

# ETI

## ELECTRONICS TODAY INTERNATIONAL

TOMORROW'S TECHNOLOGY TODAY

# MOVIE TECHNOLOGY

**How electronics has  
changed the way  
movies are made**

**Build the ETI  
mobile robot**

## PLUS

- *Portable EPROM programmer*
- *Measuring light*
- *Mini data terminal*
- *The Stamp microcomputer*

**NO COVER  
DISK?**

**THEN ASK  
YOUR  
NEWSAGENT**

**FREE DISK**  
PIC microcontroller  
development  
software for PCs

APRIL 1995 £2.50



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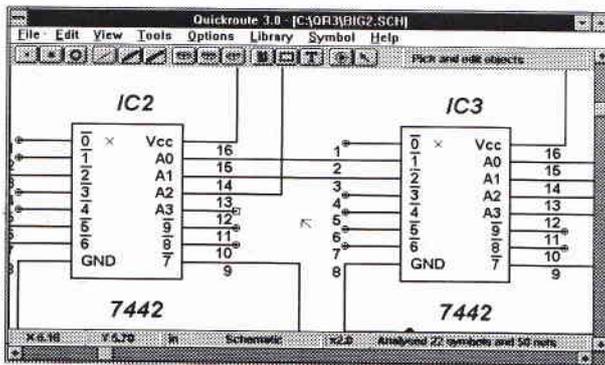
# Quickroute

to successful PCB & Schematic Design

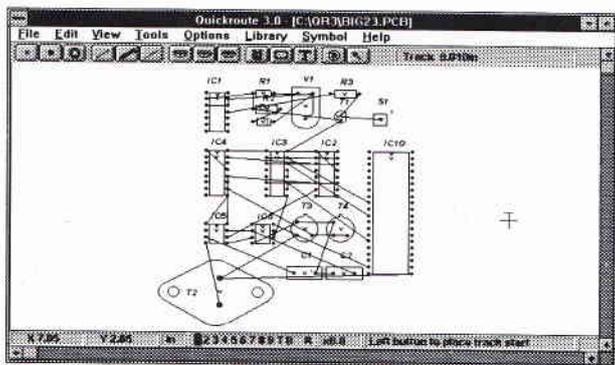
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Design PCB's and Schematics quickly



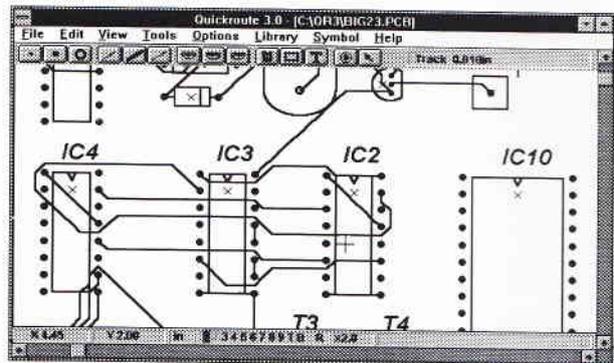
After schematic capture, components can be re-arranged prior to manual or automatic routing.



	Auto Router Max Layers	Schematic Capture	Gerber & NC-Drill	Design Size K nodes
DESIGNER	2 <i>Standard</i>	None	None	10
DESIGNER+	2 <i>Medium</i>	None	Export	20
PRO	8 <i>Fast</i>	Standard	Export	30
PRO+	8 <i>Fast</i>	Advanced	Export/ Import*	40

\*PRO+ can import Gerber files

All versions include an auto-router.



Telephone or FAX POWERware on 061 449 7101

POWERware, 14 Ley Lane,  
Marple Bridge, Stockport,  
SK6 5DD, UK.  
Payment by Cheque, Visa &  
Mastercard Accepted.

Quickroute 3.0 for Windows 3.1

DESIGNER £99.00

PRO £199.00

All prices exclude post & packing, and V.A.T.

DESIGNER + £149.00

PRO+ £299.00



DEMO  
DISK  
Available

# Contents



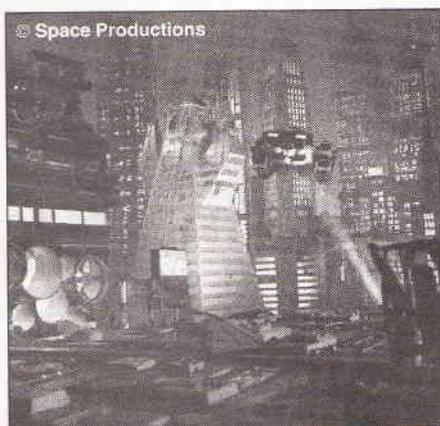
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## Volume 26 No.4

## & Features & Projects

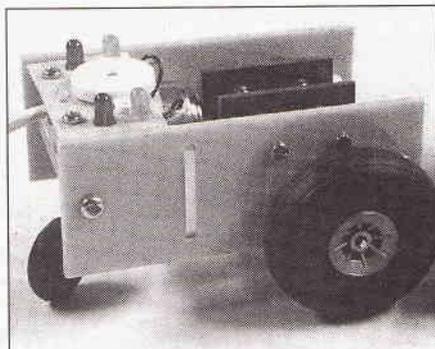
### Electronics in the movies 12

Nick Hampshire takes a look at how computers and electronics are changing forever the way in which films and TV programmes are made, with a special emphasis on the creation of special effects which are such a feature of modern films



### A mobile robot 23

Robots are fun to build and fun to play with. In this issue, Dr Pei An shows how to build a mobile PC controlled robot that could become the basis of bigger things



### Light gun base 34

In part 2 of ETI's laser tag system, Neil Birtles looks at construction of the light gun base. This project has been designed by Robin Abbott and Neil Birtles and is a computer controlled, very sophisticated interactive game for several players that rivals those used commercially

### Analysing light 40

Light is something that we all take for granted, but we are now developing increasing numbers of technologies that use light. Douglas Clarkson looks at some interesting ways of analysing and measuring light

### NiCad battery charger 44

A lot of different NiCad battery charger circuits have been published over the years but this one designed by Richard Tanfield is just that bit better

### PC Clinic 52

Part 10 of the series which shows readers how to repair, maintain, upgrade, and build circuits for, personal computers. In this issue we look at using, choosing and upgrading sound boards

### Parallax Stamp review 54

We take a look at the Parallax Stamp, an ultra-small and very low-cost computer that is easily programmable in BASIC and can be applied to solving a wide range of control problems that would previously have required complex dedicated circuitry

### A portable EPROM programmer 56

A portable EPROM programmer can be a useful addition to one's toolkit. Richard.Grodzik shows how to build one

### LCD based mini terminal 64

In this, the first of a regular series of projects designed around the Parallax Stamp, we take a look at how to use this versatile little computer system to form the heart of a simple user-interface terminal based on a 16 character LCD dot matrix display

### Garden Shed Alarm 67

Last month, Tim Parker discussed the sensors and circuit description of a multi-function security alarm. Here, he looks at its installation and testing

## Regulars

- News and event diary 6
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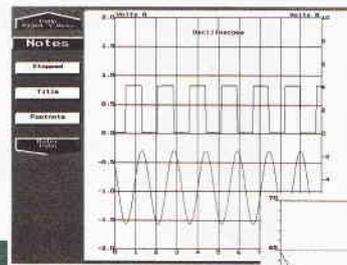
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# Pico Releases PC Potential

Pico's Virtual Instrumentation enable you to use your computer as a variety of useful test and measurement instruments or as an advanced data logger.

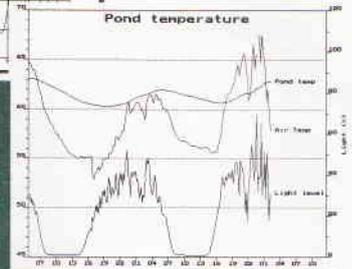


PicoScope 'Virtual instrument' software.

Hardware and software are supplied together as a package - no more worries about incompatibility or complex set-up procedures. Unlike traditional 'plug in' data acquisition cards, they simply plug into the PC's parallel or serial port, making them ideal for use with portable PC's.

Call for your Guide on 'Virtual Instrumentation'.

PicoLog  
Advanced data logging software.



## NEW SLA-16 Logic Analyser

Pocket sized 16 channel Logic Analyser



- Connects to PC serial port.
- High Speed - up to 50MHz sampling.
- Internal and external clock modes.
- 8K Trace Buffer.

SLA-16 with software, power supply and cables £ 219

## NEW ADC-100 Virtual Instrument

Dual Channel 12 bit resolution



- Digital Storage Scope
- Spectrum Analyser
- Frequency Meter
- Chart Recorder
- Data Logger
- Voltmeter

The ADC-100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general purpose test instrument either in the lab or in the field. Flexible input ranges ( $\pm 200\text{mV}$  to  $\pm 20\text{V}$ ) allows the unit to connect directly to a wide variety of signals.

ADC-100 with PicoScope £199  
with PicoScope & PicoLog £209

### ADC-10

1 Channel 8 bit

- Lowest cost
- Up to 22kHz sampling
- 0 -5V input range

The ADC-10 gives your computer a single channel of analog input. Simply plug into the parallel port and your ready to go.

ADC-10 with PicoScope £49  
PicoScope & PicoLog £59

Carriage UK free, Overseas £9  
Oscilloscope Probes ( x1, x10 ) £10  
Existing ADC 10/11/12/100 users can add PicoLog for £25

### ADC-11

11 Channel 10 bit

- Digital output
- Up to 18kHz sampling
- 0 -2.5V input range

The ADC-11 provides 11 channels of analog input in a case slightly larger than a matchbox. It is ideal for portable data logging using a "notebook" computer.

ADC-11 with PicoScope £85  
PicoScope & PicoLog £95

### ADC-12

1 Channel 12 bit

- High resolution
- Up to 17kHz sampling
- 0 -5V input range

The ADC-12 is similar to the ADC-10 but offers an improved 12 bit (1 part in 4096) resolution compared to the ADC-10's 8 bit (1 part in 256).

ADC-12 with PicoScope £85  
PicoScope & PicoLog £95



ADC-10 Simply plug into the parallel port and your ready to go.

### ADC-16

8 Channel 16 bit+sign

- Highest resolution
- 2Hz sampling - 16bit
- $\pm 2.5\text{V}$  input range

The ADC-16 has the highest resolution of the range, it is capable of detecting signal changes as small as  $40 \mu\text{V}$ . Pairs of input channels can be used differentially to reject noise. Connects to serial port.

ADC-16 with PicoLog £115

PICO TECHNOLOGY



Pico Technology Ltd. Broadway House, 149-151 St Neots Rd, Hardwick, Cambridge. CB3 7QJ  
Tel: 01954 - 211716 Fax: 01954 - 211880



Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT

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

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

**LOW COST LASER NIGHT SIGHT** just £79!!!

Cheaper version of our £245 Cyclops model, works ok in low light levels or in complete darkness with the built in Laser. ref 95/79 (please allow about 1 month delivery for these due to import difficulties)

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

**LOW COST RADAR DETECTOR** Built and tested pocket radar detector, ideal for picking up speed traps etc. Why pay £70 or more? ours is just £24.99 ref 95/25

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

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

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

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

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

**SHOP WOBBLERS!** Small assemblies designed to take D size batteries and 'wobble' cardboard model signs about in shop windows! £3.99 Ref SEP42

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

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

**STEREO MICROSCOPE** 155x195MM, up to 600mm high, so items up to 10" will fit under lens. Rack and pinion focusing, 6 interchangeable rotating objective lenses, interchangeable eye pieces, +scaled eyepiece for accurate measuring etc. Powerful low voltage illumination system with green filter and variable intensity, 100mm black/white+ground glass stage plate, 70mm swivel mirror, adjustable eyepieces (both focus and width). Magnification range 4.6-100x, field of view 39-2.4mm. Price is £299 for complete setup. Ref 95/300.

**3D 35MM CAMERA SYSTEM** Complete kit to convert a standard 35mm camera into a 3D version, enable you to take 3D colour slides with your own camera! Kit contains a prism assembly for the front of your existing lens, a sample 3D slide, a 3D slide viewer and 2 different lens mounts 49mm and 52mm, (other sizes available from photo shops at about £3 ea) all you need is standard slide film. Price for the complete kit is £29.99 ref 95/30.

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

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

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

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

**OMRON ELECTRONIC INTERVAL TIMERS.**

Miniature adjustable timers, 4 pole o/o output 3A 240v, HY1230S, 12VDC adjustable from 0-30 secs. £9.99  
HY1210M, 12VDC adjustable from 0-10 mins. £9.99  
HY1260M, 12VDC adjustable from 0-60 mins. £9.99  
HY2460M, 24VAC adjustable from 0-60 mins. £5.99  
HY241S, 24VAC adjustable from 0-1 secs. £5.99  
HY2460S, 24VAC adjustable from 0-60 secs. £5.99  
HY243H, 24VAC adjustable from 0-3 hours. £8.99  
HY2401S, 240v adjustable from 0-1 secs. £9.99  
HY2405S, 240v adjustable from 0-5 secs. £9.99  
HY24060m, 240v adjustable from 0-60 mins. £12.99

**PC PAL VGA TO TV CONVERTER** Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. £49.95. Ideal for laptops or a cheap upgrade.

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

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

**300v PANEL METER** 70x60x50MM, AC, 90 degree scale. Good quality meter. £5.99 ref MAG 6P14. Ideal for monitoring mains etc.

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

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

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

**FLOPPY DISCS** DSDD Top quality 5 1/4" discs, these have been written to once and are unused. Pack of 20 is £4 ref AUG4P1.

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

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

**MILITARY SPEC GEIGER COUNTERS** Unused as straight from Her Majesty's forces. £50 ref MAR 50P3.

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

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

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

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

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

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

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

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

**300DPI A4 DTP MONITOR** Brand new but shop soiled so hence bargain price! TTL/ECL inputs, 15" landscape, 1200x1664 pixel complete with circuit jig to help you interface with your projects. JUST £14.99. REF JUN15P2.

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

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

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

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

**SWITCHED MODE PSU** ex equip, 60w +5v @5A, -5v @ 5A, +12v @ 2A, -12v @ 5A 120/220v cased 245x88x56mm IEC input socket £5.99 REF MAG7P1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**LQ3600 PRINTER ASSEMBLIES** Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc In fact everything bar the case and electronics, a good stripper £5 REF: MAG5P3 or 2 for £8 REF: MAG8P3

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

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

**\*FM TRANSMITTER** housed in a standard working 13A adapter! the bug runs directly off the mains so lasts forever! why pay £700? or price is £26 REF: MAG26 Transmits to any FM radio.

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

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

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

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

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

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

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

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

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

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

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

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

**6"x12" AMORPHOUS SOLAR PANEL** 12v 155x310mm 130mA Bargain price just £5.99 ea REF MAG6P12

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

**HEATSINKS** (finned) TO220, designed to mount vertically on a pcb 50x40x25mm you can have a pack of 4 for £1 ref JUN11P1

**INFRARED LASER NIGHT SCOPES**

Image intensifier complete with hand grip attachment with built in adjustable laser lamp for zero light conditions. Supplied with Pentax 42mm camera mount and normal eye piece. 1.6kg, uses 1xPP3, 3xAAA's. Please allow us about 1 month for delivery on this product due to import problems. £245+vat

**NEW HIGH POWER LASERS**

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

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**3FT X 1FT 10WATT SOLAR PANELS**

**14.5v/700mA**

**£44.95**

(PLUS £2.00 SPECIAL PACKAGING CHARGE)

**TOP QUALITY AMORPHOUS SILICON CELLS HAVE ALMOST A TIMELESS LIFESPAN WITH AN INFINITE NUMBER OF POSSIBLE APPLICATIONS, SOME OF WHICH MAY BE CAR BATTERY CHARGING, FOR USE ON BOATS OR CARAVANS, OR ANYWHERE A PORTABLE 12V SUPPLY IS REQUIRED.**

**PORTABLE RADIATION DETECTOR**

**WITH NEW COMPUTER INTERFACE.**

**£59.00**

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

\*SOME OF OUR PRODUCTS MAY BE UNLICENSEABLE IN THE UK

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**250 PORTLAND ROAD HOVE SUSSEX**

**BN3 5QT (ESTABLISHED 50 YEARS)**

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PLEASE ALLOW 7-10 DAYS FOR DELIVERY

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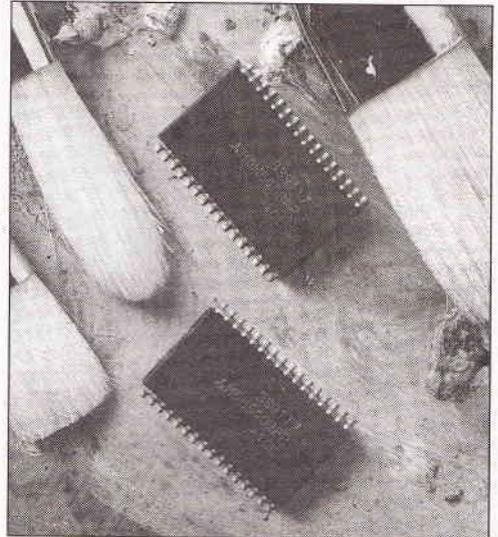
ELECTRONICS TODAY INTERNATIONAL

## LOW POWER, HIGH RELIABILITY 4MBIT TFT SRAMS

Mitsubishi has just started shipping production quantities of its new 4Mbit thin film transistor (TFT) cell based SRAM. The TFT cell, in conjunction with the chip's 0.5um full CMOS circuitry, has realised the high density, low power design which is ideal for high reliability portable applications and telecommunications equipment, as well as IC and memory card type applications where battery back-up is used to provide portable, non-volatile mass data storage.

The 4Mbit device is organised as 512K x 8bits and is available in 55, 70, and 100ns versions. Typical access time of the 70ns version is 45ns. Exceptionally low power provides the optimum solution for portable applications. The 3V SRAM typically consumes just 50mA in operation and 0.4uA at 3V on standby.

For further information contact Mitsubishi in Hatfield on 01843 866 607.



## World's smallest self-resetting fuse

Industry demands for smaller circuit protection devices with higher current carrying capabilities and lower resistance, Raychem is introducing the smallest, surface-mountable circuit protection device available today.

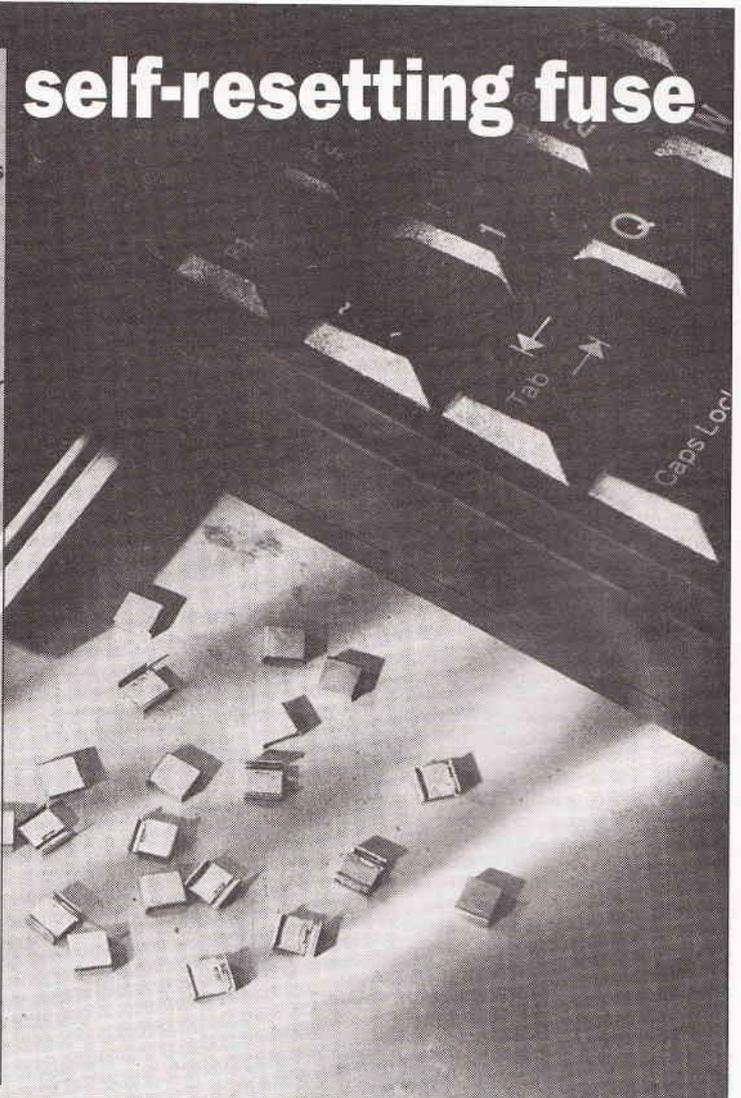
The Polyswitch SMD100-2018 circuit protection device is designed to fit electronics applications. These include hard disk drives and notebook computer adapter cards approved by the Personal Computer Memory Card Industry Association (PCMCIA).

The Polyswitch is just 0.06 inches high, with a 0.2inch by 0.18 inch footprint. It has a hold current rating of 1.1 amps and a maximum voltage rating of 15V. Its maximum resistance is 0.4 ohms.

Unlike fuses, which must be replaced after they blow, the Polyswitch device resets once the power is removed. This results in fewer service calls and lower warranty costs for equipment manufacturers.

The devices are made from solid state conductive material, and form a positive temperature coefficient resistor that has extremely low resistance under normal current flow in an electrical circuit. If an overcurrent occurs, the device switches to a high resistance state, interrupting current flow and preventing damage to the computer's circuitry. After the fault condition is cleared, the Polyswitch device returns to a low resistance state and regular circuit operation resumes.

For further information on this device contact Raychem of Swindon on 0793 528171.



# New Liquid Light



Ultra Violet Products Ltd of Cambridge has launched a new series of liquid filled light guides (LLG) to complement its current range of UV products. With superb optical transmission characteristics and exceptional mechanical strength, these flexible guides offer superb value for money and are ideal for UV curing and medical applications such as endoscope illumination and microscopy.

LLGs, with their high quality optical glass end pieces, provide improved UV transmission coefficients compared to traditional glass fibre filled media, and the risk of fibres breaking is completely eliminated.

Available in lengths from 0.5 to 3.0 metres and with diameters of 3, 5 and 8mm, LLGs have strong spiral cladding which remains kink-free even when it is bent to its minimum radius. An 8mm guide, one metre long, for example, has a bend radius of about 100mm.

For further information contact UV Products on 01223 420022.



## Fast 4MBit SRAMs from NEC

NEC Electronics is claiming to be the first memory manufacturer to be making volume shipments of fast 4Mbit CMOS static RAMs. The new devices have an access time of 20ns (max). In common with NEC's fast 1Mbit products, released in mid 1993, they have centre ground and power pins to minimise 'ground bounce' and provide an easy upgrade path.

There are two products in the series: uPD434004 which is arranged as 1M x 4 bits and uPD434008 arranged as 512K x 8 bits. Both of the products run from a single +5volt supply rail and are available in 20ns and 25ns speed grades.

The uPD434004 is packaged in a 32 pin plastic 400mil SOJ pack. Power dissipation is 0.75watts for the 20ns option and 0.7Watts for the 25ns version. The uPD434008 is packaged in the same manner but dissipates 0.95Watts at 20ns and 0.85Watts at 25ns.

Ground bounce is becoming a serious high speed logic problem and occurs at major output changes. For instance, when all output bits except one change simultaneously from a logic high to a logic low, with one output remaining low. In this case, the single logic low output voltage may rise slightly and be interpreted as a logic high state. Positioning the GND and Vcc pins at the centre of the package rather than at opposite diagonal corners reduces lead inductance and significantly alleviates this problem.

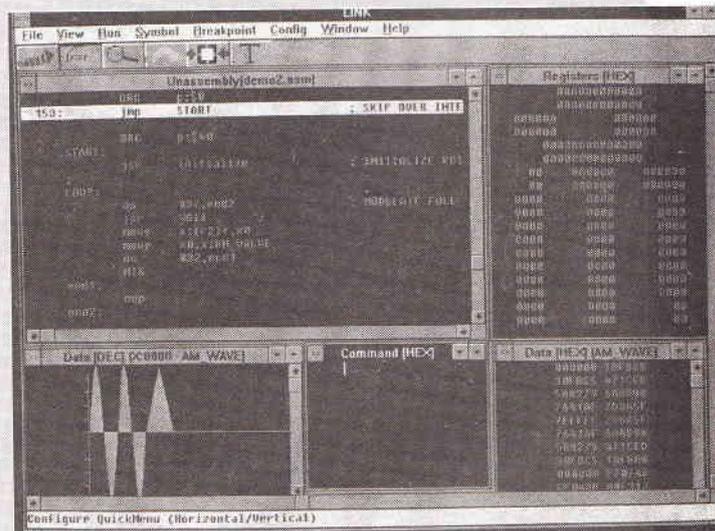
For further details of these chips contact NEC in Milton Keynes, on 0908 691133.

## Windows-based DSP development system

A new Windows-based toolchain for Motorola 56K digital signal processors is now available from Southampton based distributor Pentica Systems. The Link 56 DSP development and test system has been developed by Domain Technologies of Plano, Texas, and offers the user excellent facilities for testing, emulating, and monitoring DSPs within their operating environment.

The system connects between any Windows-based personal computer and the DSP target system. Full speed, non-intrusive emulation preserves all the DSP's internal and external resources. Link 56 also provides code benchmarking, with the ability to time execution between breakpoints.

For further information about this and other Pentica microprocessor development systems contact the company on 0734 792101.



## Breakthrough in LCD display technology

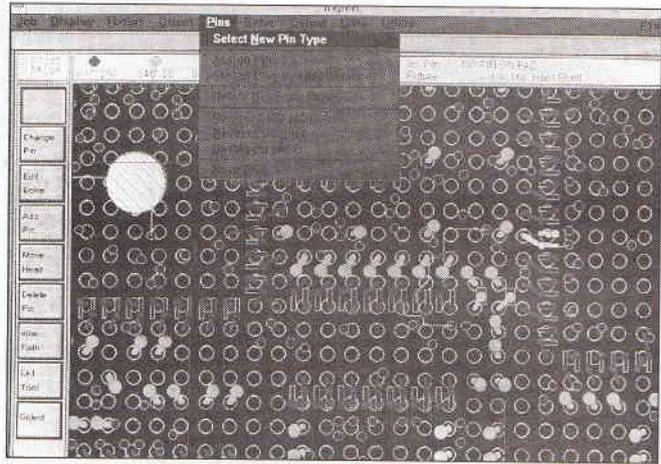
A new range of dot matrix alphanumeric Visilight LCDs have been launched by Bristol and Zurich based company FP Displays. These new dot matrix LCDs will have a wide range of applications in the areas of passenger information - at airports, railway and bus termini, for instance, and for public information/advertising displays, sports events etc.

The new technology - polymer dispersed liquid crystal - differs considerably from previous liquid crystal, which is normally sandwiched between plates of glass. The Visilight range uses a dry film technique and is manufactured on a polymer substrate, allowing production of very lightweight and flexible displays.

The new range of dot-matrix displays offers a number of benefits over traditional LCDs, including the ability to be used as a line matrix display. This allows display messages - both graphics and text - to be scrolled or flashed using a variety of character fonts. The dot matrix displays are currently available in heights of 70, 100 and 150mm.

The main benefit of the Visilight range is its excellent visibility in all lighting conditions combined with a very wide viewing angle of 160 degrees. There are no moving parts, so high reliability is combined with low maintenance costs. The product has an ultra-slim profile and is very lightweight, reducing the enclosure and support structure costs to a minimum. Displays made from Visilight are either reflective or trans-reflective (a combination of reflective and back-lit), providing even greater flexibility, whatever the application.

For further information contact FP Displays of Bristol on 0272 251125.



## Windows based board testing tool

FIXpert, an advanced Windows based software package for automatic creation of drill files and test programs for testing bear boards to original design data has been launched by Worthing-based company Circuitest Ltd. Exceptionally quick and easy to use, FIXpert allows even small PCB manufacturers to create determined fixtures in house routinely, for cost-effective, high integrity test and fault location. Determined fixtures - those which have known connections between the test points of the universal grid tester and the board - speed fault location by identifying the exact board position of the fault automatically. Test programs which test to original design data, rather than relying on a 'known good board' test method, avoid the possibility of the test process corroborating a repeated fault occurring throughout an entire batch. FIXpert software combines both these significantly cost-saving advantages in the familiar Windows environment, offering fast, reliable production of drill files and test programs for full continuity testing to design data.

For further information contact Circuitest on 01903 218086.

## Precision digital multimeter & transistor tester

The Maplin digital multimeter M125 is a high-quality digital multimeter from the highly regarded 'Precision Gold' range, offering a good range of functions at an affordable price. In addition to the standard measurement functions, the unit benefits from the inclusion of a battery tester and an audible continuity tester. The diode test function can also measure transistor forward voltage drop and transistor Hfe measurement is possible for both NPN and PNP devices up to a gain of 999. The unit is compact, battery powered and has a clear 22mm 3<sup>1</sup>/<sub>2</sub> digit LCD readout. The M125 digital multimeter is available from any Maplin Electronics store or by mail order, price £29.99. For further information, contact Maplin on 01702 552911.





For further  
information contact  
Stag Programmers  
Ltd on 0462 442987.

## Sub note book professional programmer

Hitchen-based Stag Programmers has just launched its new battery operated Orbit 48 programmer. It is a truly portable unit but with all the features found on desk-top units and, as such, is the first in the field. Only 29mm high and slightly smaller than this page of ETI, the Orbit 48 can be easily carried in a briefcase or toolbox.

This programmer offers an extensive range of device support which includes popular devices from the world's major manufacturers in the following categories: CMOS PROMs, EPROMs, EEPROMs, FLASH and Intel style (87C51 family) micros as standard, and EPLDs via a low cost docking module.

With a 48pin WideBlade ZIF socket and 4Mbit of RAM expandable to 16Mbits, the Orbit 48 can also programme 16-bit EPROMs, MROM pinout EPROMs, and 8-pin serial EEPROMs - all as standard and all from the one socket. Eight, 16 and 32 bit mode programming is made simple by using the 'Interface 2' feature pioneered by Stag which is far easier and faster than the cumbersome 'split' and 'shuffle' technique.

All the data required to program this vast array of devices is held in FLASH (non-volatile) memory. This has two distinct advantages over other systems. Firstly, the data cannot be corrupted in the way certain RAM based systems can and, secondly, updating the information can be performed without opening up the programmer - data transfer occurs via an I/O port or the programming ZIF socket.

Incorporated into the Orbit 48 is a high speed EPROM emulator which enables code to be run in a target system without having to first commit time and resources to programming and erasing devices. The emulator incorporates an 'Edit while you run' feature which allows the code to be altered even as it is being run in a target system.

Connection to the target system is via a buffered cable. This permits greater distance between emulator and target system without loss of data integrity, and allows device size selection via a series of clearly marked DIP switches. Connection to a computer is via a 9-pin D-type standard serial port connector which supports baud rates of up to 115,200, or via a 25-pin D-type bi-directional parallel port for fast data interchange. All popular data transfer formats are supported including JEDEC standard JESD 3C for PLD programming data.

In remote control, Orbit 48 runs under either Windows or MS-DOS application software. Windows provides graphically enhanced remote control for Orbit 48 from a PC and features an on screen 'programme command' keypad which offers the Windows user simple key push operation.

Local stand-alone operation is performed via a splash-proof tactile keypad with all functions being selected via a menu displayed on a 4-line x 20-character high contrast LCD. Internal rechargeable batteries provide Orbit 48's power source away from the bench. The batteries allow up to 30 hours use in 'edit' mode with data retention in stand-by mode for at least seven months.

## Event Diary

**1-2 March**

Electronic Books International, Wembley Centre, London. Tel: 0171 976 0405

**7-9 March**

Computers in Libraries, Wembley Centre, London. Tel: 0171 9760405

**16-19 March**

Computer Shopper Show, NEC, Birmingham. Tel: 0181 742 2828

**31 March to 17 April**

The Seventh Edinburgh International Science Festival; lots of different events in different parts of the city, For further details contact the organisers on 0131 556 6446.

**9-11 April**

European Computer Trade Show, Business Design Centre, London. Tel: 0181 7422828

**22 April**

International Marconi Day exhibition station at Puckpool Park Wireless Museum, IOW. Tel: 01983 567665

If you are organising an event which you would like to have included in this section, please send full details to: ETI, Nexus House, Boundary Way, Hemel Hempstead, Herts HP2 7ST. Clearly marking your envelope Event Diary.



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Fax: 01203 650773  
Mobile: 0860 400683**

(Premises situated close to Eastern-by-pass in Coventry with easy access to M1, M6, M40, M42, M45 and M69)

**OSCILLOSCOPES**

Gould OS3000 - 30MHz Dual ch.....	£250
Gould 4035 - 20MHz Digital storage.....	£600
Gould 4050 - 35MHz Digital storage.....	£750
Gould 5110 - 100MHz Intelligent oscilloscope.....	£950
Gould OS4000, OS4200, OS4020, OS245.....	from £125
Hewlett Packard 1740A, 1741A, 17744A, 100MHz dual ch.....	from £350
Hewlett Packard 1707A, 1707B - 75MHz 2ch.....	from £275
Hewlett Packard 54201A - 300MHz Digitizing.....	£1950
Hewlett Packard 54504A - 400MHz Digitizing.....	£3950
Hitachi V422 - 40MHz Dual channel.....	£300
Hitachi V212 20MHz Dual Channel.....	£175
Nicolet 3091 - LF D.S.O.....	£1100
Philips PM 3315 - 60MHz - D.S.O.....	£750
Tektronix 2213 - 60MHz Dual Channel.....	£425
Tektronix 2246 100MHz-4 channel..... (as new)	£995
Tektronix 2215 60MHz dual trace.....	£450
Tektronix 2235 Dual trace 100MHz (portable).....	£800
Tektronix 2335 Dual trace 100MHz (portable).....	£750
Tektronix 2225 - 50MHz dual ch.....	£450
Tektronix 465/465B - 100MHz dual ch.....	from £350
Tektronix 7313, 7603, 7613, 7623, 7633, 100MHz 4 ch.....	from £300
Tektronix 7704 - 250MHz 4 ch.....	from £650
Tektronix 7844 - Fitted with 7A42, 7B80, 7B85 Plug-ins.....	£1500
Tektronix 7904 - 500MHz.....	from £850
Tektronix 468 - 100MHz Digital Storage.....	£800
Phillips 3206, 3211, 3212, 3217, 3226, 3240 3243, 3244, 3261, 3262 (2ch + 4ch).....	from £125 to £350
Philips PM 3295A - 400MHz Dual Channel.....	£2250
Philips PM 3296 - 350MHz Dual Channel.....	£1950
Philips PM 3208 - 20MHz Dual Channel.....	£200
Telequipment D68 - 50MHz Dual Channel.....	£200

Other scopes available too

**SPECTRUM ANALYSERS**

Hewlett Packard 3580A - 5Hz-50KHz.....	£995
Hewlett Packard 8590A - 10KHz - 1.5GHz - (as new).....	£4300
Hewlett Packard 182T with 8559A (10MHz - 21GHz).....	£3750
Hewlett Packard 4953 Protocol analyser.....	£2500
Hewlett Packard 8561A - 6.5GHz.....	£12,000
Hewlett Packard 3585A 20Hz - 40MHz.....	£3750
Hewlett Packard 3561A Dynamic Signal Analyser.....	£3500
HP 3582A - 25KHz Analyser, dual channel.....	£2500
HP8754A - Network analyser 4-1300MHz.....	£3500
Marconi 2370 - 110MHz.....	£995
Marconi 2371 - 304Hz - 200MHz.....	£1250
Rohde & Schwarz - SWOB 5 Polyskop 0.1 - 1300MHz.....	£2750

**MISCELLANEOUS**

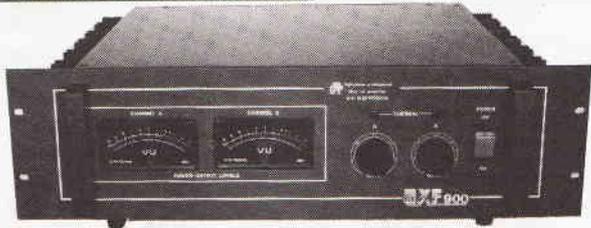
Anritsu MG642A Pulse Pattern Generator.....	£1500
Avo VCM 163 Valve Characteristic Meter.....	£400
Ballantine 323 True RMS Voltmeter.....	£350
Datalab DL 1080 Programmable Transient Recorder.....	£350
Farnell RB 1030-35 Electronic load 1Kw.....	£450
Farnell 2081 R/F Power meter.....	POA
Farnell TSV 70 MkII Power Supply (70V-5A or 35V-10A).....	£200
Ferrograph RTS-2 Audio Test Set with ATU 1.....	£500
Fluke 8010A/8012A/8050A Digital multimeters - from.....	£125
Fluke 5101A AC/DC Calibrator.....	£3500
Fluke 5101B AC/DC Calibrator.....	£6500
Fluke 5220A Transconductance Amplifier (20A).....	£3000
General Rad 1658 LCR Digibridge.....	£250
Gould TA 600 - Thermal Array Recorder.....	£400
Heiden 1107 - 30V-10A Programmable Power Supply (IEEE).....	£650
Hewlett Packard 334A - Distortion Analyser.....	£250
Hewlett Packard 436A Power meter +8481A sensor.....	£950
Hewlett Packard 3437A System voltmeter.....	£350
Hewlett Packard 3456A Digital voltmeter.....	£850
Hewlett Packard 3760/3761 Data gen + error detector.....	each £300
Hewlett Packard 3762/3763 Data gen + error detector.....	each £350
Hewlett Packard 3777A Channel selector.....	£250

Hewlett Packard 4193A Vector impedance meter.....	£3250
Hewlett Packard 5420A Digital Signal Analyser.....	£350
Hewlett Packard 5423A Structural Dynamics Analyser.....	£350
Hewlett Packard 54470B Digital Filter.....	£100
Hewlett Packard 54410A Analogue/Digital Converter.....	£100
Hewlett Packard 6632A System Power Supply.....	£450
Hewlett Packard 7402 Recorder with 17401A x 2 plug-ins.....	£300
Hewlett Packard 8011A Pulse gen. 0.1Hz-20MHz.....	£500
Hewlett Packard 8406A Frequency comb. generator.....	£500
Hewlett Packard 8443A Tracking gen/counter with 1EEE.....	£300/400
Hewlett Packard 8444A Tracking Generator.....	£750
Hewlett Packard 8620C Sweep oscillator mainframe.....	£400
Hewlett Packard 8750A Storage normaliser.....	£375
Hewlett Packard 3438A Digital multimeter.....	£200
Hewlett Packard 6181C D.C. current source.....	£150
Hewlett Packard 59501B HP.1B isolated D/A power supply programmer.....	£150
Hewlett Packard 3711A/3712A/3791B/3793B Microwave Link Analyser.....	£3500
Hewlett Packard 8901B - Modulation analyser AM/FM (150KHz - 1300MHz).....	£3750
Hewlett Packard 8903B - Audio Analyser (20Hz - 100KHz).....	£2750
Hewlett Packard 5316A Universal Counter HP1B.....	£550
Hewlett Packard 5316B Universal Counter HP1B.....	£775
Hewlett packard 5385A Frequency Counter - 1GHz - (HP1B) with OPTS 001/003/004/005.....	£995
Hewlett Packard 1630G Logic Analyser (65 channel).....	£850
Hewlett Packard 8657B 2060MHz synthesised signal generator ..... (as new)	£8250
Hewlett Packard 3779C Primary Multiplex Analyser.....	£1000
Hewlett Packard 6623A Triple output system power supply.....	£1950
Hewlett Packard 6624A Quad output system power supply.....	£2250
Hewlett Packard 35677A "S" Parameter Test Set.....	£1250
Hewlett Packard 6453A Power supply 15v-200A.....	£1250
Hewlett Packard 4261A LCR Meter.....	£400
Hewlett Packard 4271B LCR Meter.....	£900
Hewlett Packard 3764A (Opt 002) Digital Transmission Analyser.....	£3500
Hewlett Packard 3586A Selective level meter.....	£1750
Hewlett Packard 8656A 990 MHz synthesised sig. gen. ....	£1500
Hewlett packard 3488A HP - 1B switch control.....	£500
International Light - IL 1700 Research Radiometer with Erythermal Sensor Head.....	£1250
Krohn-Hite 2200 Lin/Log Sweep Generator.....	£995
Krohn-Hite 4024A Oscillator.....	£250
Krohn-Hite 6500 Phase Meter.....	£250
Leader LCR 745G LCR Meter..... (as new)	£1150
Lyons PG73N/P75/P728/P73 Pulse generator.....	from £225
Marconi 2432A 500MHz digital freq. meter.....	£200
Marconi 2337A Automatic dist. meter.....	£150
Marconi 2356 20MHz level oscillator.....	£300
Marconi 2306 Programmable interface.....	£450
Marconi 2830 Multiplex tester.....	£1000
Marconi 2831 Channel access switch.....	£400
Multicore "Vapourette" Bench Top Vapour Phase SMD Soldering Machine (New + Unused).....	£650
Philips 5390 1GHz R/F Synthesised signal gen.....	£1250
Philips PM 5167 10MHz function gen.....	£400
Racal Dana 202 Logic analyser + 68000 disassembler.....	£250
Racal Dana 9242D Programmable PSU 25V-2A.....	£300

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S.A.E. FOR LIST OF EQUIPMENT  
ALL EQUIPMENT IS USED - WITH 30 DAYS  
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HIGH POWER, TWO CHANNEL 19 INCH RACK

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**THE RENOWNED MXF SERIES OF POWER AMPLIFIERS**  
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MXF600 (300W + 300W) MXF900 (450W + 450W)  
ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

**FEATURES:** \*Independent power supplies with two toroidal transformers \* Twin L.E.D. Vu meters \* Level controls \* Illuminated on/off switch \* XLR connectors \* Standard 775mV inputs \* Open and short circuit proof \* Latest Mos-Fets for stress free power delivery into virtually any load \* High slew rate \* Very low distortion \* Aluminium cases \* MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

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**PRICES:-** MXF200 £175.00 MXF400 £233.85  
MXF600 £329.00 MXF900 £449.15  
SPECIALIST CARRIER DEL. £12.50 EACH



**OMP X03 STEREO 3-WAY ACTIVE CROSS-OVER**

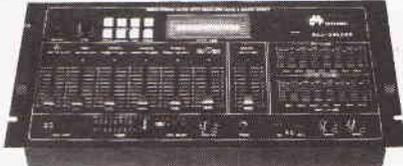


Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

**Price £117.44 + £5.00 P&P**

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**STEREO DISCO MIXER** with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. **MANY OUTSTANDING FEATURES:-** including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor, 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.



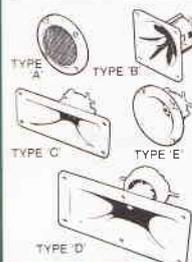
**SIZE: 482 x 240 x 120mm**

**Price £144.99 + £5.00 P&P**

**PIEZO ELECTRIC TWEETERS - MOTOROLA**

Join the Piezo revolution! The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if two are put in series). **FREE EXPLANATORY LEAFLETS ARE SUPPLIED WITH EACH TWEETER.**

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**TYPE 'C' (KSN1016A)** 2" x 5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. **Price £6.99 + 50p P&P.**  
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**OMP MOS-FET POWER AMPLIFIER MODULES**

**SUPPLIED READY BUILT AND TESTED.**

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, **NOTE** that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

**THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS**



**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**



**OMP/MF 200 Mos-Fet Output power 200 watts**  
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz  
-3dB, Damping Factor >300, Slew Rate 50V/uS,  
T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R.  
-110 dB. Size 300 x 155 x 100mm.  
**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**



**OMP/MF 450 Mos-Fet Output power 450 watts**  
R.M.S. into 4 ohms, frequency response 1Hz - 100KHz  
-3dB, Damping Factor >300, Slew Rate 75V/uS,  
T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R.  
-110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2  
Second Anti-Thump Delay. Size 385 x 210 x 105mm.  
**PRICE £132.85 + £5.00 P&P**



**OMP/MF 1000 Mos-Fet Output power 1000 watts**  
R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms,  
frequency response 1Hz - 100KHz, -3dB, Damping  
Factor >300, Slew Rate 75V/uS, T.H.D. typical  
0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan  
Cooled, D.C. Loudspeaker Protection, 2 Second  
Anti-Thump Delay. Size 422 x 300 x 125mm.  
**PRICE £259.00 + £12.00 P&P**

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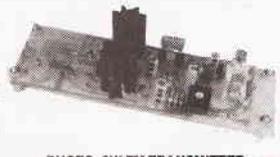


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# ELECTRONICS IN THE MOVIES

*Nick Hampshire takes a look at how computers and electronics are changing forever the way in which films and TV programmes are made, with a special emphasis on the creation of special effects which are such a feature of modern films*

**L**ike countless millions, I avidly consumed in my youth an entertainment diet of Star Trek, Dr Who, Thunderbirds, Space 1999, and an odd collection of 'B-movies' such as 'It Came from Outer Space', 'Quatermass' or 'The Incredible Shrinking Man'. At the time, the special effects used in these films, the futuristic technology, the alien life forms, the robots, and the landscapes of strange planets all seemed quite wonderful and, in many cases, believable. Today they seem rather crude and, dare I say it, amateurish.

Indeed, put side by side with the slick presentation of modern science fiction films, they are. It is not that the plots are necessarily any better - sometimes they use the same plot - nor is the script or indeed the actors. The difference lies in the smoothness of the production, with the technology which allows modern films to truly cross the boundary between reality and fantasy.

In Jurassic Park we can roam in a world full of what seem to be real live dinosaurs, not the blend of stop action animated models and live action of yesteryear, even when the models were animated by a master of the art like Ray Harryhausen. In films like Star Trek and Star Wars we can almost feel the vast emptiness of space, the enormous power of a spaceship, the speed and acceleration.

These films, and others like Alien introduce us to strange creatures from other worlds who are obviously not simply human actors with a good costume and make-up job. An introduction which has been carried much further in some of the fantasy films; just think of the prehistoric creatures in The

Flintstones. And has perhaps, reached its current peak in films such as Terminator where human actors are visibly transformed into horrifying aliens.

What all these examples show is that the enormous difference in the quality of special effects used in films that were shot 20 years ago and those being used in films shot today are the result of considerable advances in the technology of film making. Making a film is no longer a matter of putting actors on a set in front of camera, what goes on behind the camera can be of even greater importance than what goes on in front of it.

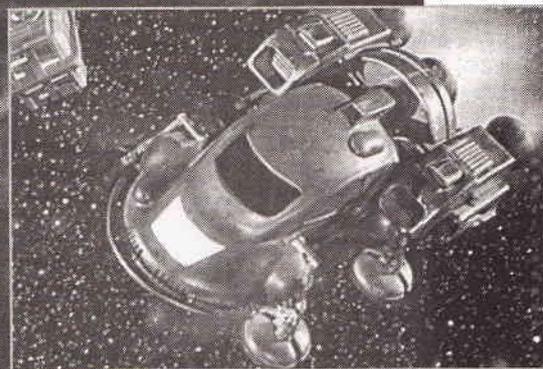
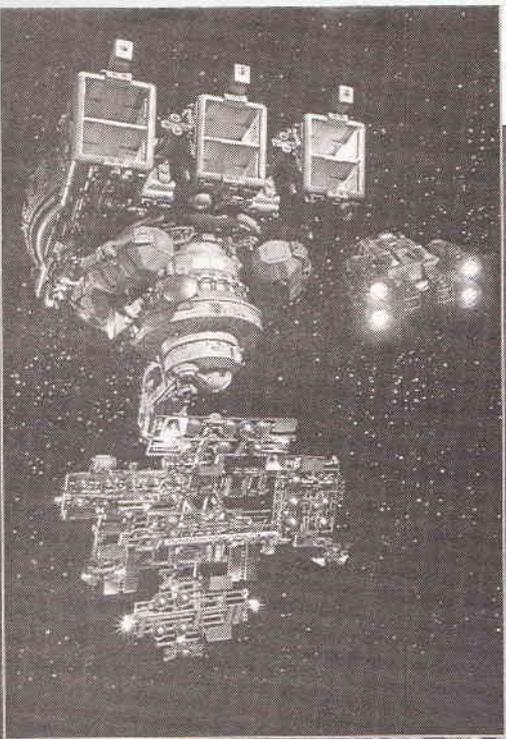
## **The making of a modern science fiction TV series**

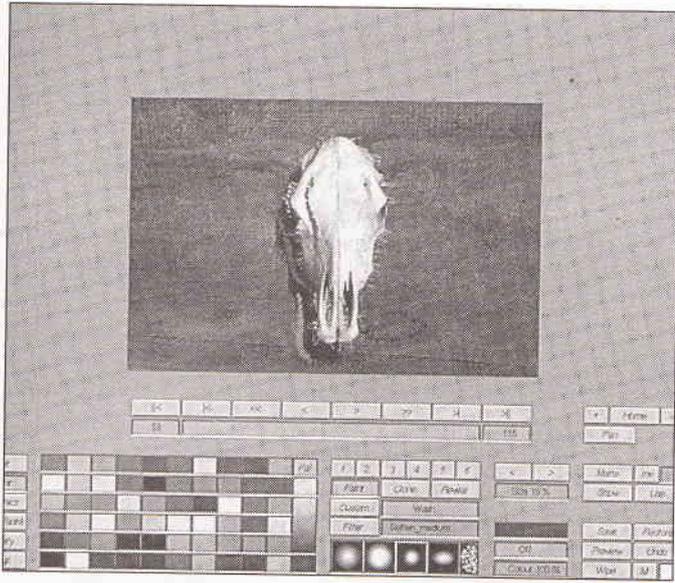
To get some idea of the technology used by the film industry in making a modern science fiction film packed with special effects and strange aliens, I went down to Shepperton Film Studios to look at the production of a new TV series by Gerry Anderson, creator of such classic TV sci-fi series as Thunderbirds, The Protectors, UFO, and Space 1999. His new series (currently showing in the US, in the UK on Sky starting March 18th and the BBC later this year) is called Space Precinct and is a blend of cop movie and sci-fi drama. It features lots of special effects, futuristic technology as well as aliens pleasant and unpleasant.

Costing over \$36million for the first 24-part series, the programmes feature a whole range of state of the art special effects. The filming is being done in the UK because British film technicians have an enviable reputation of being able to produce some of the best special effects work in the business. It is no coincidence that a great many films which utilise special effects are either made in the UK or made using British film technicians. On top of which, as Gerry Anderson was recently reported as saying, "In Britain, one gets more bang for the buck".

What makes Space Precinct so interesting is that it is made using every technique in the business. There is live action with actors, some as humans, some as humanoid aliens. There are non-humanoid aliens constructed using animatronics (these are basically very sophisticated robotic puppets). Then there are conventional special effects using models - a technique which is very much a hallmark of Gerry Anderson's films - and the use of moving models filmed with a special computer-based motion control system.

Finally, and perhaps most important of all, there are the very





sophisticated and powerful computer systems which are used to add all the effects together in digital form. The result is a smooth seamless output that will I am sure have millions of viewers glued to their TV sets over the coming months.

Space Precinct's Visual Effects Director is Steve Begg, whose previous work with Gerry include films such as Batman, Never Ending Story, and Aliens, whilst the Special Effects Model Supervisor Bill Pearson and his model building team have worked on series such as Red Dwarf and Dr Who as well as other Gerry Anderson productions.

During my visit to the studios Steve Begg explained to me how the various filming techniques are put together to generate some superb visual special effects. The crew are given just ten days to shoot each episode; they were up to episode 17 when I was there. This tight schedule means that special effects have

to be devised as they go, it is what Steve described as 'seat of the pants filming; if I can get an effect by throwing a model across a set then that is the way it will be done, there is no time to fine tune things'

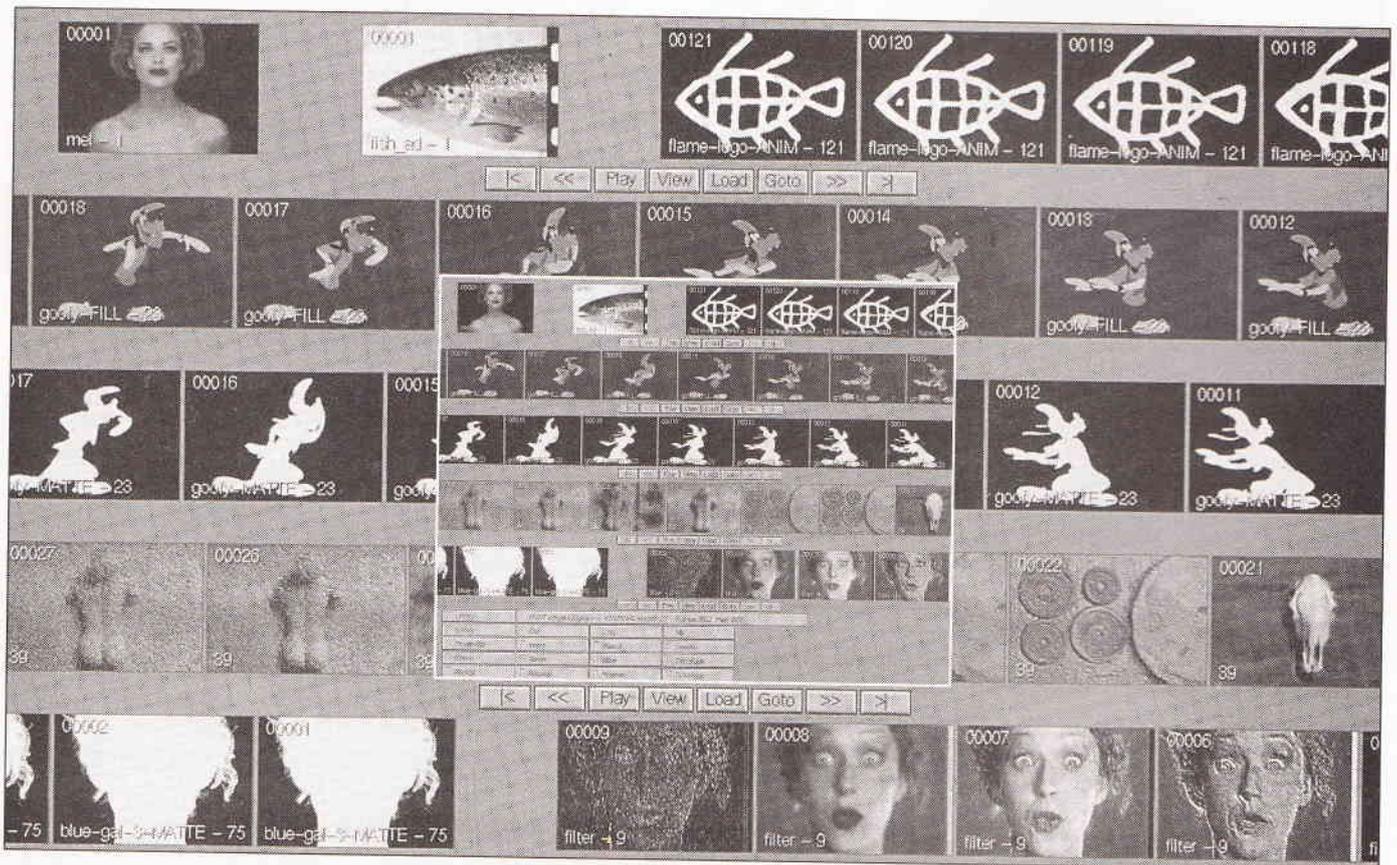
The process starts with a 'story board'. a detailed description with accompanying drawing of each shot in the film together with timing information. The story board comes down to the various film units and special effects departments from the director and the script writers, and is used as the standard information on which everyone works from set builders to computer operators and film editors.

When it receives the story board for the special effects in an episode, the special effects unit will first of all have to decide how the effects are to be achieved, and what models are needed. The models for the sets and the spacecraft are all made from ABS plastic by vacuum forming in hard wood moulds and then assembled, painted, and surface treated in the appropriate manner. The models are made in several different scales depending upon the amount of detail required.

Whilst I was there, they were filming the explosion of a flying vehicle against the side of a snow-covered building. The building was about three foot tall, the vehicle a couple of inches long and the snow was finely ground paper dust. The vehicle was slid along thin wires and a pyrotechnic device fitted at the point of impact so that when the vehicle was slid down the wires and hit the building it would explode.

The problem with special effects using models is one of scale of movement with relation to size, this is particularly important in explosions. In other words the resulting film looks like a model and a small scale explosion. The trick which overcomes this problem is to film the scene and the explosion at very high speed, when this is replayed in a slowed down form, the motion of model and explosion look correct for a full sized unit rather than the six inch long model that it really is.

This side of the special effects unit's work is fairly



conventional and would have been familiar to the producers of sci-fi films of 20 or 30 years ago. What would have been totally new for any production before about 1977 was the computerised motion control system that is used to create carefully controlled movement of both models and the camera which is photographing them.



## Motion control

The motion control unit uses much larger models than those employed by the traditional special effects unit. Here the typical model of a spacecraft could be 18 inches or two foot long; the only larger models employed are the full-sized components that are part of the live action sets.

During my visit, they were getting ready to shoot a sequence with a flying police vehicle moving down a street and hovering over a crashed vehicle. The set for the street and crashed vehicle had been built and the police vehicle was mounted on a rod connected via a gantry to a number of stepper and servo motors used to control the position of the model vehicle. The model is also fitted with lights and moving components powered by small servos.

The camera was mounted on a fully motorised crane and dolly that allowed the camera to be moved in and out of the set, as well as to either side or over the top, thus permitting photography at any angle. The entire sequence of movements of the camera system and the models is controlled by a computer running special software which is designed for the purpose. Once the data for a movement sequence has been entered into the computer it can be precisely repeated time and time again.

The ability to exactly repeat a sequence of movements is extremely important in the creation of special effects using this type of equipment. This is because motion control systems are used to create several pieces of identical film which are then combined optically or electronically to create the desired result.

Thus, if a director wants to show a spacecraft moving across a planet he will first of all have a designer create a background picture of a planet surrounded by stars. He could of course photograph a model moving across this painted background, but the focal depth would not look right, there would be a limit to the way that the spacecraft could move, and there would also be problems with lighting. The result would be a scene that did not look real. For a start, the model would be a constant size in relation to the planet, there would be no motion perspective of the craft getting bigger as it approached the viewer, or smaller as it went away.

Motion control systems (first developed in 1977 at Industrial Light and Magic by John Dykstra for George Lucas in *Star Wars*) can overcome these problems and also add the capability of creating quite complex movement that would otherwise be impossible. Perspective movement can be created by moving the camera towards or away from the model and this, when combined with model movement and the up/down side to side movement of the camera, can generate the kind of motion effect which was such a hallmark of films like *Star Wars*.

To add the image of the moving spacecraft to the background image requires a fairly old technique known as a travelling matte. This can be thought of as a stencil exactly the

same shape and position as the moving spacecraft that can be used to blank out that area of the background in each shot and thus allow the image of the spacecraft to be added precisely to the background image on each frame without any appearance of a join.

The repetitive capability of the motion control system is used to create the travelling matte. In fact, a sequence may require three or more passes on the motion control system. In the first pass, the model is filmed against a green or blue background; this is known as the green or blue screen pass and is used to create the matte. The second pass is shot with the model very carefully lit against a background of black velvet; this is known as the beauty pass and is the actual shot that will be used in the final film.

In some situations, a third pass may be necessary to add features such as the exhaust flares from a rocket, features which would not be visible in a highly-lit beauty pass. Again this will be shot against black velvet with an unlit model and will provide both image and matte.

In all three passes, the sequence is shot at a rate of one frame per second using a form of computer controlled stop action animation. Models and camera are moved by the computer the correct amount for one frame, then there is a short pause of just under one second to allow any vibrations to be damped prior to the frame being filmed. The models and camera are then moved, the next frame shot, and so on.



## Putting it all together with a computer

The special effects created using traditional techniques and motion control systems are combined with live action, then polished and embellished with new and even more powerful special effects, thanks to the very latest bit of technology to be put into the hands of movie makers. This is CGI or Computer Generated Imagery.

Going into the computer graphics department attached to Space Precinct, I was confronted by a room containing a half dozen Silicon Graphics workstations. Each of these enormously powerful computers were fitted with 128MBytes of RAM, ultra-fast R4400 RISC processor and 8Gigabyte hard disks, the kind of computer power which makes even a top range PC or Macintosh look rather puny.

Each of these computers has enough disk space to store 6,500 frames of broadcast quality video and, in any ten-day production period, these computers may be used to produce up to 25,000 frames of computer manipulated and enhanced film. At 25 frames per second that is about a quarter of an hour of film per episode. Already in 17 episodes the archive of computer manipulated film was close to the 400,000 frame mark.

The live action and special effect sequences are all shot on either Super 16mm or 35mm film stock and this film first of all goes to the editing department where it is cut and assembled in accordance with the storyboard. At this stage, no attempt is made to assemble the special effects. All that is done is to produce the accurate timing which is necessary in order to put those special effects together.

All the pieces of film that relates to the special effects sequences are then transferred to video, each frame being

scanned in at a PAL resolution of 720 lines (for movie work, frames are scanned at much higher resolutions of 2,000 or more lines). Each sequence is, on average, about 8 seconds long, and consists of about 200 frames and, where effects are being built up using composites, there may be as many as five or six digitised images used to create each frame.

The digitised sequence of frames corresponding to the timed sequence provided by the editor is then loaded onto the hard disk of one of the workstations to be transformed into the slick special effects imagery which is a hallmark of this series and of modern sci-fi films in general.

The Silicon Graphics workstations are running a range of different specialist video image manipulation software packages (this is a very rapidly expanding area of the software business and one into which tens of millions of dollars are being poured by all the big software and video technology companies). Which software package is used depends upon the type of effect which the user wants to achieve; some are better at producing one particular effect than others. The images are kept in a standard bit-mapped form on disk which allows them to be transferred easily between networked computers and different software packages.

The main software packages used on Space Patrol are Discrete Logic's FLINT, Parallax Software's Matadore. These are essentially sophisticated paint packages which have been especially designed for use in video and film production and, on Space Patrol, they are used to perform most of the CGI functions. Other software packages are also used for the creation of a handful of special effects. Dynamation is used to create effects such as ion storms, vortices, lightning flashes and sparks. Elastic Reality is used to create morphing and warping effects. They even use an Amiga computer running LightWave 3D to generate one particular special effect, a lens flare, the effect of light bursting directly into the camera.

I was shown how they created some of the special effects. The first of these was a spacecraft moving through an asteroid belt and passing between two large asteroids, a single shot of about 400 frames which took the operator two days to complete. It was a very complex piece of film that was built up from seven pieces of film. The first of these was a starfield background, then there were two green screen shots of passing asteroids with the asteroids rotating and moving across the screen, these were shot using the motion control camera system. No beauty shots of the asteroids were required since the asteroids had little intrinsic detail. Next, there were three shots of the spacecraft generated on the motion control system, a green screen shot to create the travelling matte, a beauty shot, and an engine flare shot. Finally, there was a lens flare effect created on an Amiga with LightWave.

The result of combining all these separate pieces of film into a single sequence was a very realistic shot of the spacecraft moving across the screen and between the two tumbling asteroids. Then as the as one of the asteroids moved away, the sun caught the camera in a simulated lens flare. The whole sequence was colour corrected and had a grain added to give it a consistent look to live action shots done on Super 16mm.

I was also shown how they added the effects laser gun shots to the film. The shot takes just three frames, in the first there is a bright flash at the gun barrel, in the second a warping of the entire image area around the gun barrel, and in the third a faint ring of light around where the flash had been. In all three of these frames, reflections of the flash were added to any appropriate reflecting surface, such as the eyes of the person firing the gun. The result - a superb laser gunshot effect.

When a gunshot hit a person, building or spacecraft, the laser

beam was added to three or four frames as a pulse of light tracking across the shot and towards the target. When it hit the target, the resulting explosion was created using pyrotechnics on the model set, or as a pyrotechnic effect added to the shot using the computer.

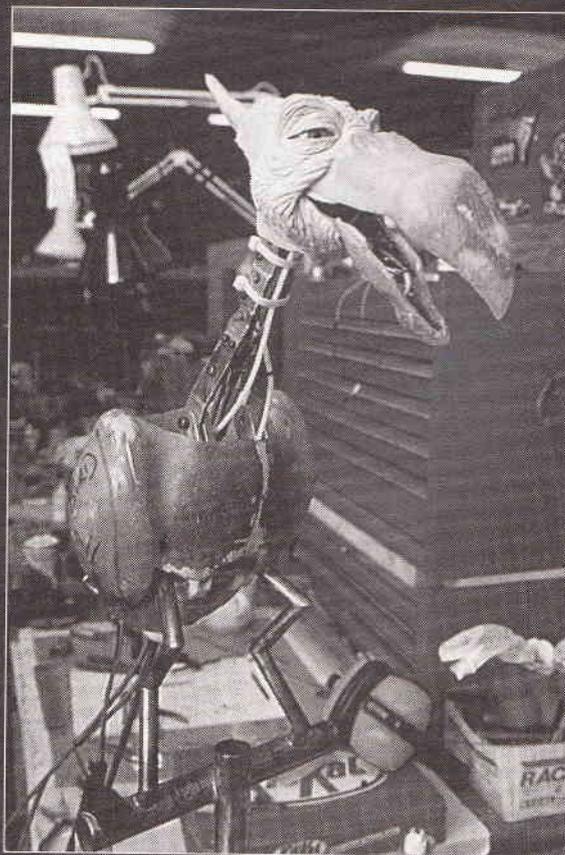
I was also shown how morphing was used to change a humanoid into an alien and back again, an effect used with great impact already in *The Mask*. Another example of computer generated special effects was the use of warping to create an alien vampire that disappeared into the body of its victims. As well as the fancy effects CGI is also employed for a lot of more mundane work such as correcting any faults in the film. For example: correcting colour imbalance, removing visible control wires, and eliminating any unwanted intrusions into a shot.

A special type of distortion was also used to add facial expressions to aliens that were played by actors using latex masks. In such cases some movements are impossible for an actor, but can be added by the CGI system where the image of parts of the face is distorted slightly to give the impression of movement.

This is a technique which was made famous in the scenes in *Forest Gump*; an image of Tom Hanks was incorporated into scenes using old newsreel film where the faces of the characters were reanimated so that they fitted the lip-sync of a new soundtrack. The result was a sequence of shots where the actor appeared to converse with historical characters.

The special effects used in *Space Precinct* - whether generated in front of the camera using models and motion control systems or in a computer - are often very impressive and should ensure that this latest series from Gerry Anderson is a big success.

# Animatronics



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## Into the future

It would seem that the way in which films of all kinds, not just science fiction and fantasy films, are being made is changing forever. Purely optical techniques are being replaced by far more sophisticated and versatile digital techniques. Human actors no longer have complete dominance of the stage, they are being joined by a host of other actors in the form of animatronics and computer animation.

Many people in the film industry are already predicting that by the end of the decade every frame of every film will be reprocessed by computer. CGI may have started in the special effects departments of companies producing science fiction films such as Star Wars or Jurassic Park, but there are now powerful economic reasons why it will be quickly applied to other areas.

A recent example of this was the use of CGI to create the crowd scenes in *Miracle on 34th Street*. In this film, it was both impractical and far too costly to hire vast numbers of extras for the enormous crowds; instead a small number of extras were multiplied by computer and then used to fill the appropriate shots of the streets of New York.

Taking the CGI based techniques of pasting characters into a scene even further, George Lucas has shown how digital technology will alter the whole future of motion picture production. In the film *Radioland Murders*, he experimented with the use of CGI to solve budgetary and scheduling problems. Thus, in one scene, an interrogation involves 30 people gathered together in one room. However, none of the actors in this scene was shot at the same time. Instead, they were shot separately and digitally composited into the scene.

This technique allows the director and producers to move efficiently and economically schedule actors. Having actors hang around waiting for other actors to become available can be very expensive. The use of CGI in *Radioland Murders* also allowed them to create many sets digitally and thus dispense with traditional set builders, again cutting costs. Costly location shots were reduced in number, and further cost savings made by digitally multiplying extras. The result was a film produced on what was, in comparison with other films, a very meagre budget of \$10million.

In fact, George Lucas's company Industrial Light and Magic is going even further. Already they have demonstrated the capability to create digital actors who look as real as real actors. But the acting profession need not worry just yet since, as Lucas admits, creating such digital actors is a very expensive process. A few hundred thousand dollars per second, and even the most highly paid actor is cheaper than that!

But this development does point to the fact that the creative process is shifting from being in front of the camera to being behind the camera. Once again, quoting George Lucas: "Actors will never be obsolete, but in time those skills once used by a performer in front of the camera will instead be used by people behind the scenes and they will be called animators not actors".

If this prediction is even remotely true then it looks as if technology has taken over in yet another area of human endeavour. For those in the acting profession, this may be bad news, but for the average viewer it should herald the beginning of an exciting era where any visual experience is possible - an era where films as we know them are merging with computer technology to become interactive multimedia entertainment.

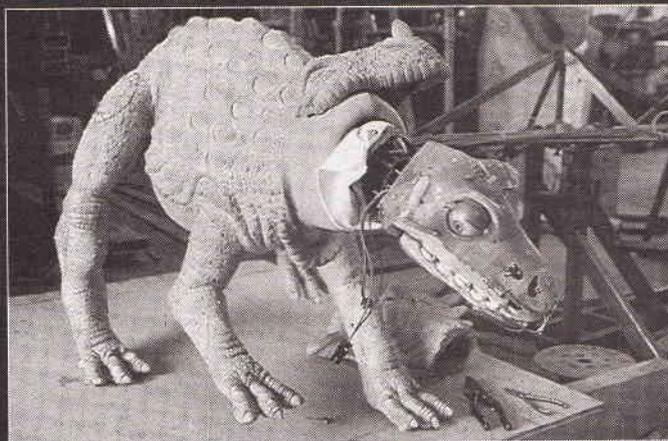
# or robotic puppetry

# S

pace Precinct makes quite a lot of use of animatronics, but to discover some more about the techniques and potential of such systems I went to see another production company which has built a world-wide

reputation in this area: Jim Henson's Creature Workshop. This is the company which brought us, amongst a host of animatronic characters, the Muppets, *Dark Crystal*, the turtles in *Teenage Mutant Ninja Turtles*, the Honey Monster, and a host of creatures in films like *Never Ending Story* and *The Flintstones*

At Henson's North London workshops, I talked to head of Control Systems and R&D, Dave Housman. He explained that the concept of animatronics, and the term itself, were originally conceived by Walt Disney in the 1950s. These early systems were used in the Disney Theme Parks and were simply puppets with a pre-recorded sequence of movement, speech, and music. These early examples of animatronics are a long way from the highly computerised robotic systems that are being created today in the Creature Workshop. The animatronic creatures created at Henson's are all unique, each designed for a specific role or function in a film. This means that there is no mass production, no standardised designs, no interchangeable parts. Each creature is, by and large, the product of craft engineering, with the skill of the animatronics engineers being employed to give the creature all the features which the designer wants. At the Creature Workshop, animatronics is a true



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fusion of art and technology.

Although all the mechanical and electronic systems used in an animatronic creature are closely allied with systems used in robots and other automated systems, an animatronic creature is not a robot but a highly sophisticated puppet whose movements are controlled in real time by one or more highly skilled puppeteers. A puppeteer can provide a subtle artistry to the movements of an animatronic creature which would be totally absent in a system with computer controlled movement. It is this artistry of movement which can give these creatures a personality of their own.

It was the late Jim Henson, creator of the Muppets, who

converted the static repetitive Disney concept of animatronics into a technique for the live, real time control of creatures in a way that will create lifelike performances. Indeed, Henson's dream was to create a puppet which moved in such a realistic way that the viewer will think that it is alive. A goal which means being able to control not just limb movement but also facial expressions, speech and muscle movements - all the little movements which make the difference between a rather stiff conventional puppet and a living creature.

The major problem with using puppets in films is that one has to keep the operator, or operators, out of shot, a factor which made it impossible to do some types of shot. It was an example of this type of problem which led Henson into animatronics. He wanted to shoot a sequence with Kermit up a tree and, to do this, he created two identical versions of Kermit, the one which was to be in the shot had servo motors doing the movement, whilst the other was moved by the puppeteer and had potentiometers in all the joints corresponding to those with servo motors in the first version.

The result of this development was a master slave system, with the animatronic slave exactly copying the movements given to it by the puppeteer's movement of the master. It was a technique which eliminated the need for control wires and rods, as well as the need to have the puppeteer close to the puppet. Now they could be at some distance from the set and, for the first time in the history of puppetry, be able to look at the puppet in the way that the audience would see it. These techniques were used to produce *Dark Crystal* which had no human actors, but was an 'in camera', real time movie that relied almost exclusively upon animatronics.

Severing the direct link between the puppeteer was one step towards Henson's dream of a having a truly realistic puppet since it also made it easier to control a larger number of different movements by using more than one puppeteer for a single creature. Thus, to mimic the facial movements during speech requires control of 15 different 'facial muscles' and therefore 15 different, but simultaneous, movements from the puppeteers.

It was virtually impossible to have half a dozen puppeteers controlling a single puppet and yet still retain any artistry of movement and therefore the inherent personality of a creature under direct human control. The solution was to use computer and control technology to create a control system that would allow a very complex animatronic puppet to be operated by a single individual.

Since they wanted lifelike performances, it was felt that use of off-the-shelf industrial control equipment would result in puppets that moved like industrial control systems. Fine if one is creating a film robot, but no good for a Kermit. Indeed, Dave Housman believes that it is best in this type of application to start from scratch and not be limited by any restrictions imposed through taking on other engineering cultures. The one major exception is their extensive use of standard radio control servo motors, chosen because they are cheap, reliable and readily available in any part of the world.

In conjunction with MicroRobotics of Cambridge they developed a control system based around a single board microcontroller with a special joystick type controller. Although Housman now says that the system was seriously underpowered, it was used to great effect in the *Story Teller* series to bring the *Story Teller Dog* to life. To allow the puppeteer to control the dog's movements, the new control

system was used with the right hand controlling lip and jaw movement whilst the left hand controlled the dog's eyeline facial movements and expressions.

The next big test for the Henson computerised control system was the film *Teenage Mutant Ninja Turtles*. In this film, an actor was enclosed in a latex suit and performed all the arm, leg and head movements. However, to retain the cartoon look of the turtles, the eyes were large and wide apart which meant that it was impossible to use a mask with the actor's eyes. The solution was to use animatronics to animate the eyes and facial expressions in a special head and shoulders unit for close up shots.

The Turtle head unit would normally have required six people to operate the facial and eye movements, or 24 puppeteers in total for scenes involving the four turtles. This would have been far too complex. As it was, the system was designed using complex servo and cable systems built into the head part of the turtle suit. These servos were then remotely controlled by a small number of puppeteers inputting voice with full lip sync and appropriate full facial movements. To enable the puppeteers to control certain movements with the tips of their fingers, special gloves were developed. These were particularly important in controlling lip movements where the movement may be as brief as one frame, in other words 1/24th of a second. Such movements also involved considerable problems in servo design since there was restricted space and a need to move a significant load proportionally.

This early work has led to a number of very sophisticated animatronic techniques being developed at the Creature Workshop. One system involves capturing 48 channels of analogue data using a commercial hardware system from Letchworth-based Adept Scientific and running on a 486PC. This was connected to a Silicon Graphix Onyx reality engine and allowed the puppet to be created by the computer in a computer generated environment, but running in real time. The hand control system has been further developed and has allowed animatronic creatures to be created which have between 60 and 70 different movements (each with its own servo system). A standard puppet control system is now in use that is based around a specially designed computer system with in-built LCD display and two-handed controls. All the software for this board is written in C.

Other processors, typically the H8, and PIC microcontrollers are embedded into the control system of the actual animatronic creature and perform some of the movement co-ordination tasks. Most of the other hardware embedded into the creature consists of servo control systems. With the technology which they are now using, Dave Housman and his team at Creature Workshop are getting close to developing animatronic creatures that almost live up to Jim Henson's dream of a puppet which moves so naturally that a viewer would be excused for thinking that it was alive.

As I left them, the little pink pig sitting amongst an assortment of other creatures in the workshop turned its head to look at me, wiggled its ears and wrinkled its nose, as if to say "but I am alive".



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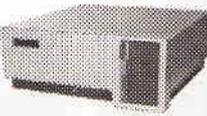
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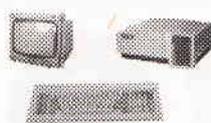
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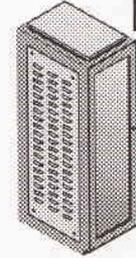
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# Cover disk

**T**his month's free ETI cover disk contains two different collections of software that will run on a standard PC. The first collection is an assembler and simulator for the Arizona Microsystem's PIC microcontroller the subject of a new ETI series starting next month; the second is a collection of programmes written for the Parallax Stamp which will be featured in a series of ETI projects starting this month.

## The PIC collection

The Arizona Microsystem's PIC microcontroller is enjoying enormous popularity amongst both electronic system designers and manufacturers. This family of microcontrollers are based on a fast RISC processor and offer a very low-cost single chip solution to a wide range of problems which would otherwise require either extensive circuitry or a much more expensive microprocessor.

For amateurs, students, and engineers on tight budgets, the PIC is ideal. It is easy to programme, with both OTP and EPROM versions available, the development hardware is cheap (under £100) and the development software will run on any PC. For these reasons, amongst others, ETI will be featuring an increasing number of projects which are based around the PIC family of microcontrollers.

In the February 1995 issue, we published an introduction to PIC programming, and in the next issue we will start a practical look at using the PIC. This introduction will also look at some of the low-cost hardware which is currently available and, to make it easier to use this hardware, we are giving readers of ETI the basic PIC software development tools, an assembler and a simulator, on this month's cover disk.

## The assembler

The Microchip PIC assembler is MPASM Version 1.02.05. This program will assemble source code written for the PIC into object files which may then be used for simulation, or directly in one of the PIC programmers to program a PIC. It is a Universal Assembler and supports the PIC16C5X, PIC16CXX and PIC17CXX families; it is also backward compatible with existing MPALC and ASM17 code.

MPASM is very easy to use. Source code should be written as an ASCII file and then assembled using the following command line:

```
mpasm <file>[.asm]
```

MPASM assembles with INHX8M as the default hex output, and generates a listing file and error file.

MPASM currently runs in DOS real mode and is more sensitive to available DOS memory. This is because of dynamic memory allocation from the heap. If you have problems related to "out of memory" or I/O errors, try freeing up some DOS memory. 530k seems to give good results even for very large programs. Less will be satisfactory for small programs.

A DOS protected mode (DPML) version of MPASM is also included. To use this assembler, you must have the files RTM.EXE and DPML16BI.OVL (distributed with this release) available in your path or in the current directory. To invoke this assembler, use the command:

```
mpasm_dp <file>[.asm]
```

For further information see the READ.1ST file on the disk and look at the example files. For details on programming the PIC, consult one of the books on the subject.

## The simulator

The Microchip PIC simulator is MPSIM Version 4.20.04. MPSIM is a discrete-event simulator designed to aid you in debugging your software applications for Microchip Technology's PIC16C5X and PIC 16CXX microcontrollers.

This program is very useful for testing PIC code in advance, as it allows the user to set up expected inputs and to test the program responses. It allows break points and single stepping and emulates most of the features of the PIC series including interrupts, the RTCC and watchdog timer.

The program is provided complete with a 25,000 word manual on the disk. This manual can be printed out using Word or any other common wordprocessor, but remember it is a long document and printing will take a very long time and a lot of paper. The manual includes many examples of how to use this PIC simulator program.

## Updates

Updates for the assembler and simulator are available for download free of charge from the Microchip bulletin board. This gives the opportunity to try sample programs and to test them. To use the bulletin board:

- 1) Set your communications package and modem to 8 bit, No parity and one stop bit; note that this is not the same as CompuServe.
- 2) Dial the nearest direct CompuServe access number (you do not need a compuserve account to access the board). The London access number is 0171-490-8881.
- 3) Type <RETURN>, ignore any garbled message which may appear.
- 4) Type <RETURN> again and "Host Name:" will appear.
- 5) Type "MCHIPBBS<RETURN>" and the Microchip BBS connection will be made.
- 6) You will need to register and check out the special areas devoted to PIC programming. Registration is free.

## System requirements

MPASM and MPSIM require an IBM PC or compatible running DOS version 3.0 or later. The PC needs a 3.5 inch floppy disk drive and at least 640K main memory. We recommend a hard disk with at least 5 MB of available space.

## Installation

In order to get all the programs onto this disk, it has been necessary to compress some files into self-extracting archives.

The programs are:

ASM10205.ZIP - PIC microcontroller assembler  
SIM42004.ZIP - PIC microcontroller simulator

To unzip these to a hard drive we suggest the following:  
Create two directories on the hard drive to hold the files

e.g. MD PICASM  
or MD PICSIM

Change to the directory created

e.g. CD PICASM  
or CD PICSIM

Place this disk in your floppy drive

Type the name of the self-extractor, including the path to the floppy drive

e.g. A:\PIC\ASM10205.EXE  
or A:\PIC\SIM42004.EXE

The files will now be extracted to the current directory

### Basic Stamp application program collection

The files shown below are the source code for the first nine BASIC Stamp projects. They will be published over the coming months in ETI. To use the programmes you will need a Parallax Stamp computer, downloading cable to connect to a PC, and the Parallax editor software; all of these items are provided in the Stamp Development kit. For further details contact the UK distributor - Milford Instruments on 0977 683665.

TERMINAL.BAS APP. #1, LCD USER-INTERFACE  
TERMINAL  
AD\_CONV.BAS APP. #2, INTERFACING AN A/D  
CONVERTER  
KEYPAD.BAS APP. #3, HARDWARE SOLUTION FOR  
KEYPADS  
SERVO.BAS APP. #4, CONTROLLING AND TESTING  
SERVOS

CAP.BAS APP. #5, PRACTICAL PULSE  
MEASUREMENTS  
DUTY.BAS APP. #5+  
TACH.BAS APP. #5+  
VCO.BAS APP. #5+  
STEP.BAS APP. #6, SERIAL STEPPER CONTROLLER  
THERM.BAS APP. #7, SENSING TEMPERATURE W/ A  
THERMISTOR  
GAUSFIT.EXE APP. #7+  
MORSE.BAS APP. #8 SENDING MESSAGES IN MORSE  
CODE  
DICE.BAS APP. #9 CONSTRUCTING A DICE GAME

Terminal.bas is the code for this month's project.  
Code provided by Parallax Inc Milford Instruments.

## Special offer for ETI readers

Bluebird Electronics are offering their book and accompanying disk - A beginners Guide to the Microchip PIC - to readers at a special discounted price of just £17 inclusive of P&P (normal price £19.95 plus P&P). Copies can be ordered direct from Bluebird Electronics, Clayshore House, 150 High Street, Worton, Devizes, Wilts. SN10 5SE.

### X:Disk label

Develop your own PIC microcontroller applications using the Microchip PIC Development system

### Free with April 1995 ETI

A full featured assembler and simulator which will run on any PC AT or compatible  
Plus a collection of application programs for the Parallax Stamp series of projects in ETI

# Seetrax CAE / Ranger / PCB Design

## Ranger 1 / £100

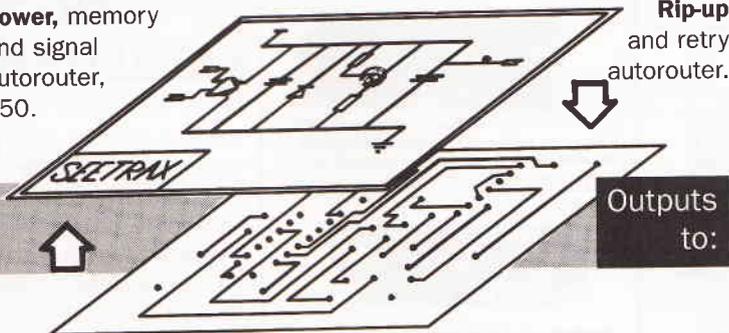
**Schematic** capture linked to PCB.  
**Parts** and wiring list entry.  
**Outline** (footprint) library editor.  
**Manual** board layout.  
**Full** design rule checker.  
**Black** annotation (linked to schematic)  
**Power**, memory and signal autorouter, £50.

## Ranger 2 / £599

**All the features of the Ranger 1, plus,**  
**Gate** and pin swapping (linked to the schematic).  
**Track** highlighting.  
**Auto** track necking.  
**Copper** flood fill.  
**Power** planes (heat relief and anti-pads).

## Ranger 3 / £3500

**All the features of the Ranger 2, plus,**  
**UNIX** or Dos versions.  
**1 Micron** resolutions and angles to 1/10th degree.  
**Hierarchical** or flat schematic.  
**Unlimited** design size.  
**Any-shaped** pad.  
**Split** power planes.  
**Optional** on line DCR.  
**100% rip-up** and retry, push and shove autorouter.



Outputs to:

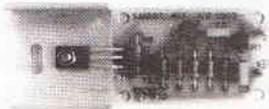
8/9 and 24 pin dot-matrix printers.  
HP Desk/Laser Jet, Canon BJet, Postscript (R3 only)  
HP-GL, Houston Instruments plotters.  
Gerber photoplotters.  
NC Drill Excellon, Sieb and Meyer.  
AutoCAD DXF.

Seetrax CAE / Hinton Daubnay House / Broadway Lane / Lovedean / Hampshire / PO8 0SG.  
Call 0705 591037 or fax 0705 599036 for further information / demo packs.

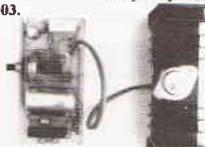
All systems upward compatible. Trade deals available. All trademarks acknowledged.



A mini FM transmitter, very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but it is easy to change it to cover 63-130Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £8.22 Kit no 1001.



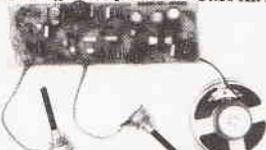
Electronic siren kit with an impressive 5 watt power output. Ideal for car/bike alarms etc. 6-12vdc, max current 1A, tone frequency 1.2khz. £7.05 Kit no 1003.



3-30v Power supply, variable, stabilized power supply for laboratory use. Short circuit protected, suitable for professional or amateur applications. 24v 3A transformer is also needed to complete the kit. £16.45 Kit 1007.



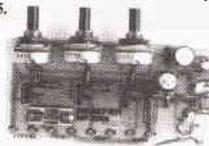
Powerful 1 watt FM transmitter supplied complete with piezoelectric microphone. 8-30vdc. At 25-30v you will get nearly 2 watts! £14.10 Kit no 1009.



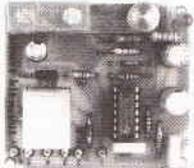
FM/AM Scanner, well not quite you have to turn the knob yourself but you will hear things on this radio (even TV) that you would not hear on an ordinary radio! Receiver covers 50-160Mhz both AM and FM. Built in 5 watt amplifier. £17.62 Kit no 1013.



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



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



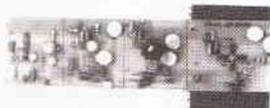
Motorbike/cycle trembler alarm, adjustable sensitivity, preset alarm time, auto reset. Could be connected to bikes horn etc. £14.10 Kit no 1011



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



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



25 watt FM transmitter 4 RF stages, preamp required (our kit 1068 is suitable). Due to the complexity of the transmitter it is supplied in built up form only. £29.37 Kit no 1031.



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



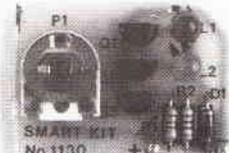
Ultrasonic radar Ideal as a movement detector with a range of about 10 metres, automate your cat flap! 12v operation so ideal for cars, caravans etc. £16.45 Kit 1049.



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



Combination lock 9 key, easily programmable, will switch 2A mains. Complete with keypad. 9v operation. £11.75 Kit 1114.



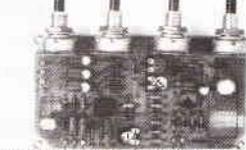
Phone bug detector, this device will warn you if somebody is eavesdropping on your phone line. £7.05 Kit no 1130.



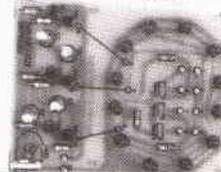
Robot voice, interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £10.57 Kit no 1131.



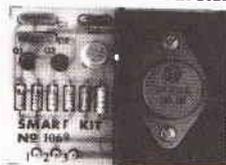
Telephone bug, small bug powered by the telephone line, starts transmitting as soon as the handset is picked up! £9.40 Kit no 1135.



function generator, produces sinusoidal, saw tooth and square waves adjustable from 20hz-20khz, separate level controls for each shape. Will produce all 3 together. 24vac £17.62 Kit no 1008.



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



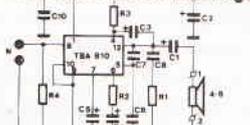
12v fluorescent. A useful kit that will enable you to light 4' fluorescent tubes from your car battery! (you will also need a 9v 2A transformer, not supplied) £9.40 Kit no 1069.



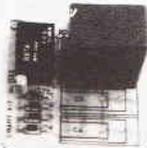
VOX switch, sound activated switch ideal for turning tape recorders on and off when sounds are heard. Makes the tape last a lot longer! adjustable sensitivity, built in delay. £9.40 Kit 1073.



Incar sound to light, Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £11.75 Kit no 1086.



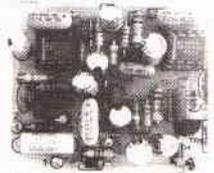
7 watt HI FI power amplifier useful, powerful, ideal for Intercomms, audio systems, car use etc. 12-18vdc 500mA. £8.22 Kit No 1025.



Phone call relay, useful device that operates a relay when ever the 'phone rings, could be used to operate more bells or signalling lights etc. Will switch mains at 2A. £11.75 Kit no 1122.



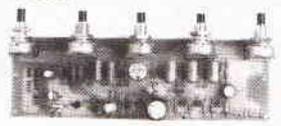
Lead acid charger, two automatic charging rates, visual indication of battery state, ideal for alarm systems, emergency lighting etc. 100mA 12vdc. £14.10 Kit no 1095.



Car alarm system, works on voltage drop and/or vibration, entry and exit delays plus adjustable alarm duration. Good for cars, caravans etc. £14.10 Kit no 1019.



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

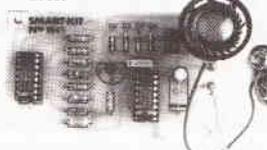


Preamp mixer, 3 input mono mixer, separate bass and treble controls plus independent level controls. 18vdc, input sens 150mv. 100mA. £17.62 Kit no 1052.

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



800 watt single channel sound to light kit, mains operated, add rhythm to your party for only £9.40 Kit no 1006.



Sound effects generator, produce sounds ranging from bird chips to sirens, complete with speaker, add sound effects to your projects for just £10.57 Kit no 1045.



Guitar preamp with tone controls, small enough to fit inside any guitar, based on TL082 IC, 9-12vdc, 50mA. £9.40 Kit no 1091.



15 watt FM transmitter, 4 stage high power, preamp required. 12-18vdc. Can use either ground plane, open dipole, or Yagi. Supplied in built form only at £81.07 Kit 1021.



Telephone amplifier, Very sensitive amplifier which uses a 'phone pickup coil (supplied) will let you follow a conversation without holding the phone. £12.92 Kit no 1059.

#### TOP 10 BEST SELLING KITS CORNER

1. Variable speed control kit for 12v DC motors up to 30A! (you may need a heat sink for 30A) £19.97.
2. Composite video kit, converts composite signals into separate Hsync, Vsync and video £9.40.
3. Geiger counter kit, contains everything you need to build a working counter £22.32.
4. Solar energy kit, contains a solar panel, motor, buzzer and cable for experiments £5.87.
5. Electronic acupuncture kit, may help with migraine, poor circulation, backache etc. £8.22.
6. Electrifying apparatus kit, produces a weak adjustable high tension of 80-300v from a 9v battery, ideal for catching worms etc! £9.40.
7. Adapter bug kit, contains everything you need to build a professional bug built inside a standard 13A mains adapter! the bug is mains powered so it operates all the time the adapter is plugged in. Price is £16.45 for the complete kit including adapter. Hand tools and glue required.
8. Nicad charger kit automatic charger for cells from 1.2v to 1.5v, 7 settings 50600mA, transformer required 18-20v 600mA. £9.40.
- 9&10. Inverter kits, produce 240vac from a 12vdc supply, two versions are available a 15w one at £14.10, and an 80w version at £23.50.

## EXPRESS COMPONENTS

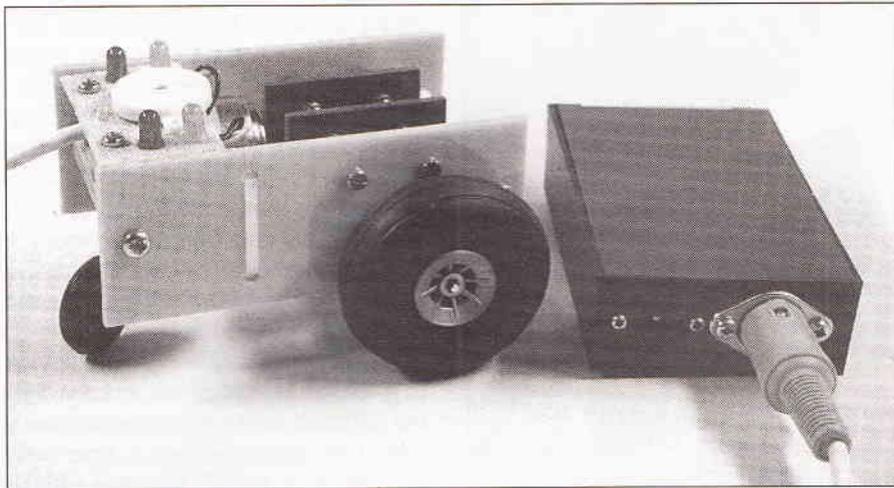
how to order.....

Remember to add £1.50 p&p.  
By phone with a credit card.  
By post with either a cheque,  
postal order or credit card details.  
By fax with credit card details.  
EXPRESS COMPONENTS, PO  
BOX 517 HOVE SUSSEX BN3  
SQZ. DEPT ETI  
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FAX 01273 206875  
Overseas orders please add £3.50  
post and packing.

# A Mobile

# Robot

**Robots are fun to build and fun to play with. In this issue of ETI, Dr Pei An shows how to build a mobile PC controlled robot that could become the basis of bigger things**



**W**hen we talk about robots, many people will think of those machines in the science fiction films. They have a man-like shape, they behave like a human being and speak understandable languages (some of them speak quite well, actually). They are made of steel, plastic and other hi-tech materials and they are controlled by some futuristic and mysterious 'brain'.

The term robot, in a broader sense, refers to a mechanical device that is capable of performing human tasks. Nowadays, robots are not only used in the film industry, they are used in a wide range of different areas. In manufacture industries, robots are used to perform repeated and tedious jobs. They work with high accuracy and without complaints. In exploration, robots are sent to hazardous areas, to deep sea or even other planets to perform the jobs which humans would otherwise have to do. Robots are also employed in hospitals to perform complicated surgeries under the control of medical experts who may be thousands miles away from the hospital.

In this article, I would like to take the opportunity to introduce a robot which does no work, but 'walks' on the floor of your home. The robot 'walks' on three wheels and can move forward and backward and turn right and left. It flashes lights to tell you where he is and murmurs some

unknown language, simply meaning 'Please master, let me have a rest'. The walking robot is controlled by your PC or laptop computer via the Centronic port (printer port). Moreover, the robot is made by you!

## The units

The mobile robot consists of two units. The first one is the interface & control unit and the other one is the robot itself. The former is plugged directly to the Centronic port of the computer; it manages the interfacing between the computer and the robot and controls the movements, the sounds and lights of the robot. The latter is the robot on wheels which moves about on the floors. The robot has two drive wheels which are independently controlled by two motors. Lights and sounder are

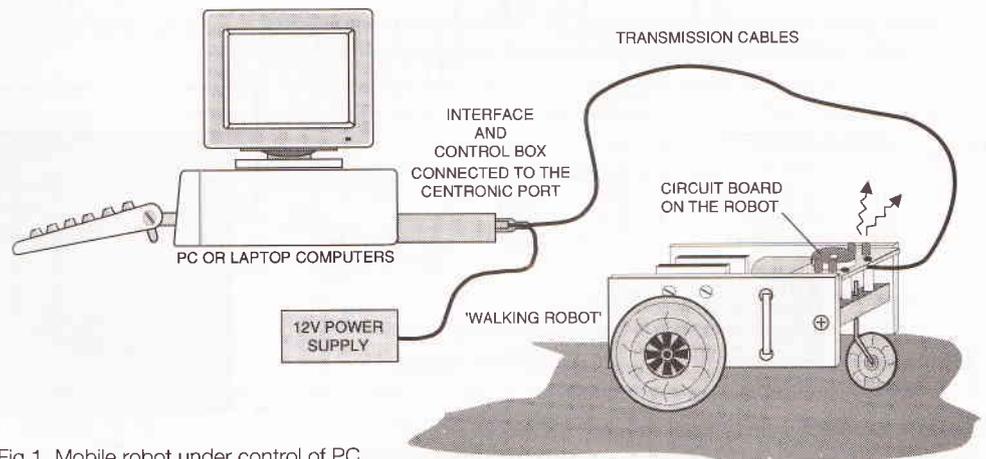
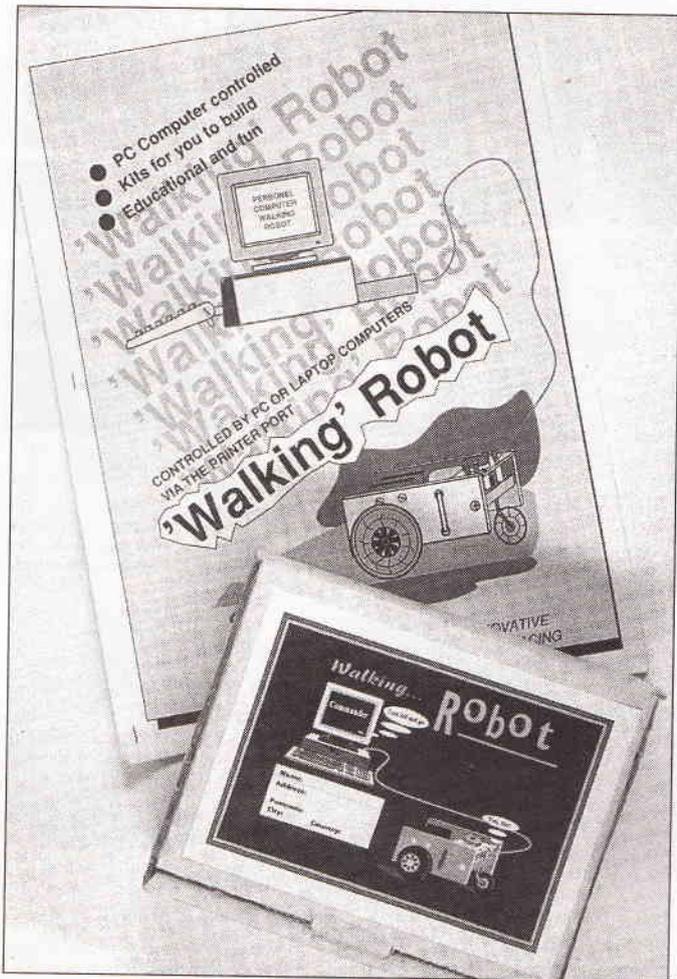


Fig.1. Mobile robot under control of PC



installed on the board to give simple light and sound effects. The robot and the interface & control unit is connected by a transmission cable. The complete walking robot system is illustrated in Figure 1.

### The works

The circuit diagram of the interface & control unit is given in Figure 2, together with the circuit of the robot comprising motors, lights and sounders. The unit is connected to the PC's Centronic port via five wires, four data lines and one ground.

Each of the four lines has a dedicated function. The first line (P1: POWER ON/OFF) controls the ON or OFF of the power supply to the motors. A logic 1 on the line will supply the power to the motors. A logic 0 will switch off the power. The second (P2: MOTOR-1) and third (P3: MOTOR-2) lines control the directions of the motors. A logic 1 on the lines will make the motor to turn clockwise and a logic low will make the motor to turn anti-clockwise. The two lines are therefore used for controlling the movements of the robot. The fourth line (P4: SOUNDER) controls the sounder on the robot. Refer to the circuit diagram (Figure 2); these four lines are connected to Pin 2 through Pin 5 of the 25-pin D-type male connector which is plugged into the Centronic port of the computer.

Those four data lines are fed into IC1 which is a device called OPTO-ISOLATOR. The data lines are connected to the light emitting diodes (LEDs) inside IC1. Resistors R1 through R4 are resistors for limiting the electric current passing through these LEDs. When a line is in logic low (note: a logic low corresponds to a voltage swing from 0V to 0.8V. It is often referred to as '0'), the LEDs will not be lit and subsequently the photo-transistor is turned off. When the line is in logic high (i.e. a voltage swing from 2V DC to 5V DC. It is often referred to as '1'), the LED will

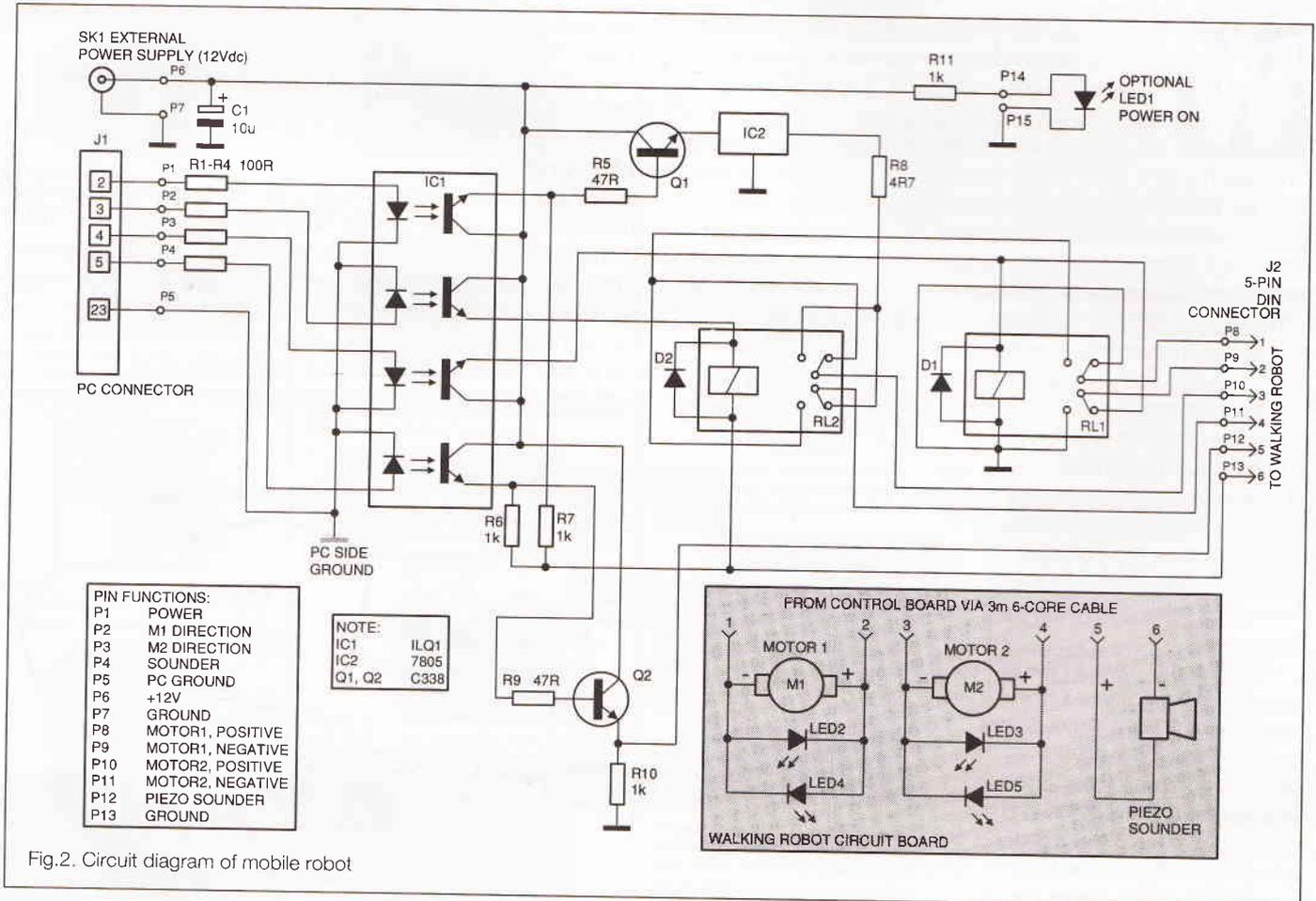


Fig.2. Circuit diagram of mobile robot

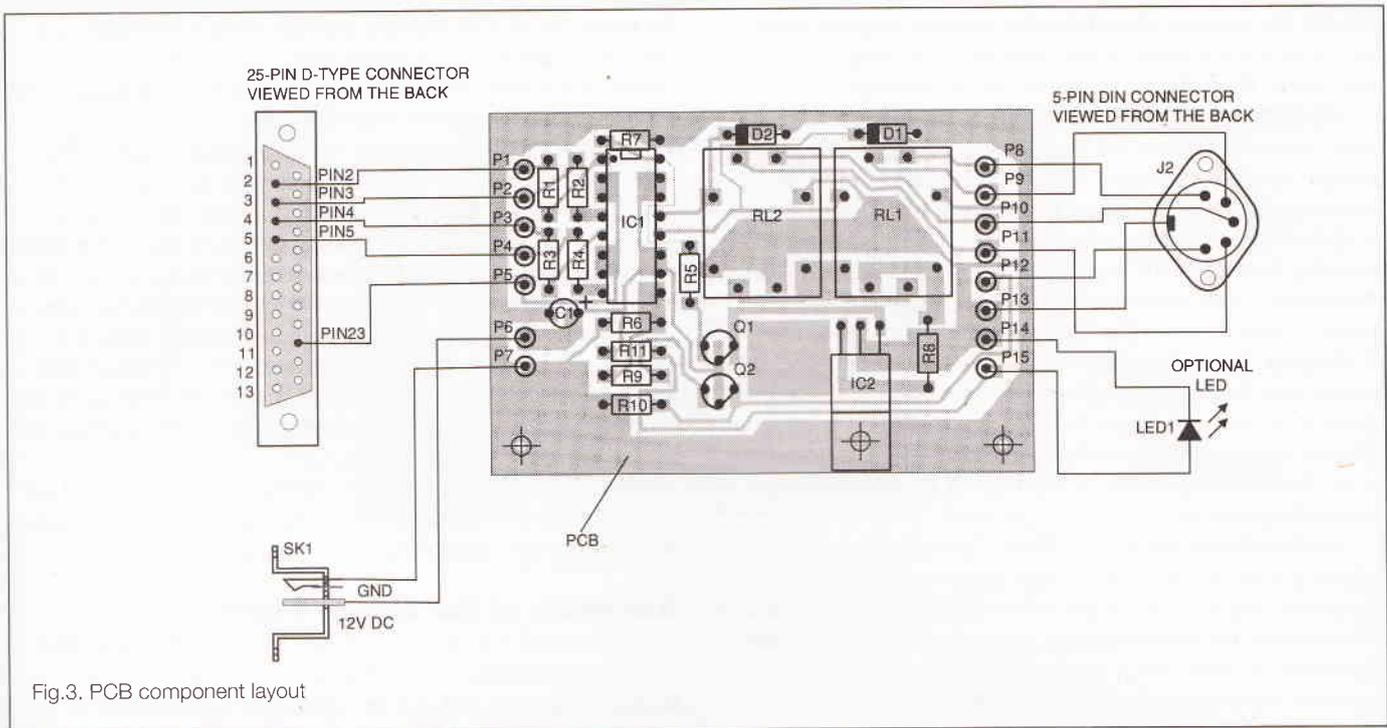


Fig.3. PCB component layout

be lit and turn on the corresponding photo-transistor. An opto-isolator provides electric isolation between two sides and the maximum isolation voltage is well over 4000V. Using such a device in the present circuit ensures that in case of anything wrong on the robot side, your computer is always safe.

### Motor power on/off

Refer to the circuit diagram; the POWER ON/OFF line controls the on/off switching of the first opto-transistor. When the line is high, the emitter of the photo-transistor goes high. The emitter signal is fed to a transistor switch based on TR1. The control signal is fed to the base of the transistor via a resistor R5. The 12V DC power supply is connected to the collector of the transistor and the controlled voltage is from the emitter of the transistor. When the base is in high state, the transistor is turned on. It just behaves like an ordinary switch which makes the 12V DC power supply to appear on the emitter. On the other hand, if the base control signal is in low state, the transistor is turned off. The controlled DC power supply from the emitter of the transistor is fed into a voltage regulator IC, 7805, which converts the 12V DC into a stable 5V DC power supply. This 5V power supply is then used for driving the two motors which are connected in series. R6 is a small resistor connected in series with the motors for limiting the current through the 7805 in case of short circuit in the transmission cable or on the circuit board on the robot.

### Directions of motors

The turning directions of the motor are controlled by a double-terminal, double-pole (DTDP) relay. In the circuit, the second and third data lines from the Centronic port control the On/Off switching of the second and third opto-transistors which, in turn, controls whether the relays are energized or not. When the relay changes its status, the polarity of the power supply to the motor is changed over to reverse the turning direction of the motor. D1 and D2 are diodes which are connected in parallel to the coils of the relays to protect the opto-isolators, since when the relay is de-energized a reverse high voltage will be generated in the coils. A red LED and a green LED with a

reversed polarity are connected in parallel to the terminals of the motor, showing the turning directions of the motor. For example, when the motor turns clockwise, the red LED will be lit; when the motors turns reversely, the green LED will be on.

### Sounder

The sounder is controlled by the fourth data line from the Centronic port. This circuit works in the same manner as the POWER ON/OFF circuit. The status of the line controls the On/Off of the second transistor TR2. A voltage oscillation is therefore produced across resistor R10. The Pizero sounder on the robot is connected in parallel with R10 and produces sound. The data line has to change its status fast enough to produce a continuous sound.

### The robot

The assembled walking robot is shown in Figure 9. It can be seen that the robot consists of two DC motors, two gear boxes, two driving wheels and a castor wheel. A small electronic board containing LEDs and sounder and providing connection of the transmission cable is also mounted on the robot. When the two motors turn in the same direction, the two driving wheels turn in the same direction and the robot moves forwards or backwards. If the two motors turn in the opposite directions, one wheel will turn in one direction and the other wheel in the reversed direction. As a result, the robot turns left or right. During turning, the castor wheel changes its direction to accommodate the movement of the robot. The control signal issued by the interface & control unit is transmitted to the walking robot via a flexible 6-core cable.

### The PCB

The Printed Circuit Board (PCB) copper foil of the circuit is shown at the back of this magazine and the component layout of the board is given in Figure 3. Before construction, check the electronic components used in the project. The electronic component list includes resistors, capacitors, diodes, transistors, opto-isolators, voltage regulators and relays etc.

Value of the resistors should also be checked by either using the colour code printed on the resistors or by using a multimeter. Then, the components can be soldered.

The components are mounted on the board in the following order: resistors, diodes, the socket for the opto-isolator, the voltage regulator, the relays, capacitor, transistors etc. When soldering capacitor, diodes and transistors, care must be taken to solder the legs of the components in the right position. When soldering the legs of the transistors, diodes and LEDs, soldering time should be as short as possible. After soldering, an M3 screw is used to fasten the 7805 voltage regulator onto the PCB board. The opto-isolator can be inserted into the socket (please note that the notch of the chip should be in the right direction as shown in Figure 4). Note also that LED1 is an optional indicator to show whether the control unit is power on or off. This is not necessary in most cases, therefore it is not supplied with the kit.

Good soldering needs a bit of skill. Generally, a good soldering point should have enough solder to solder the component leg and the copper foil securely, without excess use of the solder. The soldering point should have a smooth finish. Care must be taken not to solder adjacent copper tracks together! A final inspection must be performed to check whether the components are in the right positions and whether there are any shorts on the copper tracks! Any mistakes may result in some costly damage to the components. Careful checking can save a lot of money and time.

### The control box

Figure 4 shows the hardware detail of the box housing the circuit board. Several holes are cut on the side wall of the box

for fixing connectors including a 25-pin D-type connector, a 5-pin DIN socket and a 2.5 power plug. Two small holes are drilled on the base of the box for mounting the PCB board. A lid made of plastic is used to cover the box.

The assembly of the control box is shown in Figure 5. The PCB board is mounted inside the box using two No.6 0.50" length self-tapping screws and several spacers as shown in figure 5. The height of the PCB fixing pillars should be the same height as the relays. Double-sided adhesive tape is placed on the top of the relays for mounting the lid. The connectors are fixed on the wall with screws as stated in Figure 5. After the PCB board and the connectors are fixed, the connection wire between the connector pins and the pins on the PCB board are soldered. Make sure that the soldering point is firm and free of shorts with other connector pins.

Now the lid can be placed on the top of the box. The lid will be held in position by the adhesive tape on the relays and two PCB fixing pillars supporting the lid from underneath.

### Assembly of the circuit board

Figure 6 shows the assembly of the circuit board on the robot and the transmission cable. The circuit is made from strip board, 5 mm long and 2.9 mm wide (which correspond to 19 holes in the row and 10 holes in the column). The LEDs are soldered on the board first. Care should be taken on the polarity of the LEDs and their positions on the board (Figure 6). The soldering time should be kept as short as possible. The Pizero-sounder is mounted on the board using a double-sided adhesive pad. The terminals of the two motors are connected to the board with the polarities shown in Figure 6.

The six cores of the transmission cable are finally soldered

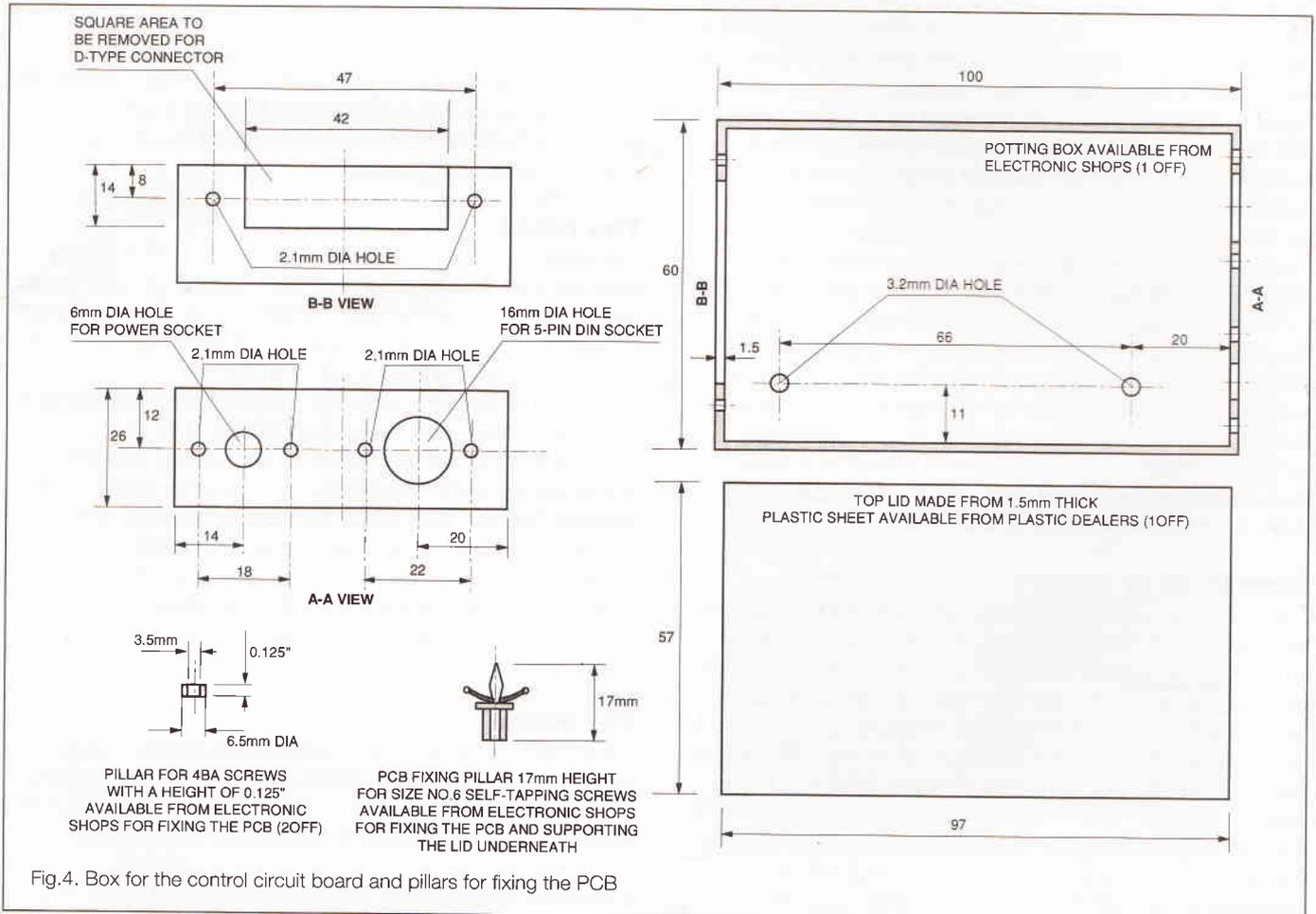


Fig.4. Box for the control circuit board and pillars for fixing the PCB

0.25" NO.4 SELF-TAPPING SCREWS

CONNECTED TO THE CENTRONICS PORT OF THE PC

0.25" NO.4 SELF-TAPPING SCREWS

DOUBLE-SIDED ADHESIVE TAPE FOR MOUNTING THE LID

M3 SCREW TO FASTEN THE REGULATOR TO THE PCB

CONNECTED TO THE ROBOT

0.25" NO.4 SELF-TAPPING SCREWS

POWER SUPPLY INPUTS

M2, 6mm SCREWS

PCB FIXING PILLARS TO MOUNT THE PCB AND SUPPORT THE LID FROM UNDERNEATH  
THE TOP OF THE RELAYS AND THE TOP OF THE PCB PILLARS HAVE THE SAME HEIGHT

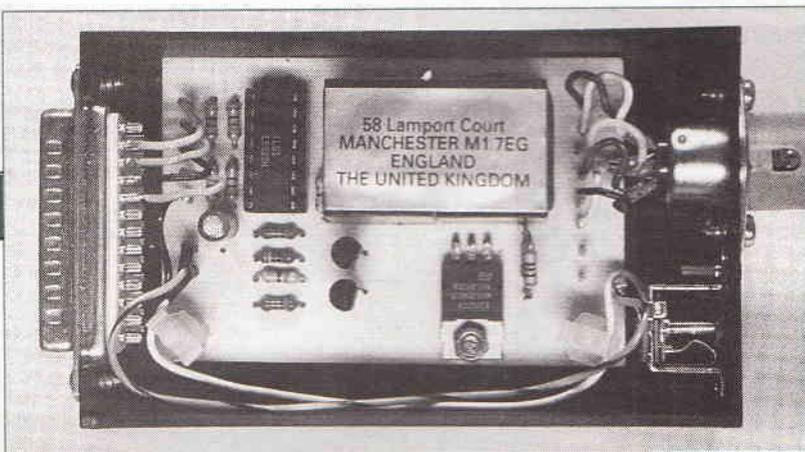
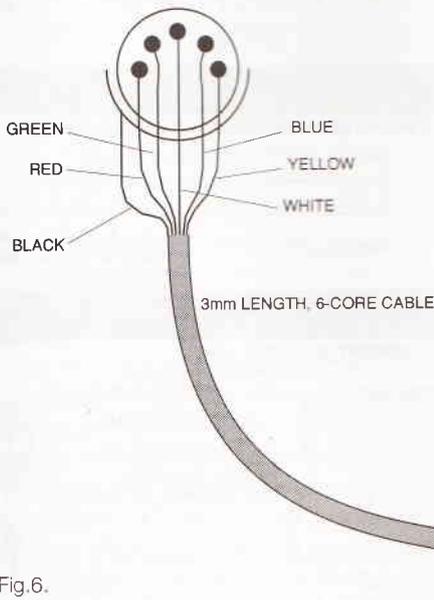


Fig.5. Construction of the control box

CONNECTION DETAILS (VIEW FROM THE BACK)



CABLE TIE FOR FASTENING THE CABLE

2.8mm DIA HOLES

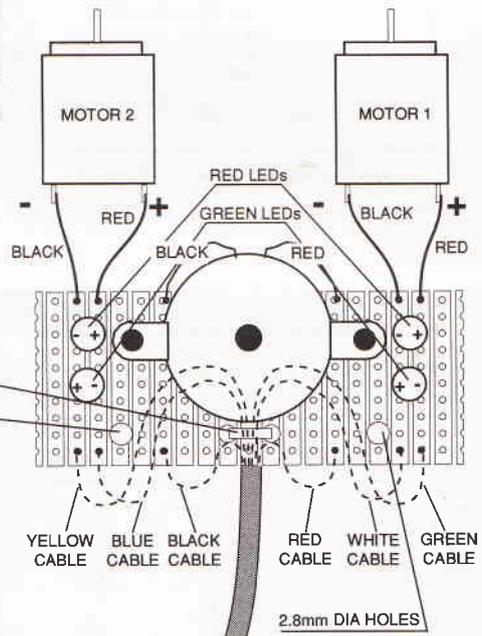


Fig.6. Construction details of the circuit board on the robot

onto the board in the order illustrated in Figure 6 in which the colours of the core is used as the reference. The cable is fastened to the underside of the circuit board using a cable tie.

The transmission cable has six cores and is about 3m in length. Standard BT telephone cable is ideal for the job. One end of the cable is connected to the circuit board as mentioned above and the other is connected to a 5-pin DIN plug. The order of connection is shown in Figure 6.

The power supply to the robot should be 9-14V DC. The current requirement is about 250 mA. Any 12V DC mains adaptors of that current rating or a battery pack can be used for the job. If you have any problems in finding one, please contact the author (see end of article).

## The robot's gear box

The robot is constructed in two halves (Figure 8) and they are put together by two beams (see Figure 9). The mechanical components for the robot is shown in Figure 8. The main frame is a rectangular plastic plate, 100 mm long, 40 mm high and 3 mm thick. A small plastic plate, 40 mm square and 3 mm thick, is fastened to the main frame by two 0.625" length 6BA spacers and 1" length 6BA screws (see Figures 8 and 9). The space between the main frame and the plate houses a gear box consisting of two plastic gears: Gear 1 and Gear 2. Gear 1 is a combination gear which consists of a big gear with 42 teeth and a small gear with 10 teeth. Gear 2 has 60 teeth. The shaft of the motor is coupled to the 42-tooth gear via a worm (Figure 8). The

10-tooth gear of Gear 1 is geared to Gear 2 which is then transmitted to the 2" drive tyre via the drive shaft. This gear box gives an reduction ratio of about 240 (i.e. the motor turns 240 revolutions to make the tyre to turn one revolution).

## Construction

First, the plastic gears and their shafts, the worms and the shaft of the motors are assembled together. The shafts (2 mm diameter metal rod) are forced into the central hole of the gears and the positions of the gears on the shafts are shown in Figure 8. Then spacers (10 mm length green plastic tubes) for positioning the gears are installed on the shaft. At this stage, all the gears can be fitted to the main frame and the small plate is fastened also to the main frame using the two sets of screws and pillars (see Figure 8). After assembling the gear box, it must be checked whether the two gears are geared properly and could be turned easily. If it is stiff, fine adjustments have to be made to change the relative positions of the main frame and the small plate.

After the gear box is properly constructed, the motor can be stuck onto the main frame using double-sided sticky pads. The position of the motor must be finely adjusted so that the worm is perfectly geared to the 42-tooth gear. A cable tie is then used to fasten the motor firmly in position. Now the gear box is assembled!. If you connect one or two batteries to the motor, the gears should turn smoothly. Finally, the 2" rubber tyres are mounted on the drive shafts. As the diameter of the central hole

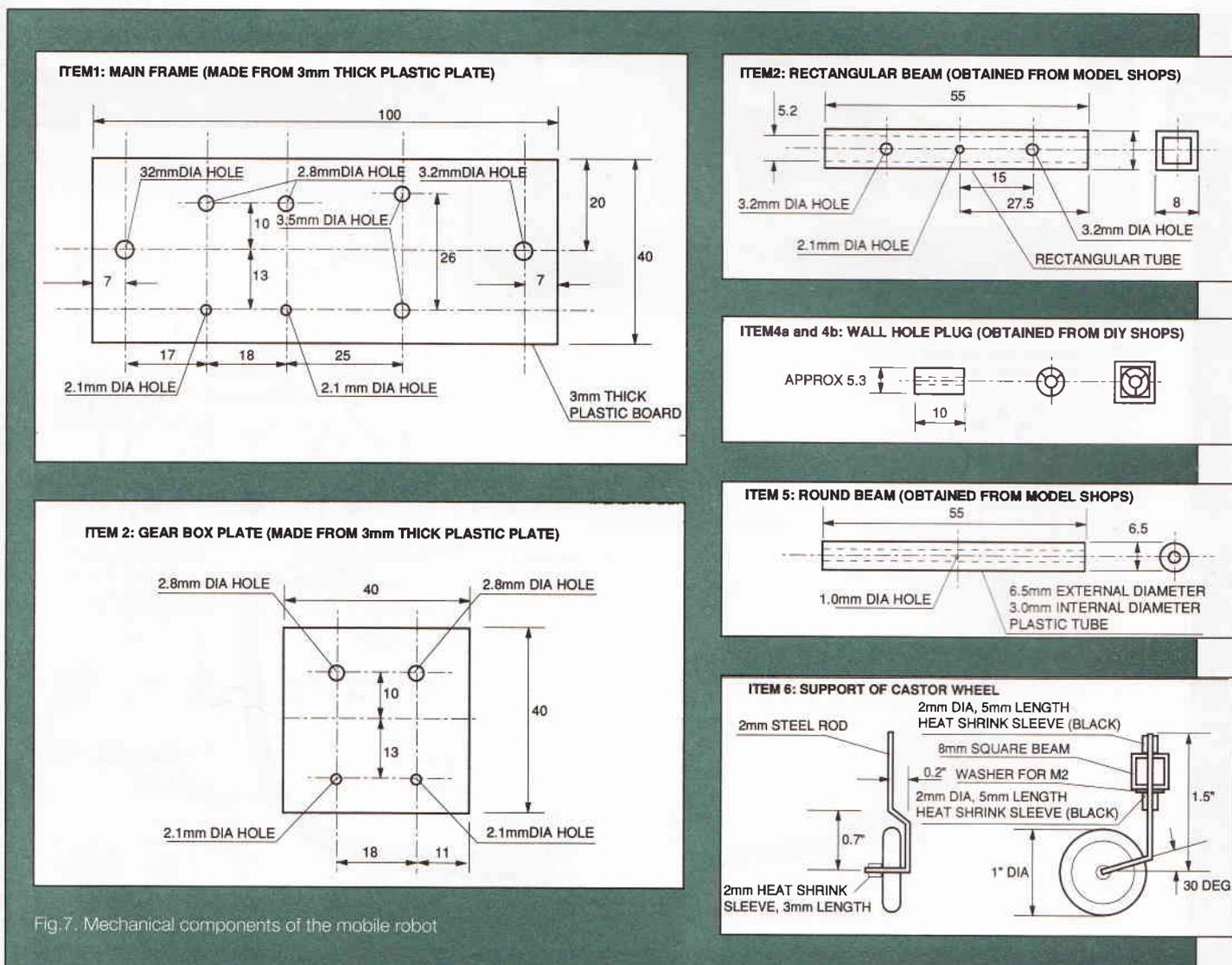


Fig.7. Mechanical components of the mobile robot

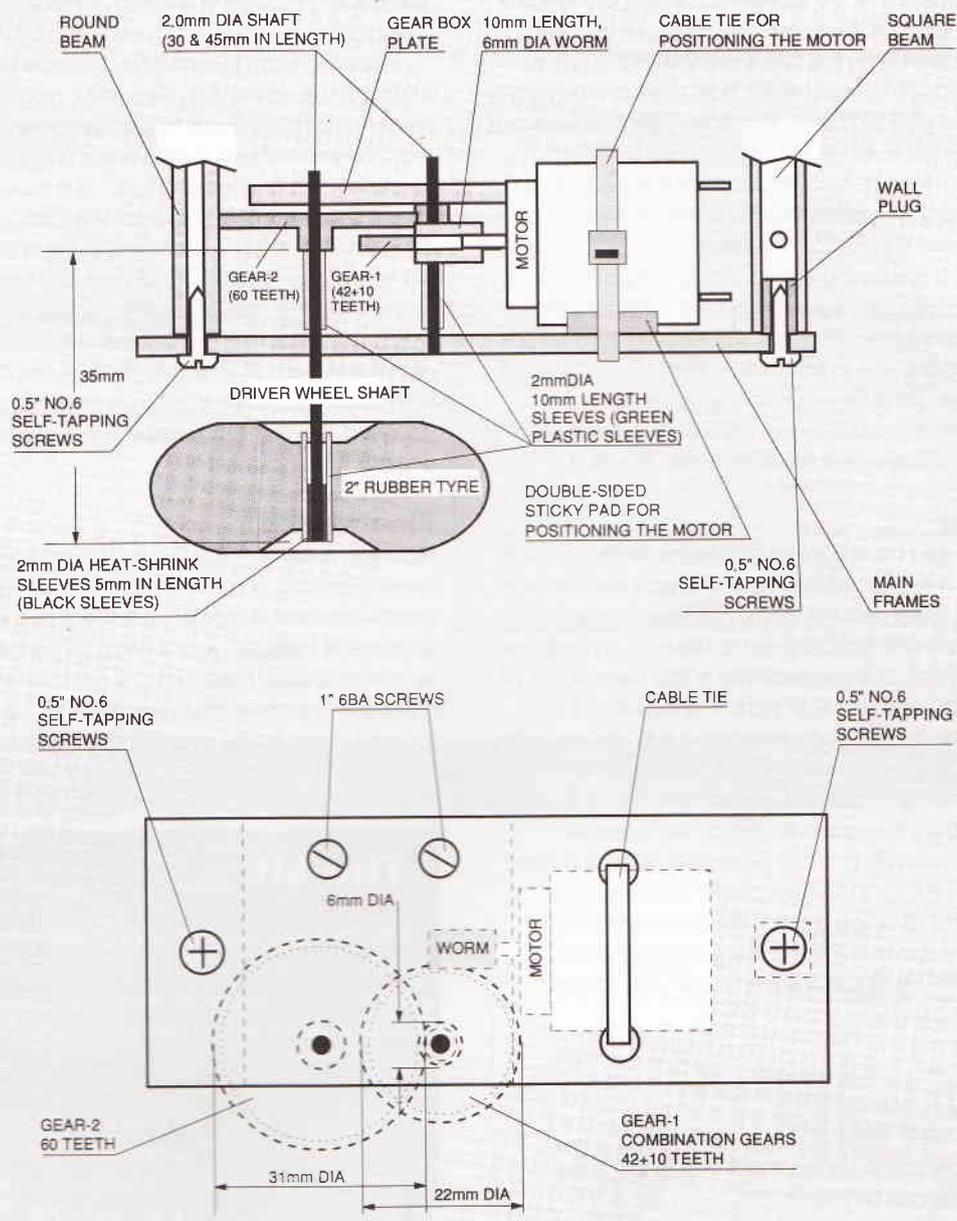
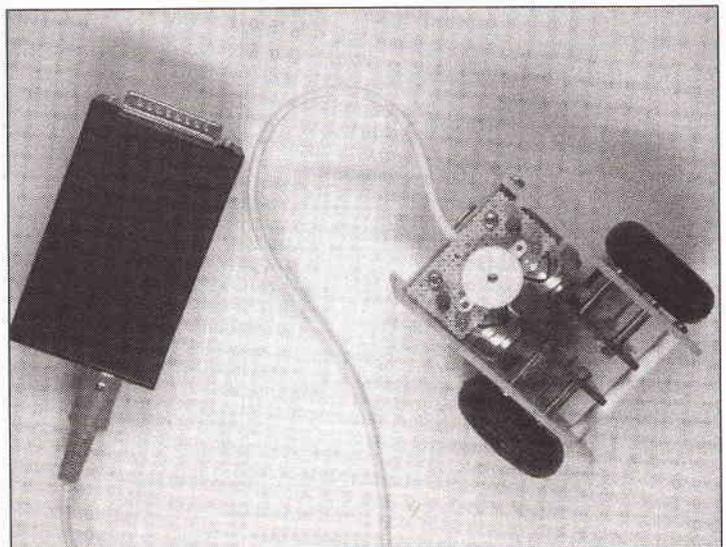


Fig.8. Assembly details of one half of the robot

of the tyres is bigger than the diameter of the rod, a 2mm diameter, 10mm length heat-shrink plastic tube (supplied with the kit) is used to cover the rod first, then a 2mm diameter, 10mm length plastic tube (also supplied with the kit) is used to cover the black plastic tube further. The overall diameter of the rod is then big enough to fasten the tyre to the rod (Figure 8).

**Connection**

The two halves are connected together by two beams. One beam is a square tube with an external dimension of 8mm square and a wall thickness of 1.5mm. The other one is a round tube 7mm in external diameter and 3mm in internal diameter (Figure 6). Self-tapping screws (size No.6, 0.5" in length) are used to fasten the two gear box assemblies to the beams. Wall plugs (10mm length) are inserted into the two ends of the square tube first and then fastened to the main frame using the self-tapping screws. The construction details are given in Figures 8 and 9.



## Mounting

The castor wheel is a plastic wheel, 1" in diameter with a 2.1mm hole in the centre of the wheel for the support which is made from 2mm diameter steel rod. The shape of the castor support and its mounting on the robot is shown in Figure 8. The rod goes through the 2.1mm diameter hole drilled in the middle of the square beam (see Figure 9). The 2mm diameter, 5mm length heat-shrink plastic tubes are used at two ends of the support and a 5mm length 2mm plastic tube below the square beam. They are used for positioning the wheel and for positioning the castor support on the beam.

The circuit board containing the sounder and LEDs is also mounted on the square beam (see Figure 9). Two hex plastic spacers (0.5" length spacers for No.4 self-tapping screws) are fastened to the copper side of the board using two 0.25" No.4 self-tapping screws. Then the assembly is fastened to the rectangular beam of the robot using two 0.5" No. 4 self-tapping screws. The detail of the assembly is shown in Figure 9.

## Programming

The robot is controlled by the computer via the Centronic port of the computer. The works of the Centronic port and the way to program it have been detailed in many books. The pin functions of the Centronic port is given in Figure 8. In brief, the Centronic port consists of three separate ports, namely, DATA port, CONTROL port and STATUS port. The DATA and CONTROL ports are output ports associated with data transfer and command issuing from the computer to the external devices. The STATUS port is an input port, which is used by the computer to read the information issued by the external devices. A PC can have up to three Centronic ports and they are labelled LPT1, LPT2 and LPT3. For LPT1 Centronic port, the addresses of the above ports are 888 890 and 889 in decimal. These three ports can be controlled separately. For example, to output a data from the DATA port, the following commands can be used:

In Turbo Pascal:

```
Port[888]:=data;
```

In GW BASIC:

```
:out 888, data
```

To read data into the computer via the STATUS port, the following commands can be used:

In Turbo Pascal:

```
data:=Port[888];
```

In GW BASIC:

```
:data=INP(888)
```

The present circuit only utilizes 4 bits of outputs of the DATA port (888 in decimal for LPT1) as described in the section 'WORK'. Therefore, to control the robot, we only need to write different data in the 4 data bits of the DATA port.

The procedure for controlling the robot is fairly simply. However, to write a complete program of using the keyboard, for example, is slightly complicated. The control program should incorporate other procedures associated with keyboard operation, monitor display etc. A program can also be written to control the robot solely by the computer itself.

A demonstration control program written in Turbo Pascal 6 is supplied in a 3.5" floppy diskette with the kit. This program allows the robot to be controlled by the computer keyboard. The arrow keys control the movement of the robot. The space-bar will make the robot stop and the backspace key will make the robot 'speak'. This program is rather rudimentary and is intended for demonstrating the software control. Readers can use their imagination to create their own much advanced and fancy control software.

## Testing

This circuit involves no adjustments at all. If all the components are properly located in position, the robot system will work straight away.

The procedure of testing is described as follows. First of all, switch off the computer. Secondly, plug the control box to the printer port on the back of the computer. Thirdly, connect the transmission cable and the power supply to the control box. Finally, switch on the computer. The robot may move at this stage, so lay the robot upside down for a moment. Meanwhile, the computer should boot itself in the normal manner. If the computer does not do so, disconnect the control box quickly and find out the reason for that. Under DOS prompt, run the program entitled 'ROBOT', then the robot is under the control of the keyboard of your computer. If the robot refuses to respond to any of your controls or behaves erratically, check your circuit board thoroughly. There must be something wrong on your circuit board.

## Final words

Now you have constructed your mobile robot and you have developed your control software. Your robot is 'walking' proudly across the floor, it travels underneath your table and explores small gaps between your furniture. It flashes its lights and sings simple melodies. Even prouder, you are sitting by your computer watching your new offspring take his first steps. Who knows? In the future, your robot could be destined for bigger and better things.

## The kit

The Mobile Robot kit is available from the author at a price of £26.50 + P&P (£3). The assembled and tested form is also available at a price of £37 + P&P (£3). Please make your cheque payable to Ms. C.X. Qiu. The author's address is:

**58 Lamport Court  
Lamport Close  
Manchester M1 7EG  
England, U.K.  
Tel/Answer/Fax:  
(U.K.) 0161-272-8279  
(Abroad) +44-161-272-8279**

The author will also provide the following hardware support: the 12V DC mains adaptor, 12V battery pack and beginners' tool box.

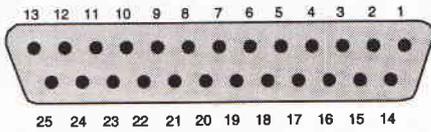
## Program 1

```
Program robot;  
{Control program for the Mobile Robot}  
{Writting by Dr. Pei An, 1/10/94}  
{Control port, DATA port of LPT1, DB0: Power to  
the motor  
DB1: Motor-1 direction control  
DB2: Motor-2 direction control  
DB3: Sound control}  
uses  
dos,crt;  
  
var  
Soundlength:longint;  
command:byte;  
status:string[20];
```

Pin functions of the Centronic port connectors

Connectors on computer	Direction	Name	Explanation
1	C to P	STROBE	Strobe data
2	C to P	DB0	Data bit 0
3	C to P	DB1	Data bit 1
4	C to P	DB2	Data bit 2
5	C to P	DB3	Data bit 3
6	C to P	DB4	Data bit 4
7	C to P	DB5	Data bit 5
8	C to P	DB6	Data bit 6
9	C to P	DB7	Data bit 7
10	P to C	ACK	Indicating data received
11	P to C	BUSY	Indicating printer busy
12	P to C	PE	Indicating paper empty
13	P to C	SLCT	Indicating printer on line
14	C to P	LF/CR	Auto linefeed after carriage return
15	P to C	ERROR	Indicating printer error
16	C to P	INITIALIZE	Initialize printer
17	C to P	SLIN	Select/deselect printer
18-25		GND	

'C' = Computer 'P' = Printer



Pin-out of the Centronic connector on PC computers - 25-pin female D-type connector

Fig.9. Centronics Port Connections

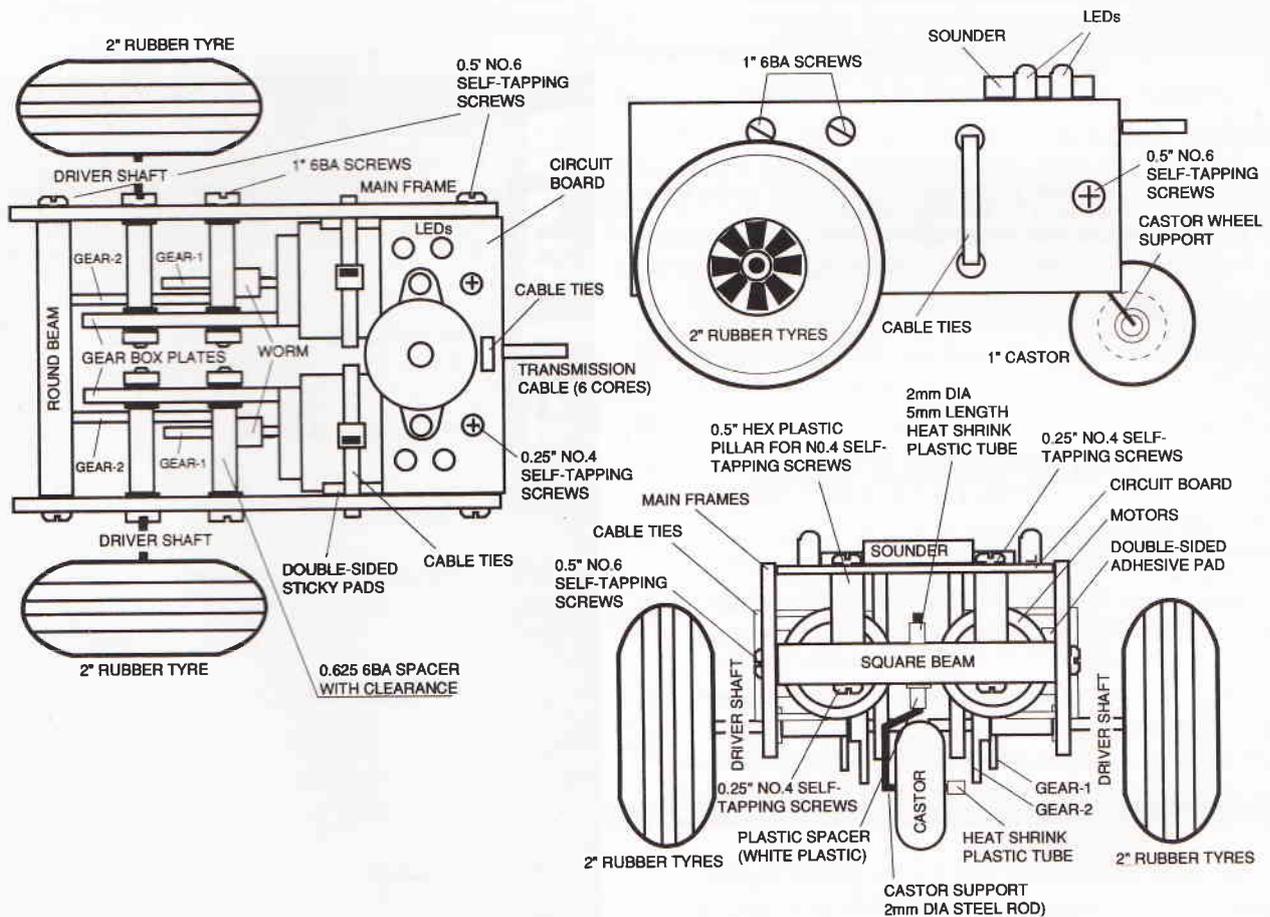


Fig.10. Construction details of the robot

```

Procedure Control_keys;
begin
  textcolor(lightblue);
  writeln('Electronics Today International
  Mobile Robot');
  writeln('_____ Robot
  control demonstration
  program_____');
  writeln('Presented by Dr. Pei An');
  writeln;
  writeln('Control key layout');
  writeln;
  writeln('Arrow keys      Movement of the
  robot');
  writeln('Space Bar      Stop the robot');
  writeln('Backspace      Sound effects');
  writeln('Return          Quit the program');
  textcolor(lightred+blink);
end;

Procedure output_byte(datax:byte);
begin
  port[888]:=datax;
end;

Procedure left;
begin
  command:=1+0+4;
  status:='Turning left';
  output_byte(command);
end;

Procedure right;
begin
  command:=1+2+0;
  status:='Turning Right.';
  output_byte(command);
end;

Procedure forward;
begin
  command:=1+0+0;
  status:='Moving forward';
  output_byte(command);
end;

Procedure backward;
begin
  command:=1+2+4;
  status:='Moving backward.';
  output_byte(command);
end;

Procedure stop;
begin
  command:=0+0+0;
  status:='I stop here';
  output_byte(command);
end;

Procedure Sound_effect(soundlength:longint);
var
  ii,kk:longint;
  delaynumber:integer;
begin
  status:='I am singing a song';
  gotoxy(29,22);write(status);
  for kk:=1 to 20 do
  begin
    delaynumber:=round(random*10/4);
    for ii:=1 to soundlength do
    begin
      output_byte(8);delay(delaynumber);
      output_byte(0);delay(delaynumber);
    end;
  end;
  delay(50);
end;

Function getkey: string;
var

```

```

  key_char:char;
begin
  key_char:=readkey; {get a
  character from the keyboard}
  if (key_char=#0) then
    begin
      key_char:=readkey;
      if (key_char = #72) then getkey:='FORWARD'
      if (key_char = #80) then
        getkey:='BACKWARD';
      if (key_char = #75) then getkey:='LEFT';
      if (key_char = #77) then getkey:='RIGHT';
    end;
    if (key_char= #8) or (key_char=#127) then
      getkey:='SOUND';
    if (key_char= #13) then getkey:='RETURN';
    if (key_char= #32) then getkey:='STOP';
  end;
end;

```

```

Procedure Movement_control;
var
  whatkey:string[10];
begin
  repeat
    whatkey:=getkey;
    if whatkey='FORWARD' then forward;
    if whatkey='BACKWARD' then backward;
    if whatkey='LEFT' then left;
    if whatkey='RIGHT' then right;
    if whatkey='SOUND' then sound_effect(50);
    if whatkey='STOP' then stop;
    gotoxy(29,22);write(status);
  until whatkey='RETURN';
  output_byte(0);
end;

```

```

{*****Main
Program*****}
begin
  clrscr;
  control_keys;
  movement_control;

```

## PARTS LIST

### Resistors

- R1-4                    00ohm 0.25W metal film
- R6,7,10,11            1Kohm 0.25W metal film
- R5,9                    47ohm 0.25W metal film
- R8                      4.7ohm 0.25W metal film

### Capacitors

- C1                      10uF 16V

### Semiconductors

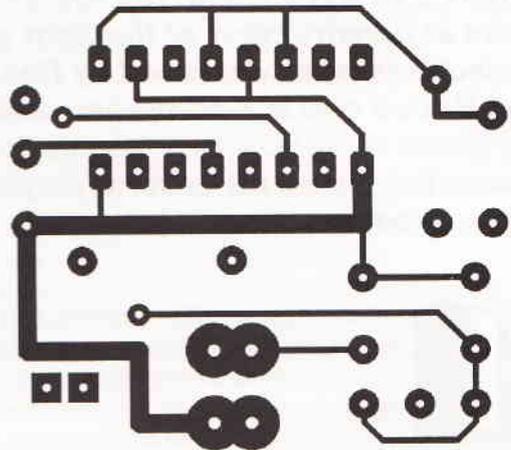
- IC1                    ILQ1 quad opto isolator
- IC2                    7805 +5V 1A voltage
- regulator
- TR1,2                  C338 NPN transistors
- D1,2                   1N4148
- LED1,2,3               Red 5mm LED
- LED4,5                 Green 5mm LED

### Miscellaneous

- RL1,2                  12V coil DPDT relays
- J1                      25pin D type male connector
- J2                      180 degree DIN socket
- SK1                     2.5mm power socket
- Motor1,2               3.6V DC motors
- P1-5                    Sounder Pizero sounder PCB pins

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# Light Gun Base

**In part 2 of ETI's Laser Tag system Neil Birtles looks at construction of the light gun base. This project has been designed by Robin Abbott and Neil Birtles and is a computer controlled laser tag game system, a very sophisticated interactive game for several players that rivals those used commercially**

## PART 2

**O**n the last issue of ETI we looked at the design and construction of the gun units and the individual player control system. In this, the second part of the light gun project, we look at the team bases. There are two bases, one for each team - red and green. In team games each team defends its own base whilst trying to destroy the other team's base. In individual games any player may attack any base. Each base has a siren and a xenon flasher to indicate when it has been "triggered"; the flasher is a different colour for each base, and the siren is of a different tone for each base.

The bases may be used autonomously when scoring can be achieved manually, or they may be wired into the light gun central which keeps scores for the teams as well as for each player. Player numbers are recognised from the gun transmission.

### Light gun base features

On the front panel of the base there are three large LEDs (10mm) arranged in a triangle shape; these indicate the status of the base. There is also a single 3mm LED in between the two larger LEDs on the bottom of the triangle. In the centre of the triangle is the infra-red detector. The LED colour is chosen to match the team which owns the base - red or green. Mounted on top of the base is a xenon warning light and a siren.

On the back of the base there are a number of sockets to connect the xenon warning light, the siren, a wire communication to the central unit and a battery recharging socket. The siren is socketed to allow silent operation if there are close (and irritable) neighbours! The xenon light is socketed to allow other devices to be connected and triggered when the base is hit, for instance firing a thunderflash makes triggering the base much more spectacular!

The LED to indicate that rechargeable battery charging is in progress is located on the left-hand side of the base. Also on the back of the base unit is a power down switch. Like the guns, the base automatically powers down after a period of inactivity - 30 minutes for the base. A period of inactivity is defined as a time when the base has not been hit and, to

"wake" the base up once it has entered sleep mode, it must be powered off and on again.

Inside the base there is all the circuitry controlling the operation of the base. The base contains its own rechargeable batteries, so that no external power supply needed.

When the small LED is flashing it indicates that the base is "active". To hit the base a player must fire at the sensor to

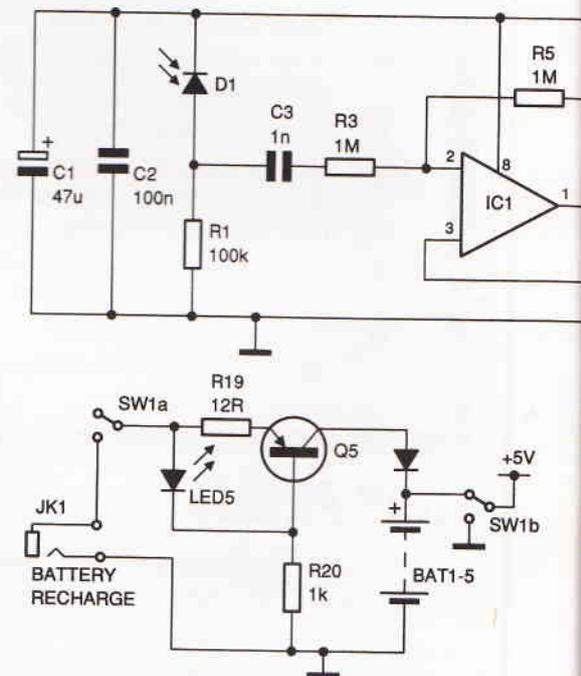


Fig.1. Light gun base circuit diagram

extinguish the LED. Six seconds later, the larger LEDs in the triangle will flash in a circular sequence; at this point the player has a further five seconds in which to fire at the base again and trigger the base. This sequence is to make it more difficult to hit the base, and to allow the defending team to repel an attack.

Once the base is triggered, the xenon warning light is activated and the siren sounds for a 30-second period during which the base cannot be hit again. The same player must hit the base on the first and second time to trigger it. The base uses the ID fired by the gun to detect who hit it. Several players attempting to hit the base simultaneously will interfere and make it impossible to successfully trigger the base. This gives an incentive for players to support each other and to act in teams rather than to go for individual glory!

Different colour bases do not differentiate between players of different teams, so it is possible to hit your own base (losing your own team points). In individual games any player can hit any base.

### Transmission to the central renewal unit

Like the guns, the bases can be used in two different modes depending on whether or not the central renewal station is being used. When the central is not being used the base stands alone. The base still operates in the same way except that the ID of the gun that hit the base is not transmitted to the base. The organisers will also have to count the number of times the base as been hit as there is no other record without the central.

In this mode the base still requires that the same player should hit it twice to trigger it. Guns which have never had their ID programmed by the renewal station will default to Red 8; therefore if the guns have not been programmed then different players will be able to make the first and second shots.

Simultaneous shooting will still interfere and make it impossible to trigger the base.

When a central renewal unit is used the bases are wired to it with single core cable. The bases transmit the ID of the user who successfully triggered them to the central which uses the IDs to keep track of individual and team scores.

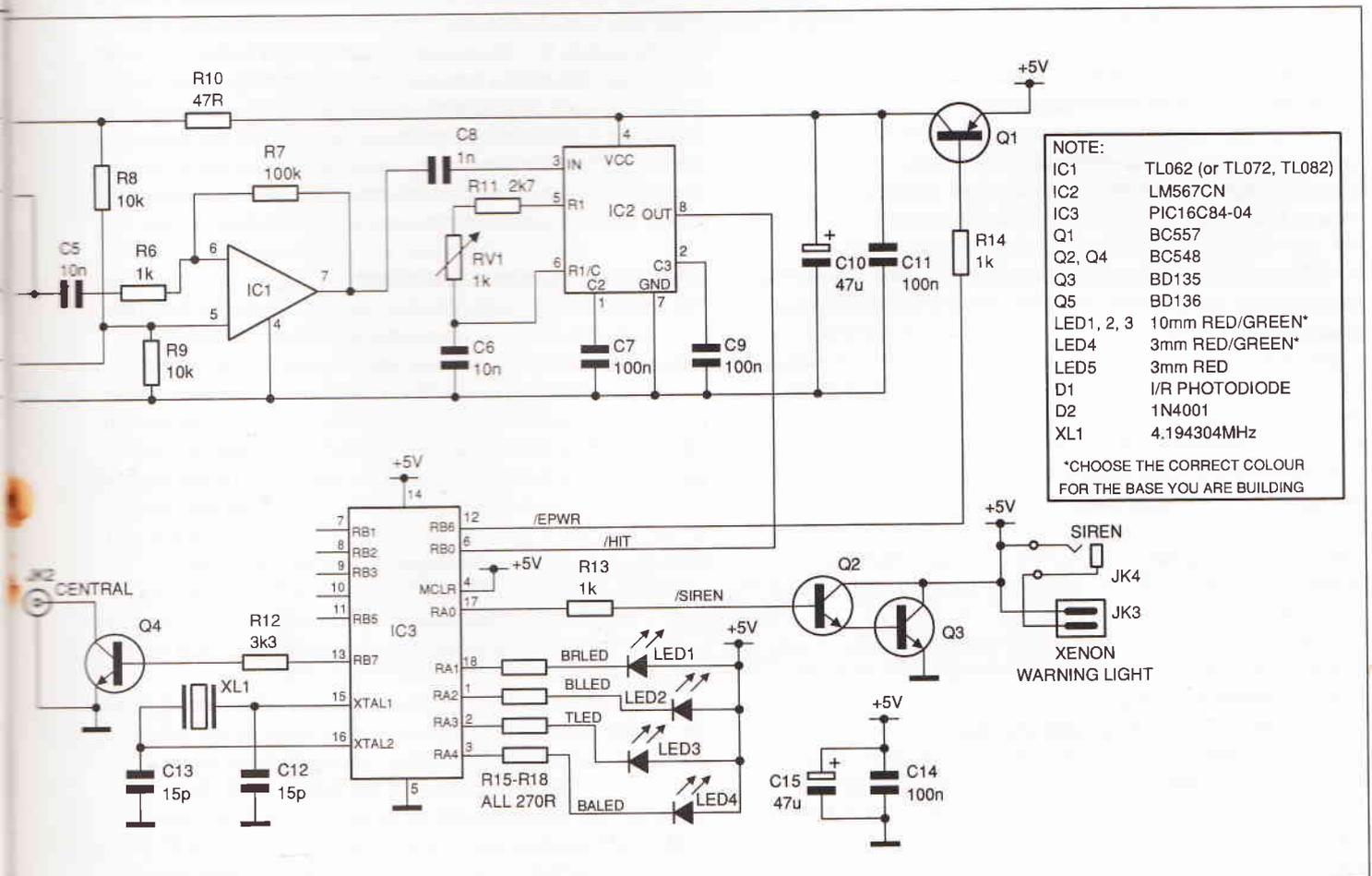
### Other features

The light gun base units have their own batteries built into the cases. The batteries we used were C type NiCds. There is also a recharging circuit built into the base. These batteries can be recharged from any 10-15v DC power supply capable of supplying 150 mA. The base is recharged by inserting a 3.5mm mono jack plug into the recharging socket on the back right looking at the back. The plug should have the ring as positive and the tip as negative (so the same charger can be used for the guns and the bases).

### Circuit description

The circuit diagram of the base is shown in figure 1. To allow minimum design and software re-use, the circuit is very similar to the light gun. However the PIC outputs are used to drive the LEDs and the serial link to the central. As with the light guns, the base uses a micro-controller - the PIC16C84. This is IC3 in the circuit diagram. The program for the base is stored in the on-chip EEPROM.

Each output from the PIC can sink up to 20mA; this enables LEDs to be driven directly from the outputs. The three 10mm LEDs and the base active LED are driven from outputs RA1 - RA4. These LEDs turn on when the output pin on the PIC goes low. Pin 17 drives the siren and the xenon strobe through a Darlington pair. TR3 is a medium power transistor to support



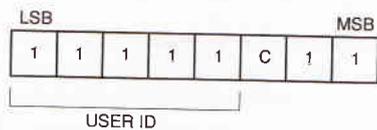


Fig.2. 8-bit message format

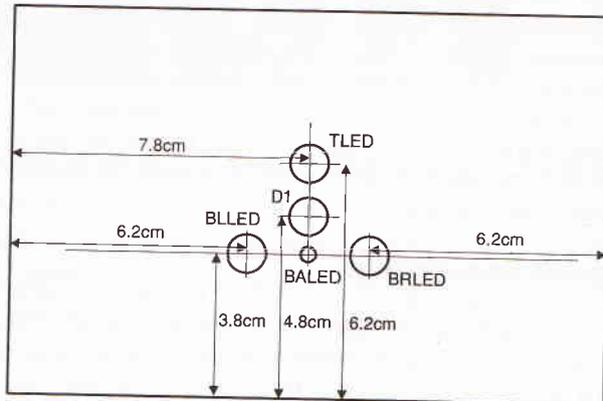


Fig.3. Front panel

the large currents drawn by the external devices.

The infra-red pre-amp circuit is similar to the light gun. The output from the sole IR detector D1 is passed to amplifier IC1. The output from the amplifier is then passed on to the PLL tone decoder IC. The PLL circuit is built around the 567 tone decoder IC set up to detect signals of 26KHz. It is important for the base that C6 be a high stability polyester or polystyrene capacitor to ensure that the frequency does not change too much with temperature. We found that if we used cheap capacitors, then perfectly working bases suddenly stopped detecting hits when taken outside in the cold. Unlike in the light guns the PLL has to detect signals fairly fast so that the PIC can correctly read the ID of the gun that just hit the base. This means that there is no capacitor to filter the input to the PIC (pin 6).

TR1 controls power to the receiver circuits, C1, C2 and R10 provide decoupling for these circuits and any switching noise generated by the PIC is eliminated by these components. Capacitors C15 and C14 provide decoupling across the whole power supply. The NiCd batteries in the base are recharged by a simple constant current source based on TR5. The charging current is controlled by R21. The charging current is about 90 mA set by R21 at 12R. There are five C cells which provide a voltage of 6.5v; this is actually outside the specification of the PIC device but worked without problem in the prototype. Five cells are used to provide the highest possible voltage for the external devices, which are specified at 12V, but which worked quite well at 6.5V.

The PIC detects the 5 bit ID transmitted when a gun fires. The ID is repeated and the base only recognises a hit when both transmissions of the ID match.

Transistor TR4 is used to send the data to the central. TR4 is controlled by RB7 (pin 13) on the PIC. The wire from the central plugs into SKT3 which is a phono socket. The link from the central is single core microphone cable. At the central there is a 1K pull-up resistor so that the base can pull the voltage at the central to 0v.

The bases transmit at a very low rate - about 1 bit per second. This allows the data transmission and detection to be made in software on interrupts. In addition, the low data rate allows simple radio links (using tone decoders) for communication, and the links are noise resistant. The prototypes drove 100m wire links to the central without problem.

Normally the line is at +5V. To transmit a '1' bit, the base sends 0v for 0.25S followed by +5v for 0.25S. To transmit a '0' bit, the base sends 0v for 0.25S followed by +5v for 0.75S. After sending 8 bits, the base holds the line at 0v for 30S until the base returns to the active state. Figure 2 shows the 8 bit message transmitted from the base to the central. The user ID is the identity of the user who triggered the base, C is the colour of the base, 0 for the red base, 1 for the green base. The base colour is "hard" programmed into the PIC.

In the warrior game, only certain players are allowed to trigger the bases. To achieve this, the central renewal station informs the guns in the renewal packets whether they are permitted to trigger the base. Guns which are not permitted to hit the bases will not transmit their IDs, and the bases will ignore hits from such guns.

## Construction

The complete component list for a light gun base is shown at the end of this article.

## Electronic construction

Electronic construction is fairly straightforward. The PCB overlay is shown in figure 6. Note that all the sockets, switch SW1, all the LEDs, the photodiode and the batteries are mounted off the PCB.

There is only one wire link on the PCB and this needs to be fitted first. Next, locate and mount the resistors in the correct places. Locate and mount the IC sockets next but do not insert the ICs yet. Mount the ceramic capacitors noting values. Next, mount the electrolytic capacitors noting polarity and value. Now mount the low power transistors and then mount the power transistors for driving the siren, xenon strobe and the recharging circuit - heat sinks are not required for the power transistors. Lastly, mount the printed circuit board pins and the crystal.

## Mechanical construction

We used a sloping case (Verobox type 217) to house the light gun base. The case has a separate aluminium front panel on which most of the components are mounted. Figure 3 shows the position and diameter of the holes in the front panel. These holes should be drilled and then any sharp pieces of aluminium removed with a file or knife. The top half of the case and the aluminium front panel should then be painted in the appropriate colour for that base (red or green). The front panel graphic is shown in figure 4, this can be photocopied on to clear film and then stuck to the panel after the LEDs have been fitted.

The bottom half of the case is to be drilled to accept the various connectors, the power switch, LED 5, and the mounting holes for the PCB. The position of these components is shown in figure 5.

A solder tag has to be attached to the aluminium front panel so that this plate can be earthed. A thick piece of aluminium foil is glued to the bottom of the case over the holes that were drilled to accept the mounting screws for the PCB. The aluminium foil should be slightly larger than the PCB, and is earthed with a solder tag; this is to reduce noise to the IR pre-amp. As in the light guns, the glue that we found best was

silicone rubber as it is flexible and will not crack when the base is shaken around or dropped.

The siren and xenon strobe are mounted on the top of the case using M3 nuts and bolts. We made our own bracket to mount the strobe. The siren has a 3.5mm mono jack plug, the xenon strobe has the 2 pin DIN plug; make sure the leads are long enough to reach the sockets.

The 10mm LEDs (red or green) can then be mounted on the aluminium front panel. LED mounting grommets can be used but we superglued the LEDs to holes that were just under 10mm in diameter so the tips of the LEDs showed through the case. We used the same method to mount the 3mm LED. The hole for the IR detector in the centre needs a piece of red filter material sticking it, the black photo-diode is then glued flat side down, directly behind the hole in the front panel.

The connectors in the back of the base and LED 5 can then be mounted in accordance with figure 5 and wired in accordance with the circuit diagram.

Finally, the batteries need to be mounted. Tin both terminals of all the batteries. This may take some time as the ends need to be quite hot before the solder will flow. Cut four lengths of wire approximately 3cm long. With one wire, join the positive of one battery to the negative of the next. Repeat this with the other three pieces of wire. The batteries need to be glued into the case. The best position for the batteries is around the outside of the case, two on the opposite side to the connectors, two down one side and one down the other side.

### Final construction

Bolt the PCB down to the case with M3 fixing screws and spacers. Cut equal lengths of 6-core cable and screened microphone cable. Solder the screened cable to the IR detector diode. The screen should be soldered to the anode of the detector diode. Figure 7 shows the connections on the detector diode and LEDs. Connect the anodes of all the LEDs mounted on the front panel with a length of tinned wire and then one core from the cable should be joined to this. Join another one of the cores to the solder tag that was fixed to aluminium front panel. The remaining four wires should be soldered to the four cathodes of the LEDs. The colours we used for the connections and the terminal pins they connect to are shown in table 1.

Wire the connectors, LED 5, and the power switch on the lower half of the case to the main PCB. Finally connect the batteries.

The renewal lead (if used) can be up to 100m of screened microphone cable (cheap cable is perfectly adequate). We used 50m of cable for each base which is long enough for most

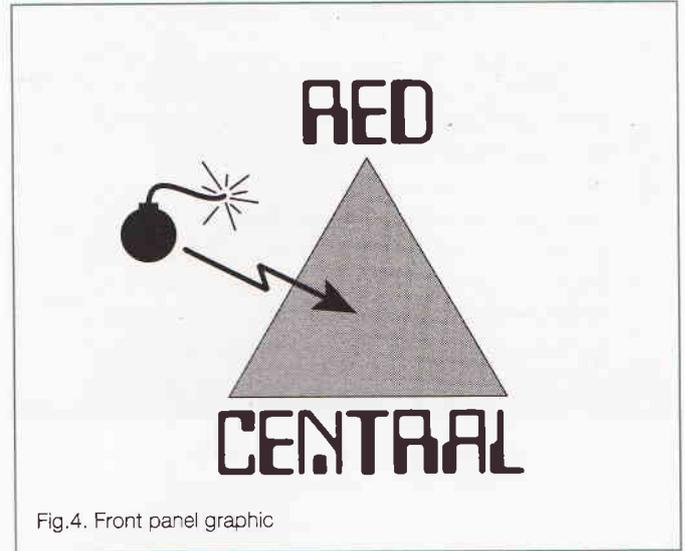


Fig.4. Front panel graphic

locations. Wire a phono plug to each end and ensure that the screen is connected to the outer connector of the plug.

### Testing and setting up

Initially the battery charging circuit should be tested. The batteries will only charge if the power switch (SW1) is off. Connect a 12v power supply to the recharging socket, centre negative, break the lead to the battery and insert an ammeter. Check that LED 5 illuminates and that the charging current is around 90mA. The batteries should be left for around 16 hours to charge.

Before inserting the ICs, the power supply to the IC sockets should be checked for polarity with a voltmeter. Turn the power off and insert the ICs. On powering up the base the small LED (LED 4) should start flashing. Use VR1 to set the frequency of the signal at pin 5 of IC2 to 25KHz. Now use a light gun to trigger the base; you may need to tune VR1 slightly to get the most reliable detection. Due to inconsistencies in the PLL, we found that detection of gun IDs was always slightly unreliable which means that often multiple shots are required to hit the base. As this makes the bases more difficult to trigger we would claim this as a positive feature!

Finally, the link to the renewal station can be tested. In all game types where base hits are allowed, the renewal station will show the ID of the user who last triggered a base, and this can be used to check the link. Note that due to the low bit rate then the user ID will only be displayed a few seconds after the base has been triggered.

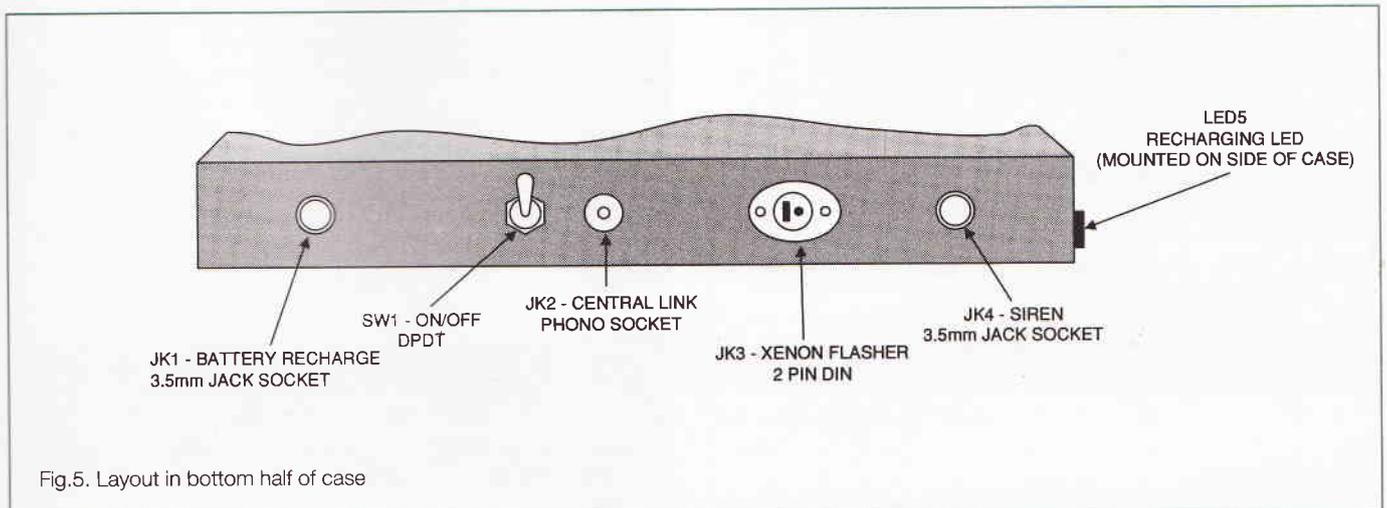


Fig.5. Layout in bottom half of case

## Programming PIC's

The author is prepared to program PIC16C84 devices with the code required for the bases. Please send the devices together with a cheque or P.O. for £5.00 (made payable to R.J.Abbott) for each device, and include an SAE. Send to Robin Abbott, 37 Plantation Drive, Christchurch, Dorset. BH23 5SG. Please state whether you wish the device programmed for a red or green base, or one each for a pair.

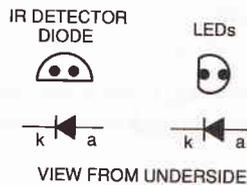


Fig.7. Diode connections

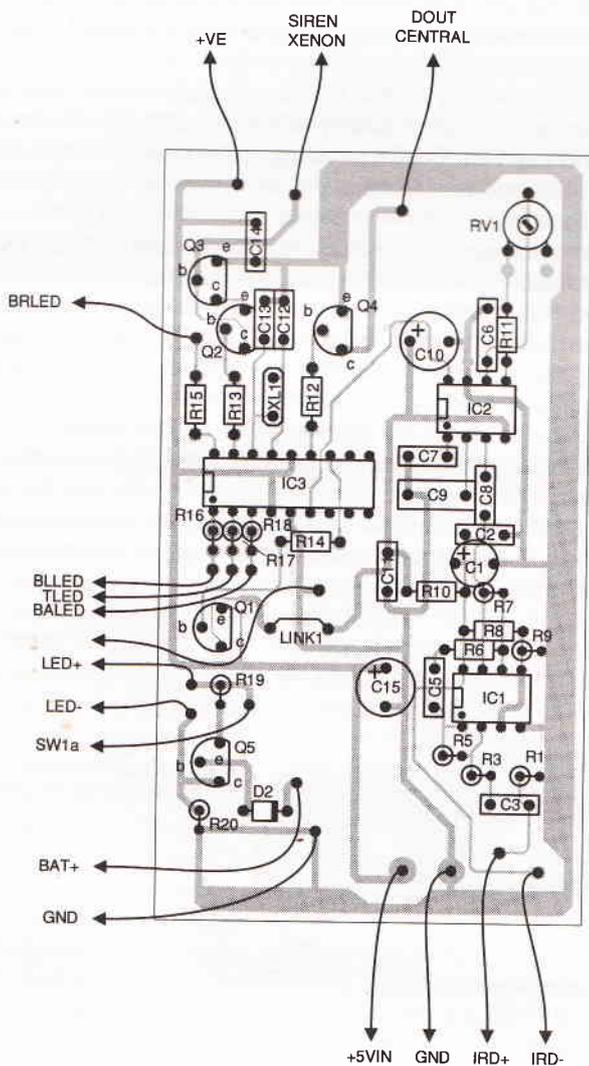


Fig.6. PCB layout

## PARTS LIST

### Resistors (0.6 watt 1% metal film)

- R1,R7 100k
- R3,R5 1M
- R6,R13,R14 1K
- R8,R9 10K
- R11 2K7
- R15,R16,R17,R18 270R
- R19 3K3
- VR1 1K min hor preset

### Capacitors

- C1,C10,C15 47 $\mu$  16v radial elect
- C2,C7,C9, C11,C14 100n ceramic
- C3,C8 1n ceramic
- C5 10n ceramic
- C6 10n polyester
- C12,C13 15pf ceramic

### Crystal

- XTAL1 4.194304MHz

### Semiconductors

- C1 TL062(or TL072, TL082)
- IC2 LM567CN
- IC3 PIC16C84-04
- TR1 BC557
- TR2,TR4 BC548
- TR3 BD135
- TR5 BD136
- LED 1,2,3 10mm red / green LED\*
- LED 4 3mm red / green LED\*
- LED 5 3mm red LED
- D1 I/R photodiode
- D2 1N4001

### Miscellaneous

- JK1 3.5mm jack chassis socket
- PLG1 3.5mm mono plug
- JK2 chassis mounting phono socket
- PLG2 phono plug - data to central O/P
- JK3 2 pin phono chassis socket
- PLG3 2 pin speaker plug
- JK4 3.5mm jack chassis socket
- SW1 DPDT toggle switch
- STROBE 12v strobe such as Maplin order code YK39N
- SIREN Mini siren such as Maplin order code JK43W
- Bat1-5 Ni-Cd rechargeable "C" cells
- Case Verobox 217 wire, pcb, etc.

\* Choose the correct colour led for the base you are building

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- Intelligent wires (automatic junctions)
- Dynamic connectivity information
- Automatic on-line annotation
- Integrated on-the-fly library editor
- Context sensitive editing
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- Back annotation from BoardMaker2

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## BoardMaker

*BoardMaker1 - Entry level*

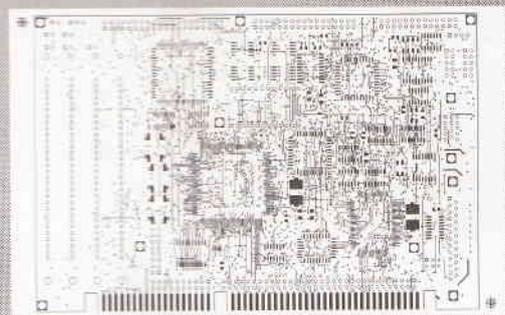
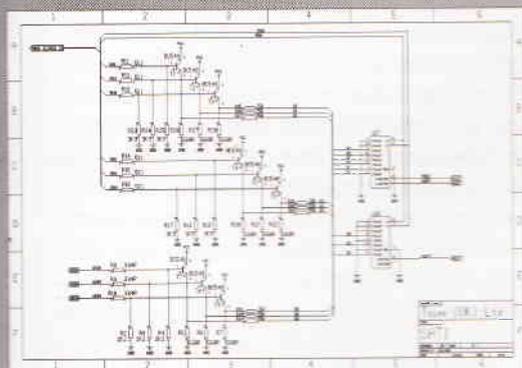
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- Component renumber with back annotation
- Report generator- Database ASCII, BOM
- Thermal power plane support with full DRC

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## Board Router

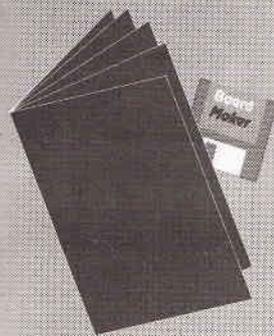
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- Full interrupt, resume, pan and zoom while routing

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- Photoplotters - All Gerber 3X00 and 4X00
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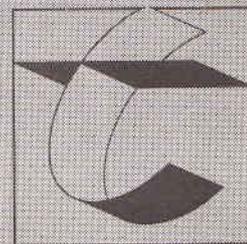
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**tsien**



As more and more technology uses light in all its various modes, it is becoming increasingly relevant to understand more about light in general and ways of measuring it. There is no better way of doing this than to split light down into its various colours and make measurements of relative intensity at specific wavelengths.

### Splitting up Light: Diffraction Gratings and Films

There are many examples where light is split up into its various component colours - the best being that of the rainbow. For this project, what is required is a diffraction grating film. In professional scientific equipment used for splitting up light and measuring, e.g. solar spectra, diffraction gratings are expensive items and cost typically several thousand pounds each. This project uses relatively inexpensive diffraction gratings on transparent flexible film, available from scientific equipment suppliers such as Edmund Scientific (see notes at end on availability). A piece approximately only two inches square is required.

In a diffraction grating light which is incident as a parallel beam onto the grating passes through transmission grooves. The particles of light or photons are 'perturbed' as they pass through this constriction and can pass through on the other side at various angles to their 'straight' through position. This is the process of diffraction.

If the light is considered as a wave motion, it follows that photons of a given wavelength which have travelled a whole number of wavelengths since they were incident on the grating interfere CONSTRUCTIVELY and should be seen as light of the appropriate wavelength.

If, for example, at point Y, the increase in distance XY is a whole number of wavelengths, then constructive interference will take place and light of that specific wavelength will be replicated along that angle.

With a given geometry of the experiment, it is possible, from knowledge of the number of lines per mm of the diffraction grating, to calculate the wavelength band produced at a given angle.

The angles at which lines are split are given by:-

$$\sin(A) = m \frac{L}{d}$$

d

where A = angle

m = order of spectrum (m = 1, 2, 3 etc)

L = wavelength

d = line spacing

As shown in figure 1, the light from a source is split into its component colours on either side of the central beam of light. While figure 1 shows the higher order spectra, in these experiments, it is the first order only which is being measured. The higher orders are considerably fainter and more difficult to detect.

The bright colours of the diffraction grating can be readily demonstrated by taking a battery torch, placing the diffraction grating over it, and displaying the emergent transmitted light on a surface in a dark room. The ideal source of light is a 'chink' of bright sunlight - it is very bright and very parallel.

### Experimental Set-up

This project seeks to use relatively inexpensive diffraction grating film to demonstrate the diffraction of light and also allow measurements to be made that can relate to relative spectral measurements (see notes on availability of gratings). The technology to undertake the measurement is very simple at the electronics level. What is required, however, is some inventiveness in constructing the experimental set up to direct light through the diffraction grating and measure its output. There is also the opportunity to measure the optical transmission of light of coloured films at different wavelengths. The spectra of different light sources can also be compared. One way is to place an average sized torch in a horizontal position on a chair. Take a piece of heavy card about 12 x 28cm in size. Fold it in two and cut an aperture 3cm wide and 5cm high on one side so that the light from the torch beam passes through the aperture. Take a section of diffraction film and attach it to the inside of the card in contact with the torch so that light passes from the torch and through the diffraction grating.

*Light is something that we all take for granted, but we are now developing increasing numbers of technologies that use light, Douglas Clarkson looks at some interesting ways of analysing and measuring light*

# Analysing

During measurements it is important to keep the position of the torch and the card unit constant. Coloured films can be placed over the outside of the aperture in order to observe and measure the spectra that are transmitted. A simple op-amp circuit using, for example, the LM358 can be used using the circuit of figure 3 to measure the light level along the line of the coloured spectrum. Such a circuit will operate on a single supply of a PP3 9V battery. The output can be measured using a DVM with 2V full scale. Current generated in the photodiode is converted to a voltage by the LM358 - although it is a dual amplifier - only one amplifier needs to be used. Silicon photodiodes are ideal for making such measurements. A so-called 'eye response' diode has the spectral response as shown in figure 4a - it peaks at 550 nm (in the green) and progressively falls off towards the red and towards the blue. Such a response is set by use of special filters. 'Standard' silicon photodiodes, however, have standard wavelength responses as shown in figure 4b. Devices can also be obtained with 'blue enhanced' sensitivity (shown in figure 4c) for increased sensitivity in the blue and especially the ultra-violet area of the spectrum. Such diodes will give the best sensitivity. Photodiodes have sensitivity listed in A/W (Amps per Watt) of incident power. The incident power of a photodiode is proportional to the sensitive surface area - the bigger the area the larger the signal. An excellent range of photodiodes is available via the Radiospares catalogue.

The coloured spectrum should fall on a piece of thick card with a horizontal scale marked on it as shown in figure 4. The photodiode can be moved over the range of spectra and the value recorded at specific distances from the central axis. For a grating with 21165 lines per inch, and for a distance of 50cm between the grating and the image plane, the beginning of the violet/blue should be detected at about 18cm from the central axis and the end of the red about 40cm from the central axis (see figure 4).

The card onto which the spectra is shone should be marked off in 2cm divisions from the centre of the axis of measurement of the beam using a measuring tape so that the position of the photodiode can be referenced at all times to its distance from the central axis of the incident beam. The card can be pinned to a wall and the photodiode moved over the line of the coloured spectra. In the photodiode circuit, a value of R1 the gain resistor of 1 M ohm will provide a voltage output of 1V for an input current of 1 micro amp. This should be sufficiently high to provide sufficient sensitivity.

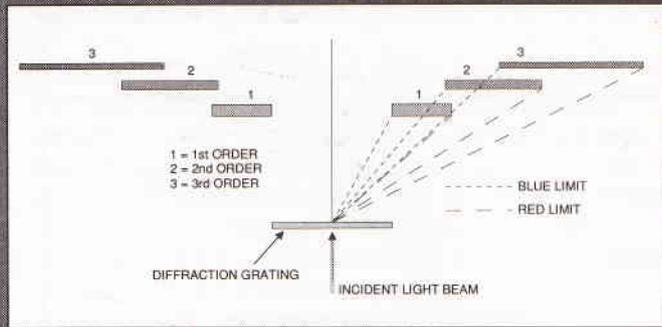


Fig 1: Orders of diffracted light which are split by the diffraction grating. Usually most light is present in the first order.

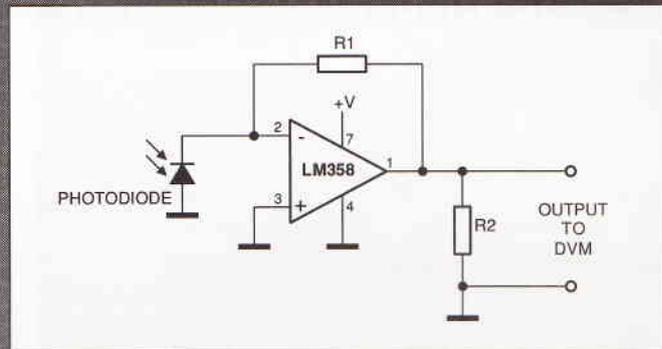


Fig 2: Circuit diagram of simple photodiode detection unit.

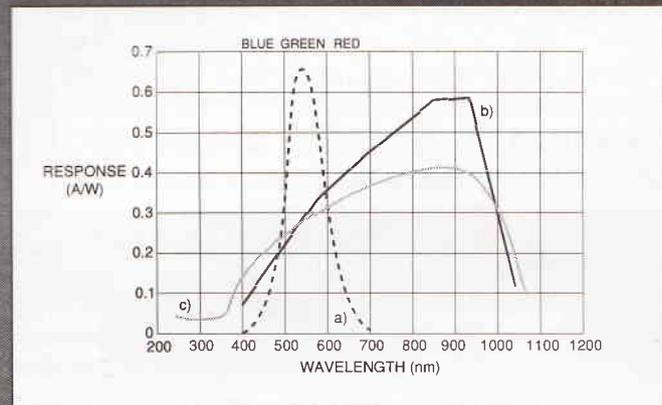
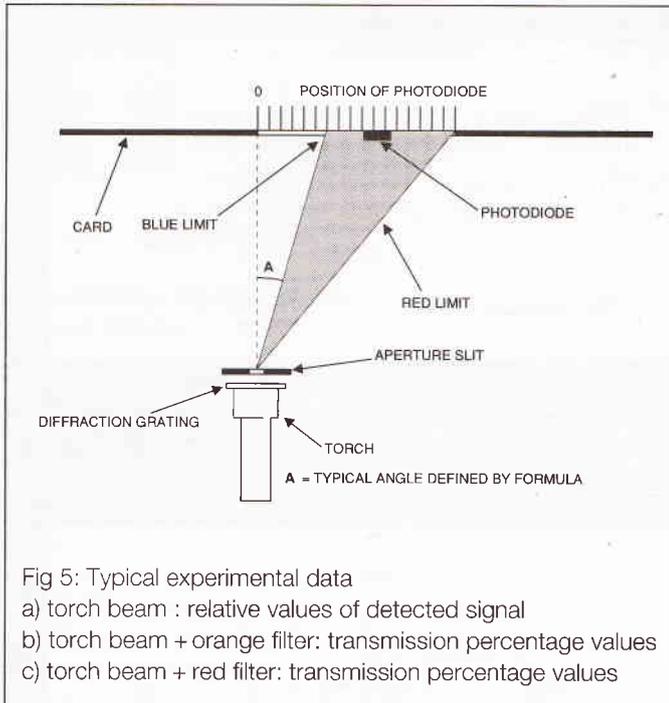


Fig 3: Spectral responses of various silicon photodiodes  
a) 'eye response'  
b) 'standard' silicon  
c) UV enhanced

# Light



red at around 700 nm.

When measurements are being made, the width of the band of colour will be several cms. Select the maximum value by moving the sensor across the band of colour. It is also necessary, however, to measure the background light level (not coloured) just above or below the coloured spectrum. This represents the contribution from stray light of all sources. This background value should be subtracted from the values obtained in the colour spectrum.

Values can be observed when coloured filters are placed over the light slit. Measurements need to be made compared against the respective background values. Comparisons can also be made of the spectra of different light sources.

### Young Eyes - Old Eyes

The sensitivity of the eye to colour (photopic) vision peaks at 550 nm and falls away towards the blue (shorter wavelengths) and the red (longer wavelengths) as indicated in the eye response detector curve in figure 4a. One interesting exercise is to take a group of observers and ask them independently to indicate the limits of the blue/violet and the red end of the spectrum as a distance from the central measuring line. There will be some natural variation between individuals in the range of colours that can be observed. With age, the spectral range of the eye will tend to decrease. Silicon diodes can normally readily detect longer wavelengths than the red.

### Making Measurements

The circuit can now be used. Diffraction film typically has a ruling spacing of about 1200 nm. This is equivalent to 8333 lines per cm or 21165 lines per inch. Table 1 shows what should be observed when, for example, a torch beam and grating are 50 cm from a surface onto which the diffracted beam is shone for the first order spectrum as indicated in figure 4.

There can be problems with the actual number of lines per inch provided with diffraction grating films. One grating film provided with a claimed 13200 lines per inch had in fact 21000 lines per inch. Where the spectrum is observed by the human eye, the eye will begin to see violet/blue at 400 nm and cease seeing

### Typical Results

If the experiment is set up with a slit width of 3 cm and a distance of 50 cm set between the diffraction grating and the diffracted image, then figure 6a shows typical values that can be obtained of the unfiltered light signal. An enhanced blue sensitivity photodiode was used. The signal is, in fact, generally rising with increasing wavelength. This, it should be remembered, is the combination of photodiode sensitivity and spectral input. There is also the effect of the grating. The actual voltage detected by the circuit is a function of a range of parameters. Where, however, the incident light is

Table 1:  
Positions of diffracted colours for 21000 lines/inch diffraction grating film

Wavelength (nm)	Angle degrees	Distance from central axis (cm)* to axis
330.8 (UV)	16.0	14.3
410.5 (blue limit)	20.0	18.2
488.1 (blue/green)	24.0	22.3
563.4 (green)	28.0	26.6
636.0 (orange)	32.0	31.2
705.4 (red limit)	36.0	36.3
771.4 IR**	40.0	41.9
833.7	44.0	48.3
891.9	48.0	55.5
945.7	52.0	64.0
994.9	56.0	74.2

Note:  
\* for grating 50cm distant from diffracted image.  
\*\* all higher wavelengths are infra-red for this order.

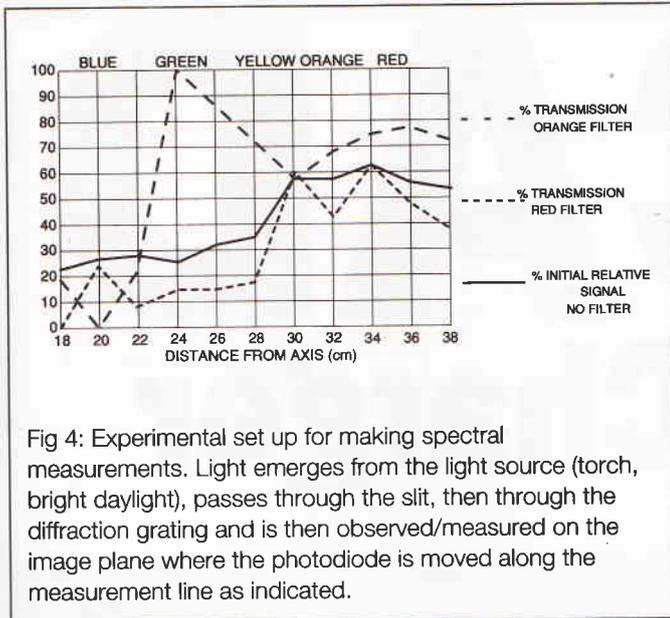


Fig 4: Experimental set up for making spectral measurements. Light emerges from the light source (torch, bright daylight), passes through the slit, then through the diffraction grating and is then observed/measured on the image plane where the photodiode is moved along the measurement line as indicated.

transmitted through a filter, then the transmission of various colours is changed. Figure 5b shows the transmission of an orange filter. There is very high transmission in the green wavelengths. Figure 6c shows what happens when a red filter is placed in line with the light source. The transmission level at the green is about 15% - rising to about 60% in the red. A green filter was also tested, but although the green spectrum was visible, it was too low in intensity to be detected with the detector. Generally the blue spectrum is difficult to measure even though it is visible to the eye.

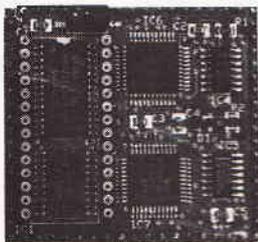
# Summary:

Although this project is relatively simple, it demonstrates important basic principles of optical measurement using diffraction gratings. While professional equipment operates basically by rotating the diffraction grating and moving the spectra past a stationary detector, the simple approach here of moving the photodiode over the split spectra is easier to undertake and is a good introduction to the basic principles of more complex and expensive equipment. The experiment described is basic in the extreme but indicates some very basic techniques of light measurement systems in general.

## Notes on Availability of Diffraction Film:

Stock code: N40267: 12' x 11' sheet of diffraction film (price around £2.00).  
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 Watford,  
 WD2 4PW.  
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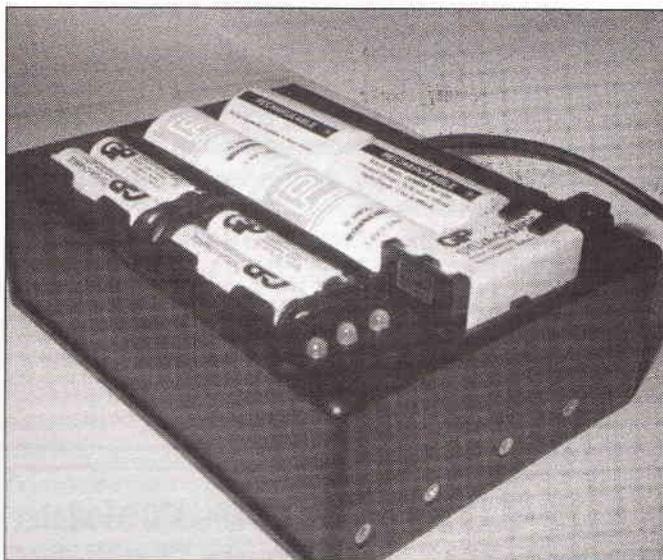
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# NICAD Battery Charger

**A lot of different NiCad battery charger circuits have been published over the years but this one designed by Richard Tanfield is just that bit better**



**T**here are almost as many charger circuits for rechargeable Nickel-Cadmium batteries as there are batteries themselves, so here is another one! This one enables you to simultaneously charge three of the most commonly used sizes of batteries ( 4 x AA, 4 x D and 1 x PP3 or 8 x AA and 1 x PP3 ). The circuit also has optional features of a 14 hour timer to prevent overcharging the batteries and a simple current meter to give an indication that the battery is actually being charged. After all, there is nothing worse than finding that your batteries haven't been charging for the past 14 hours because one of them wasn't making proper contact with the battery holder.

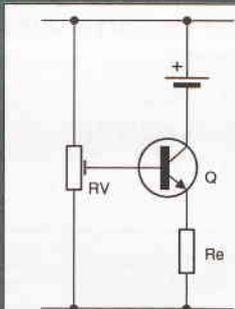


Fig. 1.  
Basic charger circuit

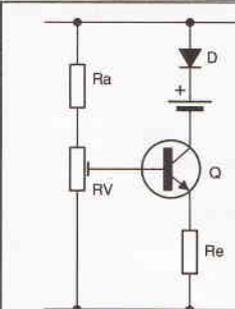


Fig. 2.  
Improved charger circuit

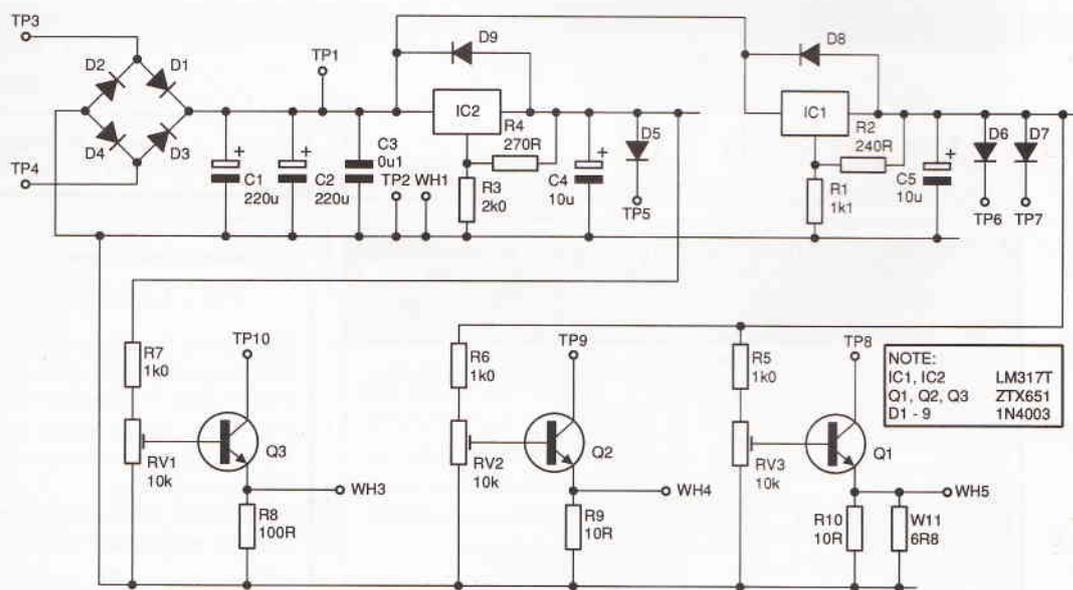


Fig. 3. Full charger circuit

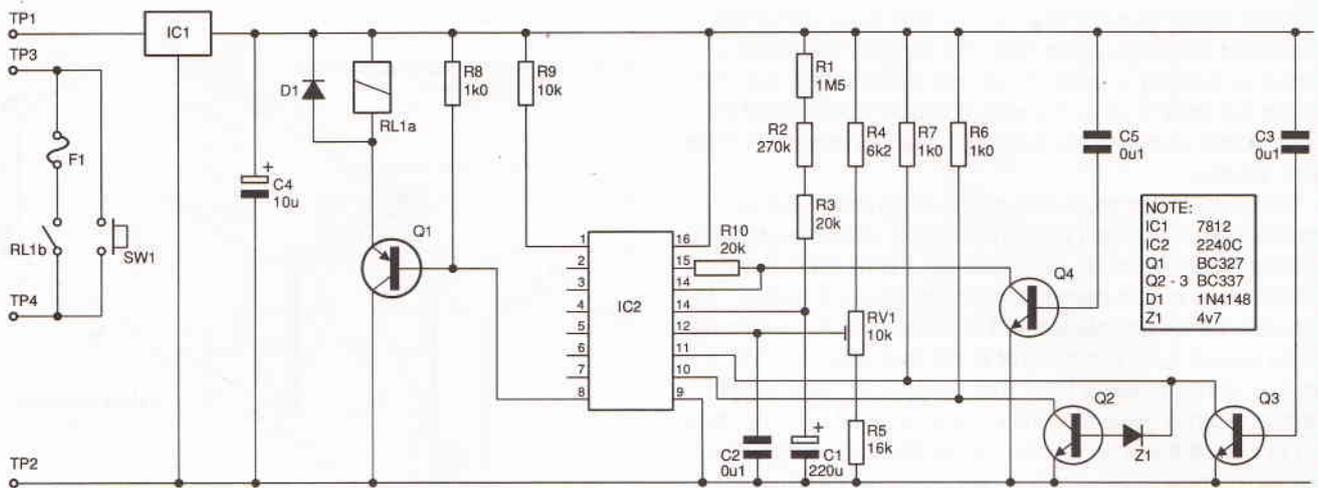


Fig.4 Timer circuit

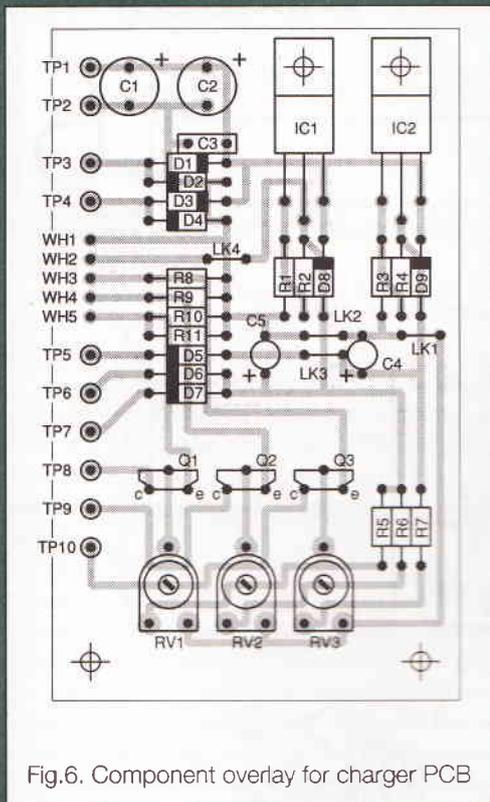


Fig.6. Component overlay for charger PCB

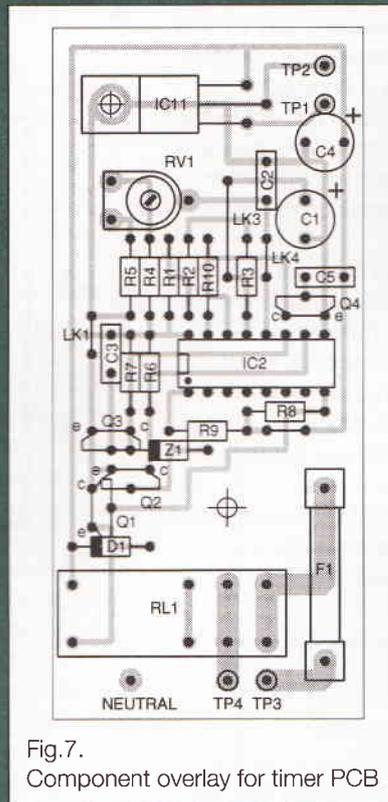


Fig.7. Component overlay for timer PCB

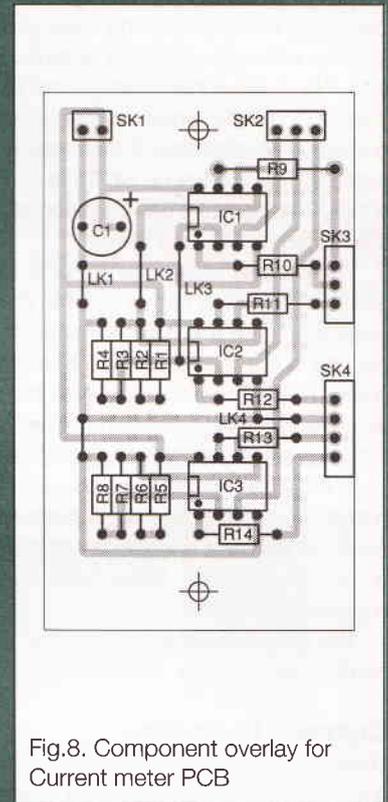


Fig.8. Component overlay for Current meter PCB

### Constant Current Charger Circuit

The charger circuit consists of a constant current circuit fed from a regulated supply. The basic circuit is shown in Figure 1. The transistor is biased on by the base voltage set by RV. This causes a certain amount of collector current to flow through the transistor, the battery and  $R_e$ .

Now suppose that the current is made to increase. This will cause a greater voltage drop across  $R_e$  which will make the base-emitter voltage of the transistor decrease which has the effect of turning the transistor further off, causing the collector current to be reduced. The opposite will happen if the collector current is reduced which will cause the base-emitter voltage to increase and turn the transistor further on. This results in the circuit giving a constant current into

any load.

The basic circuit is further improved by placing a diode in series with the battery in order to prevent the battery from discharging itself back through the charger circuitry when the charger is turned off (Figure 2.) Another way of achieving this would be to put a relay in series with the battery so that the relay disconnects the battery when the charger is switched off. However, I felt that a diode was a much simpler way of achieving this although the forward voltage drop of the diode must be taken into account when setting the supply voltage to the circuit. If RV was set to give maximum base voltage there would be no resistance to limit the base current and the transistor would be destroyed. For this reason an extra resistor,  $R_A$ , is included.

## Timer

The timer circuit consists of a 14 hour time delay and a relay to disconnect the mains power from the charger. The circuit is started by pushing a switch to connect mains to the unit. This causes the timer to close the relay contacts which keeps the mains power connected to the circuit after the push switch has been released.

The usual way of producing a time delay relies upon a capacitor being charged through a resistor, as is the case with the popular 555 timer i.c. Unfortunately, this method is not suitable for long time delays where huge values of resistance and capacitance are needed and the tolerance of these large values causes quite a large error in the time delay. For this reason, I chose to use a short time delay which is repeated a number of times using a counter circuit to count the time delays and to turn off the charger after the counter has reached the required number. I was about to start designing such a circuit with a 555 timer running in astable mode and an 8 bit counter when I became aware of such a circuit built into one i.c.; the  $\mu A2240C$ .

The  $\mu A2240C$  consists of an oscillator whose frequency is controlled using an external resistor and capacitor, and an 8 bit counter with open collector outputs. The capacitor is charged from  $\frac{1}{3}$  of the supply voltage until its voltage is equal to the voltage on pin 12 which causes a clock pulse to be sent to the counter. The capacitor is then rapidly discharged and the cycle repeats. The voltage on pin 12 is normally around  $\frac{2}{3}$  of the supply voltage but it can be externally adjusted to provide adjustment of the time delay.

The i.c. also has a reset input to stop the oscillator and reset the counter, and a trigger input to restart the oscillator. The reset is actually a synchronous reset which means that the counter is not reset until after it has received another clock pulse. This led to a problem with the prototype since I had wrongly assumed that the reset was asynchronous. The delay between clock pulses is approximately 7 minutes due to the large RC time constant and this would have meant that the start button would have had to be pressed for 7 minutes before the circuit would start up. This led to a small modification which causes a clock pulse to be generated as soon as the circuit is powered up.

The timer has been designed on a separate PCB so that it can be used in other applications.

## Current Indicator

The current indicator uses a multicoloured LED to show the amount of current being drawn by the batteries while they are charging. The LED starts off at red with maximum current and then changes to yellow and then green as the current decreases. The circuit measures the voltage drop across the emitter resistor of the charger circuit since this is proportional to the current flowing through it to the batteries (remember Ohm's law?). This voltage passes to a pair of comparators which control the colour of the LED.

## Construction

The construction of the PCBs is quite straightforward and should cause no major problems. See component overlays and circuit diagrams, Figs. 3-8. As usual, begin with the small components and fit the larger ones last. While we are on the subject of large components, you may be wondering why C1 and C2 aren't replaced by one capacitor. The reason for this is simply due to the height restriction imposed on the board since it has to fit underneath the D size battery holder and a large

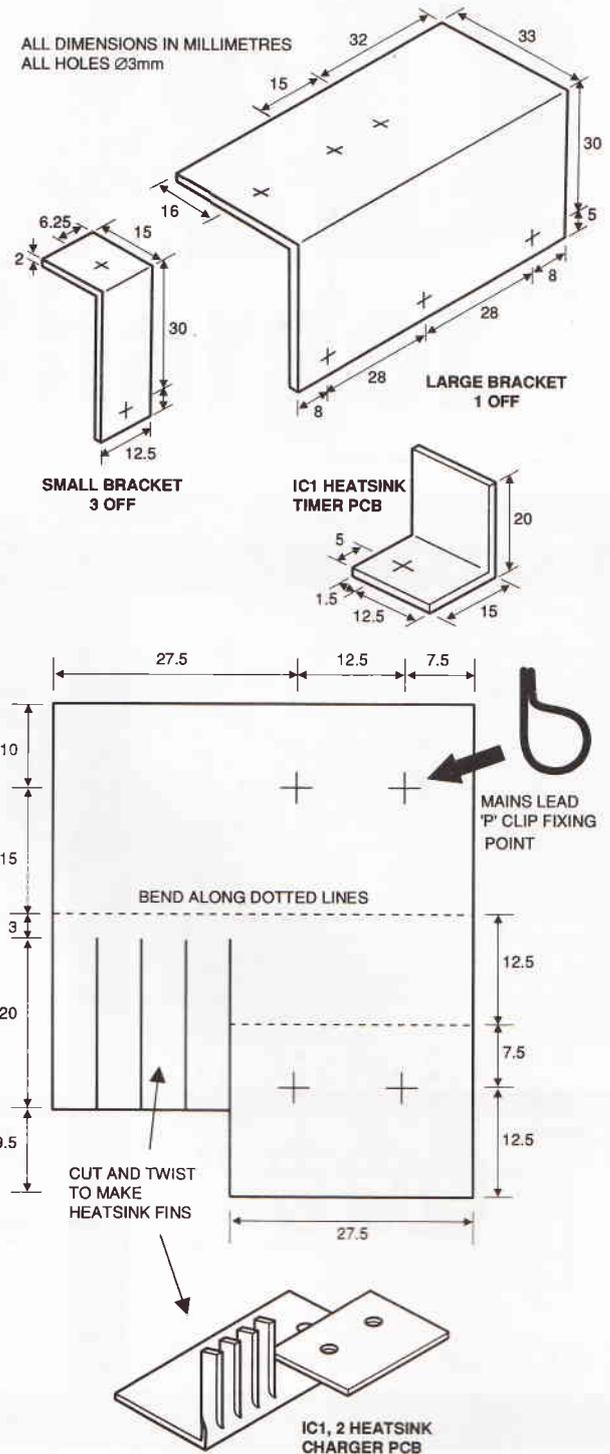


Fig.10. Brackets and heatsinks

capacitor would not fit.

The two voltage regulators on the charger PCB will need to be insulated from the heatsink using mica or mylar insulators to prevent them from shorting to each other. Fit veropins for all off-board connections, marked TP on the PCB layouts. If you intend to use the current meter PCB then wires should be fitted to WH1-5 on the charger PCB at this stage ( see Figure 13 ). If you intend to charge AA size batteries instead of D size batteries then R11 should be omitted so that the current meter will receive the correct input voltage from the charger circuit.

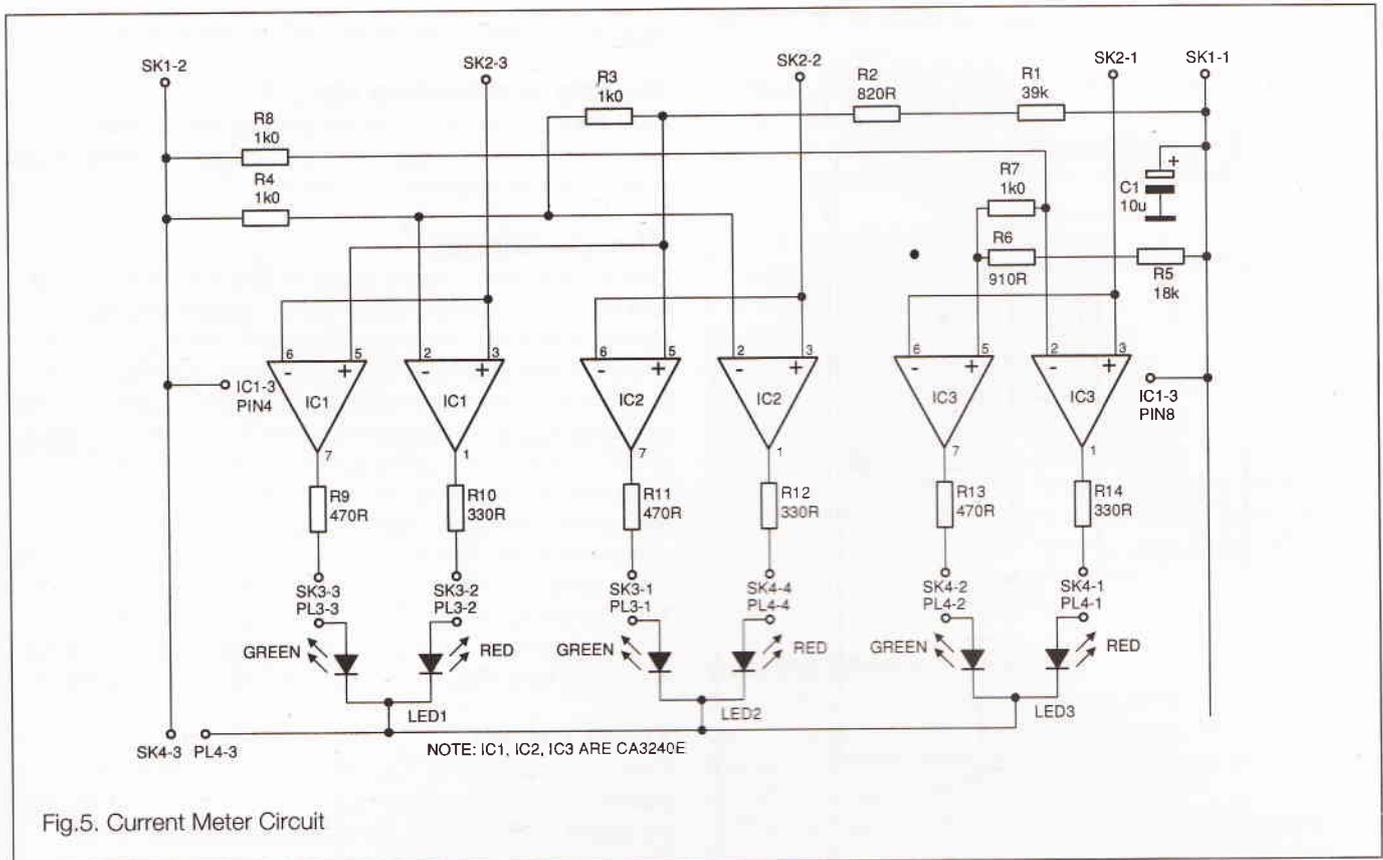


Fig.5. Current Meter Circuit

Finally check your work for reversed components and bad soldering.

At this stage it is advisable to test the PCBs to check that they are working and to set them up before fitting them into the box (See 'Testing and Setting Up').

The box construction may look quite difficult at first but it is quite easy when broken down into individual stages. The box itself is a plastic one available from Maplin Electronics. I chose a plastic box rather than a metal one as it is much easier to cut out the large hole from the top of the box if the box is made of plastic.

The box has six mounting pillars moulded into the base but these are not used in this project. In fact, two of these have to be removed to allow the transformer to fit flat to the bottom of the box. The pillars are easily removed using a large drill.

The first job is to drill the fixing holes in the bottom of the box (see Figure 9). A good tip is to cover the box surface with masking tape since it provides a good surface for marking out the hole positions and it also protects the box from scratches. All the holes will need to be countersunk from the outside. You will notice that the positions of the holes in Figure 9 are not given any dimensions as this drawing is only to illustrate the positions of the PCBs relative to each other. The actual hole positions can be drilled using the PCBs as templates. Next, drill the holes in the sides of the box for the various brackets. The brackets are made from thin aluminium; the dimensions are shown in Figure 10, along with the heatsinks for the charger PCB.

The next job is to make a suitable base to fasten the AA and PP3 battery holders to (Figure 11). The main object of the base is to block any small gaps between the battery holders to prevent small objects from dropping inside and also to prevent access to the live parts of the circuitry. The prototype was made from a piece of glass fibre PCB with the copper removed, although it can be made from any thin, rigid material. However, remember to fit an earth connection if you make the base from metal.

The back panel of the box will need to be removed to drill a

hole for the mains cable. A suitable rubber grommet should be fitted to the hole to prevent damage to the cable. I chose not to use a strain relief grommet to hold the cable to the back panel as the panel is quite thin and a good tug on the mains cable

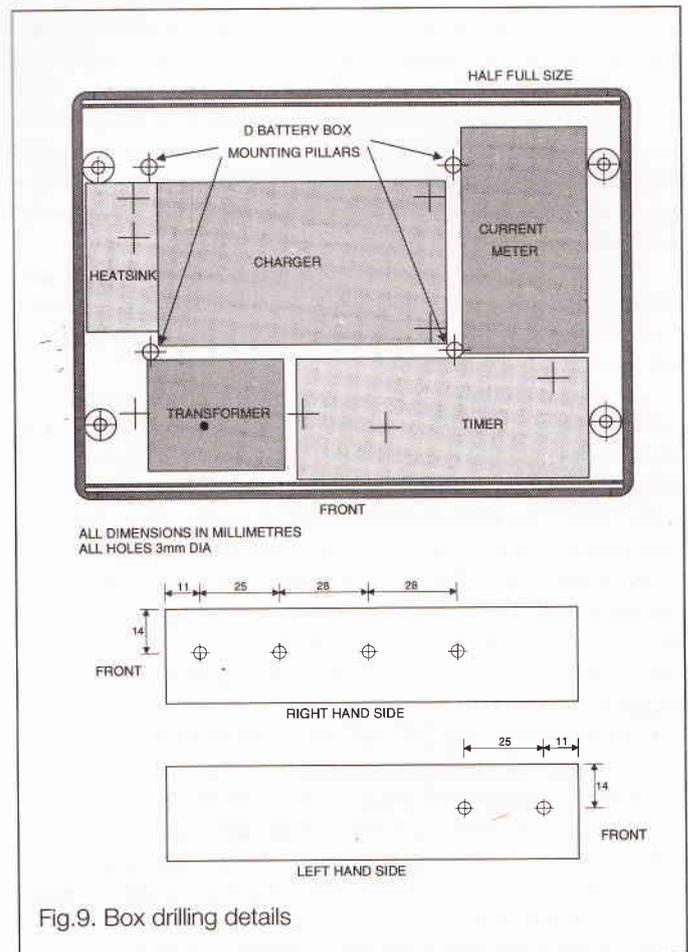


Fig.9. Box drilling details

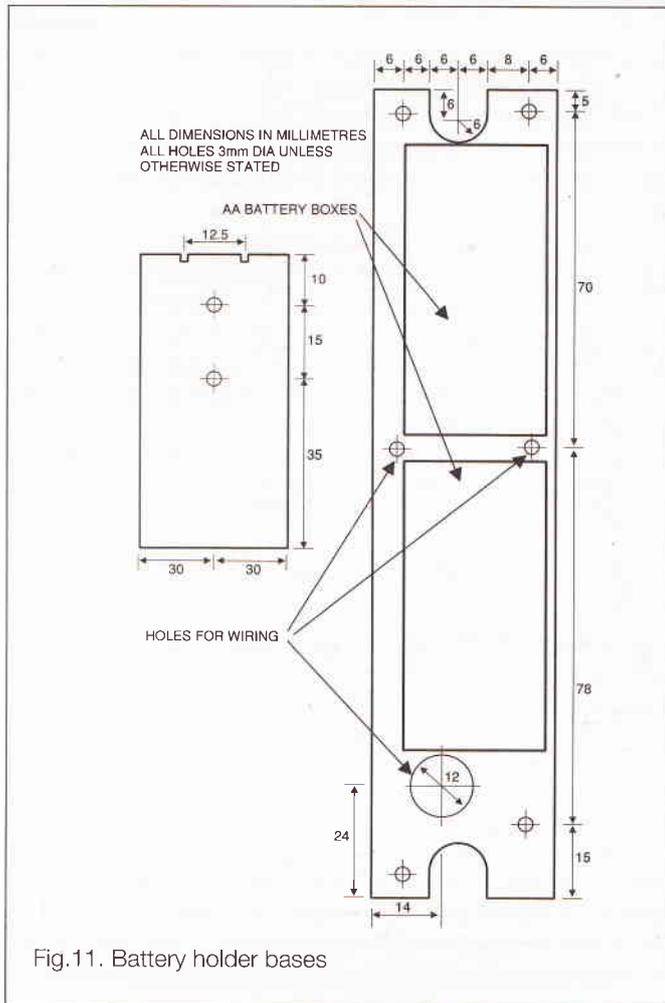


Fig. 11. Battery holder bases

would probably rip the entire panel out of the box. Instead, the cable is securely anchored to the bottom of the box using a P clip. The battery holders can now be fitted into the case.

A large hole needs to be cut out from the top of the box to allow the battery holders to fit through. I found it easier to make a cardboard template of the shape of the hole and then to draw this shape onto the top of the box, again using masking tape to cover the box.

The next bit is very important. The two halves of the box are tongued and grooved so that they will only fit together one way round. Make sure that you check this before you begin to cut out the hole in the box top.

Cut the hole smaller than required using a coping saw or a junior hacksaw blade. Now for the time-consuming bit. The hole needs to be carefully enlarged with a file until it is a good fit around the battery holders. It is a good idea to fit some batteries into the holders while doing this as the battery holders may stretch slightly when the batteries are fitted. Next, drill the holes for the 'ON' button and the three LEDs if you intend to use the current meter PCB. The LED holes are drilled so that the LEDs are a good fit and they are secured with a blob of glue. If you don't want to build the current meter then I would suggest fitting an LED to the top of the box to show when the charger is working. The LED can be connected across TP1 & 2 on the charger PCB with a suitable series resistor.

Finally, the battery holders will need to be removed so that the PCBs can be wired up to each other (see Figure 13). Take care to connect the battery holders the correct way round otherwise you will have a battery discharger! The point marked 'Neutral' on the timer PCB is only used if you are using a wire ended transformer and is simply a connection point to join

together the transformer primary and the mains neutral.

## Testing and Setting Up

All of the PCBs should initially be powered from a variable d.c. power supply and the input current should be monitored in case of short circuits or reversed capacitors.

## Charger Circuit

Connect the variable power supply to TP3 & 4, either polarity, and slowly increase the voltage to 18v. while monitoring the current. If all is well, check the voltages on the anodes of D8 and D9. These should be 7.0v. and 11.7v. respectively. This indicates that the voltage regulators are working. Set RV1-3 fully clockwise and connect an ammeter to TP7 and TP10, positive to TP7. Adjust RV3 to give a current reading of 10mA. This value may drift slightly as the circuit warms up and should be readjusted if necessary. Next, do the same with the meter connected across TP6 and TP9, positive to TP6. Adjust RV2 to give a current of 50mA. Finally connect the meter to TP5 and TP8, positive to TP5 and adjust RV1 to give a current of 120mA. If you wish to charge eight AA cells instead of four AA and four D cells, then omit R11 and adjust RV1 to give 50mA.

## Timer Circuit

Connect the variable d.c. power supply to TP101 & 102, positive to TP101. Increase the supply to 18v while monitoring the output of IC101 which should begin to regulate at 12v. Switch off the supply for a couple of seconds and then switch on again. The timer should reset which will be indicated by RL101 closing. Monitor the voltage on IC102, pin 13 which should show a gradually increasing voltage. This indicates that the timer is charging C101 which means that the reset and trigger circuits have worked correctly to start the time delay.

The next part is extremely time-consuming. The time delay needs to be accurately adjusted in order to produce a 14 hour delay. Fortunately you don't have to sit and watch it for 14 hours in order to adjust it. The first stage of the counter can be monitored on pin 1 of IC102. First measure the time delay between the changes of state of pin 1. Ideally this needs to be 394 seconds. If the time delay is too long then the voltage on pin 12 needs to be reduced by adjusting RV101, and if the delay is too short the voltage on pin 12 needs to be increased. Then it is just a matter of trial and error until the time delay is correctly set. One point to note is that when the circuit is first switched on the first timing cycle will be slightly longer than the others. This is because the timing capacitor, C101, is initially discharged and takes longer to charge to the same voltage as pin 12. When the circuit is running normally, C101 is charged and discharged between approximately 3v. and 8v. Anyone who has used a 555 timer as an oscillator will probably be aware of the same problem.

## Current Meter Circuit

This is the easy bit. There is nothing to set up on this circuit so all that is required is a simple check to see that all the LEDs are working. Plug in the LEDs to SK203 & 204 and apply 7v. to SK201, positive to pin 1, and check that all three LEDs show green. If any show red, then they are wrongly connected. A more complete check of this board can be carried out when it is connected to the charger PCB but there is very little that can go wrong with it.

## Charger Circuit

12v. a.c. is applied to TP3 & 4 where it is rectified by D1-4 and

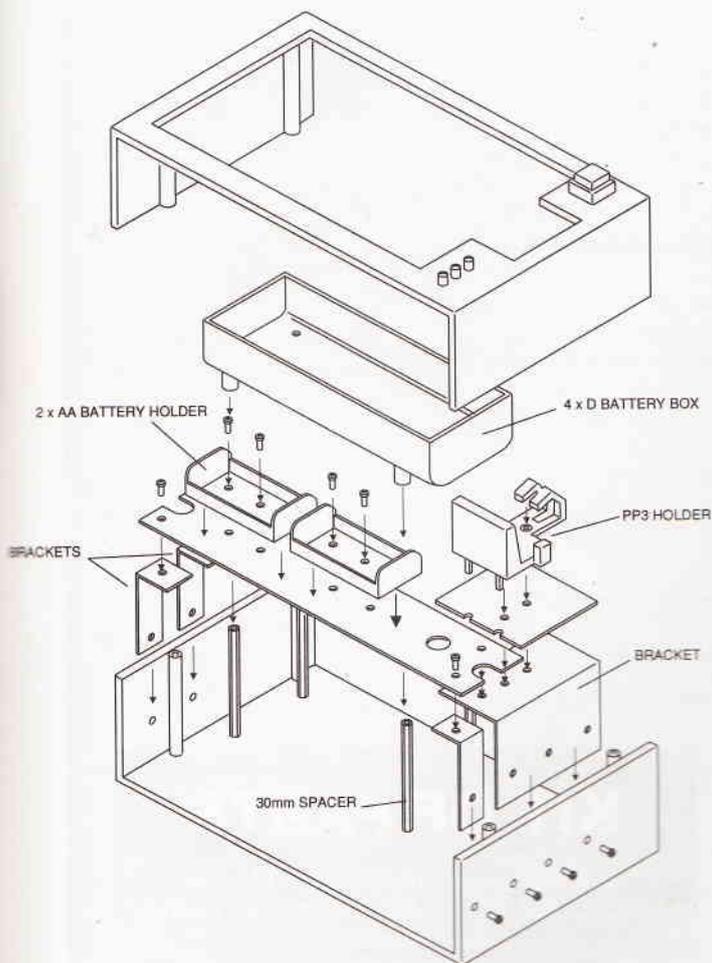


Fig. 12. Exploded view

smoothed by C1-3. This gives approximately 17v d.c. which is then dropped to 7v. and 11.7v. by voltage regulators IC1 & 2. The rest of the circuit consists of three constant current circuits. In each circuit the transistor (Q1, 2 or 3) is biased on by the difference in voltage between its base and emitter terminals. As the current flow to the battery increases it causes a greater voltage drop across the emitter resistor (R8, 9 or 10) which reduces the base-emitter voltage which, in turn, turns the transistor further off. The opposite happens when the current flow decreases. This results in a constant amount of current flowing to the battery. The current is adjusted by RV1, 2 or 3 which control the base voltages of Q1, 2 and 3.

### Timer Circuit

The timer circuit takes its power from the charger PCB via TP101 & 2. The supply is regulated to 12v. by IC101 and smoothed by C104. When power is first applied to the circuit, a short pulse of current flows through C103 which causes Q103 to turn on briefly. This pulls the trigger input of IC102 low and turns off Q102 which allows the reset input of IC102 to go high causing the timer to reset. When C103 is fully charged, no more current flows to the base of Q103 and it turns off. This allows the trigger input of IC102 to go high which starts the oscillator. It also turns on Q102 which pulls the reset input low.

The Zener diode, Z101, is needed to allow the voltage on the trigger input to reach a sufficiently high level. Without Z101, the voltage on pin 11 of IC102 would only vary between 0v. and 0.7v. due to the connection to Q102 base, and IC102 would

see both these voltages as a logic low.

The timer works by charging C101 through R101-3. When the voltage on C101 becomes equal to the voltage on pin 12 of IC102, the capacitor is rapidly discharged to approximately 3v. and a clock pulse is passed to the counter circuit. The time delay can be adjusted by altering the voltage on pin 12 using RV101.

Q104 is also briefly turned on through C105 when power is first applied. This injects a clock pulse into the time base input of IC102 which, combined with the signal on the reset input, causes the counter circuit to reset immediately. This causes all eight counter outputs to go low. These outputs are open collector outputs and require external pull-up resistors to make them work. In this circuit, only the highest bit of the output is used. This output is initially low, which turns on RL101 via Q101 which causes the relay contact to close, bypassing the push switch, SW101. This keeps mains power applied to the unit after the push switch has been released. After 14 hours have elapsed, the counter's MSB output goes high which turns off RL101 and removes the mains input from the unit.

### Current Meter Circuit

This circuit takes its power from the regulated 7v. rail, and its current sense inputs from the emitter resistors, R8-11, on the charger PCB. The current meter consists of three similar circuits so I will describe only one of them.

R201-4 form a potential divider across the power supply. The voltages at the junctions of R202 & 3 and R203 & 4 form reference inputs for the dual voltage comparator, U201. These voltages correspond to 1/3 and 2/3 of the maximum voltage developed across the emitter resistor of the charger circuit.

When maximum current is drawn from the charger circuit the voltage at pin 3 of IC201 is higher than the voltage at pin 2 which causes pin 1 to go high and the red part of LED201 illuminates. Also the voltage at pin 6 is greater than the voltage at pin 5 which keeps pin 7 low and prevents the green part of LED201 from lighting. When the voltage at pins 3 & 6 is between 1/3 and 2/3 of maximum, both outputs of IC201 will go high and both parts of LED201 will light, causing it to appear yellow. At input voltages below 1/3, only the green part of LED201 is lit since the voltage at pin 6 is lower than pin 5, and pin 3 is lower than pin 2.

A different pair of reference voltages are required for the PP3 meter circuit. These are provided by the potential divider chain of R205- 8.

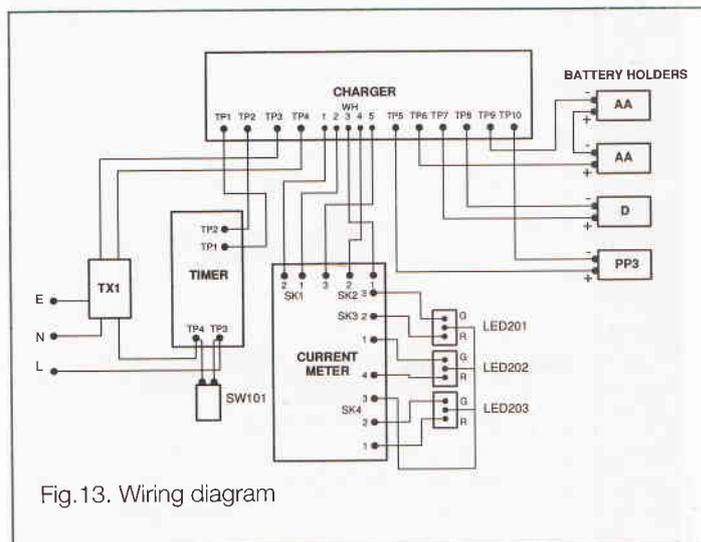


Fig. 13. Wiring diagram

## Charger

- R1 1k1
  - R2,4 240R
  - R3 2k0
  - R5,6,7 1k0
  - R8 100R
  - R9,10 10R
  - R11 6R8  
( Omit for 8 x AA charger )
  - RV1-3 10k Horizontal Preset
  - C1,2 220 $\mu$  25v
  - C3 0u1 63v
  - C4,5 10 $\mu$  16v
  - D1-9 1N4003
  - Q1-3 ZTX 651
  - IC1,2 LM317T
  - TX1 12v. 6VA
- Order code : 88-0260

## Timer

- R101 1M5
- R102 270k
- R103,10 20k
- R104 6k2
- R105 16k
- R106-8 1k0
- R109 10k
- RV101 10k Horizontal Preset
- C101 220 $\mu$  16v
- C102,3,5 0u1 63v
- C104 10 $\mu$  16v
- D101 1N4148
- Z101 4v7 500mW
- Q101 BC 327
- Q102-4 BC 337
- IC101  $\mu$ A7812UC
- IC102  $\mu$ A2240C
- RL101 12v. coil, 240v. 5A contact
- SW101 Square push to make, non-locking  
20mm fuseholder with cover
- F101 250mA 20mm fuse

## Current Meter

- R201 39k
- R202 820R
- R203,4,7,8 1k0
- R205 18k
- R206 910R
- R209,11,13 470R
- R210,12,14 330R
- C201 10 $\mu$  16v
- LED201-3 5mm. Multicolour LED
- IC201-3 CA3240E

## Order Code

- SK201 2-Way plug RK65V
- SK202,3 3-Way plug BX96E
- SK204 4-Way plug YW11M

- PL201 2-Way socket HB59P
- PL202,3 3-Way socket BX97F
- PL204 4-Way socket HB58N
- Terminals for PL201-4 YW25C

## Miscellaneous

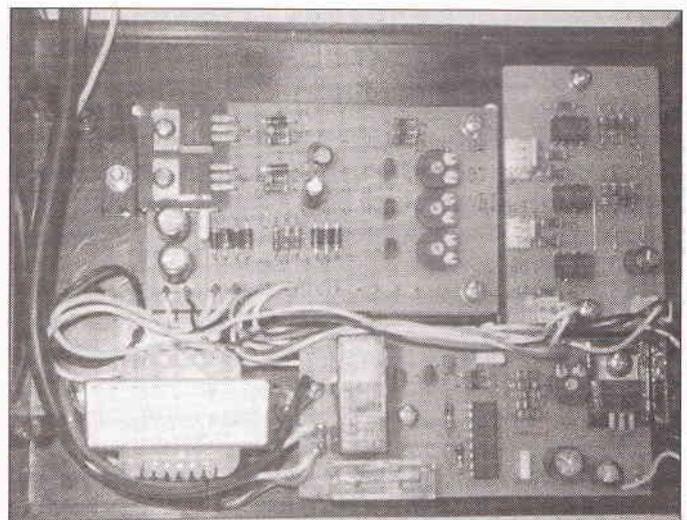
- ABS instrument case KC61R
- Rubber cabinet feet
- 2AA battery box 2 off YR60Q
- 4D battery box JK34M
- PCB mounting PP3 battery holder JK65V
- PP3 battery clip 2 off HF28F
- 3-core 3A mains cable
- 6.4mm grommet
- P clip
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# PC Clinic

***This month in PC Clinic we look at choosing, installing, and using sound cards***

**P**robably one of the most popular upgrades for PC owners at the moment is the addition of a sound card, or audio adapter as it should properly be called. The reason for this is the enormous boom in so called 'multimedia applications' programmes which make full use of text, static images, video clips and sound to convey information, or to add an extra dimension to games.

Although every PC has a built-in speaker it is really only designed for making beeping noises. This is because the speaker is attached to a digital I/O line and the controlling software, part of the BIOS routines, produces a noise simply by toggling the line on and off. By varying the frequency at which this switching off and on takes place it is possible to use the internal speaker on a PC to play a tune or even output very crude speech.

However, real sounds, such as music, the singing of birds, or the human voice are all composed of complex waveforms, certainly not a square wave of variable frequency. This means that there is no way that one could output a Beethoven symphony at CD sound quality through the PC internal speaker. One could only do this by first of all converting the analog sound waveform into digital data for storage on the computer's hard disk and then when you wish to play it outputting the digital data through a digital to analog converter. This is exactly what a sound card does; it is a fairly sophisticated A/D and D/A converter.

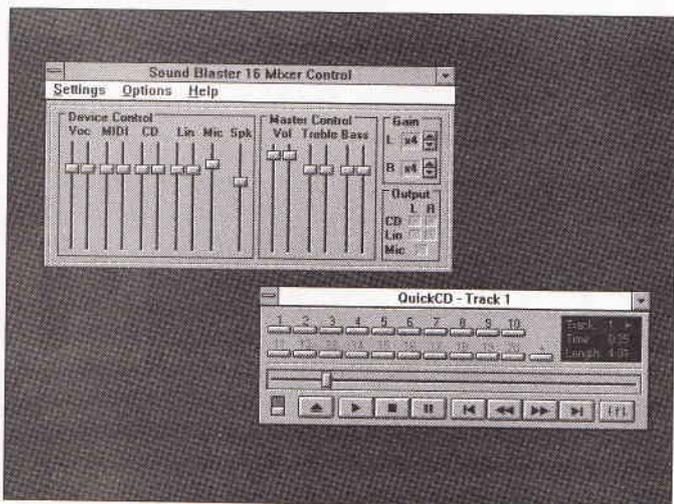
Early generations of sound card worked with eight bit waveform digitisation. This gave a reasonable quality sound output, but because the digitisation step was fairly large it had a rather poor output quality at high frequencies. A problem which was compounded by the use of fairly low frequency sampling rates; at the very minimum, one needs a sampling rate that is twice the maximum frequency to be sampled.

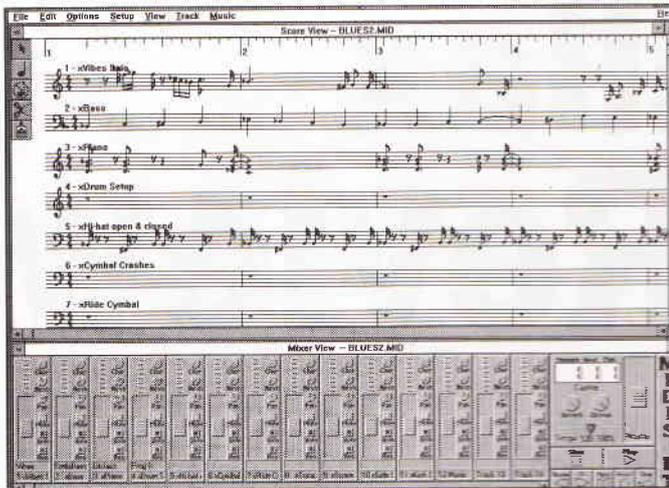
Today, most good quality sound cards use 16bit digitisation and have sampling rates of 44KHz. This allows the card to support sound reproduction of CD quality. With such a card fitted, it should be possible for your computer to play music as well as any reasonable quality stereo. It will also be able to record sounds, pieces of music, voice annotations etc which can then be stored on disk and replayed later.

## **Choosing a sound card**

There are a wide range of different sound cards on the market today, and when buying one it is important to check the features offered by the card and the software that is supplied with it. Before buying a card, one should first of all listen to the sound output from that card, then if it is up to your expectations go through the following checkpoints:

- Does it have a full CD-ROM interface? This is important if you intend buying a CD-ROM drive at some later time. If you want to use a SCSI drive, then make sure that the sound card supports a standard SCSI-2 interface.
- Does it support Windows 3.1 multimedia extensions? If it does then one can take full advantage of all the sound features incorporated in Windows, including annotation of documents using OLE sound clips.
- Does it have compatibility with MPC Level 2.0? If it conforms to the multimedia PC standards, then it should be usable as part of most multimedia software and hardware systems. It should support MIDI in, out, and pass through, as well as input mixing. Sampling rates should be either 11KHz, 22KHz or 44KHz with sampling at either 8 or 16 bits. Also the sound card should not use more than 10% of the computer's processor time.
- Bundled software. Look for a card with as much good quality bundled software as possible, in particular voice synthesis/recognition, CD playback, sound recording/playback/waveform editing etc.
- Sampling and playback rates should be as high as possible; 44KHz or higher sampling/playback will give CD quality sound reproduction.
- Check that the card supports stereo playback for optimum sound quality, also check that it has a built-in amplifier on the sound card so that one can use unamplified speakers.
- It should have full MIDI support, with all the appropriate MIDI software and a standard MIDI port for connection to a MIDI device such as a keyboard. Check the maximum number of stereo voices supported; the more voices, the more complex the compositions that the sound card can render.
- Voice recognition/synthesis is a useful feature that is available on many cards. Cards that support voice recognition will have a microphone input and be supplied with a microphone.
- Soundblaster and AdLib compatibility is now becoming





standard on most sound cards and sound output/multimedia software; compatibility is particularly important if you want to get the best games sound effects.

### Installing a sound card

Like many adapter cards, a sound card will require a free IRQ and also perhaps a free DMA channel. These must be identified prior to attempting to install the sound card and this can be done with the aid of the Microsoft Diagnostic program, or MSD, which should be located on your hard disk in the DOS directory (MSD V2.01 is provided free with MS-DOS 6). MSD is an easy to use menu-based program and will show which IRQ and DMA are currently being used.

This information can be used to select an appropriate free IRQ and DMA. The sound card should then be configured to the chosen IRQ and DMA; configuration is usually done with the aid of jumpers or DIP switches. At this point, the manual should be very carefully checked to make sure that the correct jumpers are being set and that they are being set correctly.

Note that on some systems this configuration process is done by software rather than with the aid of hardware jumpers or switches.

Once the board has been configured, turn off the power to the system and open the case.

Before installing the card in one of the expansion slots, check for any cables that need to be attached to the card; you may well find that it is easier to attach these cables before inserting the card. Make sure that you choose the correct adapter slot; for an 8-bit card this can be either an 8 or a 16 bit slot and for a 16-bit card just a 16-bit slot. Push the card carefully into the slot and secure with a screw.

There are a number of cables which will need to be connected, those going to the CD-ROM drive, the speakers, the microphone and perhaps output to a stereo system, or a MIDI device. We will ignore the CD-ROM cables for the time being, these will be looked at in greater detail next month.

The speaker output is designed to be connected to a pair of standard table-top speakers using a single stereo cable connection between the card and one of the speakers and a cable connection between the two speakers. If you are using this type of speaker, then they are best placed on either side of your computer and angled so that the beams of sound converge just a few inches in front of the user. You might also find that the sound quality is better if the speakers are raised to the user's ear level.

If you do not want to buy speakers, then it should, in most cases, be possible to output sound from the sound card

through a standard stereo system. If the stereo has standard auxiliary jacks then the sound card can be connected to these jacks. The output from the sound card is a single cable, and the input to the stereo is probably in the form of a left and right input. To overcome this problem you will need a Y cable with a single stereo connector at one end and two channel connectors at the other ends. Note that since the standard jack systems are different, you will probably need to use an adapter. Both cable links and adapters are available from most audio shops.

If your stereo does not have an auxiliary jack, and many cheap single unit stereo systems do not, then it may still be possible to use your stereo provided that you don't mind opening it up and making a slight modification. What you are looking for in your stereo are the connections between the turntable or tape decks and the amplifier. In most cases, stereo systems are modular inside and the output from the turntable to the amplifier is made using a connector. Having identified the cable and connector, one needs to make a splitter cable which will allow the amplifier to be connected to the sound card as well as the turntable.

### Software support for sound cards

Unless you are running Windows 3.1 on your system you will lose many of the advantages of having a sound card. This is because Windows is now specifically designed as a multimedia interface; in other words, sound can be integrated into the Windows environment. One can assign sounds to Windows events, record and embed sound objects in a Windows document, add voice notes to a document and, of course, one can use Windows with a CD-ROM drive to play ordinary audio CDs in the background whilst you are using your computer. Another fascinating application area for sound cards with Windows is as a music composition and mixing system, assuming that the sound card supports a full featured MIDI interface then one can attach a MIDI keyboard and, running a program like MIDIsoft, compose music on the keyboard and record, annotate and replay it on the computer, mixing together multiple tracks, controlling tempo etc.

## What a sound card will do

- Play audio CDs on a PC with full software control of volume, treble, bass, etc.
- Play different types of sound files.
- Compose music on your PC.
- Use your PC as an audio editor and mixer.
- Add realistic sound effects to games, applications programmes etc.
- Add digitised sound samples to documents, such as voice notes.
- Digitise and store sounds from a microphone, stereo, CD etc.
- Run or create multimedia systems.
- A sound card will also probably allow one to add a CD-ROM drive to the PC.

# Parallax Stamp Review

**We take a look at an ultra-small and very low-cost computer that is easily programmable in BASIC, and can be applied to solving a wide range of control problems that would previously have required complex dedicated circuitry**

**T**he Stamp system has been developed by the Californian based company Parallax Inc. Essentially, it is a standard PIC microcontroller which has been programmed to run tokenised code that was originally written in BASIC.

By using a standard very low-cost microcontroller chip as the basis of the system it has been possible to keep the cost down to a level where the Stamp can be used as a replacement for even quite small dedicated circuits. By using BASIC, Parallax have made the Stamp very easy to use.

The BASIC interpreter has been designed to handle control applications. Thus, commands covering the 8 programmable I/O lines mean that they can be used standard digital control lines, or they can be used as serial data I/O lines handling baud rates of up to 2400, in addition they can be programmed to control pulse width modulated servo systems, and they can even be used to measure analog data from a potentiometer or other variable resistive device.

For example, one can easily use the Stamp chips to construct a small data terminal that can display messages derived from a computer via a serial I/O line. For this application, all one needs is the Stamp, a few discrete components, a dot matrix LCD display panel and a fairly simple programme.

Using a conventional hardware approach, this application would take a long time to develop and debug. Even using a standard microcontroller it would take long enough, but with a Stamp it could be built and up and running in just a few hours.

## The Stamp system hardware

The Parallax Stamp is currently available as either a basic development system or as a chip set. The development system is a 1.5 x 2.5 inch PCB which contains the Stamp circuit, a couple of 9volt battery clips, a 5volt regulator a PC header for connecting the board to a PC for programming, and an I/O header which provides connections for I/O power and ground. There is also a small prototyping area.

The Stamp system as it is being sold at the moment consists of three chips and a few discrete components. The main chip is an 18-pin BASIC interpreter (actually a Microsystems PIC 16C56), the BASIC programme which it executes is stored

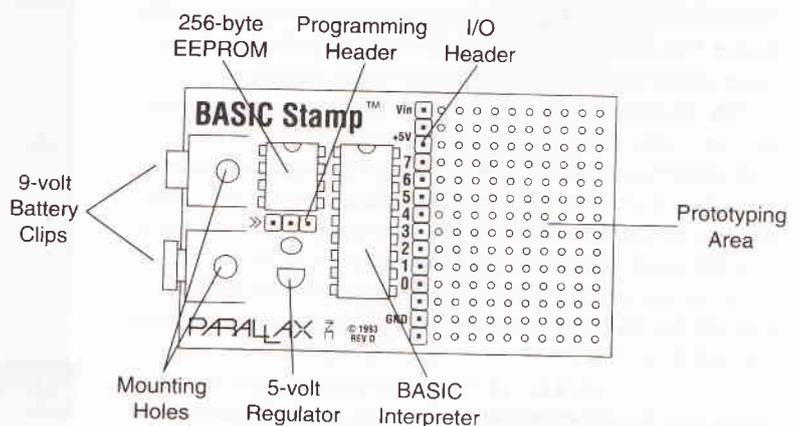
in the second chip, a 256byte EEPROM and the third chip is a 4MHz resonator.

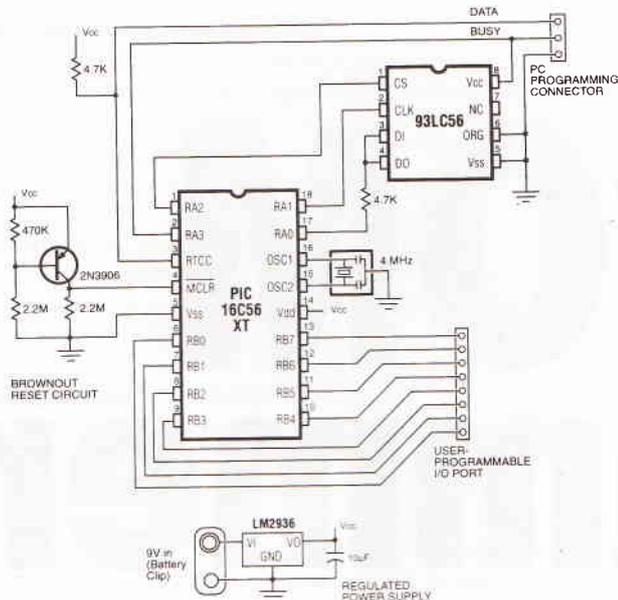
The whole system requires just a single 5volt power supply. Without driving any I/O the typical power consumption of the system is just 2mA, and in sleep mode (this can be software initiated) current consumption drops to just 20uA.

By the time you read this, a new version of the Stamp should be available to readers in the UK - the Stamp II. It is constructed using surface mount technology and consists of just a single 24-pin DIP package. Parallax will be continuing the Stamp I but it will also be produced using surface mount technology and packaged as a 14-pin SIP package. Both of these developments will make the Stamp system a lot easier to use and a lot more compact; three chips and some discrete components will be replaced by just one chip.

There are 8 I/O lines derived from the interpreter chip (on the about to be launched Stamp II system there are 16 I/O lines). Each of these lines can sink 25mA and source 20mA, although the total sink and source for all 8 I/O lines should not exceed 50mA (sink) or 40mA (source). This should be enough to drive a lot of common I/O hardware, but if a larger sink or source current is needed then the appropriate driver circuitry should be employed.

The fact that the EEPROM will only store 256 bytes may seem like a rather severe limitation on code size; however, the tokenisation used in this system is very efficient and each BASIC instruction only takes about 2 or 3 bytes of the EEPROM. This means that programmes can be up to about 80





STAMP INTERNAL CIRCUIT

or 100 lines long, sufficient for some quite complex pieces of software. On the new Stamp II system the amount of EEPROM is expanded to 2048 bytes, sufficient for programmes of about 600 instructions long.

The 4MHz resonator means that programmes run at about 2,000 instructions per second, more than ample for most control applications. If more speed is needed, then the new Stamp II has a 20MHz resonator and thus runs at about five times the speed of the earlier model.

### Programming the Stamp

The BASIC Stamp is programmed in a simple version of the BASIC language. The language includes many familiar instructions such as FOR...NEXT, IF...THEN, and GOTO, as well as special Stamp instructions such as SERIN (serial input), PWM, and BUTTON (button input).

To write software for the Stamp, you will need the programming package which is supplied with the development kit. This package consists of an editor programme which runs on a standard PC and a programming cable which connects between the three-pin programming header on the Stamp board and the PC's parallel port. The package also contains full documentation on the Stamp.

To start using the BASIC Stamp you will first need to connect it to some source of power. Battery clips are provided on the board for connecting it to a standard 9V battery, this is probably the most convenient way of powering the Stamp. Alternatively, a bench power supply could be used. Before writing any code the Stamp should also be connected to the PC using the programming cable that is provided as part of the programming package.

The BASIC programme is written using the editor programme which runs on the PC (minimum system requirements are an IBM PC or compatible with 3.5inch disk drive, parallel port, 128K of RAM and DOS 2.0 or greater). The editor is a full function system with all the features one would expect of an editor with the additional feature of being able to tokenise the programme and download the resulting code to the Stamp EEPROM via the programming cable.

This technique of writing the programme using a PC based editor and then tokenising and downloading allows one to very easily write and test a programme. Downloading typically takes a few seconds and a bargraph on the PC screen shows how

the download is progressing. Once the programme is downloaded it will automatically start running on the Stamp. Once the Stamp has been programmed the programme will stay in the EEPROM until it is erased and reprogrammed.

Some of the new BASIC commands which are available on the Stamp are quite powerful, and can be used to create some complex control programmes. The use of variables is somewhat limited; the Stamp only has 16 bytes of RAM. These are organised as 56 variables: 8 words, 16 bytes, and 32 bits. The 32 bit variables cover the bottom 2 words or 4 bytes. However, despite this limited storage area, it is surprising what can be done, particularly if a little bit of thought and ingenuity are applied to the programming.

## AVAILABILITY OF THE STAMP

At the moment the Stamp is available in the UK exclusively from Leeds based distributor Milford Instruments.

The BASIC Stamp I development kit complete with Programming package costs £99

Further Stamp I systems cost £33 each

The Stamp chipset consists of two chips each of the interpreter, EEPROM, and resonator, and costs £33. (this set obviously makes two Stamps.)

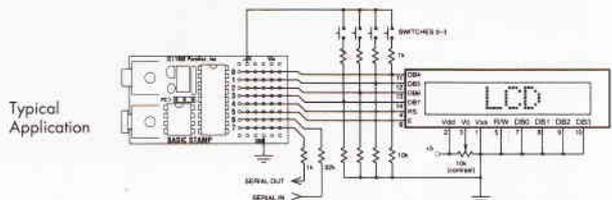
The SIL version of the Stamp I costs £29 with volume discounts for orders of 5 or more.

All the above prices are exclusive of VAT and P&P. For further details contact Milford Instruments on 01977 683665, or write to them at: Milford House, 120 High Street, South Milford, Leeds LS25 5AQ.

## BASIC Stamp -Stamp sized Computer runs BASIC

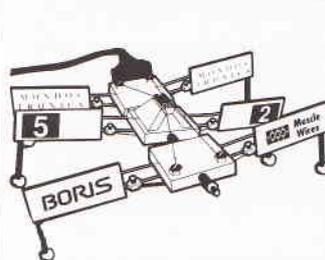
The Basic Stamp by PARALLAX measures only 40x60mm yet is a true microcomputer that runs BASIC programmes written on your PC. Its size, ease of use and extensive I/O features make it an ideal tool for both educational and industrial applications as well as for the serious hobbyist.

Writing programmes for the Stamp is easy. A 3-pin cable connects the Stamp to your PC printer port. One piece of software is used to enter, debug and download your programme. Features include 8 I/O lines, non-volatile memory, serial comms, pulse measurement and PWM; all achieved with a minimum of external components.



The BASIC Stamp Development Kit at £99 includes; 1 BASIC Stamp, instruction manual, PC cable, software and extensive application notes. Further Stamps are available from £29.

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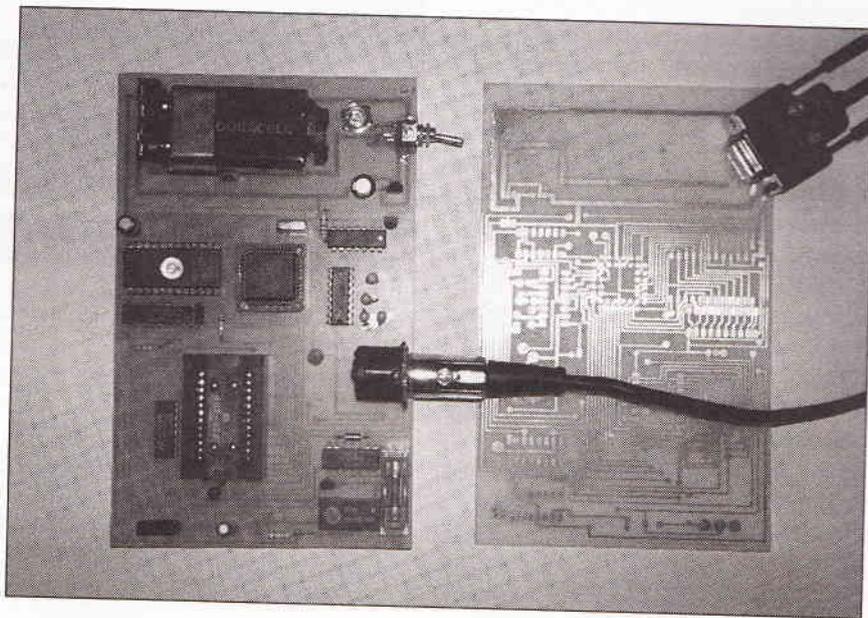
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# A Portable EPROM Programmer

*A portable EPROM programmer can be a useful addition to one's tool kit. Here, Richard Grodzik shows how to build one*



**M** New Technology? Not really, the EPROM (erasable programmable read-only memory) has been around for 20 years. You'll find them in millions of PCs and countless numbers of embedded computer systems. The ubiquitous 2716 EPROM is still going strong and with a capacity of 2048 bytes is an ideal starting point for ROM-based projects. Available from most component suppliers as type number M2716-1F1, this EPROM requires a 25 volt programming voltage and will interface to most microprocessors. The older D2716-1 EPROMs have slightly different fanout characteristics and are best left alone.

With the availability of modern components, the design of a portable EPROM programmer becomes realizable. The provision of a 25 volt supply is easily achieved utilising a dc-dc converter. The 0512D converter takes a 5 volt input and produces +ve and -ve 12 volt outputs: strapping the -ve 12 volt

rail to ground produces a 24 volt potential difference - in practice, this is more like 25 volts which is perfect for the  $V_{pp}$  supply to the EPROM. To keep battery current low (< 100 mA), a low drop 5 volt regulator is used to provide power for the board's electronics. So with a typical ampere-hour capacity of 300 mA·H, a PP3 battery should provide a typical operating time of at least a couple of hours.

Programming couldn't be simpler. Utilising a public domain terminal emulator such as 'TELIX', the onboard software (resident in a 2716 of course), first checks that the EPROM is fully erased i.e. all locations contain FFH. If this is so, the file containing the object code (size 2048 bytes) is sent from a PC along the serial link to the programmer and programming commences under software control. Just time to make a cuppa, since it takes approximately 1 minute 40 seconds to program the entire EPROM, at which time a 'Completed Programming' message is flashed on the PC's screen.

## Hardware Handshaking.

Since the serial link of the portable programmer communicates with the PC at 9600 baud, a handshaking arrangement has to be provided as each EPROM location takes 50 ms to program. A 9600 baud rate transmits a 10 bit RS232 word, including start and stop bit every 1 ms. By controlling the CTS (clear to send) input of the PC's serial handshake input, the programmer allows 1 byte to be sent from the PC's port every 50 ms + software overhead time. If using a terminal emulator other than TELIX, ensure that the CTS/RTS hardware handshake has been enabled.

## Circuit Description.

The block diagram shows the major components of the portable Programmer. Based on the 80C31 embedded microcontroller, a PLCC package with very low current consumption and a small footprint. The software in the 2716 controls all communications between the Programmer and the PC. The only intervention by the operator is to type 'G' at the PC's keyboard to activate the system, and then to send the ROMable code to the programmer.

Table 1 details the logic levels and Vcc/Vpp voltage levels required by the EPROM for blank checking and then for programming, with the associated waveforms shown in figure 1. The OE line is held at logic low for reading (blank checking) and at logic high when programming. The 50 ms programming pulse is applied to the CE/PGM pin, and simultaneously this pulse is also applied to the clock input of the 4040 counter chip. See diagram 1.

As the train of programming pulses increment the address counter and burn the EPROM, the data bytes received from the PC are applied to the data lines of the ZIF socket via the 80C31 port lines P1.0 thru P1.7. This arrangement works because the counter increments on the trailing edge of the programming pulse i.e. at the completion of the 50 ms programming pulse.

A reed relay with an operating coil resistance of 500 ohms - again to limit battery current consumption, comes into effect when the Programmer has received a G signal from the PC. An LED indicator signals that the relay has been activated and that the ground pin of the ZIF socket has been grounded, allowing programming operations to take place. Do not insert or remove the EPROM from the ZIF socket when the LED is on, since damage could be sustained to the dc-dc converter or the EPROM. A 100 mA fuse has been included to provide a safeguard, but this cannot be guaranteed. On completion of programming the LED will extinguish, and the EPROM can then be safely removed.

## Construction tips

As with most microprocessor based projects, it is definitely a non-trivial task to accommodate all the printed wiring on a single sided board. Inevitably, a dozen or so wire links have to be made. The prototype has been given a neat appearance by including all the links on the underside of the board. The connecting pads were not drilled and, once tinned, insulated wire-wrapping wire was easily soldered in place to provide these links - a quick and convenient process that dispenses with the fiddly job of conventional wire linking.

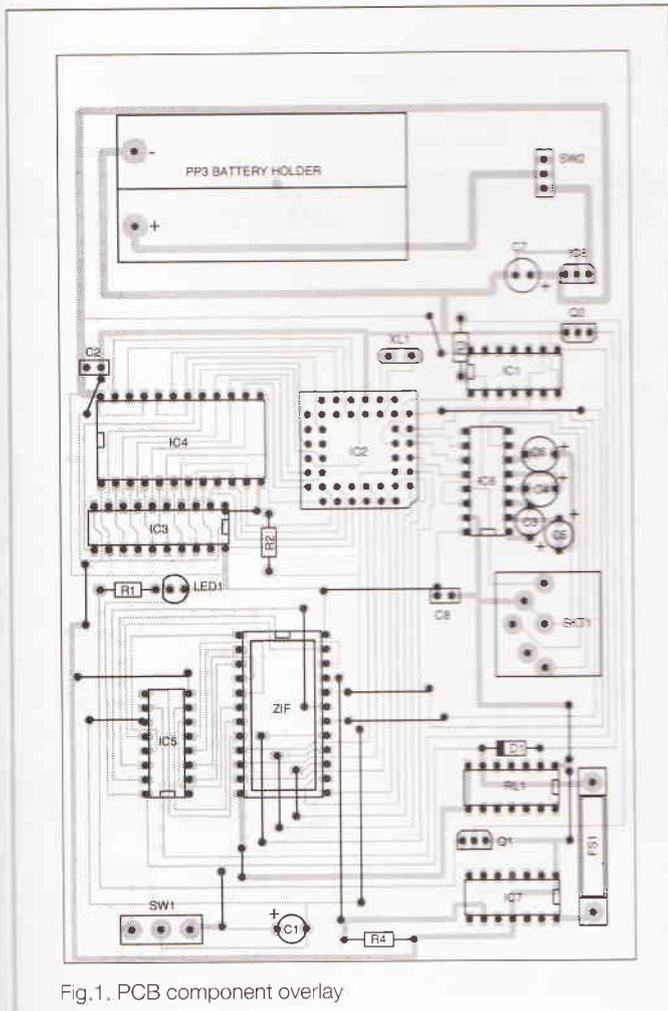


Fig.1. PCB component overlay

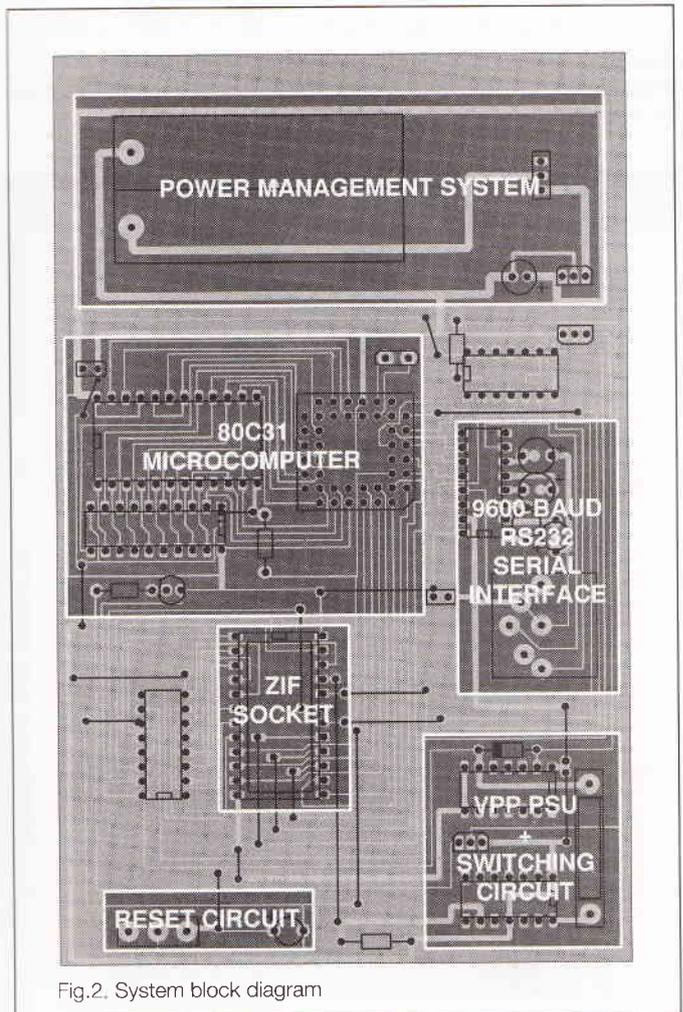


Fig.2. System block diagram

The PLCC socket for the 80C31 requires care when drilling. Use a 0.6 mm drill and accurately drill these holes, since it is nigh enough impossible to located these chip carriers if a hole has been misplaced. The drill size is recommended since using a larger diameter drill will not leave sufficient copper on the board for soldering. For those readers wishing to manufacture their own PCB, an artwork file is available on a floppy 'Circuit' which will print from DOS to any printer using the MSDOS command PRINT .i.e. enter PRINT CIRCUIT.

## Using TELIX

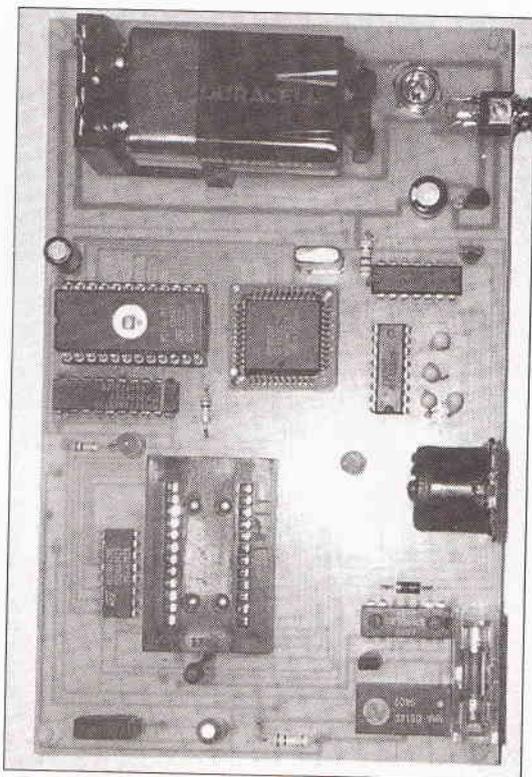
Version 3.15 of TELIX supports hardware handshaking. Note that this software is a user supported software product and users must satisfy the conditions of the limited licence. A copy of this software is available from the author. Alternately any terminal emulation software may be used such as Terminal supplied with 'Windows', or communications software, notably 'Protel'.

If using TELIX, the user must configure the software as follows:

- Select configure telix (ALT O)
- select terminal options, option K - CTS/RTS hardware flow control - on.
- Select filenames and paths. Select UPLOAD directory and enter Directory name containing object files for transmission.
- enter G.
- press Page up key, select ASCII, and enter file name of code to send to the Programmer.
- press enter key.

Note that the file size should be 2048 bytes (0800H). This can be checked by DEBUG command RCX, which returns the number of bytes in the file.

A 3 1/2 floppy containing the PCB artwork, hexdump of the operating system ROM and a copy of TELIX is available from the author: Mr.R.Grodzik (Micros), 53 Chelmsford Road, Bradford BD3 8QN West Yorkshire U.K. Price: £12.50 including P & P.



## B1: Features of portable EPROM programmer.

- Serial 9600 baud interface.
- Battery powered.
- Uses PC terminal emulation software.
- 'Smart' embedded programming software.
- Connects to the COM1 or COM2 port of any IBM compatible PC.

```
#INCLUDE SFR51.EQU

;PORTABLE EPROM PROGRAMMER SOURCE CODE
.org 0

START:

    LCALL DEBOUNCE      ;CLEAR SCREEN AND SEND
                        ;MESSAGE

    MOV DPTR,#CLRSCR
    ACALL MESSAGE
    LCALL INIT          ;INITIALISE UART
    LCALL GO            ;WAIT FOR 'G' FROM PC
                        ;TERMINAL

    CLR TR1

    MOV DPTR,#CLRSCR
    LCALL MESSAGE

    LCALL BLANKCHECK   ;TEST IF EPROM IS BLANK
                        ;I.E ALL LOCATIONS CONTAIN
                        ;FFH

    LCALL DEBOUNCE
    CJNE A,#'P',START ;BLANKCHECK FAILED,RESTART
    MOV P1,#0FFH      ;DATA FFH
    CLR P3.2          ;SWITCH ON RELAY/LED
    LCALL DEBOUNCE    ;AND WAIT FOR DATA

    MOV DPTR,#00      ;BYTE COUNTER
    LCALL INIT

                        ;TAKE IN SERIAL DATA FROM
                        ;TERMINAL
                        ;AND BURN EPROM

RECEIVE:CLR P3.4     ;ENABLE CTS

LOOP:
    JNB RI,LOOP      ;IF FLAG RI IS SET,BYTE
                        ;HAS BE
    CLR RI            ;CLEAR BYTE RECEIVED FLAG
    SETB P3.4        ;DISABLE CTS

    MOV A,SBUF
    MOV P1,A          ;BURN EPROM
    CPL P3.3
    LCALL DELAY       ;PGM/CE PULSE
    CPL P3.3
    INC DPTR          ;NEXT ADDRESS LOCATION
    MOV A,#8          ;LOOP UNTIL ALL LOCATIONS
                        ;PROGRAMMED

    CJNE A,DPH,RECEIVE
    CLR P3.4          ;ENABLE CTS LINE
    SETB P3.2        ;LED/RELAY OFF

    MOV DPTR,#FINISH ;COMPLETED PROGRAMMING
                        ;MESSAGE SENT TO TERMINAL

    LCALL MESSAGE

    MOV P1,#0FFH
```

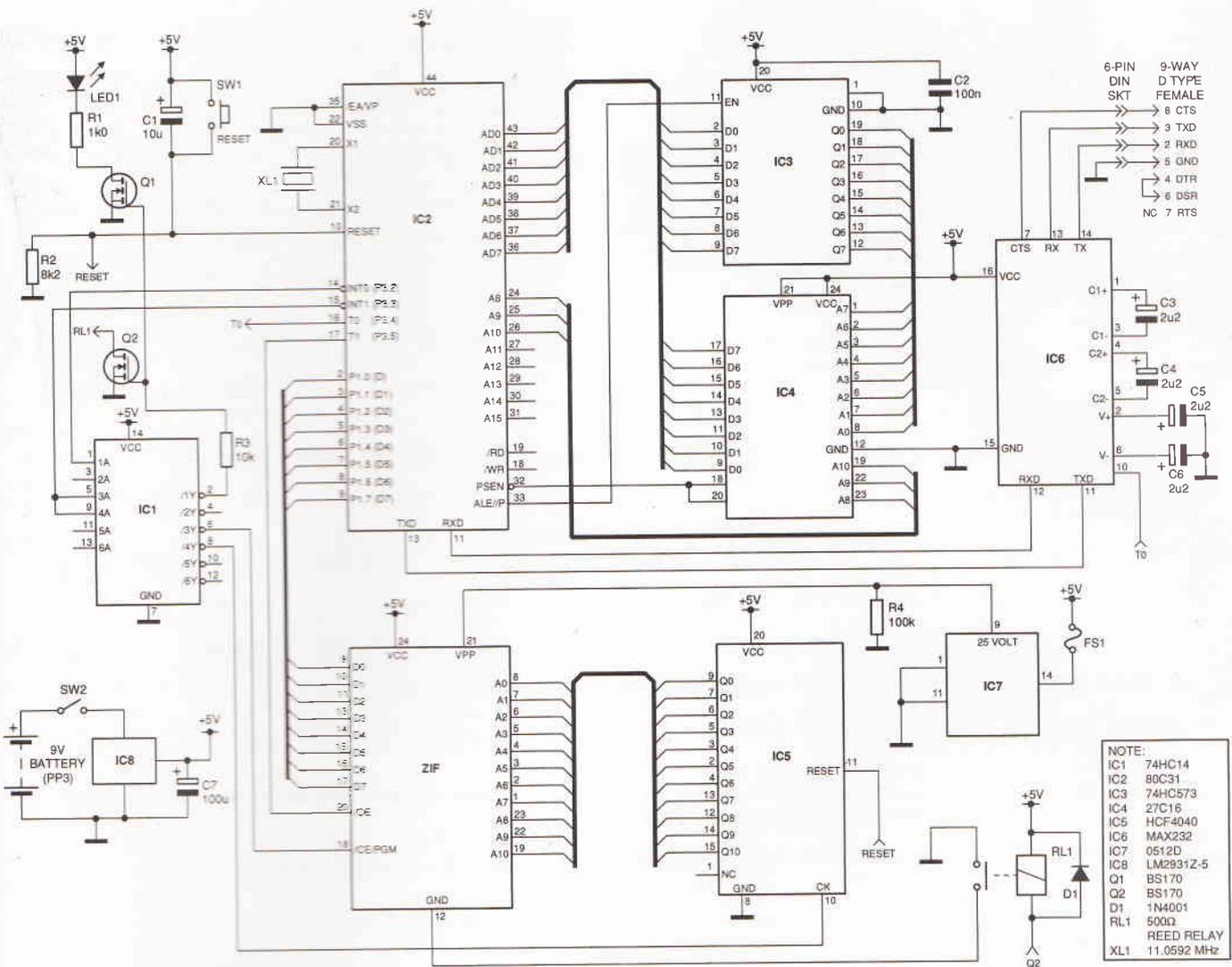


Fig.3: Portable EPROM programmer circuit diagram

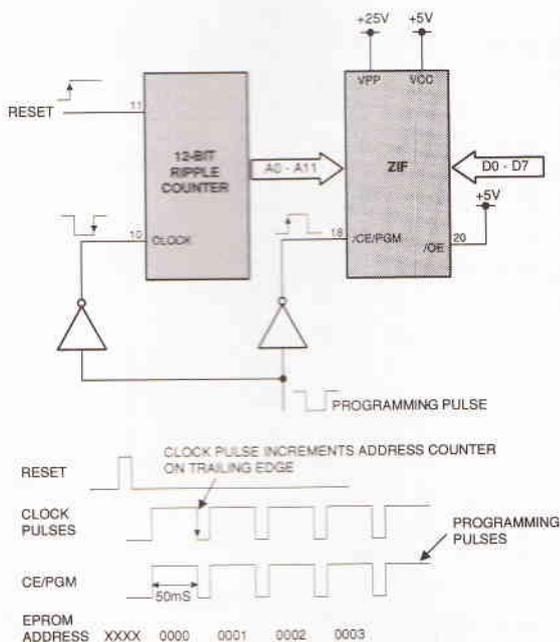


Fig.4: EPROM programming waveforms

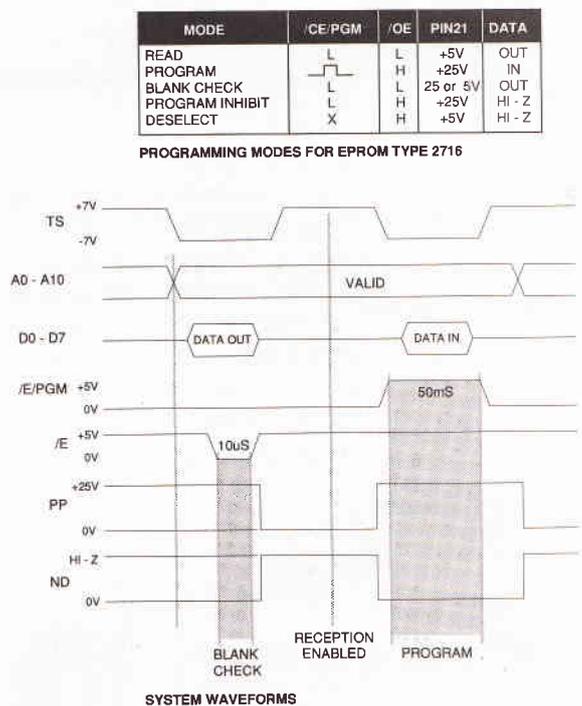


Fig.5: EPROM programming logic levels

```

SETB P3.3          ;DISABLE BURNING
STOP:SJMP STOP

GO:
CLR P3.4           ;ENABLE CTS LINE
H:  JNB RI,H       ;WAIT FOR SERIAL BYTE
    CLR RI
    MOV A,SBUF
    CJNE A,#'G',START ;IF RECEIVED BYTE IS NOT
                        'G' THEN ABORT
    SETB P3.4      ;IF 'G' THEN CONTINUE
    RET

BLANKCHECK:
CLR P3.5           ;EPROM READ MODE
CLR P3.2           ;LED IS ON

MOV DPTR,#0        ;BASE ADDRESS OF EPROM
                        0000
MOV B,#0FFH        ;COMPARE EACH ADDRESS
                        LOCATION WITH FFH
MOV P1,#0FFH
CONT1:MOV A,P1

CJNE A,B,FAIL      ;NOT FFH,BLANKCHECK FAILED
MOV A,#8           ;ADDRESS 0800H
CJNE A,DPH,CONT; IF LAST BYTE OF EPROM I.E.
                        07FFH
                        ;HAS BEEN CHECKED,THEN
                        SEND
SJMP PASS          ;BLANKCHECK PASSED MESSAGE
                        TO TERMINAL
CONT:INC DPTR      ;NEXT EPROM ADDRESS

CPL P3.3           ;TOGGLE PGM/CE LINE
CPL P3.3           ;I.E. INCREMENT 4040
                        ADDRESS COUNTER

SJMP CONT1        ;LOOP UNTIL ALL ADDRESSES
                        CHECKED

PASS:
MOV DPTR,#PMES    ;EPROM IS BLANK
LCALL MESSAGE
MOV A,#'P'        ;LOAD VARIABLE WITH 'P'
SETB P3.5
SETB P3.2
RET

FAIL:
MOV DPTR,#FMES ; FAIL BLANKCHECK MESSAGE
LCALL MESSAGE
MOV A,#'F'      ;LOAD VARIABLE WITH 'F'
SETB P3.5
SETB P3.2
RET

TXD:
MOV SCON,#050H ;TRANSMISSION ROUTINE
                        ;PROGRAM 8031 SFR'S
MOV TMOD,#020H ;FOR TRANSMISSION
MOV TH1,#0FDH
MOV SBUF,A     ;BYTE IN ACCUMULATOR IS
                        TRANSMITTED
SETB TR1

LOOP3:
JNB TI,LOOP3
CLR TR1
CLR TI
RET

MESSAGE:
;TRANSMIT MESSAGE STRING

MOV A,#0
AGAIN:
PUSH A
MOVC A,@A+DPTR
CJNE A,#24H,OVER
LJMP OUT1

CLRSCR:
.BYTE 07 ;BELL
.BYTE 0CH ;FORMFEED I.E. CLEAR
                        SCREEN
.TEXT "SYSTEM INITIALISED .."
.BYTE 024H ;END OF TEXT ($) MARKER

PMES:
.TEXT " CHECK PASSED - SEND DATA"
.BYTE 00DH ;RETURN
.BYTE 00AH ;LINEFEED
.BYTE 024H

FMES:
.TEXT " CHECK FAILED - PROGRAMMING ABORTED"
.BYTE 00DH
.BYTE 00AH
.BYTE 024H

FINISH:
.TEXT " PROGRAMMING COMPLETED"
.BYTE 00DH
.BYTE 00AH
.BYTE 024H

OVER:
MOV SCON,#050H
MOV TMOD,#020H
MOV TH1,#0FDH
MOV SBUF,A
SETB TR1

LOOPX:
JNB TI,LOOPX
POP A
INC A
LJMP AGAIN

OUT1:
POP A
CLR TR1
CLR TI
RET

TRANSMIT:
SETB TR1 ;NOT USED
MOV SBUF,#'.'
LOOPZ
JNB TI,LOOPZ

```

```

CLR TI
RET

INIT:
;INITIALISE 8031 UART FOR
;9600 BAUD
;RECEPTION AND
;TRANSMISSION

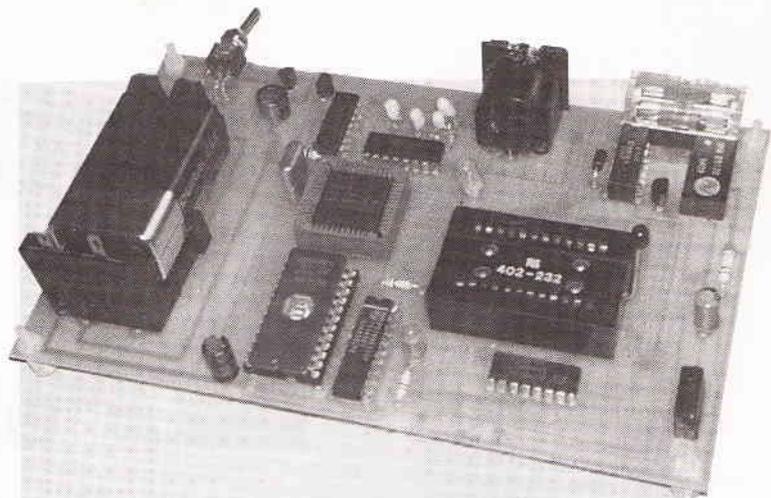
MOV SCON,#050H ;SERIAL MODE 1,RECEIVER
;ENABLE
MOV TMOD,#020H ;TIMER 1 8-BIT AUTO
;RELOAD
MOV TH1,#0FDH ;TIMER RELOAD VALUE FOR
;9600 BAUD
CLR EA ;DISABLE GLOBAL INTERRUPT
SETB TRI ;TIMER 1 ON
RET

DEBOUNCE:
MOV R6,#0FFH ;RELAY CONTACT DEBOUNCE
D3: DEC R6

MOV R7,0FFH
D4: DEC R7
CJNE R7,#00,D4
CJNE R6,#00,D3
RET

DELAY:
;VPP PULSE 50-55
;MILLISECONDS
PUSH A
PUSH PSW
MOV R6,#03DH ;SET PULSE WIDTH

```



```

D2: DEC R6

MOV R7,#0FFH
D1: DEC R7
CJNE R7,#00,D1
CJNE R6,#00,D2
POP PSW
POP A
RET

.ORG 0800H
;FILE SIZE 2048 BYTES

.END

```

Olivetti HEXDUMP -- Release 01.0

Dumping File: C:BURN.OBJ

0010:	12 01 6a 90 00 c1 11 b6 12 01 5c 12 00 58 c2 8e	".j.....\..X.."
0011:	90 00 c1 12 00 b6 12 00 67 12 01 6a b4 50 e1 75	".....g..j.P.u"
0012:	90 ff c2 b2 12 01 6a 90 00 00 12 01 5c c2 b4 30	".....j.....\..0"
0013:	98 fd c2 98 d2 b4 e5 99 f5 90 b2 b3 12 01 77 b2	".....w.."
0014:	b3 a3 74 08 b5 83 e6 c2 b4 d2 b2 90 01 1b 12 00	".t....."
0015:	b6 75 90 ff d2 b3 80 fe c2 b4 30 98 fd c2 98 e5	".u.....0....."
0016:	99 b4 47 9c d2 b4 22 c2 b5 c2 b2 90 00 00 75 f0	".G...".....u.."
0017:	ff 75 90 ff e5 90 b5 f0 1b 74 08 b5 83 02 80 07	".u.....t....."
0018:	a3 b2 b3 b2 b3 80 ed 90 00 d9 12 00 b6 74 50 d2	".....tP.."
0019:	b5 d2 b2 22 90 00 f5 12 00 b6 74 46 d2 b5 d2 b2	"....".....tF...."
0020:	22 75 98 50 75 89 20 75 8d fd f5 99 d2 8e 30 99	"u.Pu. u.....0.."
0021:	fd c2 8e c2 99 22 74 00 c0 e0 93 b4 24 76 02 01	"...."t....\$v.."
0022:	4a 07 0c 53 59 53 54 45 4d 20 49 4e 49 54 49 41	"J..SYSTEM INITIA"
0023:	4c 49 53 45 44 20 2e 2e 24 20 43 48 45 43 4b 20	"LISED ..\$ CHECK "
0024:	50 41 53 53 45 44 20 2d 20 53 45 4e 44 20 44 41	"PASSED - SEND DA"
0025:	54 41 0d 0a 24 20 43 40 45 43 4b 20 46 41 49 4c	"TA..\$ CHECK FAIL"
0026:	45 44 20 2d 20 50 52 4f 47 52 41 4d 4d 49 4e 47	"ED - PROGRAMMING"
0027:	20 41 42 4f 52 54 45 44 0d 0a 24 20 50 52 4f 47	" ABORTBD..\$ PROG"
0028:	52 41 4d 4d 49 4e 47 20 43 4f 4d 50 4c 45 54 45	"RAMMING COMPLETE"
0029:	44 0d 0a 24 75 98 50 75 89 20 75 8d fd f5 99 d2	"D..\$u.Pu. u....."
0030:	8e 30 99 fd d0 e0 04 02 00 b8 d0 e0 c2 8e c2 99	".0....."
0031:	22 d2 8e 75 99 2e 30 99 fd c2 99 22 75 98 50 75	".u..0...."u.Pu"
0032:	89 20 75 8d fd c2 af d2 8e 22 7e ff 1e af ff 1f	". u....."....."
0033:	bf 00 fc be 00 f6 22 c0 e0 c0 d0 7e 3d 1e 7f ff	"....".....=".
0034:	1f bf 00 fc be 00 f6 d0 d0 d0 e0 22 ff ff ff ff	"...."....."
0035:	ff	"...."....."
0036:	ff	"...."....."
0037:	ff	"...."....."

# Practically SPEAKING

BY TERRY BALBIRNIE

**Last month we looked at some essential tools for the amateur workshop. This time we shall pursue this topic and also look at some tools which, although not essential, may be found useful.**

## Many vices

A miniature vice is extremely useful. The type which can be quickly attached to any work surface is convenient. Maplin sell their Hobby Vice for £2.65. This is made of plastic with metal faced jaws and is suitable for light electronics work. A 50mm steel bench vice will cost around £15.

For drilling holes in boxes and panels, you will need a small hand drill and a set of twist drills to go with it - say, 1.5mm to 6mm or the imperial equivalent. The drill itself could be an ordinary DIY type and possibly shared with other uses around the house. However, the drill bits themselves should be reserved for electronics purposes. A centre punch and a small hammer will be necessary for accurately marking the centre of the hole to be drilled and to give a start to the process. This will prevent the drill bit from slipping and scratching the surface.

## Fine work

For drilling holes in PCBs and other fine work, you will need a miniature 12V drill fitted in a vertical drill stand. Unfortunately, these do not come cheap. You will need to pay from £15 up to £30 for the drill and about the same for its power supply (although a suitable 12V supply may already exist or it could be operated from the 12V lead-acid battery in the Mains Free Workshop (Practically Speaking September, 1994). The stand will also cost around £30. At a pinch, you could use the drill without a stand but this is both tedious and drill-breaking work. For PCB drilling you will need some very thin drills - about 0.5mm to 1.5mm. Some people drill all PCB holes 1mm diameter minimum but this size is too large for many component leads.

You will need some small needle files. These are often supplied as a set in a plastic wallet - perhaps, flat, round, half-round, square and triangular. Expect to pay between £5 and £10 depending on the quality. Make sure they have handles to prevent the tang jabbing into your hand if the file unexpectedly sticks in use.

A particularly useful tool is the taper reamer. This may be used to clean up holes in panels etc. It is also handy for enlarging holes when the largest available drill is still too small -

for example, to make the hole for a potentiometer. Filing out a hole is tedious but the reamer will do the job in a very short time. A good taper reamer will cost £10 but adequate ones will cost about half this amount. A suitable size is 3mm to 10mm.

## Crafty stuff

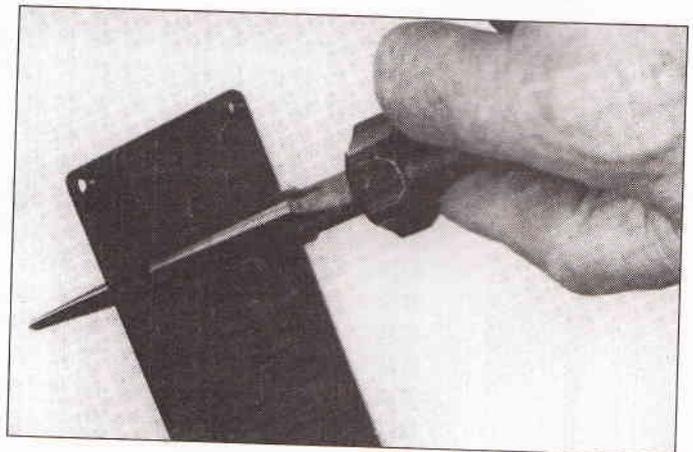
A craft knife will always be useful. Usually people already have their preferences as regards style. It is, however, a good idea to buy one with a retractable blade.

I once bought a "pearl catcher" to make an order up to minimum value. I'm glad that I did because I have used it quite a lot. To readers unfamiliar with a pearl catcher, it is a small pencil-like device. When the end is pressed, spring prongs emerge from the other end. These may be placed around a small item and the plunger released. The part is then gripped firmly by the prongs. Pearl catchers are handy for recovering small screws which have dropped into the depths of some piece of equipment. They cost less than £1 so it is worth having one.

You need a small hacksaw for removing excess spindle from potentiometers and rotary switches - this is another piece of equipment which could be shared. A magnifying glass is always useful. Even those with good eyesight may need this to see the lettering on a small component such as a Zener diode or to locate the exact position for a hole when drilling a PCB.

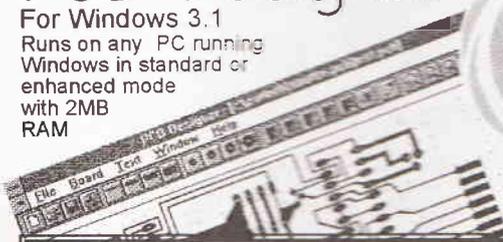
Items for the short list are a set of Allen keys (say, 1.5mm upwards) and some nut spinners - say, 3mm to 5mm. A small spanner set between 4mm and 6mm will also be needed every now and again.

That's all for this month. Next time, we shall look at PCB making equipment.



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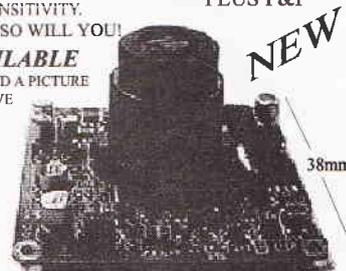
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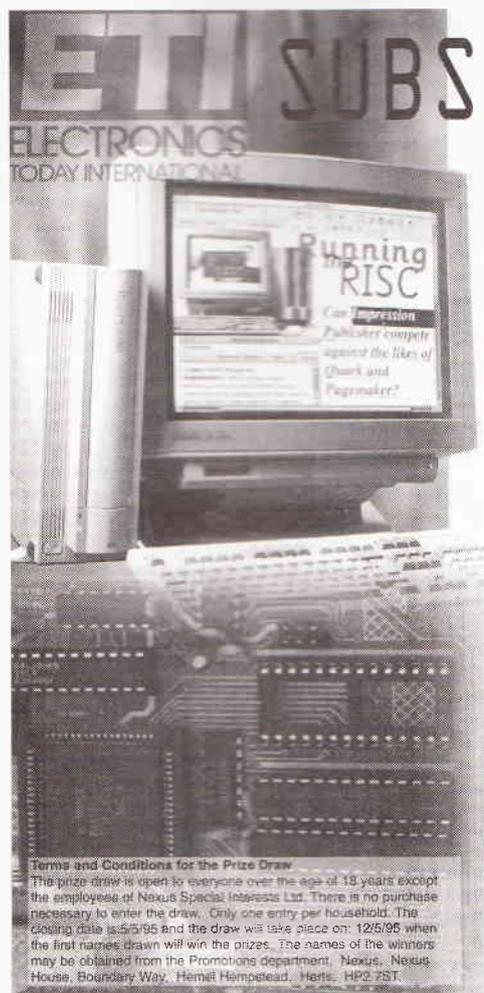
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# LCD based mini terminal

**In this, the first of a regular series of projects designed around the Parallax Stamp, we take a look at how to use this versatile little computer system to form the heart of a simple user-interface terminal based on a 16 character LCD dot matrix display**

If you look around you will probably find dozens of applications for small data displays with a few input buttons. Applications such as cash tills, drinks dispensers, photocopiers, phone boxes, CNC machine tools, laser printers, top range audio equipment, motor cars and, of course, a whole range of instrumentation from EPROM programmers and multimeters, to gas chromatographs and mass spectrometers.

Another application area for small data displays lies in systems which use a central host computer to control a number of remote functions. At various locations in such systems, users communicate with the main system via small terminals that display system status and accept a minimal range of inputs. This could, for example, be an environmental or security control system.

One can of course buy complete display modules which accept serial data input and are simply plugged into any application to provide the desired terminal function. However, they are expensive and one is confined to using a set design. Neither of these factors will find particular favour with the experimenter or the designer of one-off systems.

The alternative is to build and design one's own data display terminal. The use of conventional logic circuitry is one obvious choice. But although the circuitry would be cheap, the time taken to design and debug the circuit would be prohibitive. A much easier solution would be to use a microcontroller chip and write the display control functions in software.

However, the problem with a standard microcontroller is that the designer needs to have all the appropriate development hardware and software together with a reasonably good knowledge of the microcontroller instruction code. None of these are likely to be possessed by the average occasional microcontroller user.

Enter the Parallax Stamp, a microcontroller which can be programmed in a language that most computer users are familiar with, BASIC.

The BASIC Stamp's ease of programming and built-in support for serial communications make it a good candidate for such user-interface applications. Indeed all that is needed to construct a simple data terminal is a Stamp, a dot matrix LCD

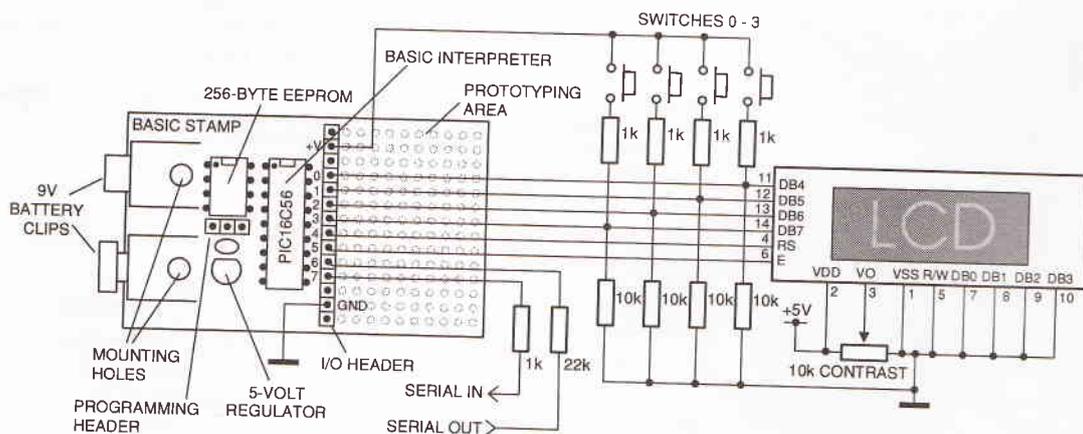


Fig. 1 Terminal circuit

display, a few push buttons and a few resistors; the circuit is shown in Fig. 1.

It should be noted that in this project the liquid-crystal display (LCD) that is used is based on the popular Hitachi 44780 controller IC. These chips are at the heart of LCDs ranging in size from two lines of four characters (2x4) to 2x40. These modules are widely available from most electronic component suppliers.

### How the Stamp based terminal works

When power is first applied, the BASIC program initialises the LCD. It sets the display to print from left to right and enables an underline cursor. To eliminate any stray characters, the program clears the screen.

After initialisation, the program enters a loop waiting for the arrival of a character via the 2400-baud RS-232 interface. When a character arrives, it is checked against a short list of special characters (backspace, control-C, and return). If it is not one of these, the program prints it on the display, and re-enters the waiting-for-data loop.

If a backspace is received, the program moves the LCD cursor back one space, prints a blank (space) character to blot out the character that was there, and then moves back again. The second move-back step is necessary because the LCD automatically advances the cursor.

If a control-C is received, the program issues a clear instruction to the LCD, which responds by filling the screen with blanks, and returning the cursor to the leftmost position.

If a return character is received, the program interprets the message as a query requiring a response from the user. It enters a loop waiting for the user to press one of the four pushbuttons. When he does, the program sends the character ("0" through "3") representing the button number back to the host system. It then re-enters its waiting loop.

Because of all this processing, the user interface cannot receive characters sent rapidly at the full baud rate. The host program must put a little breathing space between characters; perhaps a 3-millisecond delay. If you reduce the baud rate to 300 baud and set the host terminal to 1.5 or 2 stop bits, you may avoid the need to program a delay.

At the beginning of the program, during the initialisation of the LCD, you may have noticed that several instructions are repeated, instead of being enclosed in for/next loops. This is not an oversight. Watching the downloading bar graph indicated that the repeated instructions actually resulted in a more compact program from the Stamp's point of view. Keep an eye on that graph when running programs; it a good relative indication of how much program space you've used. The terminal program occupies about two-thirds of the Stamp's EEPROM.

From an electronic standpoint, the circuit employs a couple of tricks. The first involves the RS-232 communication. The Stamp's processor, a PIC 16C56, is equipped with hefty static-protection diodes on its input/output pins. When the Stamp receives RS-232 data, which typically swings between -12 and +12 volts (V), these diodes serve to limit the voltage actually seen by the PIC's internal circuitry to 0 and +5V. The 22k resistor limits the current through the diodes to prevent damage.

Sending serial output without an external driver circuit exploits another loophole in the RS-232 standard. While most RS-232 devices expect the signal to swing between at least -3 and +3V, most will accept the 0 and +5V output of the PIC without problems.

This setup is less noise-immune than circuits that play by the RS-232 rules. If you add a line driver/receiver such as a Maxim MAX232, remember that these devices also invert the signals. You'll have to change the baud/mode parameter in the instructions SERIN and SEROUT to T2400, where T stands for true signal polarity. If industrial-strength noise immunity is required, or the interface will be at the end of a mile-long stretch of wire, use an RS-422 driver/receiver. This will require the same changes to SERIN and SEROUT.

Another trick allows the sharing of input/output pins between the LCD and the pushbuttons. What happens if the user presses the buttons while the LCD is receiving data? Nothing. The Stamp can sink enough current to prevent the 1k pull-up resistors from affecting the state of its active output lines. And when the Stamp is receiving input from the switches, the LCD is disabled, so its data lines are in a high-impedance state that's the next best thing to not being there. These facts allow the LCD and the switches to share the data lines without interference.

Finally, note that the resistors are shown on the data side of the switches, not on the +5V side. This is an inexpensive precaution against damage or interference due to electrostatic discharge from the user's fingertips. It's not an especially effective precaution, but the price is right.

```
' PROGRAM: Terminal.bas
' The Stamp serves as a user-interface terminal.
It accepts text via RS-232 from a ' host, and
provides a way for the user to respond to queries
via four pushbuttons.
```

```
Symbol S_in   = 7 ' Serial data input
pin
Symbol S_out  = 6 ' Serial data output pin
Symbol E     = 5 ' Enable pin, 1 = enabled
Symbol RS    = 4 ' Register select pin, 0 =
instruction
Symbol keys  = b0 ' Variable holding # of key
pressed.
Symbol char  = b3 ' Character sent to LCD.
Symbol Sw_0  = pin0 ' User input switches
Symbol Sw_1  = pin1 ' multiplexed w/LCD data
lines.
Symbol Sw_2  = pin2 Symbol Sw_3 = pin3

' Set up the Stamp's I/O lines and initialise the
LCD.

begin: let pins = 0 ' Clear the output
lines
let dirs = %01111111 ' One input, 7
outputs.
pause 200 ' Wait 200 ms for LCD
to reset

' Initialise the LCD in accordance with Hitachi's
instructions for 4-bit interface.

i_LCD: let pins = %00000011 ' Set to 8-bit
operation.
pulsout E,1 ' Send data three
times
pause 10 ' to initialise LCD.
pulsout E,1
pause 10
pulsout E,1
pause 10
let pins = %00000010 ' Set to 4-bit
operation.
pulsout E,1 ' Send above data three
times.
pulsout E,1
pulsout E,1
```

```

let char = 14      ' Set up LCD in
                  ' accordance with
                  ' Hitachi inst manual.
gosub wr_LCD
let char = 6      ' Turn on cursor and enable
gosub wr_LCD      ' left-to-right printing.
let char = 1      ' Clear the display.
gosub wr_LCD
high RS           ' Prepare to send characters.

' Main program loop: receive data, check for
backspace, and display data on LCD.

main: serin S_in,N2400,char ' Main terminal loop.
      goto bksp
out:  gosub wr_LCD
      goto main

' Write the ASCII character in b3 to LCD.

wr_LCD: let pins = pins & %00010000
        let b2 = char/16      ' Put high nibble of
                              ' b3 into b2.
        let pins = pins | b2  ' OR the contents of
                              ' b2 into pins.
        pulsout E,1          ' Blip enable pin.
        let b2 = char & %00001111 ' Put low nibble
                              ' of b3 into b2.
        let pins = pins & %00010000 ' Clear 4-bit
                              ' data bus.
        let pins = pins | b2  ' OR the contents
                              ' of
                              ' b2 into pins.
        pulsout E,1          ' Blip enable.
        return

' Backspace, rub out character by printing a blank.

bksp: if char > 13 then out ' Not a bksp or cr?
      ' Output character.
      if char = 3 then clear ' Ctl-C clears LCD
      ' screen.
      if char = 13 then cret ' Carriage return.
      if char = 8 then main  ' Reject other non-
      ' printables.

      gosub back
      let char = 32          ' Send a blank to
      ' display

      gosub wr_LCD
      gosub back            ' Back up to
      ' counter LCD's auto-
      ' increment.
      goto main            ' Get ready for
      ' another
      ' transmission

back: low RS                ' Change to instruction
      ' register.
      let char = 16         ' Move cursor left.
      gosub wr_LCD         ' Write instruction to
      ' LCD.
      high RS              ' Put RS back in
      ' character mode.

      return

clear: low RS              ' Change to instruction
      ' register.
      let b3 = 1           ' Clear the display.
      gosub wr_LCD         ' Write instruction to LCD.
      high RS              ' Put RS back in character
      ' mode.

      goto main

' If a carriage return is received, wait for switch
input from the user. The host program (on the other
computer) should co-operate by waiting for a reply
before sending more data.

cret: let dirs = %01110000 ' Change LCD data lines
      ' to input.

```

```

loop: let keys = 0
      if Sw_0 = 1 then xmit ' Add one for each
                              ' skipped key.

      let keys = keys + 1
      if Sw_1 = 1 then xmit
      let keys = keys + 1
      if Sw_2 = 1 then xmit
      let keys = keys + 1
      if Sw_3 = 1 then xmit
      goto loop

xmit: serout S_out,N2400,(#keys,10,13)
      let dirs = %01111111 ' Restore I/O pins to
                              ' original state.

      goto main

```

## Note:

the Stamp Basic program for this project is, together with the programs for the other projects in this series, stored on the cover disk provided free with this issue of ETI. This program has the file name **TERMINAL.BAS**.

## PARTS LIST

### Resistors

- R1,2,3,4,5      1K
- R6,7,8,9        10K
- R10                      22K
- VR1                      10K

### Display

- LCD                      Hitachi 44780 controller based dot matrix display size can be from two lines of four characters to two lines of forty characters, available from a variety of manufacturers.

### Switches

- SW1,2,3,4            push button keypad switches

### Controller

- Parallax BASIC Stamp 1.

All components are widely available with the exception of the Stamp which can be obtained directly from Milford Instruments, Milford House, 120 High Street, South Milford, Leeds LS25 5AQ. Tel: 01977 683665.

# SHED ALARM

## PART 2

**Last month, Tim Parker discussed the sensors and circuit description of a multi-function security alarm. Here, he looks at its installation and testing**

**T**he installation procedure outlined here applies mainly to wooden sheds; some minor adaptations may be required for concrete or steel garages and lock-ups, but this shouldn't prove to be too difficult.

From the point of view of gaining access to the entry timer switch SW1, it is best if the case can be mounted on a flat surface which has an area large enough to take the whole case. If not, the optional push-button PB1 may have to be used. The mounting position for the shed alarm is simply a matter of personal choice and practicality, the more probable place being just inside the door, and more than likely on the same wall if you intend to make use of SW1.

Drill two holes at convenient positions in the back of the case, and mount it - without the PCB fitted - using good sized pan headed screws fitted with large diameter washers. These will increase the surface area of shock vibration transfer from the shed to the case. With the case mounted, very carefully drill a very small hole (just large enough to poke a matchstick size implement) through the shed wall at the position of the entry timer switch SW1, taking care not to splinter the wood when breaking through to the outside, as this might result in a rather obvious looking "hole for a purpose" hole. Remove the case, fit the board, then re-mount the case.

Complete the wiring up in accordance with that shown in figure 1. Almost any suitable 2-core cable (speaker wire for instance) can be used for the reed switches, and for the optional push switch if you intend to use it. The two contact terminals of the reed switches are usually identified by chrome plated screws; the others are spare terminals to allow series connections to extra switches. If more than two reed switches are used, they should be connected the same as RS1, and the last one on the loop the same as RS2. As will be seen, this results in one continuous normally closed loop, and opening any one of them will trigger the alarm. When securing the reed switches and magnets (they can be mounted horizontally or vertically), make sure the magnet is within about 5mm of the

reed switch and lies in parallel with it, and remember, the closer to the hinge you fit them, the more the window or door will have to open to set off the alarm. On the other hand, if you have an ill-fitting window or door, the more likely you are to get false alarms the further away from the hinge you fit them. In these cases, choose a happy medium of about 2/3 of the distance away from the hinge. If no reed switches are to be used at all, the terminals shown as RS on the PCB (5 & 6) MUST be shorted together with a wire link, otherwise you will have a permanent fault and the alarm won't work at all.

### Testing

When testing the alarm, always bear in mind one fundamental aspect: if ANY of the sensors are active and the fault indicator is lit, then NONE of the other sensors will function. For instance, don't try to test the shock sensor with the door or window open. And don't try to test ANYTHING if LDR1 is exposed to light with LK1 fitted - it won't work. Remembering this will prevent an awful lot of frustration.

### Testing the door & window contacts

Set VR1, VR2 and VR3 to mid positions. Remove LK1 and LK4 and slot them onto just one of their pins for safekeeping. Insert the test link LK3, make sure the door and window are shut and turn on the alarm. The exit buzzer should now sound for about 10 seconds and the fault indicator should be off. If the exit buzzer doesn't stop, check the soldering around SW1 and connections to the remote push switch PB1; also, make sure that it's a push-to-make, not a push-to-break type. When the buzzer does stop, try opening the door or window; the alarm should sound for about 1 second each time one or the other is opened. If not, check the wiring to the reed switches, making sure you have continuity when all of switches are closed and that this breaks when any one of them opens. If this fails, then you've either wired them up incorrectly or you've got normally closed versions that open when the magnet gets close to them - you need normally open types.

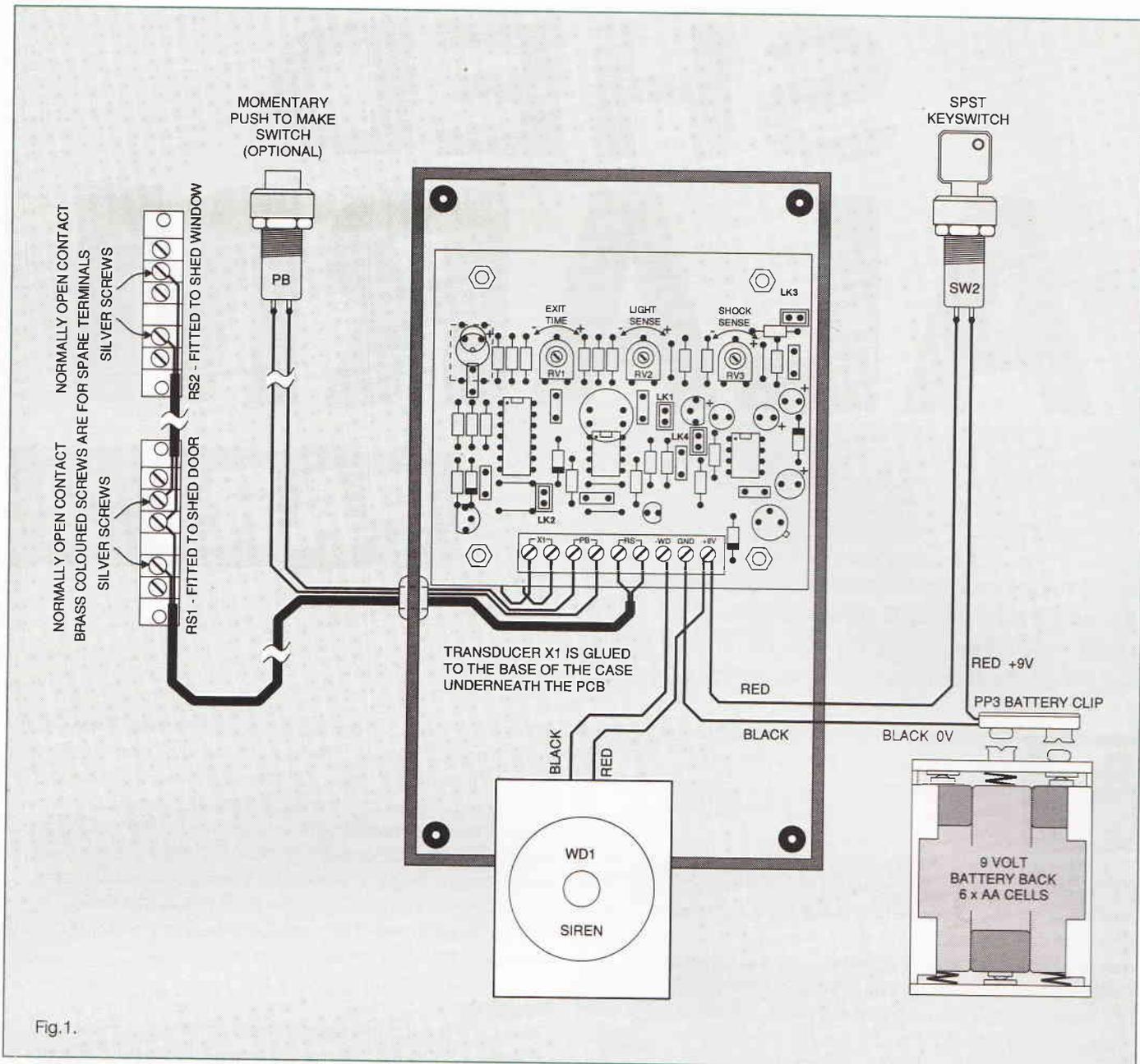


Fig.1.

### Testing the shock vibration sensor

With the door and window closed, strike the frame of the shed with a hard object such as the handle of a screwdriver. The alarm should sound again. If not, try adjusting the shock sensitivity control VR3. Also ensure jumper link LK2 is fitted, then try the test again.

### Testing the light sensor

This can only be set accurately in the dark, however it is possible to check the operation of the light sensor during the daytime as follows: turn off the alarm and insert jumper link LK1. Hold the lid of the case in its correct position to prevent any light entering the case and being reflected onto the back of LDR1. With the door and window closed, turn the alarm back on. Ignore the fact that the fault indicator is lit; this is because light is falling on LDR1. When the exit buzzer stops, cover the light sensor LDR1 with the palm of your hand - the fault indicator should go out. If it doesn't, adjust the light sensitivity

control VR2 and try covering the light sensor again. Slowly move your hand away from the light sensor and, when sufficient light hits the sensor, the fault indicator should light and the alarm will sound for 1 second. Adjust VR2 to give suitable operation - you don't have to turn the alarm off and back on again in between adjustments.

### Testing the latch function

At any time during the above tests, jumper link LK4 can be inserted to test the latching action of the shed alarm, which will result in the alarm sounding continuously once triggered, and can only be stopped by turning it off with the keyswitch (or removing LK4, of course). If the alarm stops after 1 second with LK4 fitted, the most probable cause will be the type of 555 timer (IC3) you have fitted - see ALARM TIMER.

After testing, set VR1, VR2 & VR3 to the desired settings and insert the links required to obtain your preferred operating modes. Remove the test link LK3 and fit the lid to the case. The alarm is now ready for normal operation.

## VARIATIONS

If your shed door has a mortice lock fitted (as opposed to a padlock on the outside), you may find it possible to open it up and fit a subminiature microswitch inside in such a position that the microswitch is activated as the bolt retracts from the keep. The normally closed terminals of the microswitch can then be wired back to the keyswitch on the shed alarm. In this way, the alarm can be made to arm automatically on locking up the shed, in which case the exit time can be set to minimum, to give a brief audible indication that the alarm has set.

Individual items of the shed contents can be protected by threading a loop of wire through a non-removable part of them. This loop should then be connected in series with the RS terminals (5 & 6). As the loop is broken the alarm will sound, assuming of course the alarm is set.

Because X1 has its own terminals (1 & 2), it is possible to add extra transducers to various other positions around the shed, or even to otherwise normally immovable items of equipment (fixed bench tools for instance - grinders, sanders, tool cabinets) which would have to be subjected to vibration in order to remove them.

Although figure 1 shows a siren module (WD1) fitted across the two output terminals (8 & 9), there is no reason why this cannot be replaced by a suitable 6V - 12V relay, and the contacts of this used for remote indication of the alarm activating, or even for just turning on a light for 30 seconds. The relay (or the siren for that matter) does not have to be fitted inside the case, by using a length of 2-core cable it can be installed at any suitable remote location - inside the house for instance - and since the cable only carries low voltages there is no danger of electrical shock from it.

It is possible to connect a standard Passive Infra Red (PIR) detector to the alarm by including its own N/C output terminals in series with the reed switch input terminals (5 & 6). However, if this is to be powered from the shed alarm, it's best to use a 9V - 12V mains adaptor, because of the extra drain placed on the batteries. There are one or two points to bear in mind if you do decide to use a PIR detector. These devices detect heat movement - and not just (human) body heat. Although they cannot "see" through glass, do not point the detector towards a window which is subjected to direct sunlight, as this will result in false alarms. As dark clouds pass the sun, the detector will see the heat change across the glass of the window and trigger the alarm. The second point is draughts. If the inside of the shed is quite warm, and the door or window doesn't fit too well, then a sharp draught will disturb the air movement and so produce a quick heat change, which again will set off the alarm. These, and similar situations must be taken into account before deciding on the use of a PIR detector.

Finally. The quiescent current of the standard shed alarm is only about 2mA, so should give at least a few weeks of continuous standby operation from the 9V battery pack. If the alarm does get prolonged use, check the battery pack on a weekly basis, and replace all of the batteries once the pack voltage falls below about 6.5 Volts.

The shed alarm won't turn your shed into Fort Knox, but it will add quite a degree of security, and it'll cost less than replacing the more expensive contents of your shed.

## kit of parts...

A complete kit of parts for the garden shed security alarm (including PCB, case, siren, remote push button, two reed switches with magnets and 10 metres of cable, but excluding batteries) is available from the author by mail order only (no callers please) at the following address:

**DTE Micro Systems**  
112 Shobnall Road  
Burton-on-Trent  
Staffordshire DE14 2BB

The complete kit price is £29.99; the PCB can be bought separately for £5.85. These prices are exclusive of post and packing (£2 UK, £3 elsewhere). Please make cheques/postal orders payable to Data Micro Systems. If ordering from overseas, payment must be in pounds sterling (£) and cheques must be drawn on a British bank. Goods will normally be dispatched within five working days from receipt of order (subject to availability).

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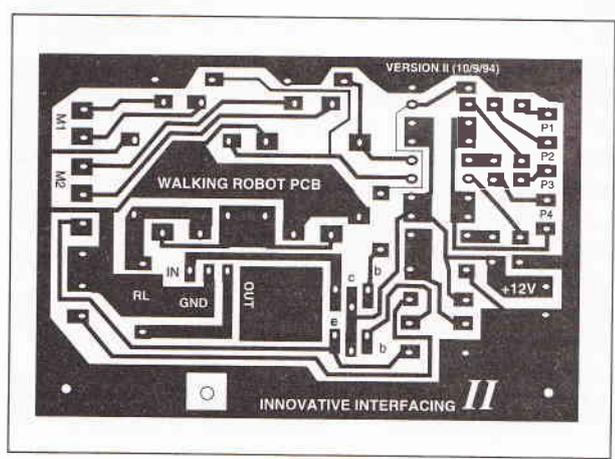
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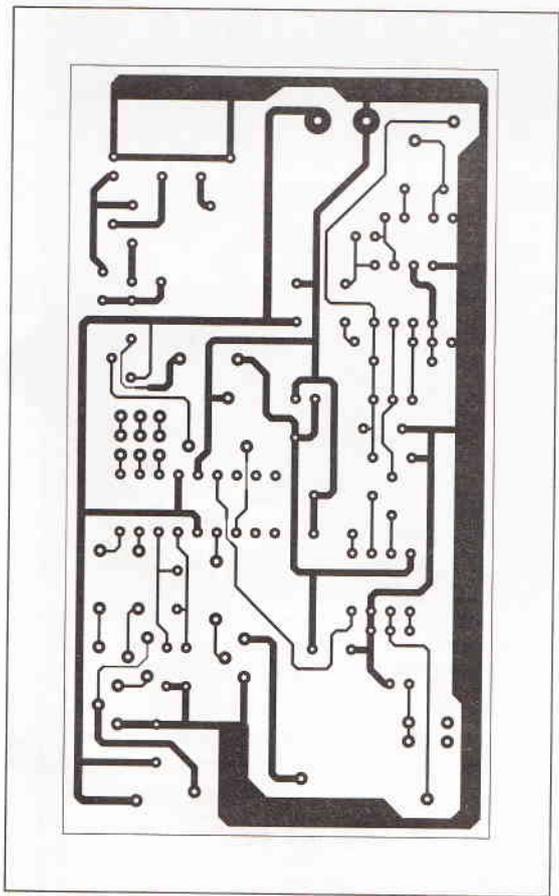
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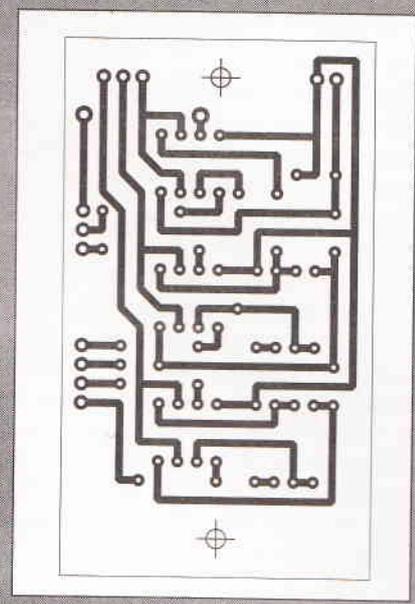
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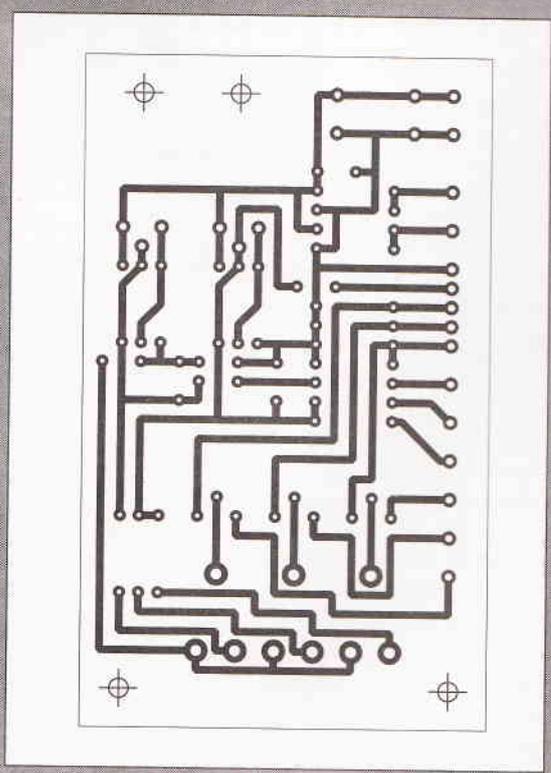
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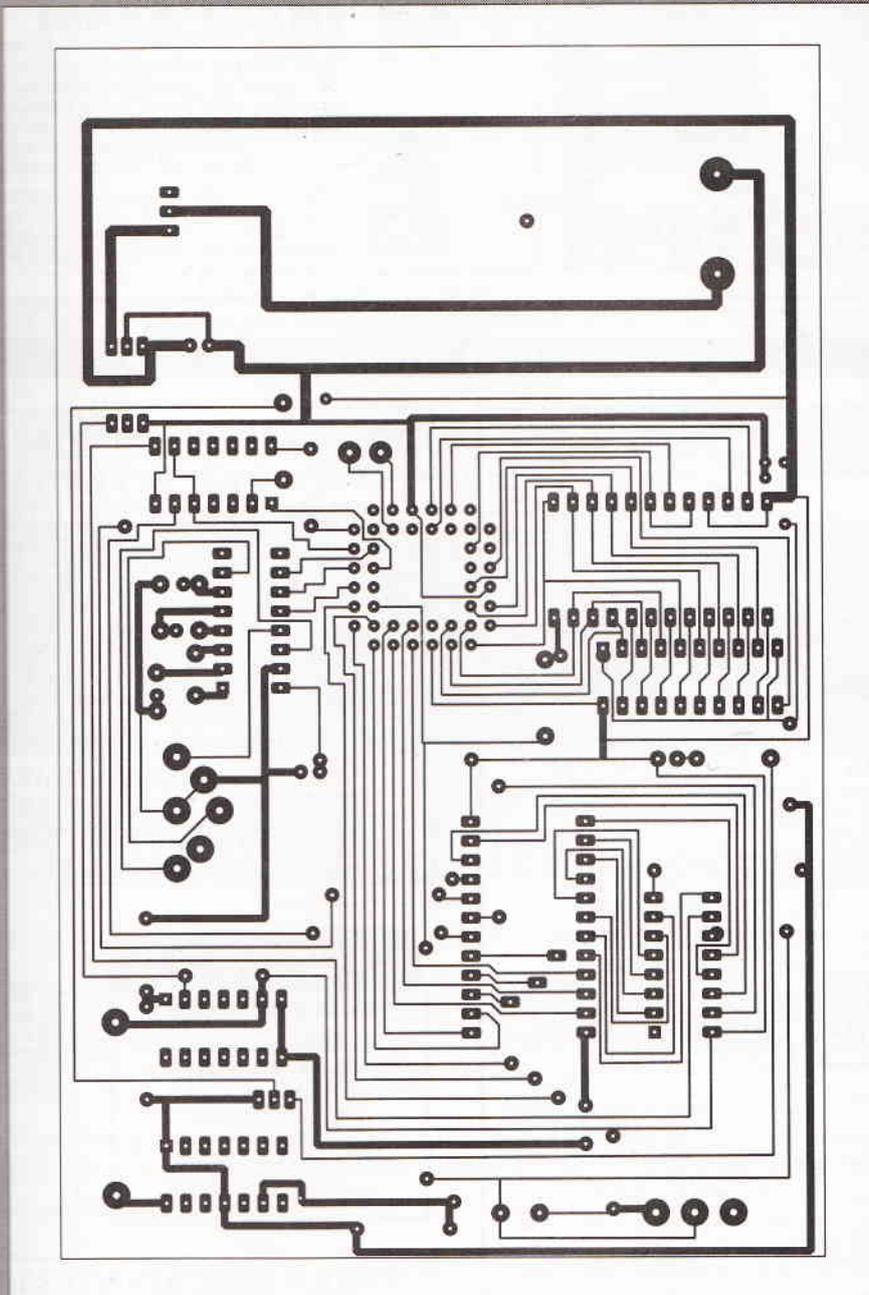
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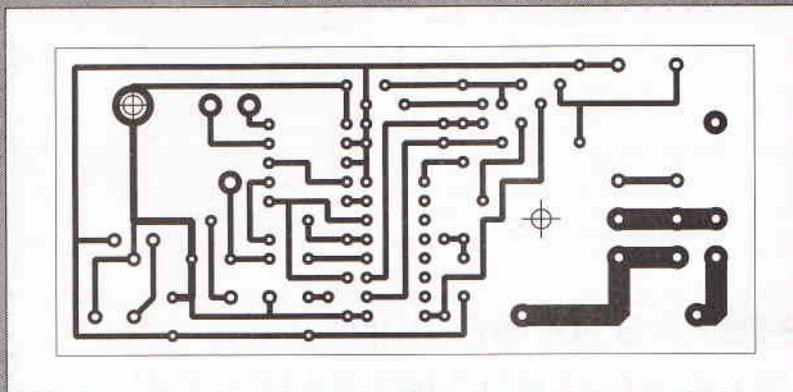
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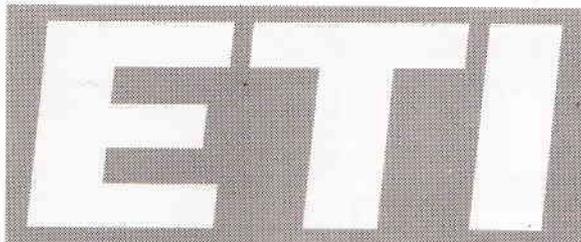
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**A** lot of people, particularly politicians, talk rather glibly about the need to train more engineers and scientists. They state, and not without justification, that the

economy needs more skilled people if it is to retain its high technology industries. It is certainly true that skill shortages are one of the main factors which can hold back the expansion of high technology companies.

The answer to this problem from politicians of all parties is, as one would expect, all too often rather simplistic. Provide more places in the appropriate subjects at universities, make it easier to get into these courses by lowering the entry standards, and generally oil the process by throwing money at it.

I do not think that this approach will work. In my opinion, cultural attitudes are as important as knowledge or qualifications in the creation of a scientist or engineer.

By cultural attitudes, I mean ways of thinking. For the engineer and scientist this includes an enormous enthusiasm for the subject, a natural optimism about mankind's power to solve problems and discover all that there is to know about the world around him. It also includes a natural inquisitiveness about how things work, a natural desire to take things apart and improve them, a very practical bent, an interest in making things, and a love of problem solving.

These are ways of thinking that are, in most cases, first acquired long before a child goes to school; they are not taught in the conventional way. They are ways of thinking that are caught from another person who has that innate fire and enthusiasm for the subject - a fire which when transmitted means that the individual's future is sealed.

It is, I think, no mere accident that so many of the best engineers and scientists come from families where their parents or grandparents were also engineers and scientists. A similar trend is true in other professions; doctors, lawyers, teachers, musicians, artists, actors, even businessmen.

Such individuals tend to put their profession above such factors as monetary reward, or career advancement. It is a way of life, a

vocation, rather than simply a job.

If I am right in my hypothesis that cultural factors are very important in the making of a scientist or engineer, then a policy of 'channelling' otherwise unwilling students into these subjects is likely to fail dismally. Some may catch these cultural factors from a very enthusiastic and committed teacher, but I suspect most will not and will be doomed to a career that they are unhappy in, not very good at, and certainly not committed to.

Perhaps a better solution would be to adopt the American approach. As a society they have an unequivocal commitment to, and faith in, high technology. Consequently, they too have an enormous need for good engineers and scientists; in fact, like us, more than they can train themselves. But the Americans have accepted that there is now a world-wide free market in such skills. They accept that if they want the best then will have to hire them from this global pool of skilled people.

The Americans can do this because they have, by and large, accepted that skilled people should earn good wages and be given all the resources necessary to make the best uses of those skills. They do this because they realise that the future of the country and of the individual companies depends upon the skills of their scientists and engineers.

In this country we should do the same; engineers and scientists should be paid similar wages to doctors and lawyers. They should have the same professional and social status as doctors and lawyers. They have in Germany, and the USA, why not here? The future of the economy of this country relies just as heavily upon the work of our engineers and scientists as do the economies of Germany and America.

If as a society we accept that engineers and scientists are important and should be rewarded in accordance with that importance then there will be no problem about shortages. For then the best in the world will come flocking to our shores and contribute their talent to the betterment of us all and, at the same time, will reinforce the cultural attitudes that will foster future generations of scientists and engineers.

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## Next Month...

In the May 1995 issue of ETI we will continue our laser tag game project where Robin Abbott will show how to construct the light gun central. We will also look at another of Richard Grodzik's add-on boards for his 80188 single board computer project, a 4 channel touch switch.

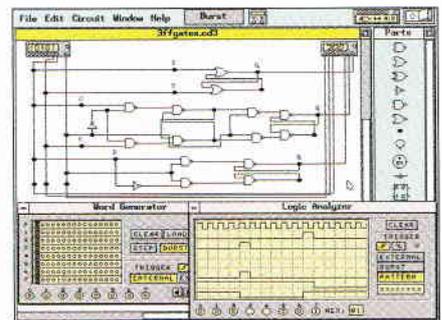
With Lottery fever rife, we have an amusing little project from John Scott Patterson to build a Lottery Random Number Generator to help you pick out your numbers. For the naturalists amongst our readers, we have a project to build a bat sound detector, an interesting frequency conversion problem. We continue our new series of projects built around the Parallax Stamp computer with a look at building a remote analogue signal measurement system that will connect to your PC. We will also be starting a series on using the PIC microcontroller with a look at available development hardware, and a project to build your own PIC programmer (can be used with the development software in April ETI's free disk)

From Douglas Clarkeson there is an in-depth look at the development and use of NiMH batteries, a technology which offers considerable potential in the development of electric vehicles. Whilst the main feature will delve into the technology behind the world of virtual reality. PC Clinic will look at CD-ROM drives.

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Production Engineer Technician*

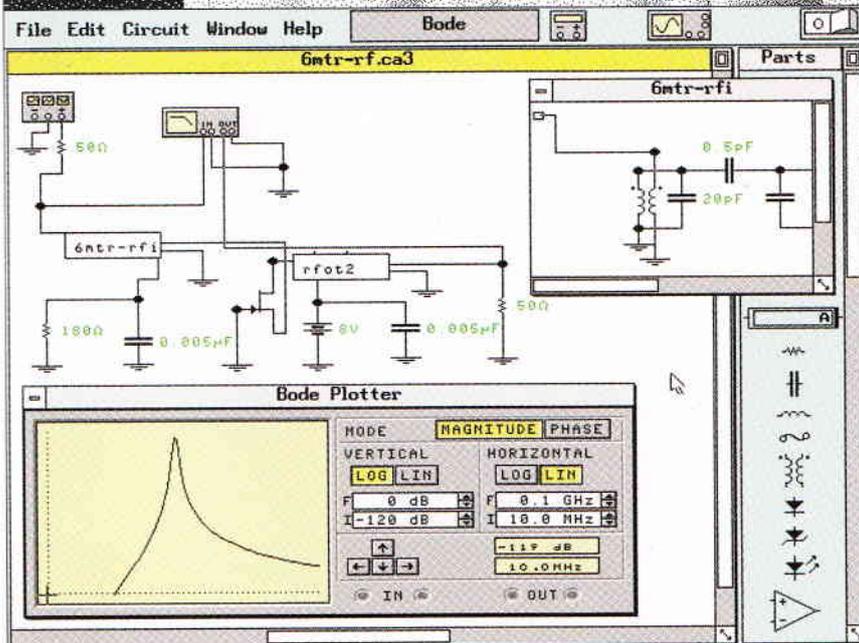
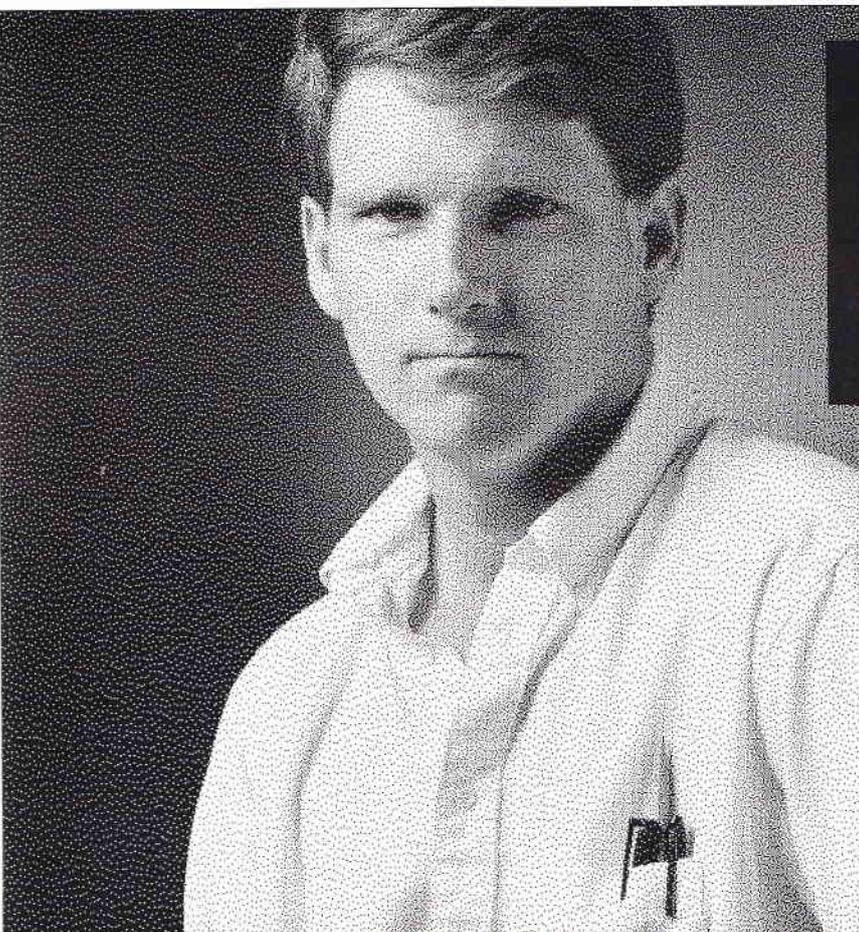
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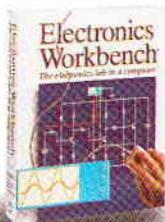
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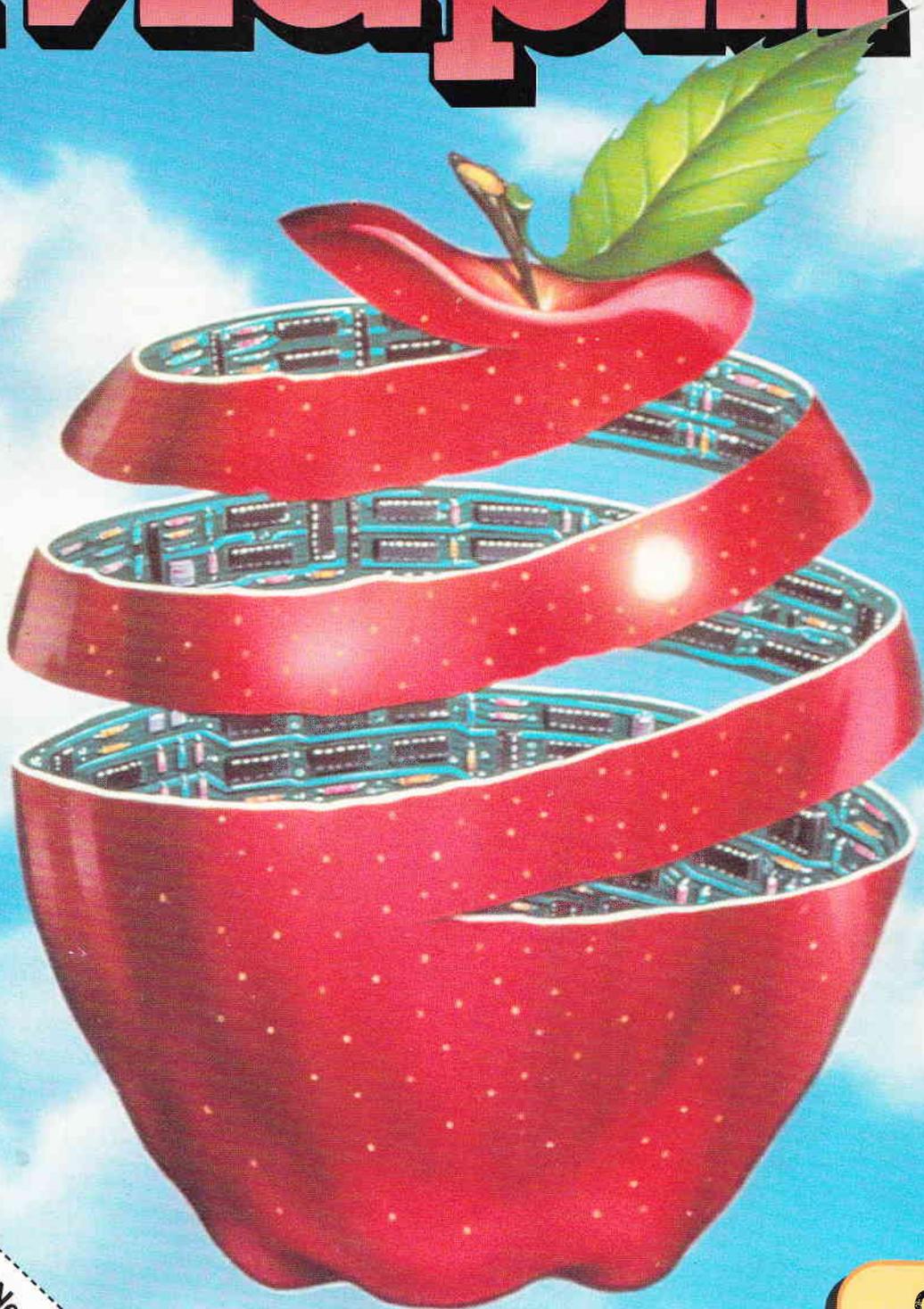


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