker instead of a high impedance type. This could damage the semiconductors in the circuit driving the loudspeaker, and (or) result in severe overloading of the loudspeaker. Substituting a high impedance loudspeaker for a low impedance type should be quite safe, but the maximum output power and volume will both be substantially reduced.

DIODES

Occasionally a special diode of some kind will be required, but in most cases projects just use "bog standard" silicon types such as the 1N4148 and 1N914, or very occasionally germanium diodes such as the OA90 and OA91. Substituting one silicon diode for another, or one germanium device for another should not give any problems.

However, do not use a germanium device in place of a silicon type, or vice versa. They have very different characteristics, and are not usually interchangeable.

On the face of it there is no problem in using a silicon rectifier such as a 1N4002 instead of a silicon diode such as a 1N4148. In practice this is not usually a good idea. There are subtle differences between the two types of component which could cause difficulties.

Rectifiers generally have lower forward voltage drops which could cause problems in biasing applications. They also have slow response times which could produce poor results in a.c. applications.

Substituting a rectifier having a higher than specified voltage or current rating is perfectly safe. For example, a 1N4002 (1A 100V) rectifier can be used in place of a 1N4001 (1A 50V) type. Going up to a higher current rating is safe from the electrical point of view, but bear in mind that a higher current rating usually means a much larger physical size as well.

Never use rectifiers having lower voltage or current ratings than the specified components. Apart from the almost certain and spectacular destruction of the substitute rectifiers, other components in the circuit could be damaged.

RESISTORS

Most components list specify something like "0·25 watt 5 per cent carbon film" for all the resistors. This is a minimum requirement, and it is quite in order to use higher quality components such as one per cent metal film resistors.

It is also in order to use a higher wattage than that specified in the "Comps list." However, note that in many cases this would mean trying to use resistors that were far to large to fit into the available spaces on the circuit board.

In the vast majority of cases you can get away with using one value up or down from the correct one (e.g. a 12k or 8k2 resistor instead of a 10k type). This may cause some loss of performance though, and it is advisable to fit the correct value as soon as a suitable component can be obtained.

If you try using a "logarithmic" (log.) potentiometer instead of a "linear" (lin.) type, or vice versa, the project will work properly. The substitute potentiometer will have rather an odd control characteristic though.

For example, suppose you used a logarithmic potentiometer instead of a linear type for the balance control in a stereo amplifier. This would provide the correct channel balance with the control set almost at one end of its adjustment range, rather than at a roughly middle setting. This is again fine for a temporary fix until you can obtain the right type, but does not provide a satisfactory long term solution.

TRANSISTORS

With projects that operate from a small 9V battery and use transistors as simple amplifiers and switches, BC549s and BC559s can respectively be used in place of virtually any *npn* and *pnp* transistors. There are plenty of other transistors which are suitable as general purpose *npn/pnp* substitutes (BC109/179, BC547/557, etc.).

When using substitutes make sure that you connected the transistors correctly. The fact that two transistors have the same case style does not necessarily mean that they have the same pin leadout configuration.

Using substitutes where higher powers and higher frequencies are involved is rather more tricky. Even very experienced constructors can run into difficulties when attempting this type of thing. For the beginner the best advice is to not bother trying substitutes for any transistor that is at all out of the ordinary.

INTEGRATED CIRCUITS

In general it is not possible to use substitutes for integrated circuits (i.c.s.) due to their specialist nature. However, one exception is operational amplifiers.

There are plenty of operational amplifiers which are designed to be superior versions of the industry standard μA741C. This includes popular devices such as the TIL071CP, TIL081CP, CA3140E, and LF351N. Using one of these instead of a μA741C, or in place of another "super" 741C device is almost invariably all right.

Using a μA741C instead of a "super" 741C is more dubious. The project is almost certain to work, but with some reduction in performance.

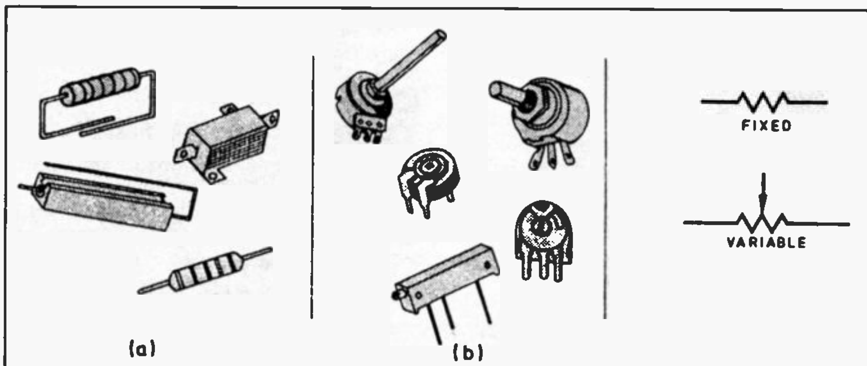
Some circuits make use of the CA3140E's ability to operate with a single supply rail in situations where other types require dual supplies. Using a substitute in such a circuit is more or less guaranteed to prevent it from working at all

There are various families of TTL logic integrated circuits, with each family having "pin-for-pin" equivalents to the devices in the other families. Compatibility between these logic families is actually quite an involved topic, but there is a fairly high degree of compatibility between most of them.

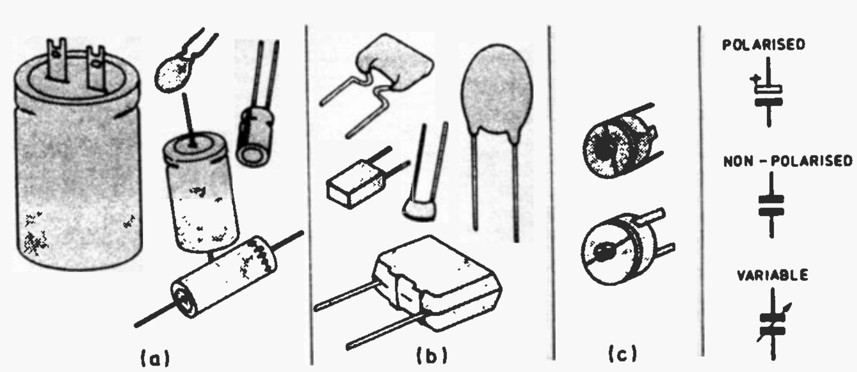
Compatibility is to some extent dependent on the exact way in which a device is used. A substitution might be successful in one circuit, but unreliable in another.

Compatibility is very good between the original 74 series, the popular 74LS series, and the increasingly popular 74HCT devices. It is highly unlikely that an unsuccessful substitution will cause any damage, so the "suck it and see" approach is quite acceptable.

In practice with 74 series substitution you seem to be able to get away with rather more than the theory would dictate. Unfortunately, this is not the case with most component substitution.



Fixed and variable resistors.

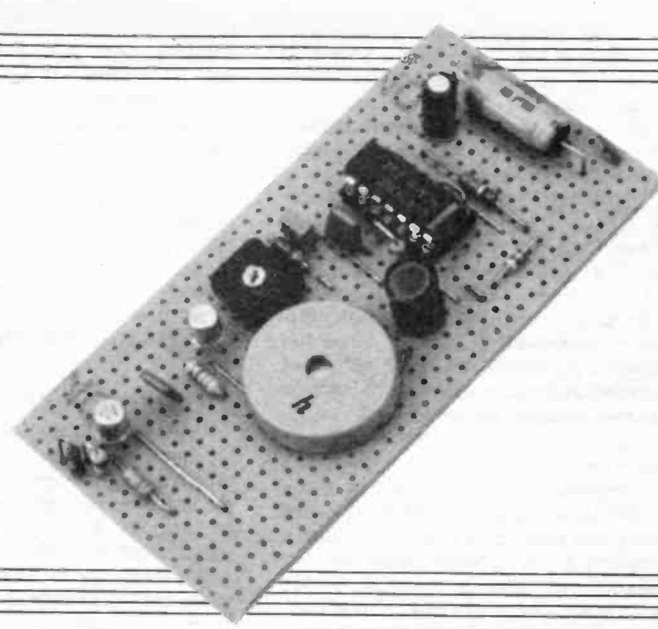


Fixed and variable capacitors.

Constructional Project

VIBRATION SENSITIVE ALARM

M. G. ARGENT



Safeguard your valuables with this novel alarm. Endless possible applications in and around the home.

THE VIBRATION alarm circuit to be described here consists of a piezoelectric sounder (which is used both as a vibration sensor and also a mini speaker), a latch and two oscillators formed by a CMOS quad 2-input NAND Schmitt trigger i.c., and two transistor amplifiers.

HOW IT WORKS

The circuit block diagram is shown in Fig. 1. Vibration of the piezoelectric transducer WD1 generates small voltages which are amplified by the transistor amplifier TR2 and provides a negative "feedback" pulse to flip the latch IC1a and IC1b.

When the unit is switched on, the latch automatically resets itself. When triggered by TR2, the latch changes over, and remains in this "alarm" state until the unit is switched off.

The output of the latch enables two oscillators, creating the required pulsed tone for the alarm sound. The output from the last oscillator is connected to the same transducer WD1 as is used for the alarm sensor. This eliminates the need for two piezoelectric devices and also provides a regenerative action, guaranteeing positive triggering.

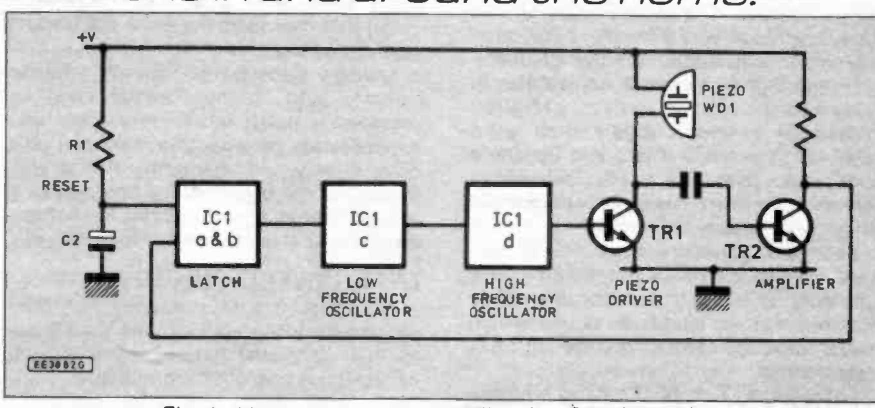


Fig. 1. Block diagram for the Vibration Sensitive Alarm.

CIRCUIT DESCRIPTION

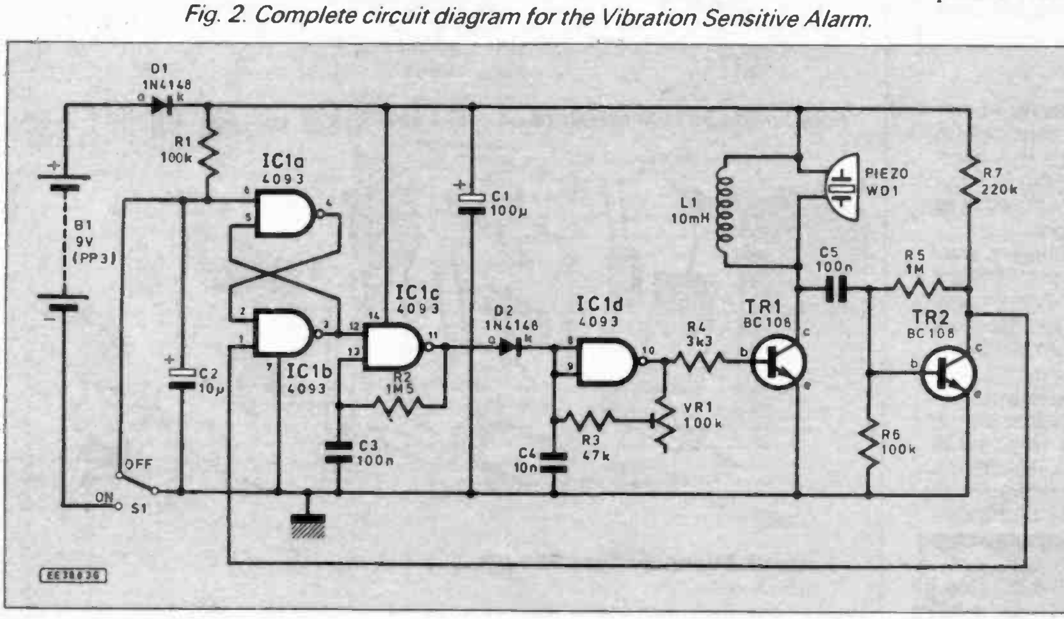
The full circuit diagram for the Vibration Sensitive Alarm is shown in Fig. 2. The latch, IC1a/IC1b, mentioned earlier is reset by the resistor capacitor combination R1/C2. Capacitor C2 always starts up from the uncharged state due to it being shorted out by the On/Off switch S1 each time the unit is switched off.

The latch output at IC1 pin 3 will be "low" (0V) when the unit is on but not triggered. When the latch changes state, due to a negative pulse from TR2, it's output goes "high" (+9V) enabling the low frequency oscillator formed by IC1c.

This oscillator pulses on and off a high pitched audio oscillator IC1d, providing the alarm sound. The frequency of the second oscillator is adjustable by VR1 to set the loudest (and most nauseating) frequency. This is then buffered by transistor TR1 to drive the piezo sounder WD1.

Piezoelectric devices are excellent for low power consumption but are not generally loud enough to be heard far away. This problem is easily overcome by connecting an inductor L1 across it. When transistor TR1 is switched on an off at the high pitched audio frequency, L1 "rings" and provides a large voltage swing across the transducer WD1, giving a greatly increased volume than otherwise available.

Fig. 2. Complete circuit diagram for the Vibration Sensitive Alarm.



If an inductor is not readily available, it can be substituted with a resistor, typically 10 kilohms, and the unit will function as normal except for the reduced volume, which might still be sufficient in many cases.

Diode D1 is provided to protect the unit against accidental battery reversal.

CONSTRUCTION

The complete unit can be built up on a piece of 0·1in matrix stripboard, size 36 holes by 17 strips, and the topside component layout is shown in Fig. 3. There are 14 copper track breaks required and these are shown in the underside plan view.

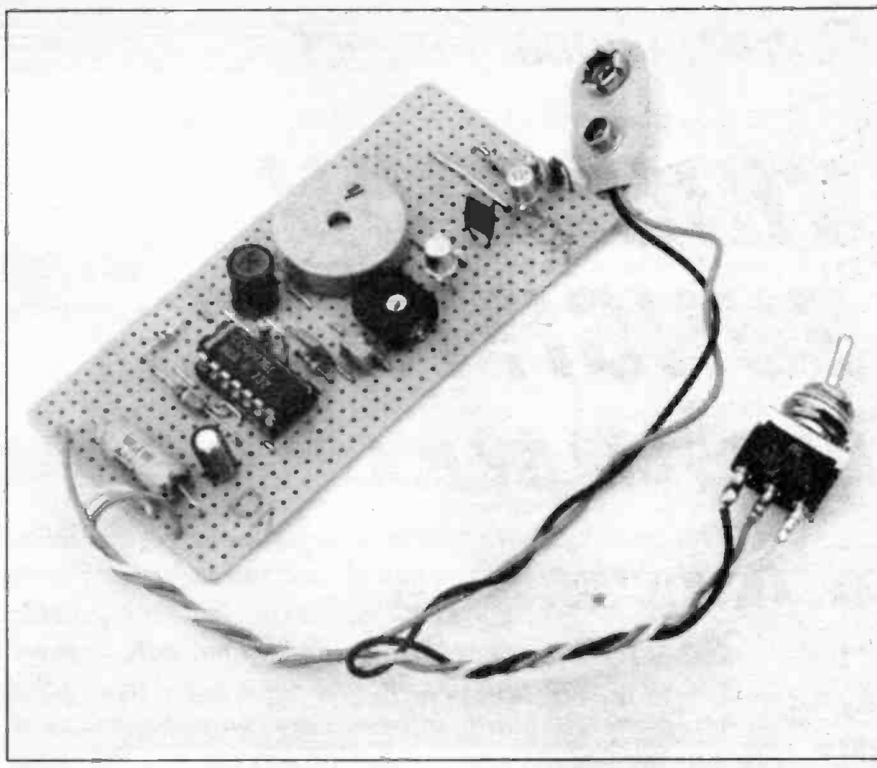
Commence construction by inserting the 11 link wires and i.c. socket. This provides a good reference point when mounting components later. The i.c. should not be mounted in it's socket until all wiring has been completed and checked.

The small links can be made with bare off-cuts from component leads, but the longer ones should be made with insulated wire. Before adding the components, double check the position and wiring of the links; this will save a lot of headaches at the testing stage.

The rest of the components should now be mounted and soldered on the circuit board. The order should be in ascending size, i.e. diodes, resistors, capacitors . . . transducer.

It might be wise to leave the transistors until last as they are not to happy about being exposed to heat and they must be put in the right way round. Also, be careful to check the polarity of the diodes and the electrolytic capacitors.

It only remains to wire the slide switch to the board and the battery clip leads to the board and switch. In this design, the On/Off slide switch is wired in the negative, black, battery lead. This is to ensure that in the off position the electrolytic capacitor C2 is discharged.



No details have been provided for a case and this has been left to individual choice. However, a small hole or series of holes should be drilled in the case above the sound transducer.

TESTING

Once assembled, check the board for any errors or solder shorts across copper tracks, plug the i.c. into its socket and connect up the battery. The diode D1 protects against reverse battery polarity.

Switch on and wait a few seconds while the unit resets itself, via R1/C2. Tap the piezoelectric transducer WD1, this should give out a pulsed high pitched sound.

Leave the alarm running and adjust preset VR1 for the loudest and most annoying output. This type of sound carries a long way and would, hopefully, deter most unwanted intrusions. □

COMPONENTS

See SHOP TALK Page

Resistors
R1, R6 100k (2 off)
R2 1M5
R3 47k
R4 3k3
R5 1M
R7 220k
All 0·25W 5% carbon film

Potentiometer
VR1 100k skeleton carbon preset, lin.

Capacitors
C1 100µ axial elect., 35V
C2 10µ radial elect., 16V
C3, C5 100n ceramic or poly (2 off)
C4 10n ceramic or poly

Semiconductors
D1, D2 1N4148 signal diode
TR1, TR2 BC108 *npn* silicon transistor (or similar)
IC1 4093 quad 2-input CMOS Schmitt trigger

Miscellaneous
L1 10mH p.c.b. mounting choke
S1 Single-pole slide or toggle changeover switch
WD1 Piezoelectric transducer
Stripboard, 0·1in. matrix, size 36 holes x 17 strips; 9V PP3 battery and connector leads; plastic case to choice; board spacers; fixing nuts and bolts; solder etc.

Approx cost guidance only **£4** plus case

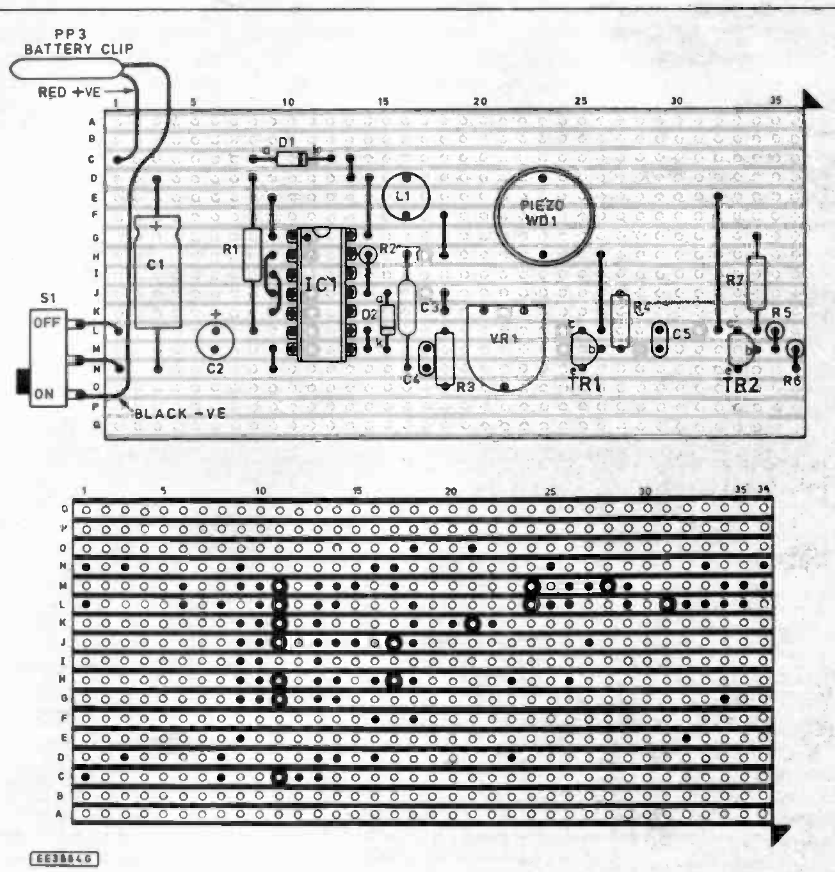
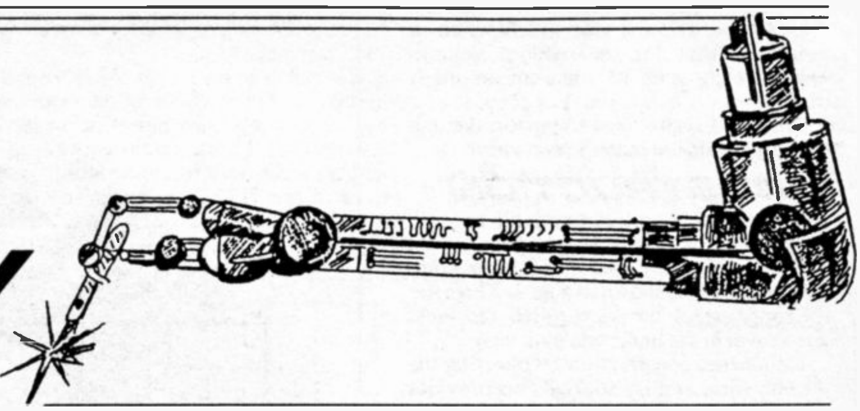


Fig. 3. Stripboard component layout and underside details of breaks required in the copper tracks.

Regular Clinic

CIRCUIT SURGERY



MIKE TOOLEY B.A.

Welcome again to* Circuit Surgery, *our regular clinic for readers' problems and a particularly warm welcome to readers of* Practical Electronics. *For the benefit of our new readers,* Circuit Surgery *provides a regular "self-help" forum for readers problems. We aim not only to provide a regular cocktail of practical hints and tips but also some rapid feedback (including modifications and trouble-shooting information) concerning many of the projects which have appeared in the pages of both* Everyday *and* Practical Electronics. *Naturally, this column relies almost entirely on input from readers, so please drop me a line and let me know what topics you would like me to cover.

This month's *Surgery* should have a particular appeal to the audio enthusiast. We shall be describing some simple circuitry for compressing audio signals, a power supply for a low-noise pre-amplifier stage, and also suggesting some useful background reading on "digital audio".

Finally, for those who may not be so interested in audio, we include some information on the popular RS-232 serial communications interface.

Constant level

Audio enthusiast ***Chris North*** writes from Bristol with a request for a simple circuit which will help him keep the level of a microphone signal reasonably constant. Chris writes:

"I am regularly involved with public address work and often have difficulty with varying microphone levels. I need a circuit which will accept a signal from a medium impedance dynamic microphone and deliver a constant output signal to the power amplifier."

The output signal from a microphone can vary from less than a hundred microvolts to several tens of millivolts depending upon the distance of the source and the intensity of the sound and such varying signal levels can be a real problem with public address equipment.

Unfortunately, inexperienced public address users are often blissfully ignorant of this fact and frequent adjustment of the volume control may be required in order to provide an acceptable output level (neither deafening an audience nor straining their ears).

The solution to this particular problem is a circuit which will provide a rapidly falling voltage gain as the amplitude of an input signal is increased above a threshold level. Such a circuit is known as a "compressor" and a practical example (based on two commonly available operational amplifiers) is shown in Fig. 1.

The compressor circuit can be used to replace an existing microphone preamplifier but offers the advantage that its output remains reasonably constant (at about 2V peak-peak) for any input greater than 20mV peak-peak. The circuit has a frequency response which extends from 100Hz to over 10kHz and thus should be more than adequate for most public address work.

Preset VR1 sets the amount of compression provided by the circuit and the correct setting for this component will usually require a little experimentation. If no compression is required, VR1 should be set to minimum (slider at 0V). In this case, the circuit will operate as a "straight" preamplifier with a voltage gain of about 750 (the signal shunt, TR1, will never be driven into conduction).

If high-quality low-output microphones are to be used, greater sensitivity may be required. In this case both R2 and R7 can be increased to 470k. The onset of compression will then be reduced to approximately 5mV with VR1 at maximum setting.

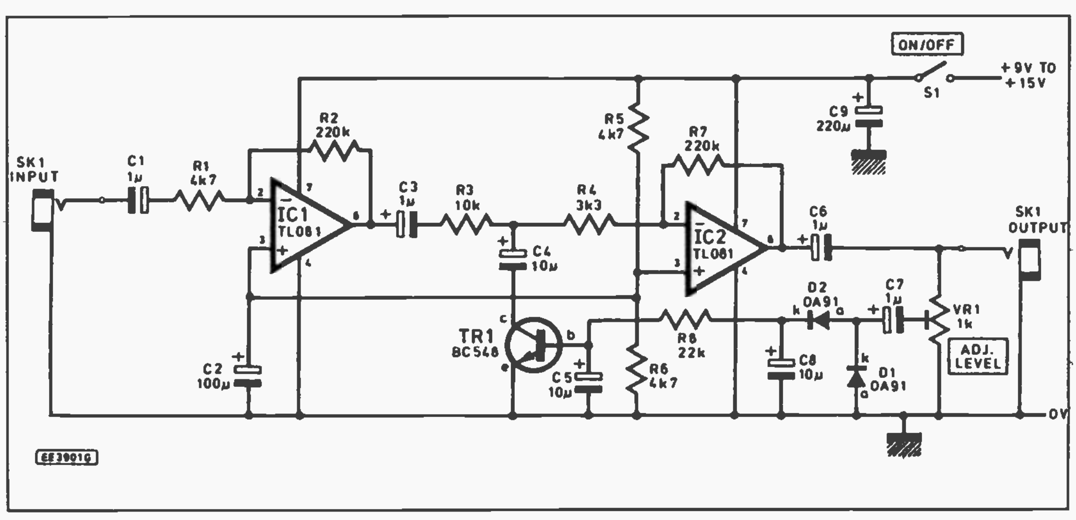
30V power supply

Regular reader ***Simon Jones*** writes from Liverpool with a request for information on the design of a 30V power supply. Simon writes:

"I am constructing an ultra low-noise preamplifier based on a TDA3410. This requires a 30V power supply. Can you provide me with a circuit which can power two identical pre-amplifiers using this chip?"

The TDA3410 requires a fairly modest supply current (approximately 10mA) and thus a simple

Fig. 1. Circuit of the audio compressor.



transformer/rectifier/regulator combination should suffice, see Fig. 2.

The 14-pin d.i.l. regulator (IC1) is capable of operation over a very wide voltage range (2V to 37V at a maximum load current of 150mA) and thus should be more than adequate for this application. The output voltage of the power supply is set by means of VR1 whilst the current limiting resistor (R2) has been chosen so as connected in series. Maplin's WB10L is ideal for use in this circuit. The bridge rectifier, D1-D4, is a W01 device (100V PIV) rated at 1A.

It is worth pointing out that care should be taken when positioning the power supply within the pre-amplifier enclosure. The transformer, T1, and mains wiring should be kept well away from the input connections to the TDA3410 devices in order to

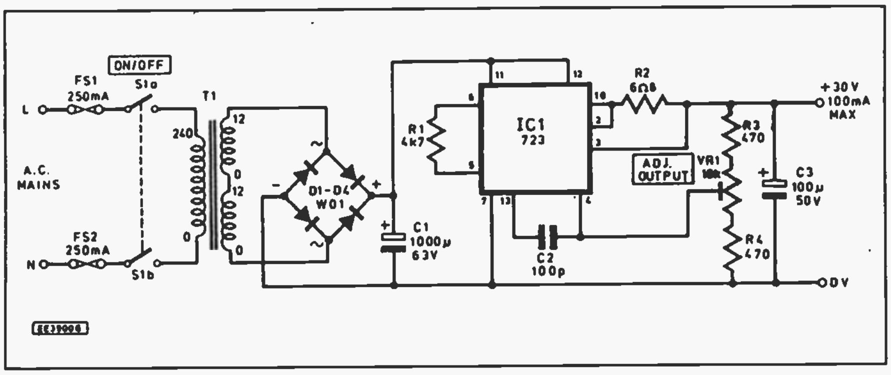


Fig. 2. Circuit of the 30V power supply.

to provide a maximum output current of 100mA (sufficient for several TDA3410 devices).

The mains transformer, T1, should be rated at 6VA (or more) and should have two 12V secondaries (each rated at 250mA) prevent hum and induced noise. Furthermore, an earthed metal enclosure should be employed (with ground connections taken to a single common earth point in order to prevent earth loops) and all internal signal wiring should use screened audio cable.

Digital audio

Judging from a number of readers' letters "Digital Audio" is quite a "hot" topic these days! Unfortunately, the subject often does not feature in many of the older textbooks and several readers have asked me to suggest sources of information. Two books which are well worth reading are:

The Art of Digital Audio (Focal Press, ISBN 0-240-51270-7) by John Watkinson provides an excellent introduction to the subject. It contains all of the essential theory of digital audio and should appeal to those with little previous experience of the subject. John Watkinson provides a very detailed description of digital audio coding, processing and conversion without getting too bogged-down in complex mathematics. The book then continues with a description of a number of current digital standards and error correcting techniques before describing a variety of equipment.

Digital Audio and Compact Disk Technology (Heinemann Newnes, ISBN 0-434-91868-7) is edited by staff from the Sony Service Centre (Europe) and contains a wealth of information relating to a wide variety of digital audio equipment. The book provides a useful introduction to the principles of digital signal processing, sampling, quantization, conversion and coding and also contains chapters on Compact Disk players, Video 8, Digital Audio Tape (DAT) and Digital Audio Stationery Head (DASH) formats.

Modem connections

George Smith writes from Edinburgh with a query relating to the the serial port connections on a BBC Micro:

"On reading your Circuit Surgery *article in which you supplied Mr Ron White with connection details of the SCART connector, I wonder if you could help me with a similar problem.*

I purchased a British Telecom Mainstream modem model FM 1200 from a sale. Unfortunately it did not contain any technical data. The problem is that there is a 25-way D-socket on the rear panel of the modem which I wish to connect to the 5-pin domino DIN socket fitted to the RS-423 port of a BBC Micro.

The pins on the RS-423 port are: A – data in; B – data out; C – 0V; D – CTS; and E – RTS. Do you have any idea of the pinout of the 25-way D-socket?"

The RS-232/CCITT V.24 interface undoubtedly reigns supreme as the most widely used standard for serial communication between microcomputers, peripheral devices, and remote host computers. which were not defined under RS-232C. The standard was first defined by the Electronic Industries Association (EIA) in 1962 as a recommended standard (RS) for modem interfacing.

RS-232 relates essentially to two types of equipment; Data Terminal Equipment (DTE) and Data Circuit Terminating Equipment (DCE). Data Terminal Equipment (e.g. a microcomputer) is capable of sending and/or receiving data via an RS-232 serial interface. It is thus said to "terminate" a serial link.

Data Circuit Terminating Equipment (formerly known as Data Communications Equipment), on the other hand, is generally thought of as a device which can facilitate serial data communications and a typical example is that of a modem (modulator-demodulator) which forms an essential link in the serial path between a microcomputer and a conventional analogue telephone line.

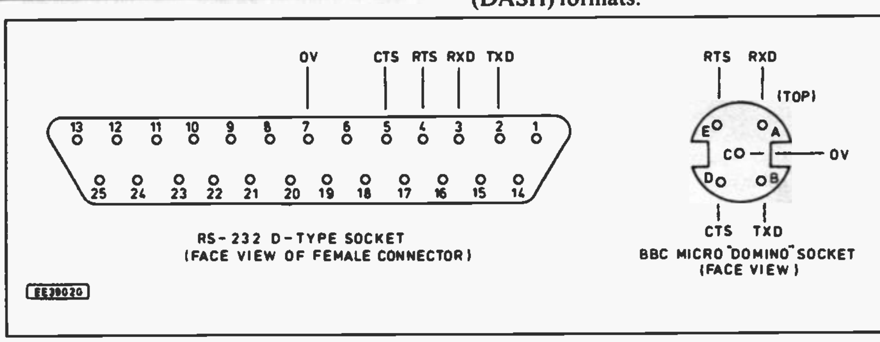


Fig. 3. Pin connections for the 25-way D-Connector.

Data terminal equipment (DTE) is normally fitted with a male connector whilst data circuit terminating equipment (DCE) conventionally uses a female connector (note that there are a few exceptions to this rule!).

Fortunately the solution to Mr Smith's problem should be fairly straightforward since the BBC Micro uses only a subset of the full set of RS-232 port connections. Furthermore, the wiring of the 25-way modem connector should be reasonably standard and should obey the following convention in respect of the most important signals present:

Pin no:	Signal	Function
1	FG	Earth connection to the equipment frame or chassis.
2	TXD	Serial data transmitted from DTE to DCE.
3	RXD	Serial data received by the DTE from the DCE.
4	RTS	When active, the DTE is signalling that it wishes to send data to the DCE.
5	CTS	When active, the DCE is signalling that it is ready to accept data from the DTE.
6	DSR	When active, the DCE is signalling that a communications path has been, properly established.
7	SG	Common signal return path (0V).
8	DTR	When active, the DTE is signalling that it is operational and that the DCE may be connected to the communications channel.

Next month:

In next month's *Surgery* we shall be attempting to explain the mysteries of "safe area protection". We shall also be taking a look at several probes which can be used to extend the functions provided on basic test equipment. We also have a "round-up" of hints and tips sent in by readers over the past six months.

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.

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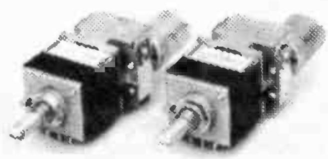

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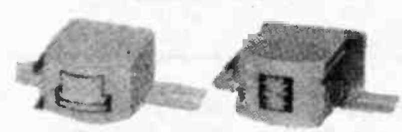

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INTERFACE

Robert Penfold

JUDGING from readers' letters, playing around with stepper motors is currently a popular pastime for the electronic hobbyist. Driving stepper motors is actually much more simple than many people seem to imagine. It looks complex because most stepper motors have about six leads, as opposed to the two of an ordinary d.c. motor.

Also, stepper motors are normally driven via special driver circuits which are almost invariably based on dedicated integrated circuits. The circuit diagram therefore gives few clues as to what is going on.

Next Step

The stepper motors that are available to the hobbyist are virtually all of the four-phase variety. You need to be slightly wary of cheap surplus stepper motors as these are often something other than four-phase types, and could be very difficult to drive properly. Fig. 1 shows the basic way in which a normal four-phase stepper motor functions.

The basis of the motor is two electro-magnets in an "X" formation. Each electro-magnet has two coils wound in anti-phase, so that the polarity of the magnetic field can be changed by switching over from one coil to the other.

Obviously the same thing could be achieved by having a single coil and changing the polarity of the drive voltage. However, the driver circuit can be more simple if twin anti-phase windings are used.

A bar magnet is fitted to the drive shaft, and the orientation of this magnet will depend on the polarities of the electro-magnets. Bear in mind here that like poles repel, and unlike poles attract.

As you will see from Fig. 1, by altering the polarities of the electro-magnets in the correct manner the bar magnet can be dragged round in 90 degree increments. By repeating the sequence over and over again the magnet can be made to rotate continuously. By reversing the sequence it can moved in the opposite direction.

In a practical stepper motor there are usually several sets of electro magnets, giving much smaller steps. The Maplin stepper motor for instance, has 7·5 degree steps, or some 48 steps per complete turn.

Clearly a much finer degree of control will be needed in most applications, but this can be provided by some step-down gearing. For example, with an eight-to-one step-down ratio there would be 384 steps per turn, and slightly better than one degree resolution.

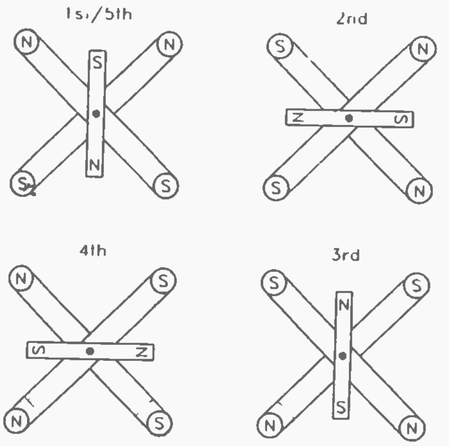


Fig. 1 Method of operation used in a four-phase stepper motor.

Stepping Power

An important point to bear in mind is that stepper motors are not very powerful, and even with the aid of step-down gearing they can only drive light loads. It should also be borne in mind that they are not really a good choice where continuous rotation is required. An ordinary d.c. electric motor can usually handle that type of thing perfectly well, and at a fraction of the price.

Four-phase stepper motors have six leadout wires. Two of these are "common" leads which simply connect to the positive supply rail. The other four are driven from open collector outputs, which should include protection diodes because the solenoids in the motor obviously provide highly inductive loads.

One way of handling things is to simply control the solenoids directly from some digital outputs of the computer. Outputting the appropriate values in the correct order then steps the motor in the required direction. Most people prefer to use a proper driver circuit, which usually means one based on the SAA1027 integrated circuit. Control of the motor is then very straightforward, and is achieved using two outputs. Pulses on one output provide stepping of the motor, while the logic state of the other output determines the direction of the motor.

Next month we will consider some practical stepper motor interface circuits.

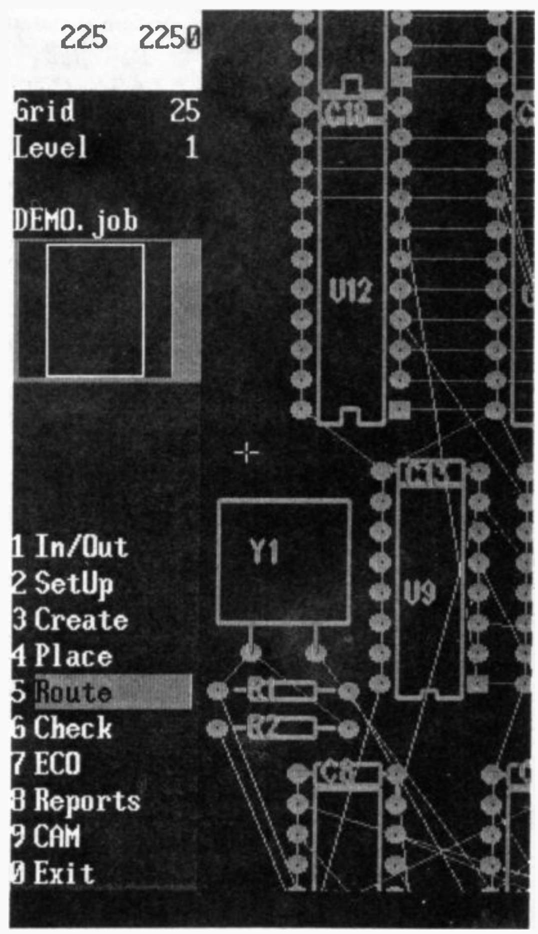
P.C.B. Shareware

In the past there has been plenty of high cost software for producing printed circuit board designs on a computer, but there has been little low cost commercial or shareware software of this type. In recent times some good low cost p.c.b. software has appeared, some existing programs have been subjected to spectacular price cuts, and some good shareware p.c.b. programs for the PCs have appeared. I reviewed the British produced "Quickroute" a couple of months ago, and this was probably the first shareware program to offer a real alternative to the low cost commercial p.c.b. programs.

Pads-PCB

Now there are two new shareware p.c.b. programs for the PCs in the form of "Pads-PCB" from the USA, and "LAYO1" from France. These are both sophisticated programs, and "Pads-PCB" would seem to be the most advanced shareware p.c.b. program currently available. It has facilities which rival the cheaper and mid-priced commercial offerings.

Unfortunately, it is sufficiently advanced to be *unusable* on many PCs. To run this program you require at least an 80286 based PC fitted with 640K of RAM and a hard disk with at least seven megabytes of free space. A V.G.A. display is also needed, and some super V.G.A. modes are also supported.



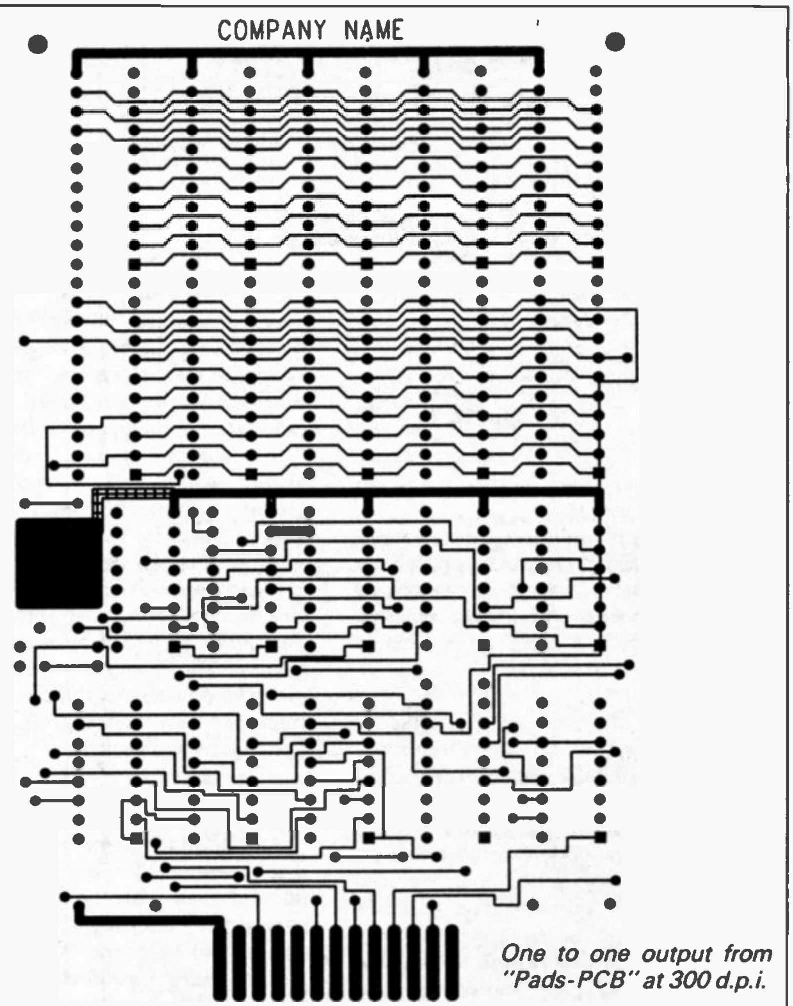
Part of a screen dump from "Pads-PCB". Showing a zoomed "ratsnest" and menu bar and status information.

Control of the program is via a combination of the keyboard and a Microsoft compatible mouse. The program is supplied on three high density 3·5 inch or 5·25 inch disks.

There are really two programs, one of which is a front-end which is used to produce circuit diagrams (or "schematics" in American terminology), and to produce netlists which are fed to the second program. A netlist is basically just a components list together with details of all the interconnections.

The second program takes the netlist and converts it into physical representations of the components, complete with a "ratsnest" of interconnections. The components can be placed onto the board manually, or there is an auto-placement facility which can be used. This is quite an advanced feature which is normally only found on very expensive p.c.b. design programs.

In the "ratsnest" each connection runs straight from one pin to the next, probably crossing several other tracks and a few pads on the way. Each track therefore has to be carefully routed to avoid any short circuits. The routing can be performed manually, and there are plenty of editing tools which permit corners and angles to placed in the tracks, the track width to be varied, etc.



One to one output from "Pads-PCB" at 300 d.p.i.

Auto-Routing

There is also an automatic routing facility with various options that can alter its approach to routing a "ratsnest". In common with other auto-routers which use "maze-search" and other relatively simple methods, it will work quite well with certain types of board, but is virtually useless with many other types.

The problem with virtually all auto-routers is that they tend to produce complex two-sided layouts, whether or not the design really justifies it. Also, they generally complete about 90 per cent or so of the tracking, leaving the user to finish the rest.

This would be fine, but most auto-routers tend to "paint you into corners", possibly leaving a board that is impossible to finish without some substantial redesigning. Simple auto-routers are great fun to try out, but are not usually of much practical help.

The "Pads-PCB" actually has two auto-routers, and these seem to be better than most. Although the success rate is not exceptionally high, the routers do seem to route the tracks more sensibly than much of the competition.

Both routers are also much faster than many other auto-routers I have tried. Great claims are made for the 100 per cent rip-up-and-retry and "power" routers, but unfortunately these are not included in the shareware version of the program.

The netlist approach is the one favoured by most professional p.c.b. designers, but it is a bit over the top if you only need to draw up relatively simple printed circuit designs. Like most p.c.b. design programs, "Pads-PCB" allows you to use the p.c.b. design part of the program as an electronic drawing board if that is all you need.

The program can output to a wide range of devices, including dot-matrix printers, laser printers, plotters, and photo-plotters. I tried printing out one of the demonstration designs on a 24-pin dot-matrix printer and a 300 d.p.i. laser printer, and the quality seemed to be about as good as the printers would allow.

In a short review of this type it is impossible to cover such a complex piece of software in detail. It is a very sophisticated and well thought out program, and it seems to be reasonably bug-free. There is plenty of documentation in the form of ASCII files on the disk, and the documentation is very concise and complete by shareware standards.

If you have a suitable computer and you are interested in electronics, then this is a program that you should definitely give a try. The running demonstration for the p.c.b. section of the program will give you a good idea of what "Pads-PCB" can do.

The shareware version is limited to logic boards having about 30 integrated circuits, or analogue boards having an equivalent number of interconnections. However, this should be sufficient for the majority of do-it-yourself projects.

If the shareware version is sufficient for your needs, then "PADS Software Inc." are apparently quite happy for you to go on using their program, with no registration fee being required. All you pay is the £18-00 (including V.A.T. and postage) for the three high density distribution disks. This must be one of the best software buys of all time!

LAYO1

It is difficult to comment on the "LAYO1" program. It is produced in France, but the on-disk documentation is in English. At least, it is almost in English. Unfortunately, the documentation is rather cryptic and contains more than a few errors. The program seems to be fairly sophisticated – it includes an auto-router for example. I found it difficult to get this program to do anything worthwhile though.

The hardware requirements seem to be similar to those of "Pads-PCB", and the program is supplied on a single high density disk. Be warned that the installation program generates a large sub-directory structure which it fills with dozens of files. If you have suitable computer equipment it is probably worth giving this program a try, but you will need plenty of time to work out how to use it!

"LAYO1" and "Pads-PCB" are available from *The PDSL, Dept EE, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL* (☎ *0892 663298*), and are on disks H027 and H031A/B/C respectively. They might be available from other shareware libraries, but will have different catalogue numbers.

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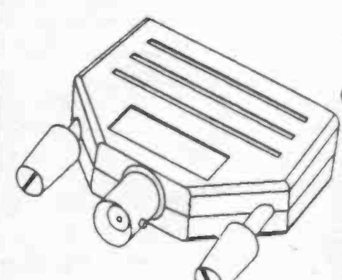

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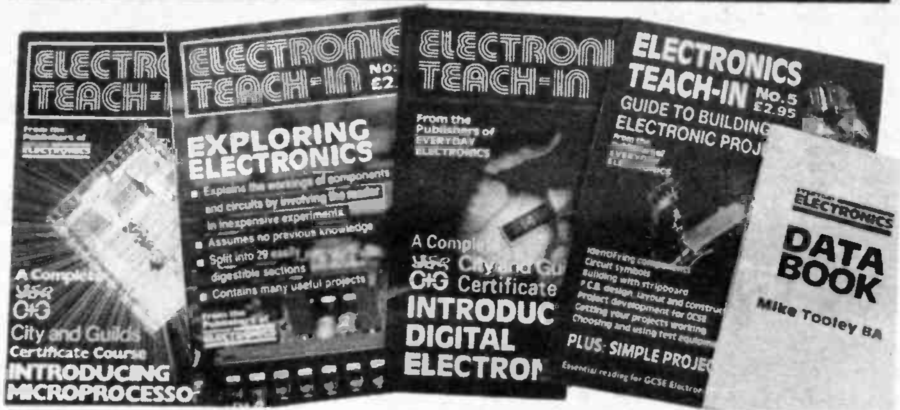

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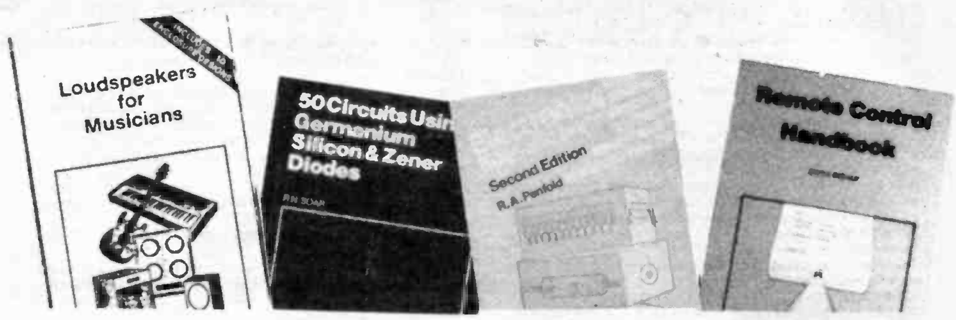

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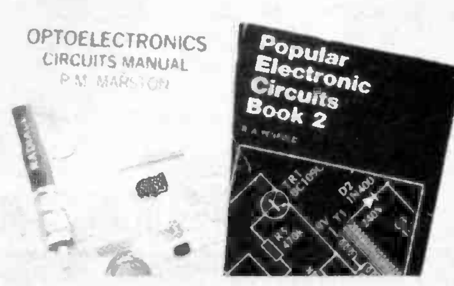

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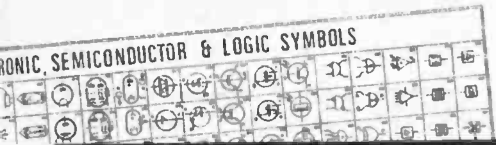

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Humidity Tester [APR'91]	716	£4.97
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Electronic Die (Teach-In '91 Project 5)	737	£4.93
Teach-In '91 Part 5 – Digital Counter Module	738	£4.35
Modular Disco Lighting System [MAY'91]		
Switched Power Output Module	739	£5.91
Digital LCD Thermostat – Control Board (£5 for pair)	740	£4.05
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Pulse Generator (Teach-In '91 Project 6)	742	£4.97
Teach-In '91 Part 6 – Timer Module	743	£4.62
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Automatic Light Control – PSU Board [JUN'91]	747	£4.88
Logic Board	748	£5.17
Radio Receiver (Teach-In '91 Project 7)	749	£4.57
Teach-In '91 Part 7 – R.F. Amplifier Module	750	£4.23

PROJECT TITLE	Order Code	Cost
Modular Disco Lights – Masterlink [JULY'91]	752	£6.36
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Mod. Disco Lights – Pattern Gen [AUG'91]	760	£6.79
Teach-In '91 Part 8 – Light Sensitive Switch	761	£4.74
Opto-Link (Teach-In '91 Project 9) – Transmitter	762	£4.85
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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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PSU	777	£4.73
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

WHAT'S IN A NAME?

From the earliest days, radio amateurs in the United States have been known as "radio hams", or simply "hams", although amateurs in some countries have resisted the term for various reasons, preferring to be known as "radio amateurs". Some are simply resisting the spread of "Americanisms", and others see it as a derogatory term, wrongly implying a less than satisfactory level of competence.

There are any number of different explanations of the origin of the term. One version credits three amateurs whose combined initials spelt out the word HAM to provide their station's call-sign. This particular station is said to have been discussed by Congress when considering a Wireless Regulations Bill in 1911, and nationwide publicity of the proceedings resulted in the term being used from that time on to describe all amateur radio stations.

Another version describes how *Home Amateur Mechanic* magazine, in the early 1900's, published details of how to build the "Home Amateur Mechanic" (HAM for short) radio. Thus, those who built and used these sets became known as HAM radio operators.

A less complimentary explanation is that landline Morse operators used the word to describe inexperienced or poor operators. I have a copy of *The Telegraph Instructor* by G. M. Dodge, proprietor of Dodge's Institute of Telegraphy in Valparaiso, Indiana, 4th edn. 1908, for instance, which defines a "ham" (or alternatively a "plug") as a telegraph operator who is not proficient. It has been suggested that the professionals extended this term to apply to the new amateur radio operators who were trying to emulate their skills.

SKILLED INVOLVEMENT

There are any number of other sug-

amateur radio operator. This policy was revoked early this year after taking into account "the increased use, public understanding and acceptance of the expression to denote a radio amateur without any derogatory intent; the meanings of 'ham' and 'amateur' in the Australian Macquarie dictionary; and the need to explain amateur radio in terms easily understood by the public and so raise their awareness of our hobby."

Having said that, the WIA added a conciliatory note for the benefit of the "anti-hams" to the effect that it was not actively advocating the use of the word "ham", but was simply no longer objecting to people using it when describing an amateur radio operator.

ANNUAL REPORT

The 1991/92 Annual Report of the Radiocommunications Agency, as ever, covers the whole range of the Agency's activities, national and international, involving many different types of radio service from amateur to popular radio and TV broadcasting, including technical issues, law enforcement, and much more. Space permits reference here only to hobby radio but a free copy of the full report can be obtained from the RA Information and Library Service, ***Tel: 071-215 2352.***

In the year under review, a contract for amateur licence distribution was awarded to Subscription Services Ltd (SSL), a subsidiary of the Post Office, the aim of which was to achieve cost savings and an improved licence issue service.

The Agency and the Radio Society of Great Britain have been working to improve the management of the amateur repeater network and a new licensing procedure has been introduced. A scheme for reporting interference on the amateur bands to the Agency has also been estab-

already led to some

saw the launch of
(Novice) Licence,
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cy has sought views
radio community on
third party traffic by
cy continues to spon-
teur of the Year Award,
e given in this column,

h 1992, there were

33,280 Amateur Radio "A" Licences, 27,738 "B" Licences, 46 Novice "A" licences, and 378 Novice "B" Licences, representing an increase of 558 in the total number compared with the previous year.

The Radio Investigation Service continued to investigate interference and other problems over the whole range of licensed transmissions covered by the Agency. Four amateurs were prosecuted and convicted for activities contravening the licence regulations, and warning letters were sent to three others.

Virtually all amateur radio information sheets published by the Agency were revised during 1991/92 and of particular interest to those considering taking up the hobby is RA 190 *How to become a Radio Amateur* – March 1992, available free of charge by telephoning 071-215 2072 (24-hour answerphone service).

In the CB field, a consultative exercise confirmed the view of users that CB should continue to be a licensed service and licensing was centralised through SSL. The new arrangements are expected to save some £200,000 which would otherwise have had to be recovered by increasing the licence fee.

As at 31 March 1992, there were 64,944 CB licences on issue compared with 69,803 the previous year. 112 persons were prosecuted and convicted for licence offences and 655 warning letters were sent out. A revised set of CB information sheets has been published and these are available from the Library Service, as above.

An intriguing implication of the licence statistics suggests that if the present trend continues the number of amateur licences next year may well exceed the number of CB licences on issue. This compares dramatically with the situation following the introduction of CB in the UK when the number of licences surged initially to around a quarter of a million.

AMATEUR SSB ENHANCER

A recently unveiled amateur radio version of its Link-Plus digital signal processing technology, called the MULE (Multi-Use Link Enhancer), is claimed by Link Plus Corp. of Columbia, Maryland, USA, to eliminate most noise and interference from single sideband voice communications, thus producing a significant boost in effective signal strength.

In 18 separate tests, carried out on three days, over an 1800 mile path under a variety of transmission conditions, Link-Plus processing produced an average 22dB improvement in HF-SSB signal-to-noise ratio. In layman's terms, the unprocessed signal had, on average, 160 times more noise content than the Link-Plus signal.

The MULE connects to any HF radio by external cables, but at $2,995 it is probably beyond the reach of most amateurs at the present time. (*W5YI Report*).

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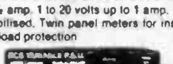

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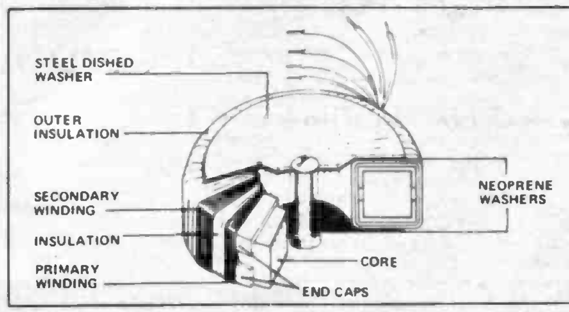

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Battery snaps for PP3 - 6p for PP9 ... 12p
L.E.D.'s 3mm. & 5mm. Red, Green, Yellow - 10p. Grommets 3mm - 2p. 5mm ... 2p
Red flashing L.E.D.'s require 9-12V supply only ... 50p
Mains indicator neons with 220k resistor ... 10p
20mm fuses 100mA to 5A. O. blow 6p. A/surge 10p. Holders, chassis, mounting ... 6p
High speed pc drill 0.8, 1.0, 1.3, 1.5, 2.0mm - 30p. Machines 12V dc ... £7.00
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OMP MOS-FET POWER AMPLIFIERS HIGH POWER/TWO CHANNEL 19 INCH RACK

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THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

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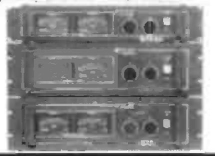

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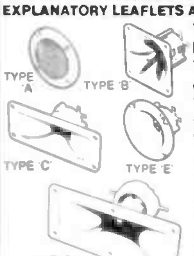

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ALL POWERS INTO 4 OHMS
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PRICES: 150W £49.99 250W £99.99
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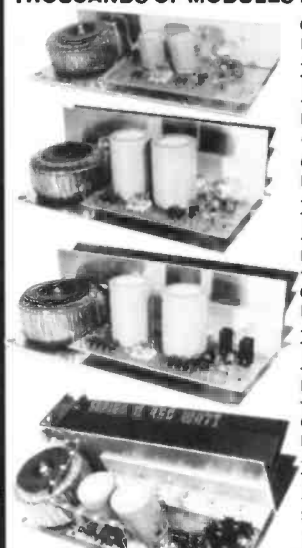

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

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PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

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NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

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