STATE OF THE QUARK
Electronics, the universe and everything

EPROM EMULATOR PROJECT
Your Spectrum as a development tool

BEGINNERS
1st CLASS
TV aerial booster project

FREQUENCY METER
Budget project for the workshop

NEWS, REVIEWS, CIRCUIT IDEAS AND MORE

AUDIO•CO•M•G•MUSIC•DOMESTIC

www.americanradiohistory.com
**PIEAPPLE SOFTWARE**

Programs for the BBC model 'B', 'B+', Master and Master Compact with disc drive

**DIAGRAM II** - now also available for ARCHIMEDES

Diagram II is a completely new version of Pieapple's popular diagram drawing software. The new version has a whole host of additional features which make it into the most powerful and yet quick to use drawing program available for the BBC micro. The new features mean that Diagram II can now be used for all types of drawings, not just circuit diagrams. Scale drawing can be handled and the facilities for producing circles and other figure lines together with the pixel drawing routines make any type of drawing possible. This update has been produced completely using Diagram II.

**Diagram II features:**
1. Works on all model BBC computers and makes use of Shadow memory if poss.
2. Pidd line drawing routines used to create circuits diagrams.
3. Rubber band line and single drawing modes.
4. Takes use of the normal BBC RAM to produce ellipses, arcs, sectors, chords and flood filling.
5. The line drawing mode allows very fine line detail to be added.
6. Defined areas of screen may be moved, popped, deleted or saved to disc.
7. On-screen cursor movement indication allows easy drawing to be made.
8. Keyboard keys may be defined to print User Defined Characters allowing new character sets to be used.
9. Underwire files may be loaded and formatted into defined areas.
10. Input to BBC's 75 shadow memory available, 80i without shadow.
11. Supplied with Marconi Trackball and mouse almost any
12. Computer system is included.
13. Completely scalable print routines allow any area of the diagram to be printed either horizontally or through 90°. In scalable, in scales that may be varied by up to 50%, or 100%, with screen size by 40%, 50%, 75%, 100%.
14. Smooth scrolling over the whole of the diagram.

**Diagram II costs:**
- £55.00 + VAT

**MARCONI TRACKBALL**

**For Model 'B' and 'B+' (with Joop Artmaster) £60.00 + VAT
For Master 128 (with Pointer Rom) £60.00 + VAT
For Power Master 256 (with Pointer Rom) £60.00 + VAT
Pointer Rom available separately £15.00

**RMA 600**

**600 W RMS**

**GENERAL SPECIFICATION**

<table>
<thead>
<tr>
<th>Module</th>
<th>Power Handling (Watts)</th>
<th>Frequency (Hz)</th>
<th>Drive Amplifier</th>
<th>Input Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMA300</td>
<td>300</td>
<td>20-0-2000</td>
<td>10kΩ</td>
<td>0.775V</td>
</tr>
<tr>
<td>RMA600</td>
<td>600</td>
<td>20-0-2000</td>
<td>10kΩ</td>
<td>0.775V</td>
</tr>
<tr>
<td>RMA150</td>
<td>150</td>
<td>20-0-2000</td>
<td>10kΩ</td>
<td>0.775V</td>
</tr>
</tbody>
</table>

Available for the first time, MosFet power amplifier modules derived from internationally acclaimed RAUCH Pre-Audio technology.

**RAUCH precision**

**RAUCH PRECISION ENG LTD**

**DEPT II**

**BLACKHILL IND EST**

**SNITTERFIELD**

**STRATFORD ON AVON**

**WARWICK WYTHALL**

**TEL:0789 731133**

**FAX:0789 731075**

**TELEX:312242**

ETI SEPTEMBER 1988

---

**PRICE: £29.00 + VAT**

**MITEYSPICE** - Powerful A.C. & D.C. circuit analysis package - £119.00 with Graphics output. Send for more details + VAT

---

**PCB**

Pineapple's now famous PCB grating add graphics called 'double sided' PCB's very easily using any model BBC computer and any floppy discs. The program is supplied on floppy and uses a mode 1 screen to display the side of the board in red and blue either separately or superimposed. Component layout screens are also produced for a silkscreen mask.

The print routines allow complete printouts of each side of the board in an extended definition high contrast 11.5g 1/21 scale. The print time is typically about 3 mins for a 11 print. This program has too many useful features to adequately describe here, so please write or phone for more details and sample printouts.

**£85.00 + VAT**

**Platter driver to suit most plotters or cutter £35.00 + VAT**

---

**ADFS Utilities**

**RCA VESTAGIA**

**ADFS Utilities Rom**

was an invaluable utility for all ADFS sets. It adds over 22 new commands to the ADFS filing system as well as providing an extensive Menu facility with over 40 sub commands and functions. This program includes: Saving, loading, sorting, using, auto-batching of files and many more.

**PRICE: £29.00 + VAT**

---

**MITEYSPICE** - Powerful A.C. & D.C. circuit analysis package - £119.00 with Graphics output. Send for more details + VAT

---

**EXTRAORDINARY OFFER: £1,500.00 TO SATISFACTION CUSTOMERS WORLDWIDE**

---

**RAUCH PRECISION ENG LTD**

**DEPT II**

**BLACKHILL IND EST**

**SNITTERFIELD**

**STRATFORD ON AVON**

**WARWICK WYTHALL**

**TEL:0789 731133**

**FAX:0789 731075**

**TELEX:312242**

ETI SEPTEMBER 1988

---

**MITEYSPICE** - Powerful A.C. & D.C. circuit analysis package - £119.00 with Graphics output. Send for more details + VAT

---

**EXTRAORDINARY OFFER: £1,500.00 TO SATISFACTION CUSTOMERS WORLDWIDE**

---

**RAUCH PRECISION ENG LTD**

**DEPT II**

**BLACKHILL IND EST**

**SNITTERFIELD**

**STRATFORD ON AVON**

**WARWICK WYTHALL**

**TEL:0789 731133**

**FAX:0789 731075**

**TELEX:312242**

ETI SEPTEMBER 1988

---

**MITEYSPICE** - Powerful A.C. & D.C. circuit analysis package - £119.00 with Graphics output. Send for more details + VAT

---

**EXTRAORDINARY OFFER: £1,500.00 TO SATISFACTION CUSTOMERS WORLDWIDE**

---

**RAUCH PRECISION ENG LTD**

**DEPT II**

**BLACKHILL IND EST**

**SNITTERFIELD**

**STRATFORD ON AVON**

**WARWICK WYTHALL**

**TEL:0789 731133**

**FAX:0789 731075**

**TELEX:312242**

ETI SEPTEMBER 1988
September 1988
VOLUME 17 No 9

REGULARS

6

News

54

PCB Service

62

Open Channel

8

Read/Write

56

Oops!

9

Insight

56

PCB Foil Patterns

11

Next Month

59

Classified Ads

16

Subscriptions

62

Special Offer

51

Keep Regular!

53

Readers' Free Ads

54

Playback

62

Ad Index

63

Blueprint

64

Book Look

65

Photocopies

ETI SEPTEMBER 1988

1 Golden Square
London W1R 3AB
Tel: 01-437 0626
Telex: 8811896

Member of the Audit Bureau of Circulation

ISSN 0142-7229 ABC

ETI is normally published on the first Friday in the month preceding the cover date. The contents of this publication, including all articles, designs, plans, drawings and programs, and all copyrights and other intellectual property rights therein, belong to Argus Specialist Publications Limited. All rights conferred by the Law of Copyright and other intellectual property rights and by virtue of international copyright conventions are specifically reserved to Argus Specialist Publications Limited and any reproduction requires the prior written consent of the Company. © 1988 Argus Specialist Publications Ltd. All reasonable care is taken in the preparation of the magazine contents but the publishers cannot be held legally responsible for errors. Where mistakes do occur, a correction will normally be published as soon as possible afterwards. All prices and data contained in advertisements are accepted by us in good faith as correct at date of going to press. Neither the advertisers nor the publishers can be held responsible however, for any variations affecting price or availability which may occur after the publication has closed for press.

ETI SEPTEMBER 1988

FEATURES/PROJECTS

26

Speaking For Yourself
Malcolm Walmsley has emerged from the garage with sawn fingers, hammered thumbs and a pair of Maplin loudspeaker kits

12

It's A Small World
Steve Malone goes deeper into theory than ever before with a complete explanation of the Universe along with instructions for building your own!

17

Op-amps
Paul Chappell continues the Circuit Theory look at op-amps with an in-depth investigation of offset voltages

21

Brought To Light
Mike Barwise has found a cheap laser diode for experimentation or blinding the neighbour's cat and he is devoting this month's Chip In to handling this versatile device

28

Travellers' Aerial Amp
Keith Brindley takes to the road with a simple-to-build 1st Class project to give you better TV pictures in your caravan or tent

31

Recurring Dream
Paul Chappell has the low down on turning last month's respiration and heart rate meter into a lucid dream stimulator

34

Frequency Meter
Low cost is the watchword for this useful item of workshop equipment from Mark Thewlis

41

Spectrum EPROM Emulator
Graeme Durant, fresh from his exploits with the ETI Spectrum second processor has turned his humble home computer into a fully-fledged development tool

48

Model Railway Circuits
Robert Penfold enters a second (or third?) childhood with a collection of Tech Tips for the model train fanatic

51

No Holds Barred
More silly puns to announce the results of the July ETI bar code competition

Snooker balls, cue and bridge in the cover photo courtesy Lillywhties of Piccadilly Circus, London.

www.americanradiohistory.com
END OF INDI RECORDINGS

At last Indonesia has agreed to halt or at least curb music piracy of European recordings. Until May such flagrant disregard of copyright has been legal in Indonesia and vast numbers of unofficial copies have found their way into Europe, perhaps the most notorious example being the official Live Aid cassette in 1985.

The International Federation of Phonogram and Videogram Producers has been lobbying for action ever since piracy was sent underground in Singapore and Hong Kong and many copying operations moved to new bases in Indonesia. It is expected that the next shift will be to the Philippines, although hopefully it will be some time before operations will grow to reach their present strength.

Indonesia's agreement to clamp down comes after an official investigation by the European Community, instigated primarily by the IPPV.

IMPROVING ON PERFECTION

The 'perfect' sound of compact discs can be significantly improved, claims Arcam, the British hi-fi manufacturer based in Cambridge.

Arcam has launched a 'black box' digital audio interface that takes the discrete signal-converting stages of CD operation away from the host CD-player where RFI leaks from noisy drive mechanisms and processes can dull just the musical accuracy that the CD fraternity swears by.

The unit is based around one custom ASIC developed in conjunction with Newmarket Microsystems. The ASIC takes over the processing tasks generally performed by some 25 standard CMOS chips — 1000 gates in all.

The launch has taken the hi-fi community somewhat by surprise — not least the Japanese electronics giants, whose earlier attempts to solve the problems resulted in add-ons that were prohibitively expensive for the consumer market.

The Black Box Digital Audio Interface will retain around £250. Contact A&R Cambridge (Arcam), Pembroke Avenue, Waterbeach, Cambridge CB5 9PB. Tel: (0223) 861550

SPEAKER DESIGN

A CAD package for loudspeaker optimisation has been produced by an Australian software house, CALSOD from Audiosoft uses curve fitting to develop minimum phase transfer functions for impedance and sound pressure response.

The program will handle a cross-over network of 60 components (passive only) and CALSOD optimises the summed acoustic output of the multiway speaker system to get — or approximate — a desired response.

The mail order price to England is $330AUS — about £150.

For full details write to Audiosoft, 128 Oneil Road, West Heidelberg, 3081, Melbourne, Australia.

SOLAR FLAIR

The summer sun should be beating down on tanned ETI readers this month and TK Electronics has introduced some giant size solar cells to make the most of the hot house temperature.

The panels are 12ns square, deposited on glass. Each panel can produce 200mA at 2.1V in bright sunlight, though TK is honest enough to estimate that most British summer days (dull and overcast) will deliver about 60mA at 11.5V, still useful for trickle charging a car battery, or NCDs to run equipment after dark.

The panels cost £14.50 + VAT and there is a £1.75 postage charge to cover the careful packing of these delicate items.

Contact TK Electronics, 13 Boston Road, Ealing, London W7 3SJ. Tel: 01-567 8910.

NICAM STEREO UPDATE

The slow crawl towards NICAM 758 stereo television continues with both the BBC and IBA moving for a national stereo network in the early years of the next decade.

Although the BBC has officially shelved NICAM indefinitely with a review in 1991, recent directives to the Director of Engineering show that transmitters will continue to be updated to handle NICAM as routine maintenance takes place. This would produce a complete network by the end of the decade.

The feeling within the BBC is that a service of sorts may well be underway by then, in the same way that stereo radio was broadcast in national or two hours a day, without being described as an official service.

The IBA is testing next year and should have a stereo service on both channels in London, Yorkshire and possibly Somerset in Autumn 1989, with a national service the following year.

Meanwhile you can tune your NICAM VCR to Wogan, Top of the Pops and various BBC outside broadcasts, all of which are being regularly transmitted in stereo to the Home Counties.

Soccer Fans show card

In an attempt to banish hooliganism from the terraces, Reading Football Club is issuing its supporters with 'ROM cards'.

The scheme is being sponsored by British Rail South East, and pre-empts the Government's insistence that all League division grounds must introduce identity systems for the 1989 season. The cards use the Cardkey system from Datacard of Hampshire.

Club members pass their cards through a Cardkey reader on entry to the ground and any banned supporters will be refused entry and set off a security alarm.

The credit card format of data retention is becoming increasingly popular, Datacard now produces more than 7 million plastic cards a year.

Hakuto of Waltham Cross is now producing EEPROM cards as well as SRAM, PROM, EPROM and OTP masked ROM formatted cards.

The latest 64Kb 'smart cards' produced by Bull CP's of France are finding applications throughout Europe and beyond.

The University of Rome has just issued 168000 cards to all students and staff for administration tasks from enrolment to library registration.

In Australia, the Westpac Banking Corporation is using the Bull cards for its top business clients, providing a simple card-reader that interfaces with the client's PC, enabling them to conduct financial transactions by phone. Multiple access codes reduce the risk of fraud and other Australian banks are expected to follow suit.

For further information contact Datacard, New Lane, Havant PO9 ZNR or Bull CPS, rue Eugene Harff, BP45, 78193 Trappes Cedex, France. Tel: 33 1/3069050.
Controversy has arisen over a recent article in the quarterly newsletter of Electronics and Computing for Peace describing the shipping of obsolete medical electronics to Nicaragua. The equipment was contravening the UK's Health and Safety laws and was due to be scrapped until it was saved in cooperation with the Nicaraguan Health Fund for use in the third world. Safety regulations in South America are less stringent than our own and medical equipment is in short supply.

Enter Edwina Currie, branding a copy of ECP's newsletter and ordering an investigation by the NHS auditors. The NHS employees responsible suffered quite some embarrassment and distress for what seems on the whole to have been a charitable act.

ECP has now sent an open letter to Mrs Currie asking that she decide whether electronic equipment that becomes available in future should be allowed to be used in third world countries, or whether it should be scrapped as NHS property.

For full information contact ECP on 01-344 2509.

FREEBIES

If you're short of things to read on the beach this month, dip into the ETI guide to freebie literature.

An interesting guide to making and commissioning videos is available from Documentary Video Associates, explaining in a compact 24-page booklet what video could do for you and why ECP should do it. It normally costs £2.95, but mention ETI and you'll get it for free. Write to DVA, 16 Ferrnhall Road, Fareham, Hants GU14 9RX.

British Telecom International has published a new guide to international data communications, covering mainly Datel and IPSS and aimed primarily at PC users. Not only is the handbook free, those awfully nice BT people have opened a Freephone line to order it on. Telephone (0800) 400435.

West Hyde has produced a summer leaflet covering various rocks, boxes and bits (phone (0908) 640695) and JA Crew has issued a supplement to its 1988 hardware catalogue, available on (0908) 583522.

Hitachi has a 16-page brochure describing its ZTAT (Zero Turn Around Time) microcomputers. Write to Hitachi, 21 Upton Road, Welford, Herts WD1 7TB.

And lastly, for those in search of second-hand (but guaranteed) test gear, Instrument has an 8-page list of available stuff. Telephone (0753) 44878.

SM TOOLS

Surface mounting electronics tools form the latest range of hardware from CK, the toolmakers. Flies and cutters are all boxed joint with good solid grips, and the tweezers (nine varieties in all) are manufactured from anti-magnetic acid resistant steel.

For details of the full range contact CK, Pwllheli, Gwynedd LL53 5LM.

Tel: (0758) 612254.

PLANT GROWTH

Westode, the Hawker Siddley subsidiary, is helping to put some marrow back into the backbone of the UK semiconductor industry by opening a new £8 million manufacturing plant in Chippenham, Wiltshire.

Westcode is using the plant to produce power semiconductor products to the highest standards for use within the UK and for export to Europe, North America and Into the difficult marketplace of Japan.

The plant is one of the most sophisticated in Europe complete with ultra-clean facilities for producing uncontaminated silicon wafers.

Electron beam evaporation, photolithographic and diffusion technologies are all carried for, with many production materials being specially processed in Westcode's new facilities.

For more information contact Westcode Semiconductors, Langley Road, Chippenham, Wiltshire SN15 1UL. Tel: (0249) 654141.

COPY KITTEN

A neat little portable plain paper photocopier has just hit the streets courtesy of Panasonic. The FN-P300 weighs just 6kg and can copy A4 or smaller using digital scanning (similar to fax scanning) and thermal printing. The front section of the unit is the A4 plate and the unit scans statenoy pages rather than feeding sheets, which enables books and magazines to be copied — a feature often unable on other personal machines.

The FN-P300 is also cheaper than competition — it retails at £449 + VAT.

Information from Panasonic Office Automation, 300-318 Barth Road, Slough, Berkshire. Tel: (0753) 345522.

ON THE RACK

Nineteen inch rack mounting units are the specialisation of Rack of Bristol.

Racks produce a wide range of units (and the cabinets to slot them into), all constructed from 0.9mm PVC pre-coated steel with aluminium front panels. Enclosures are supplied in flatpack kit form with assembly instructions.

The latest range includes a sloped desk mixer (order code M6U) retailing at £29.

For details of the complete range contact Rackz, PO Box 1492, Mangotsfield, Bristol BS17 3RY. Tel: (0749) 840102.

REPLY FROM BT

British Telecom has responded to the widely publicised Which? magazine survey that concluded BT's performance since privatisation has been a 'big disappointment'.

BT is still a virtual monopoly in most areas and has little incentive to perform efficiently. The report recommends Government action to produce tougher legislation or effective competition.

British Telecom admits that through most of last year, many services were not up to its own targets. But the Which? survey is six months out of date, it points out, and was largely based on information gathered after last year's storms wrecked a third of the country's overland infrastructure.

Many of the services suggested by Which? such as itemised billing and compensation are already on the way. The Oftel agreement announced on July 7th brings a much wider range of services under price control, BT will now operate a price freeze until August 1989 followed by a 4-year Oftel price cap of 4.5% below increases in the RPI.

RND KITS

The Random Number Display from last month is now available in kit form from GP Electronic Services in Durham.

The complete kit includes all parts except the case and window filter and costs £24.98 including VAT and p/p. The case of the prototype was constructed from hardboard and a red plastic A4 cover makes a good window filter for the 86 LED display.

GP is also supplying the PCB for the project at £9.98. It is not available from the ETI PCB Service as we started last month (orders sent there will be forwarded to GP).

Contact GP Electronic Services, 87 Willowtree Avenue, Durham DH1 1DZ.
VENERABLE SAGE

After reading the news story in ETI June issue I bought a pair of the Sage Supermos modules and power supply components from Sage Audio. I'm glad I did! I have heard many esoteric amplifiers in hi-fi shops costing up to £5000. Some of these are very good but I thought it would be interesting to compare the Sage amps with a friend's Karl. I may have been hearing things but I couldn't believe my ears! The Supermos sound was effortless and much more relaxing to listen to.

After several months of comparisons my friend has finally swallowed his pride and bought a Sage amp.

So, full marks to Sage Audio for an excellent product and friendly service, and to ETI my favourite high street mag. More hi-fi and sound articles please and less computer and printer projects.

L Atkinson
Carlton, West Yorkshire

CHOCOLATE BARS

Well you can't say I didn't try. Into Salisbury's I boldly strode, hiding my July ETI among my basket of sickly chocolate and cured pork and as the girl on the till weighed up my moggies I ran the ETI cover over their bar code machine.

No sale! Nothing, dastardly looks from the queue behind me.

Now come on ETI, did it mean anything? How am I supposed to work out how to read this—the cover was no simple 'wide or narrow' barcode like the ones for the ones in the shops. Inside. What was the secret message? (This Saturday, try Safeways.)

Nigel Griffiths
Proportion, Cambridgeshire

How dare you! Sir. Of course there was a meaning to the July cover (there's a deep philosophical meaning to all our covers — this month the meaning is that all matter is Inert, made of bright plastic balls and that the Universe is finite and surrounded by six pockets.)

The code is much more complicated than the Bar Code Lock system.

It is in fact the EAN 13 figure system (as used on your chocolate cake and cured pork) and is all revealed in the competition results elsewhere in this issue.

Unfortunately the readers in Salisbury's simply can't fit a code into those staggeringly proportions into their field of vision.

DISH OF THE DAY

A bit of bad timing. I fear. Why should I want an £1300 satellite television system courtesy of Pace and Vivor (your June/July competition) when I shall soon be able to have a complete system for £200 from Amstrad to watch Rupert Murdoch's new channels? If anything is going to kill off satellite TV (not that it requires much Mac), it's the way of a death blow by the new satellite TV!

Who is going to watch Sky and Superchannel when all the new BSB channels appear? I bet all those who have already spent £1000 odd on an STV system are really locking themselves now.

Alan Wilson
Neasden, London

Whoa Not so fast! Don't dismiss satellite TV that easily. First, the Amstrad system will not be able to pick up signals from any other satellite except Astra (unless it is set up to point at another satellite, in which case it won't pick up Astra). Good STV systems (such as the price in ETI's Reach For The Sky competition) have point mounts and actuators so they can be pointed at any satellite between the horizons (local scenic permitting). Amstrad is promising an add-on to allow this with the E200 system but it's not known if this will appear or how much it will cost.

We all have a pair of Sage Supermos modules here at ETI for review and so far it must be said that they live up to all that Sage claims for them. A full review of these modules will appear in ETI shortly.

Meanwhile, readers may like to refer back to the review of Sage Audio Superamp bipot amp module in the May 1987 issue of ETI.

We shall be carrying further hi-fi projects in ETI in the near future but we can't promise to cut out all the computer and printer stuff too.

L Atkinson
Carlton, West Yorkshire

HOT BREATH

Congratulations on the excellent heart and respiration rate monitor recently (and finally) completed in the August issue of ETI.

This really is a remarkable device and a serious rival to many commercial units I have considered buying in the past (but much much cheaper!).

George Lawson
Maidstone, Kent

In fact, it is mainly the heart rate section I am interested in (for medical experiments) and I must say that I have never before come across a commercial unit which combines the compactness, low cost and accuracy of your design. Thank you!

ETI September 1988
The report hold nothing but optimism for the future. The video market will be boosted by the appearance of S-VHS in the autumn—particularly in the camcorder market although a summer lull in sales is likely until the new format cameras reach the market. CD-video should be briefly noted—although the success of CD-audio will certainly assist its introduction, it must be remembered that video discs have flumped once in the UK already.

In the audio market the appearance of DVD is predicted to have only a slight impact on CD sales if it manages to take off as a consumer product at all.

The report's greatest optimism is for the TV market, with satellite broadcasting producing a possible extra million units a year market by the mid-90s.

If the recently announced Murdoch-Sugar coalition achieves its target, the market may be bigger still.

They plan to get an Astra targeted system on the marketplace under £250 by broadcasting in PAL format, thus removing the expense of D-MAC conversion decoders.

That could be the lever that finally gets STV rolling as a mass market success.

The report The UK Consumer Electronics Market was prepared by Ferguson, Cambridge House, 270 Great Cambridge Road, Enfield, Middlesex EN1 1ND. Tel: 01 363 5353.
POWER CONDITIONER
FEATURED IN ETI JANUARY 1988

The Ultimate meal circuit, ideal for interlaced or
crossfire video and stereo, this unit provides
isolated fixed output with an on/off switch for
fast full load adjustment.

The heater works in two stages, controlling separate and two current balanced outputs, together with a bank of six +0.4% stabilised outputs to make interference. A line LED display gives a security anemometer and a complete instrument panel for the
operator. All approved parts are found consistent and PCBs all components, including highly stabilised masts (4% tolerance), DC isolated +12 and full modulation.

PARTS SET £19.95 + VAT

Slight parts and availability may differ. Parts are sold in sets of 2 @ £19.95 + VAT, 1 @ £11.95 + VAT how with parts only.

KINGDOM
FEATURED IN ETI JULY 1988

This list is working points to your Lumberjack Measure, Baths or any other box for that matter. Picture this, it's powered up in line swag the tool and using the rear. You find a switch to start the display a control box and a panel of four 'power' buttons, two set to
control output, and two set to provide, a panel of light become a dark, balancing to your control while
along the way. Press any one and you are left to patterns. An LED display on the control box is seen with the main display.

The superhero is fitted to any car it makes an excellent beauty on each power button it captures any kind of car or
bicycle to a spectacular TV age out.

The parts setting allows of PCB and components for correct PCB and components for sequence board, a full instructions.

Larger than usual.

PARTS SET £19.90 + VAT

RAINY DAY PROJECTS
All can be built in an afternoon!

JUPINX JACK FLASH (ETI March 1988)

£5.90 + VAT

Powerful projects with an extra 130 volt output line. The basic kit is printed Circuit Board and 10S or more.

CREDIT CARD CASINO (ETI March 1988)

£5.90 + VAT

The actual poker gambling machine

MAIN CONTROLLER (ETI January 1987)

Standard Keypad to x worth £1

MATCHBAXX AMPLIFIERS (ETI April 1989)

Latter +1 in g+1 if you wish any extra energy enough with 4 in a maximum.

Platform Matrix (1989)

£5.90 + VAT

LED Power Meter TV with cats and circuits

TACHO-DWELL METER (ETI January 1987)

Tach +1 M.O.D. for Porsche

HI+PPower METER (ETI Feb 1987)

Meteors in 3x in output up to 30MW

Interface RS232, Interface

Moh power meter

Sane power meter

PARTS SET £23.80 + VAT

THE DREAM MACHINE
FEATURED IN ETI DECEMBER 1988

Adapt the coordinates to your motor in the gaia
resting space and over 1.5m. As you might have seen from
what's up, the wind through the trees. Almost hypnotic, the
adjustable drive is a peaceful, soothing sleep.

For many, the thought of a rest and sleep low
perhaps the live, subtle depth peoples, exciting enough
it is. For those always active there is strange and
intriguing a dream experiences waiting. Take this dreams,
for evidence. Imagine keeping doors of your dreams and able
to change their world to your wakings and fantasies
the Joom Machine. It is easy!

The approved parts setting consists of PCB all components
controls including power supply, knobs, lamp,. Instructions, mains power supply, prestige case full instructions.

PARTS SET £16.50 + VAT

MAIN CONTROLLER
FEATURED IN ETI SEPTEMBER 1986

Clear up mains pollution wisely and effectively
You will hardly be aware of the difference in your Hifi TV, Video, and all other equipment.

PARTS SET £4.90 + VAT

Purchased in kit case £1.65 + VAT

POWERFUL AIR IONISER
FEATURED IN ETI JULY 1987

Ioniser has been described as being "ancient wisdom, and
"nature's way" and have been found everywhere from
using such tree leaves and enemies in every country and
using as an elixir. Although some of the claims may be exaggerated, there are about 1.4 billion air purifiers in the
world today. If you want a more in-depth explanation, talk to the
Lecturer at the weekend workshop in your area. As for the
Direct on, the result of a great deal of research when a
client requested a product, there was an order
that never materialized with the Direct's commercial products
who would perhaps be said to - and few people from the
various applications... the idea for the finished product was
then... the idea for the finished product was
then... the idea for the finished product was
then... the idea for the finished product was...

The next chapter contains a complete and
based on the work of the Direct on the
Including an introduction to the product.

PARTS SET £13.95 + VAT

BIO FEEDBACK
FEATURED IN ETI DECEMBER 1988

Biofeedback comes of age with the latest equipment
well-balancing in the

The powerful circuit is based upon application in clinical situations and has been used in the fascination of the
energy workers. The device was designed to assist in
achieving the ultimate in relaxation.

The complete parts kit includes PCB, components, endostats, conductive gel and full instructions.

PARTS SET £12.50 + VAT

BIO FEEDBACK BOOK £3.95 (ETI July 1987)

LEDS

Green-noise air LEDs

555 + 10 ohm to £3.50

551 to £2.50

105 to £2.00

401 to £1.50

DIGITAL AND AUDIO EQUIPMENT - LEDs

Disagreed 3mm (LEDs) led, green, yellow and orange

25 of 100 LEDs for £10.00

Individual designs to suit.

PARTS SET £8.50 + VAT

BRAIN MONITOR

FEATURED IN ETI AUGUST 1988

The most advanced project to date in the application of
electronics. Neuronal and peripheral techniques to the
monitoring of the brain's electrical activity.

PARTS SET £39.60 + VAT

ALPHABET PLANN BOOK £2.50

SILVER SOLUTION £1.00 + VAT

These parts are available at the

ORDER END OF YEAR

Parts are available at the

www.americanradiohistory.com
Next month ETI is more than usually educational. To coincide with the start of the new academic year, the October issue is a careers and educational special. If you are about to look for an electronics course to take on after A-levels, you'll want to read the ETI low down on the types of course (diplomas, and degrees) available to the school leaver. If you are about to get your degree or HND we have information on the jobs available — the companies and who they are looking for.

For those ETI readers already far beyond all this and now teaching others, we reveal how electronics teaching is changing with the new GCSE curriculum and what the teachers really want.

Projects are not forgotten in the October issue. For the beginners we have a deafening bicycle siren to frighten the neighbours, a sophisticated peak programme meter for your hi-fi or recording studio and a super-powerful fully variable air ioniser. Plus, there's news, reviews, and lots, lots more in the high-octane October issue.

Don't be an ocker, get the October ETI – out Sept 2nd

The articles mentioned here are in preparation but circumstances may prevent publication.
Stephen Malone accepts no responsibility for any universe created using the forces described in this look at state-of-the-quark physics.

IT'S A SMALL WORLD

Does matter exist? We really should be told. For decades scientists have been 'discovering' particles that are getting smaller and smaller and smaller. Some people are now wondering if there is actually anything there at all.

For most of this century following the confirmation of the nuclear model of the atom, scientists have been engaged in a search for the fundamental forces and the fundamental particles of nature.

It was all getting along fine until Heisenberg hit them with electrons being waves and particles at the same time. And although they took that on board, as they peered deeper things seemed to dissolve in the uncertainties of Quantum Theory.

So what is really there among the fuzz of quantised energy and empty space? What holds it all together? Why does it hurt when you walk into a wall? Well since you ask...

Force-carrying Particles and Sub-atomic Structure

First the electric force. The tricky thing about electromagnetic interaction is that it involves action at a distance — you waggle an electron over here and it affects that one over there. But the reaction is not instantaneous, the force travels at the speed of light (even thinking in the abstract doesn't mean you can violate the Theory of Relativity!).

But what is the force? What travels at the speed of light?

Well, the force-carrying particle is a photon (or indeed a wave-packet of electromagnetic energy, but if you don't know what that is, forget it). See Fig. 1. Richard Feynman won himself a Nobel prize for coming up with these nifty little diagrams — they're actually very useful for doing the maths as well as looking pretty. In practice the two electrons would swap many photons back and forth in the course of the encounter, but the simpler diagram is easier to understand.

Okay, but where do the photons come from? (I was afraid you might ask that.)

Heisenberg's Uncertainty Principle

This is generally expressed in terms of momentum and position, $\Delta p \Delta x \geq \hbar$ — the more exactly we know the position of our particle, the less exactly we know
its momentum and vice versa (well, it stands to reason really — we can only measure the momentum by letting it move — so where is it? Somewhere between here and there. And if we fix it to an exact spot at an exact moment in time, how can we measure its momentum?).

However we can equally validly express it as \( \frac{\delta E}{\delta \mathbf{p}} \geq \hbar \) (you can do the dimensional analysis yourself), and energy and time are what we are concerned with here.

In any given very short period of time, there is a very large uncertainty in the amount of energy present, and as Einstein said \( E = mc^2 \). So, with a flick of the wrist, nothing up my sleeve guy, honest, we have our photon.

It doesn't last long of course, it's not allowed to — but the electron keeps at it, flashing on and off as it moves along (about 1.137 on off, don't ask me why). And when it meets another one, a quick barrage of imaginary energy and away they go.

The scientists had lots of fun arguing about whether these particles of light were real or not — they are by definition impossible to detect or measure — and in the end plumped for calling them 'virtual' particles. But virtual or not they can change the world around them — much as you could get a million pounds out of the Autobank on Friday night, buy a cut-price Van Gogh in America and sell it in Japan (but only for a million again, don't forget the conservation of energy) and then get the money back in the bank first thing Monday. You've changed the world by moving a Van Gogh across the world and a million pounds in the other direction, without your bank balance changing at all.

Of course there's more fun to be had with this. Virtual energy can exist even in empty space because of the impossibility of measuring its lack of energy instantaneously (nice sentence, though of course it's really the 3K microwave background that we're failing to measure accurately instantaneously).

This energy can create short lived pairs of particles and anti-particles as in Fig. 2. These are always in pairs — can't go round changing the total amount of matter in the universe with virtual energy now can we! Empty space could be thought of as seething with short-lived particles — electrons and anti-electrons, protons and anti-protons (shorter lived because heavier) and so on.

So, what about our little photon. Well the photon passing between the two electrons could be thought of as consisting of an electron and an anti-electron (Fig. 3). This is perhaps more figurative than literal — most photons would not be energetic enough to actually materialise a pair of particles — but the electric charges cancel out and the combination works just like a photon.

So why don't they annihilate each other? Well, you could say they do — and the product of the annihilation is our friendly photon. But it is a useful convention, emphasising that the force carrier exists at the very interface of the universe and anti-universe, and since the creation of a matter/anti-matter pair need not alter the net contents of the universe they are very useful for carrying a force whenever the need arises.

Mesonic Handshakes
The strong nuclear force is around 100 times stronger than the photon-carried electric force and is carried by mesons. This force holds nuclei together as in Fig. 4. (Okay so it's an attractive force, but this is the convention in these diagrams).

Why does it operate on so short a range? Well mesons are heavy, it takes a lot of energy to make one, they don't last long and don't go very far — but protons flash with mesons the way electrons flash with photons.

That's all about the Strong Force for a while, but if you hang in there we'll come round to these mesons again.

Confused yet? No? Okay then, here goes nothing! Ever wondered how a star manages to burn hydrogen to make helium — four protons giving two protons and two neutrons? Something is changing protons into neutrons. You can go on like this as far as iron. To get your heavy elements first explode your star — the resulting neutrons tack on to existing nuclei, some of them become protons — hey presto, a heavier element. Something is changing neutrons into protons.

The Weak Force
This is a tricky one. It's not a force in the sense of an attraction or repulsion, but we're swapping 'force'

carrying particles around and by a roundabout route it links with the electric force — the first glimmerings of unification.

Changing protons into neutrons involves us with quarks. There'll be more later, but for now we just need two — the up quark and the down quark. Protons are made of two up quarks and one down quark, neutrons of one up and two down. So for proton into neutron we have the change shown in Fig. 5, or more exactly Fig. 6.

But what's actually happening here? How does the up quark become a down quark? Brace yourself — here come some more pairs of imaginary particles.
Remembering our uncertainty about the matter/energy present at any time, we can look at it as in Fig. 7. The up quark is replaced by the down, leaving us with an up/anti-down pair which is the force carrying particle, the W⁺ boson (you could look at the electric force the same way, but it's a rather trivial case as the substitution of an electron for an electron goes largely unnoticed).

On the right of Fig. 7 we have our W⁺ boson breaking down into a neutrino and an anti-electron — it could be thought of as being made of a neutrino/anti-electron pair.

Actually it's an elusive swine our W⁺ boson, fond of disguises, never know what it's going to be from one moment to the next (Fig. 8).

The opposite process — neutron into proton (or down quark into up quark) gives us the W⁻ boson (Fig. 9). The + and — denote real unit charge (as you'll see if you balance both sides of the proton — neutron equation — down quarks have — ½ charge, up quarks ½ charge if that helps).

But there are other interactions where no change of charge is involved, such as interactions between neutrinos and quarks where the neutrino remains unchanged. This brings us to the W⁰ boson in Fig. 10. Among the repertoire of our W⁰ boson we find an electron/anti-electron pair — say hello to the electric force! But how do the W particles vary their constitution? Well, remember we are dealing with particle/anti-particle pairs. It is not so much that an up/anti-down pair is the same as a neutrino/anti-electron pair but rather that the difference between the pairs of particles is the same in each case.

So is the electric force carried by W⁰ bosons then? And if not, what's the difference? Well, the W⁰ particles are very short range, very heavy, it takes a lot of energy to make one. They could indeed be considered as freak cases of the electric force — if only one force - carrying photon in a thousand behaved this way, it would account for all the weak force interactions that take place.

This is the first breakthrough in the direction of the legendary Unified Field Theory (nowadays it's the Grand Unified Theory and they seem to be pretty much there except for the elusive graviton). Of course it wasn't worked out with pretty pictures, they were really very deep in some hairy mathematics — but it's so much easier to talk about some generalised 'gauge theory' than to get into gauge transformations of wave equations which is what the theorists were up to their eyes in.

Gauge theory? Well, that's what helped them tie up the loose ends in the maths. The possibility of multiple exchanges of force carrying particles kept giving uncomfortable answers with apparently infinite forces, but Gerald 't Hooft (I only introduce him because of that name!) came up with the gauge transformation as a mathematically valid way of providing limits to the equations and it all hung together.

The main implication for the heavy, short range force carriers is that they feel the force themselves (Fig. 11). Two particles approaching each other both send out force carrying particles. These meet in the middle and feel each other's effects which modify their behaviour.

More Quarks

Although all the matter we meet from day to day is made up of protons/neutrons/electrons in more exotic environments (ranging from cosmic ray interactions at the surface of the atmosphere to the heart of exploding stars) peculiar variants on the proton and neutron are to be found. These consist of variations on the three quark (up down) structure of the proton using any three of the six available quarks in Fig. 12. However the quark family of particles is made of any pair of quark/anti-quark.

Permuting any three from six gives us a large family of proton related particles, the more so when we take quark spin into account. With mesons it's fairly straightforward (Fig. 13), for the proton relatives slightly more complicated (Fig. 14).

So looking at just the up-down-strange combinations we have the tree for the 'souped-up' particles shown in Fig. 15. Throw in charm as well and we've got a pyramid of combinations with ccc at the apex — I won't even think about trying to represent the picture with the truth and beauty quarks thrown in, but you get the idea.

So far, so good. But then the scientists began wondering quite what was sticking the quarks together in these combinations — and came up with the gluons... and quantum chromodynamics.

The Colour Force

So why are we only allowed certain quark combinations: three quarks for protons, or quark/anti-quark in a force carrier? Why not a pair of ordinary quarks, or four quarks together? And why no lone quarks?

This is where the colour theory comes in. It proposes a new quality of matter (roughly comparable with electric charge) called 'colour'. Of course the quarks aren't really coloured in the macroscopic sense, but the analogy proves useful.

All observable particles must be 'white', but the whiteness can be produced by mixing colours in various ways (Fig. 16). The proton family are made up of one red quark, one green and one blue (anti-protons of one turquoise, one mauve, one yellow). The mesons combine a coloured quark with the appropriately anti-coloured anti-quark.

The assignment of a colour to a quark has no connection with what type of quark it is. Any quark can be red, green or blue — in fact the operation of the colour force requires that each quark in the proton is forever changing its colour (though the combination must remain white).

The force carrying particles for the colour force are our gluons. Because they are never seen outside the proton they can be non-white (the colour doesn't have to be matched by its anti-colour), and we have a variety of coloured gluons.

Fig. 8 The W⁺ particle

Fig. 9 The W⁻ particle

Fig. 10 The W⁰ particle

Fig. 11 The gauge theory Feynman diagram
red-mauve green-turquoise blue-turquoise red-yellow green-yellow blue-mauve

In addition there are the red-turquoise, green-mauve and blue-yellow which, though you and I might think make three white gluons, in fact for 'subtle reasons of group theory' mix together to make two 'off-white' combinations. Well that's what the theorists insist on giving us the family of eight gluons, shown in Fig. 17.

The force carrying gluons shuttle about between the three quarks of a proton changing their colours. The operation of six 'charges', (three colours and three anti-colours), compared with just two (+ and −) for the electric force means that the colour force is very strong indeed. But the force is essentially the same kind as the other cosmic forces and we can still draw our pretty Feynman diagram (Fig. 18). Or, remembering that coloured gluons would themselves feel the colour force, we can fit it into the gauge theory and have this diagram (Fig. 19).

One of the peculiarities of the colour force is that the force is fairly weak at short ranges, but as the quarks move farther apart they feel a stronger and stronger force binding them within the proton. One way of looking at this phenomenon is to consider the network of interactions over a larger distance as forming 'strings' between the quarks (Fig. 20). The strings are conceived of as white, each gluon cancelling the colours of its neighbours (on the very small scale, at the 'centre' of the proton, you would still have red, green and blue colours exposed and interacting).

If you tried to pull a quark out of a proton, you could only move it by making the string longer, putting in enough energy to create another gluon. This amount of energy doesn't decrease the further away you get, so the force remains as strong.

But can you break the string by pulling hard enough? Wouldn't this give you a lone quark? Well, no — because that would be like asking for a piece of string with only one end, or a single pole magnet. Snapping the string simply exposes new quarks at the broken ends (Fig. 21). The exposed end of the string running back to the rest of the proton has the same colour as the original quark, so the proton remains unchanged. All you have managed to do with your input of energy is to create a new particle — a perfectly ordinary particle, a quark/anti-quark pair of opposite colours — an ordinary 'white' meson, the strong force carrier. And this is where the strong force and the colour force tie together.

The relation of the colour force to the strong force is similar to that of the electric force to the Van der Waals force between molecules in liquids. A normal molecule is electrically neutral — a normal particle of nuclear matter is colour neutral (white). The Van der Waals force arises through electric resonance between electrons in neighbouring molecules even though they are tethered within the molecule by electric force. Similarly, even though quarks are tethered within nuclear particles by the colour force they can exchange relatively feeble 'vibrations' in the form of white force-carrying particles (Unified Field Theory? Who mentioned the Unified Field Theory?).

And there's more

What? More — you want more? No, I'm afraid that's it. Those are your fundamental forces (ok, ok, so I've left out gravity, but they haven't quite sortied that out yet) and your fundamental particles — the quark family and the electron/neutrino family. Gluons don't have to be more fundamental than quarks — quarks aren't made of gluons. As we have seen gluons are very much akin to mesons and in one sense we could say gluons are made of quarks.

But what is this with these multiple fundamental particles? Couldn't there be one thing from which all these others are built? Well, yes there is — it's called energy.

Everything's made of energy. One type of energy distribution makes up quarks, with minor variations
giving us the different types. Add the requisite ones together and you get a net energy distribution that behaves just like a proton — well it is one.

Electrons are energy (even gravitons are energy). We know that everything is Unified, it's all made of energy — what we're after is a mathematical description that will predict and explain the universe.

So if it's all just energy, why do we see objects as solid? Well, we're seeing photons reflected by these large scale organisations of energy. What are we feeling? We feel the average of incalculable numbers of interactions at the atomic level — we feel what that electric pulse travelling to the brain tells us to feel. And why does it hurt when we walk into a wall? For the same reason that a Maglev train stays hovering above the rails — energy in the right configuration can be pretty damn solid when it wants.

Okay, so there you have the basis of modern nuclear theory — but they sorted most of that out ten years ago. What's new? Superstring theory, that's what.

This starts with the idea of supersymmetry — the proposal that every force carrying particle (gluon, graviton and so on) must have a partner in the material world (gluino, gravitino). Or that every particle in the 'world' has a corresponding particle on the 'world'/anti-world interface where force carriers exist (and then a further corresponding particle in the anti-world, such as electron-selectron-positron).

And strings? Well, here comes another mathematical conceit. All attempts to include gravity in the above theories kept bringing in a new infinity again. This all comes about because the physicists, when they're not treating them as waves, treat their particles as mathematical points. If on the other hand you look on them as strings, little one-dimensional lines, things start to look friendly again.

Not only does the problem with infinities vanish, but gravity doesn't need to be added to the theory — it's already there. Gravity — specifically a graviton with zero mass and spin 2 — is a necessary part of any workable string theory of the particle world. Now they've just got to find the elusive little particles.

That's your lot. I shall pause only to add an interesting cosmological rider on the quantum fluctuations due to $M_E \gg M_h$.

In general relativity, gravity and mass have opposite energies — we label mass as positive energy and gravity as negative energy. It is possible that the gravity of the universe exactly cancels out its mass so that the overall energy of the universe is arbitrarily close to zero. If so, then the universe could be conceived of as nothing more than a quantum fluctuation with $E$ very small and $v$ very large. Fun, hey — and there's more.

Want to make a universe? All you need is the energy of a large hydrogen bomb. Confine the energy in a matchbox to squeeze a small portion of our universe into a mini black hole. Conditions within match those early in the birth of the universe where quantum fluctuations could create a small bubble of space-time. At these energies and densities the bubble would be forced out of our universe and a new 'child universe' is born in another space-time (Fig. 221).

Of course if we did create such a mini black hole it would explode within about $10^{-20}$ of a second. Not very long for a universe to evolve, you might think. But that is only the time scale as viewed from our universe. The child universe is completely separate from our space-time. Inside it the whole cycle of inflation, steady expansion, formation of galaxies and the evolution of life could run its course while we were still opening the matchbox to see if it had worked.

---

**Special Offer**

**For Spectrum and BBC Micro Owners**

Now your computer can take control for an affordable price. These tried and trusted interfaces from DCP Microdevelopments are offered at £20 off the normal price.

- Both units are extremely easy to use from both Basic and assembler/machine code and are supplied ready built and complete with all the documentation you need.
- To order by post fill in the form below (or a copy) and send it with your remittance to **ASP READERS' SERVICES (RO ETS/6)**
- 9 Hall Road, Maylswood Estate, Hemel Hempstead, HP2 7BH

Please make cheques payable to ASP Ltd. Overseas orders add £5 (Interspec) or £10 (Interbeeb) for airpost.

Access and Visa card holders can also place their order by phone on (0442) 4122

Allow 28 days for delivery.

---

**Interspec**

£29.95

The Interspec unit plugs directly onto the expansion edge connector of the Spectrum to provide a full range of interfacing facilities.

The unit is housed in a plastic case approximately 4½ x 3 x 1 in which contains the top quality double sided PCB and interface connections.

- 8-bit input port
- 8-bit output port
- four switch sensor inputs
- four relay-switched 12V 1A outputs
- eight channel multiplexed analogue to digital converter
- 15-way expansion bus

All sections of the interface are I/O port mapped and designed for maximum compatibility with existing Spectrum peripherals. Power is supplied through the Spectrum edge connector.

The expansion bus provides all the data and address/controls signals for the addition of further DCP modules or home-built devices. Connection is by multi-way PCB connector and all the information required for adding further devices is given.

---

**Interbeeb**

£49.95

The Interbeeb unit connects to the BBC micro's 1MHz bus expansion connector and is supplied complete with its own power supply unit.

The interface unit is housed in a plastic case approx 4½ x 3 x 1 in which contains the top quality double sided PCB and interface connectors.

- 8-bit input port
- 8-bit output port
- four switch sensor inputs
- four relay-switched 12V 1A outputs
- eight channel multiplexed analogue to digital converter
- precision 2.5V reference
- external power supply
- 15-way expansion bus

All sections of the interface are memory mapped in the 1MHz expansion map for maximum ease of use and compatibility with existing peripherals.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. All the information required for using additional devices is included.

---

[For more details, visit: www.americanradiohistory.com](http://www.americanradiohistory.com)
Having successfully minimised the effect of an op-amp's bias current on circuits last month, I'll now risk upsetting you by saying that unfortunately this is not the end of the story. Another cause of DC errors is the input offset voltage.

In all articles so far, I have assumed that if the two input terminals of the op-amp are at the same voltage, the output will be at 0V. This is not the case and the reason can easily be seen by inspecting the input circuits of the 741 op-amp (Fig.1). Unless the four input transistors are exactly matched, the voltage needed to cause a given current in the collector will not be the same for both pairs. Because of this imbalance, the output of the op-amp will be at 0V when a small difference in voltage exists between the two input terminals. This voltage is known as the input offset voltage, and may be around 10mV for a low cost bipolar op-amp.

Taking the same four circuits as last month (Fig. 2), let's see what effect this has on their operation, assuming once again that the gain of each op-amp is large enough for any variation in the input voltages to be neglected. In Fig. 2a, all that will happen is that the output will settle at 0V (we'll assume that the offset has + input 10mV higher than the − input).

Ah . . . but of course what I should say is that all things being equal it would settle at 0V. Last month we discovered that all things are not equal — there is already a +100mV offset due to the bias current. In this case, the output will actually settle at +90mV, so the input offset has actually resulted in a slight improvement! On the other hand, the specified 10mV voltage offset could actually be in either direction so the two might add up to give +110mV.

However, it's clear that in this circuit the output offset due to bias current outweighs that due to input voltage offset.

Adding the extra resistor in series with the + terminal will bring the bias current induced offset down to the same order of magnitude as the voltage induced offset, and you could reasonably expect the output voltage to lie somewhere between −20mV and +20mV. Zero if you're very lucky!

Figure 2b we have already found to be a dud from bias current considerations, so seeing what additional effect the input offset voltage will have is purely academic. As it turns out, the component of the output voltage necessary to maintain the − input 10mV below the + input is −10V (−10mV x the circuit gain of 1000), which means that the output is now only straining to reach 90V instead of 100V. Perhaps it won't quite dent the positive supply rail as much as before.

In Fig. 2c we have the DC coupled version of the series feedback circuit which was not too bad from a bias induced offset point of view. On the other hand, the output will still amplify up the −10mV on the − terminal to give −10V at the output. Not too good.

With bias currents safely under his belt, Paul Chappell confronts the hazards of offset voltages in the op-amp world.
In Fig. 2d this is achieved by a capacitor in series with R1, to give Fig. 2a. In Fig. 2c the capacitor goes in series with R2 to give the 'kosher' version of Fig. 2b (Fig. 3b).

That's all very well for AC amplifiers, but often an op-amp circuit is used in conjunction with, say, temperature or pressure transducers, or other applications where very slow moving signals are involved. Even if you could get hold of a large enough capacitor for the purpose, the settling time of the circuit might be hours, or even days! Let's face it, sometimes there's no alternative to DC coupling.

If the output offset is too large to be tolerable by a factor of ten or so, one way to reduce it is to apply offset trim. Many single op-amps have terminals for just this purpose: a preset pot is connected between the two terminals with its slider to one or other of the supply rails (depending on the type of IC). The effect is to vary the current ratio in the two input transistor collectors, to counteract the imbalance of their base circuits. Figure 4 shows how this works for the 741 type ICs.

**Trimming**

The offset can be trimmed to zero by this means, so it would be the ideal solution if not for the fact that the input offset voltage will vary with time and temperature. If you reckon on much more than a factor of 20 improvement over the IC in its raw state, you may be unduly optimistic. Unless of course you are willing to keep adjusting the null pot every time the drift makes itself felt.

The essential entry in the specifications table is the offset voltage drift — for general purpose op-amps it will be given in terms of so many nV per °C. For op-amps intended specifically for DC amplification, you'll probably get some indication of the long term drift with time too.

Another possibility is to arrange your own offset null. In the circuit of 2d, for instance, instead of taking the + input to ground, take it to the slider of a pot which will vary the voltage between ±10mV. Then adjust until the output is at 0V. An even better idea with dual or quad op-amp packages is to assume that the temperature drift of two ICs in the same package will be similar, and incorporate another op-amp in the nulling circuit in the hope that they will track. This can often give very good results.

An obvious solution is to apply money to the problem. Buy a better op-amp! Some very good devices can now be had for quite reasonable cost. The OP77, for instance, has a maximum input offset voltage of 60µV, a long term offset stability of around 400nV per month and a maximum temperature drift of 0.6µV per °C (all this for the GP version). These features and many more very respectable performance figures in an IC which costs less than £2!

The ultimate solution for circuits where even the slightest offset is intolerable is to use one of the many types of chopper, stabilised or auto-zeroing amplifiers. The principle of the true chopper amplifier is illustrated in Fig. 5. The chopper FET switches the input to the AC amplifier continuously between the voltages at the + and — input terminals.

The amplifier is AC coupled at both the input and output, so its own offset voltages have no bearing on the signal. The result is an amplified square wave, the amplitude of which depends on the difference in voltage between the two input terminals, but not at all on their common mode voltage.

After amplification, a synchronous demodulator restores the waveform to a DC level, which is then buffered and appears at the output. The only place
where significant DC errors can be introduced is in the output buffer, and as we've already seen it is gain that causes the problems. A unity gain buffer can be made to behave itself very well indeed.

The kind of performance possible with amplifiers of this kind is exemplified by the Analog Devices 261, with a maximum input offset of 25µV, a drift with temperature of 0.3µV/°C and with time of 0.5µV per month.

Even better performance is achieved with the auto-zero or `capacitor nulling' breed of amplifiers. Details of operation vary from device to device but all have the common feature that the input offset voltage is somehow transferred to a capacitor on one phase of the clock, then the voltage on the capacitor is added to the input signal in such a way as to cancel the offset on the other clock phase. It usually involves some fairly complicated switching - often there will be two separate amplifiers which are zeroed and used alternately, so that one or the other is always able to amplify the input signal.

Figure 6a shows the bare bones of the process (or one way of doing it, anyway) and Fig. 6b shows a practical version as used in the ICL7605/6. The principle is that in the nulling phase, the op-amp's offset is transferred to the capacitor. Let's say the offset voltage is 10mV, with the - terminal positive with respect to the + terminal. The circuit will stabilise with the output at +10mV, and a voltage of 10mV across the capacitor.

In the amplify phase, the capacitor holds the input amplifier's + terminal 10mV below the voltage at the + input of the complete amplifier. If the two input terminals were now at the same voltage, the output of the amplifier would indeed be 0V because the two terminals of the internal amplifier are held 10mV apart by the voltage on the capacitor.

The practical version of the circuit is nothing more than the basic circuit doubled, with each internal amplifier being zeroed while the other handles the signal. The switching takes place at 160Hz or 256Hz (nominal) depending on the voltage applied to the `division ratio' pin, which alters the internal clock divider.

The performance of the ICL7605/6 is maximum input offset voltage ±3µV, temperature drift 0.2µV/°C and long term offset stability 0.5µV per year.

These days the trend is for the performance of non-switching op-amps to catch up with and even to overtake that of the chopper or commutating types. The prices of high performance amps any variety are still high, so it pays to look carefully at the design problem you're faced with to see whether more careful circuit design can relax the specification of the ICs needed.

ETI's breathing rate monitor circuit is a case in point. The detection of slowly changing temperatures is an `obvious' case for DC coupling, yet by resisting the temptation it was possible to use a very ordinary op-amp and still to achieve excellent performance. There's no substitute for careful thought!

Last month the cure for the circuit in Fig. 2d was given as a 1MO resistor in series with the + terminal. The value should have been 1kO.
BARGAIN COMPONENT PACKS
Packed with those empty component drawers at a fraction of the normal price and don't forget, without that odd resistor or capacitor to complete your project. All items listed in this pack are finished parts and are to full spec, and are not seconds or surplus stock.

Pack A: 650 x 25 watt resistor 4R-10M £4.25
Pack B: 60 x 200 microfarad electrolytic 1000v £3.25
Pack C: 30 x Polyester capacitors 1uf-0.1uf £4.50
Pack D: 3 x 5 metal prew 1uF £1.50
Pack E: 30 x IC sockets 6, 14, 16 pin £2.00
Pack F: 25 x 3mm LED £1.50
Pack G: 25 x 5mm LEDs £2.00
Pack H: 30 x 5mm LEDs 10 Red £1.50
Pack J: 50 x 2414 silicon diodes £1.50
Pack K: 40 x npn transistors BC162/212 £1.50

Soldiers Breadboard (veroboard type), when you buy all ten packs.
Prices exclude VAT (15%)
Brought to Light

I thought last month that I had finished my brief introduction to opto-electronics. However, as we went to press I found a source of laser diodes at £16 (yes — sixteen quid!). This caused me to postpone my revue of electronic sensors in favour of some basic practical information on how to set up an experimental laser using one of these diodes.

Figure 1 reproduces the standard laser safety level for non-visible output lasers. The top line means what it says! Although the dispersion angle of semiconductor lasers is quite wide (minimum 8°) there is a lot of power available in addition to the small percentage of visible light. It may not look very bright, but your eyes can be damaged permanently by the invisible infra-red (IR) emission. With this diode 30cm is the absolute minimum safe viewing distance and even this is not advisable.

Figure 2 illustrates the recommended safe procedure for viewing the output from your diode. The safety glasses are not sunglasses. They are special green (usually) glasses designed to filter out the IR. The fluorescent screen emits visible light when exposed to IR so you can see an image through the glasses. I suggest that you have a chat with either your Sharp distributor or with Kodak Professional Sales in London before going ahead.

Please note that the above is no joke if you want to keep your sight undamaged. It is, however, unnecessary to assume the gormless facial expression illustrated in Fig. 2! This takes a lot of practice and contributes very little to either safety or experimental results!

Diode safety

Having looked at personal safety, we now come to diode safety. Even at £16 to £35, you don’t want to blow up too many diodes! The bees knees of laser diode handling stations is shown in Fig. 3. Once again, the facial expression is irrelevant and I think this system shown is extreme over-kill. Where I work nobody uses humidifiers or ionisers and very few use floor mats or wrist straps. The conductive bench mat is definitely essential, as is the grounded soldering iron tip but that is about all that is needed provided you are careful and intelligent about the static problem.

Obviously, you should not wear a nylon shirt and stroke the cat for half an hour before soldering your laser diode on a polypropylene carpet but it is not necessary to use a conductive neck tie attached to the ceiling unless you are really desperate.

The aim is to prevent static discharge with spike potentials in excess of about 20V (yes twenty). This is surprisingly simple. All you have to do is ensure you are resting your bare arms on the same conductive surface the diode is on at all times while you are touching it, and before you touch it if you have lost contact with it.

Here again, another warning: It is extremely dangerous to make a conductive mat out of metal or other good conductor. If your soldering iron should short out, you could kill yourself even if there is a resistor to ground proper in the lead. A conductive mat should always have an inherent resistance of 5k to 100k per linear centimetre in addition to a series resistor of 1MΩ at 2W rating as near as possible to the earth point.

The best system I have found is to use a 13A mains plug with the live and neutral pins entirely removed and to put the 1MΩ resistor inside the plug body. A substantial yellow wire (1.5mm sq/15A rating) is soldered to the resistor, the cord gripped using a nylon tie (not insulating tape as this deteriorates with age and slips) and terminated in a standard crocodile clip which attaches to the edge of the mat. To strictly conform with safety regulations, the plug body should be painted bright yellow!

Commercial conductive mats are expensive but a cheap and adequate compromise is to use a conductive bag. These can frequently be begged from electronics component shops and even a slightly damaged one will do. Shit it open and unfold it and you have a reasonable anti-static mat, albeit not very durable.

Test it with a DMM to make sure it is conductive as specified above, as many (mainly transparent or pink) bags are static passivated (they don’t generate static) but not really conductive. The bag that works would normally be black. Another alternative for the more intensive experimenter is to purchase an offcut of proper matting. These can usually be obtained quite cheaply from firms that make special mats for industry. I got a 6×2ft conductive polyethylene mat from Conductive Products as an offcut for about £15. It is a really durable material about 2mm thick, with a textured surface. The piece was not quite square but I tried it up with no more than a craft knife and straight edge.

Brought To Light

Mike Barwise enthuses over a cheap laser diode but finds using it isn’t that easy

Fig. 2 Safety precautions

Fig. 3 The over-kill workbench for the static mad

ETI September 1988
The Diode In Service

Laser diode protection does not stop as soon as you have soldered it in place. For the diode to survive it must be protected throughout its life from static and surge currents. Figure 4 shows the Sharp recommended layout for this. Note that an LC filter is assembled as close as possible to the diode. A typical filter is shown in Fig. 5. An ACC is an auto current control and an APC is an auto power control. More on these in a moment.

The final note on handling concern setting up the drive current to avoid overload and physical handling of the package.

As to power measurement, it is totally wrong and very dangerous to the diode to set up the power by measurement of input current only. The input current versus optical power and the lasing threshold vary dramatically device to device and over temperature for any given diode, so this is the best way to blow one up in less than a nanosecond.

Optical power meters are generally very expensive, but a good compromise is shown in Fig. 6. A large area photodiode (Sharp recommends the SPD102) is used with a load resistor and mV meter (DVM set to 200mV range or lower). Using the SPD102 with a 10R resistor, the output is 5mV per mW of optical power. With this detector, 200mV out should not be exceeded, as it goes non-linear above this.

 Needless to say, this test should be done in the dark. A small metal or plastic box containing the detector diode can have a hole in it through which the laser diode can be inserted.

Note that these laser diodes have internal reference diodes which are used for active power control in conjunction with a controller IC. To avoid light getting reflected back off the detector onto the reference diode which would temporarily reduce the laser output power — resulting in overdrive — the detector should be tilted at an angle of about 15°.

It is important the whole output of the laser diode falls on the active area of the detector. If in doubt, always place the two closer together rather than further apart, and do a little Pythagorus theorem on the basis of the dispersion angles given in the laser diode data before designing your little box.

When mounting your laser diode, remember it is a precision mechanical structure. The glass window can be cracked by stress, so mount by the flange only, as shown in Fig. 7. Also remember that contamination on the window will cause severe output degradation due to diffraction effects (a fingerprint will act as a crude meaningless hologram). Never touch the window but after you have, clean it with ethanol or Isopropyl Alcohol, not India Pale Ale! Although it is generally recommended that these devices are assembled in a clean room, it is not strictly necessary.

Precautions should be taken to avoid lumps of goop and pieces of fluff landing on the window during assembly and while in service but this is reasonably easy to ensure in the average electronics environment. Be extra careful if your bench is in your bedroom. If so, it is probably worth putting an open kettle of boiling water on the bench about 10 minutes before you start work to lay the dust.

The Diode — At Last!

Figure 8 shows the construction of a typical Sharp laser diode. The back-rectangular blob in the middle of the active layer is one end of the resonant cavity I mentioned last month. It has a partial mirror at each end to reflect part of the light and is of a critical length which is an exact multiple of the wavelength of the primary emitted light. Figure 9 is a section of the laser diode package showing the relative positions of the laser and reference chips.

The general term ‘coherence’ used last month actually encompasses two different attributes of laser light: temporal and spatial coherence.

Temporal coherence (Fig. 10b) is a measure of the spectral bandwidth of ‘purity’ of the emitted light. A perfect laser from this point of view might emit light at a wavelength of, say, 783nm, and no other
wavelength. This is practically impossible. There is always some spread. As will be seen later, the spread is very dependent on the proportion of maximum power at which the diode is being driven, anyway. The 'coherence length' is the distance from the diode over which the emitted light remains in phase along any one axis. The coherence length of these cheap laser diodes is very short — about 2mm. In fact, by the time the light was emerged from the package window, it can be considered temporally incoherent. This is designed-in on purpose. These diodes are produced for use in CD players, where excessive temporal coherence leads to increased noise.

Spatial coherence (Fig 10d) is a measure of how perfectly the optical wavefront conforms to segments of concentric circles centred on the emission point of the diode. The better the spatial coherence, the smaller the area of the focussed spot through a collimating lens. The spatial coherence of a CD player diode has to be good; a small spot of light is needed at the surface of the disc. Similarly, if you are to launch the light efficiently into an optical fibre (core diameter from 2 micron to 50 micron) you need a high degree of spatial coherence.

Any lens used to focus the light from the laser to a small spot is a collimating lens. Normally a microscope objective of about 10 focal length is used. In this case, the diode finishes up about 2-4cm from the threaded (back) end of the objective and the focused light is insertible into a fibre about the same distance from the other end.

Warning! Collimated laser light is extremely dangerous. The spot is very small so the relative intensity is dangerously high. Never look directly at the output of your collimating lens along the optical axis.

To set this type of system up, you need some kind of rigid adjustable support for the laser diode, the collimating lens and the fibre or other device the light is aimed at. Professional aligners are costly but so long as you have lots of patience you can use fairly crude equipment if it is rigid.

Magnetic bases with clamp-on arms are available for mounting engineers' dial guages. These will do quite well with care. A steel baseplate about 1/4in thick is then an adequate optical bench. A good size for use with magnetic bases would be about 3in wide by a foot or so long, screwed down to large enough piece of wood to ensure the system is completely stable. When aligning the system, the same detector mentioned above can be used and the different bits are manipulated until a maximum output reading is obtained. I know this sounds very rule of thumb but it is: just move things around until it comes out right!

The laser diode must be mounted on a substantial heatsink (not less than 6°C/Watt).

**Driver Chips And Control**

Sharp makes a couple of driver chips which greatly simplify the bringing up of laser diodes with internal references. If you should get a laser diode without an internal reference, then the driver circuit given last month will serve but it will be necessary to add an active cooler/heater.

All the low cost Sharp diodes have an internal reference. This is not more than a photodiode positioned to receive a constant proportion of the light emitted by the laser.

The driver circuits are shown in Fig 11. They are both shown in Fig 11a shows a simple driver with a TTL compatible control input and Fig 11b is a slightly more complex circuit which allows the use of a thermistor attached to the laser diode heatsink.
to shut it down if it overheats. There is not great advantage in using the circuit in 11a. Both circuits include slow start to eliminate switch-on spikes and both can be driven from TTL.

It is important to realise that the terms ON and OFF do not mean what you normally think. The laser is not extinguished when 'off' as, while you can modulate it within its lasing region at high speed, it is quite sluggish to turn on if you take it below lasing threshold and back.

The LC filter (Fig. 5) should always be incorporated when using these driver circuits, and their power should be supplied from a well regulated source. The TTL control input should be debounced.

**Sharp LT022MC**

Now let us look at the specific laser diode I am enthusing about: the Sharp LT022MC. This cost £16 + VAT at the last count. Some of its more important characteristics are illustrated in Fig. 12.

Figure 12a shows the dependence of forward current and voltage over temperature (which does not show much variation) and Fig. 12b shows the optical output power versus input current over temperature (which varies a lot). The transition between near-horizontal and near-vertical in this graph is the lasing threshold current. As you can see, it changes a lot with temperature, so it is important to keep the diode temperature as constant as possible. In the absence of active cooling/heating, use a large heatsink and don't keep it switched on for too long. As can be seen from the graph (12b) the threshold current at 50°C is about 62mA, which would overdrive the diode destructively at 0°C.

Figure 12c is a clearer indication of threshold current change with temperature.

Temperature change will also alter the wavelength of the emitted light (Fig. 12d) due to changes in the length of the resonant cavity. This should not be a problem for most applications, as the diode is not suitable for interferometry anyway, (which is mainly, where critical control of wavelength is required) due to its short coherence length.

What is more of a potential problem is the change in bandwidth with optical power output (Fig. 12e). As can be seen, the harder you drive the diode, the purer the output spectrum. However, it is most unwise to drive the diode at more than about 50 percent power in such lash-ups as we are discussing, to avoid frequent replacement due to blow-ups.

**Coupling To Fibre**

The main use of our laser diode will probably be the insertion of high intensity light into optical fibres. The most usable types of fibre will be large diameter plastic (1mm approx), 200 micron plastic coated silica (PCS) and possibly 50/125 silica (50 micron core, 125 micron cladding). The interference patterns described last month are quite easy to obtain and with a good ‘launch’ (optical insertion) it should be possible to throw a detectable pattern over a distance of some 4-6 inches. Sorry folks but the ‘across the room’ laser light show is not really on. Remember, also, that most of the power output is invisible with these lasers.

This is the knotty point. Optical sensing using coherent light is a pretty complex business. There are many alternatives and many modes of operation. There isn't the space to go into them in detail. The main thing is: get experimenting. You might just discover something important in this still experimental field. Above all, though: do it safely.

The laser diodes, information about safety glasses, viewing screens and detector diodes are available from Access Pacific, Bury St Edmunds. Tel: (0284) 69661.

Plastic Optical fibres are available from Electromail; silica fibres from York VSP, School Lane, Chandlers Ford SO5 3PG or: Optifile Fibre, Second Avenue, Deeside Industrial Park, Deeside, Clwyd CH9 2NX.

---

*Fig. 12 Characteristics of the LT022MC*
Construct your electronic circuits the new, quick and easy-to-learn way. WITHOUT solder. with Circuigraph Easiwire from BICC-VERO.

With Easiwire all you do is wind the circuit wire tightly around the component pins. No soldering, no chemicals, no extras, simplicity itself. Circuits can be changed easily, and components re-used.

Easiwire comes in kit form. It contains all you need to construct circuits: a high-quality wiring pen with integral wire cutter, 2 reels of wire, a tool for component positioning and removal, a flexible injection moulded wiring board, double-sided adhesive sheets, spring-loaded terminals and jacks for power connections and an instruction book. Of course, all these components are available separately too.

To take advantage of the special introductory offer, complete the coupon on the right and send it to:

BICC-VERO ELECTRONICS LIMITED,
Flanders Road,
Hedge End,
Southampton, SO3 3LG

Please rush me Easiwire kits, retail price £18-:
special introductory offer £15- (includes p & p and VAT)

I enclose cheque/postal order for... made payable to
BICC-VERO Electronics Limited

Please debit my credit card as follows:

Card Number
Expiry Date
Name
Address
Signature

or phone 04892 88774 now with your credit card number
(24-hour answering service).
Malcolm Walmsley tries his hand at putting together a Maplin loudspeaker kit. While that's drying, here's one he made earlier.

There was a time when loudspeaker kits were almost as common as their ready-made cousins. I've still got a pair of Wharfedale Dentons and a couple of Kefs made up from kits bought more years ago than I'd care to remember in 'normal' hi-fi shops in Tottenham Court Road.

Nowadays it seems speaker kits are only to be found in obscure electronics dealers and through obscure mail order firms. This is a great shame. There is nothing mystical or even difficult about making loudspeaker cabinets. Designing good ones is tricky, it's true, but putting together a few pieces of wood cut to someone else's design is (relatively) child's play. However, the savings over letting the nice man at the Korean factory do it are considerable.

The most difficult bit is making them look as good as the commercial equivalents. Even that is less difficult than it used to be, now that commercial speakers seem to be universally designed to look unattractive.

It's all to the good then, that Maplin has done its bit to straighten the record with a couple of speaker kits ideal for the home constructor like me with a badge-it attitude to DIY and very little skill.

The two kits are broadly similar and offer a 2-way 23 litre enclosure and a 3-way 40 litre enclosure. At £29.95 and £35.95 per speaker, respectively, these are well into the large savings category.

Both designs are rated at 50W and are based (if you'll excuse the pun) on a bass reflex system using Maplin's own bass driver unit with a 160 sq cm honeycomb foam diaphragm. This is supplied complete with a front baffle edging trim piece to both look and sound good.

The 2-way system has a single mid-range/tweeter unit on top of that whereas the 3-way system uses a miniature dome tweeter and a mid-range unit as well.

The 3-way enclosure is the subject of this review but many of the comments apply equally to the smaller system. Neither enclosure is on the tiny side — 40 litres is a lot of space to take out of your living room. This design is 20 x 10 x 16in in size.

The tweeters are standard enough but the mid-range unit is quite unusual. This is a ferro-fluid cooled driver (in other words it has some magnetic fluid filling the cavity around the voice coil) and is enclosed in its own sealed metal infinite baffle. This means it can be simply inserted in a cabinet and forgotten about.

The kit is not a complete MFI-type flat pack assemble-in-half-an-hour job. For a start, it does not include most of the woodwork. This kit comprises the three drive units, the crossover, a tuning duct for the reflex port, some connecting wire, damping wadding, screws and the front baffle.

The front baffle is the blessing. This is supplied cut to size (and square — nearly impossible to perform in my workshop) and pre-cut and drilled for the drive units. It is made of fibreboard (expensive but easy to work) and finished with a black textured vinyl coating.

All that is required of the constructor is the other five sides of the box to be cut from 3/4in chipboard and knocked together as per the clear instructions.

The chipboard to complete the cabinet should cost you about £5. Your local DIY warehouse will help out there. It is essential that you use the high density stuff. This not only works better but tends to be smoother surfaced too, so it looks better in the end.

I must say that I cheated. The instructions clearly tell you to put the box together with hardwood battens in the inside corners. I just glued the chipboard directly. It worked, it's strong and it was much easier!

Once the two sides, top and bottom are firmly attached to the front baffle I prettied it up! The drive units themselves are clearly designed to look good without a grill cloth and so they got none from me. Instead, I covered the cabinet top, bottom and sides with Maplin's black vinyl cabinet cloth and the front edge of the chipboard sides (not a pretty sight) with a frame made from hardwood moulding (with lovely
mittred corners — that took ages) to fit flush around the sides.

For reasons of domestic decor the front frame was painted green. (OK, so you think it’s horrible but I rather like it and you’ve got to see it in situ to really appreciate this masterpiece of design).

The drive units are then simply screwed into position with the nice pan head bolts provided. The crossover is screwed to one inside wall and wired up, the tuning duct (a bit of plastic drainpipe to you) is glued into the right hole in the baffle, the wadding distributed around the walls, the back stuck into position and away we go.

A minor quibble is that there is no back panel connection provided. Of course everyone disagrees over which type (push connectors, screw terminals, sockets, and so on) are the most hi-fi or the most convenient so I suppose leaving the choice up to the constructor is sensible enough. I would really like to have used those levered cable grips in a sunken panel as my existing speakers (which these are going to augment) use that system. However, Maplin doesn’t do those (although Tandy does!) so I plumped for screw terminals as these are the cheapest alternative.

Now came the acid test. What did my creations actually sound like?

Well I tested them next to my favourite Wharfedale Mach 3s — 2-way reflex speakers, highly efficient in the Wharfedale tradition. Many purists scoff at Wharfedales in general and the Mach range in particular but I must confess I love the sound of these. I like the extended bass response of the reflex system (despite the large size this usually entails) and the crispness and clarity (some would say colouration) of efficient speakers driven fairly hard.

Okay, so that’s why some years ago I coughed up £160-odd for the Mach 3s — what about the Maplin effort? Well, I was very pleasantly impressed. The kits are overall larger than the Wharfedales and the bass response stretched correspondingly lower. I found the low regions a little boomy, even after moving the cabinets away from the floor and walls, so this was no great advantage.

The treble was excellent. I always have the totally superfluous crossover treble control on the Mach 3s cranked up full but even then the Maplin kits gave a fuller treble without any hint of tinniness or wispiness.

The midrange is a little too subtle for my liking. It doesn’t have the real punch that I like. However, this is a very personal view and it’s unlikely to detract from most listeners’ enjoyment.

Indeed, the whole business of choosing speakers is a personal one. It is a shame you cannot go to a Maplin shop and listen to these kits made up before you decide. However, I would venture to say that to complement a reasonable hi-fi, for a price (see the panel) which should if not appeal at least not horrified most, the Maplin kits provide both a chance to let off some creative steam and produce some excellent speakers at the end of your hard work.

**Maplin 40L loudspeaker LM20W**

<table>
<thead>
<tr>
<th>The bits are separately:</th>
<th>£35.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bass driver (YN24B)</td>
<td>£14.95</td>
</tr>
<tr>
<td>Mid-range driver (YP13P)</td>
<td>£7.95</td>
</tr>
<tr>
<td>Treble driver (FD95D)</td>
<td>£3.95</td>
</tr>
<tr>
<td>Crossover (WF03D)</td>
<td>£5.95</td>
</tr>
<tr>
<td>Front baffle (XJ06J)</td>
<td>£2.95</td>
</tr>
<tr>
<td>3m Wadding (RYO6G)</td>
<td>£3.00</td>
</tr>
<tr>
<td>Reflex port tuning tube</td>
<td>£0.50</td>
</tr>
<tr>
<td>Cable</td>
<td>£1.00</td>
</tr>
<tr>
<td>Screws, nuts and bolts</td>
<td>£1.00</td>
</tr>
</tbody>
</table>

**Total**

£41.25

**Hardware: (approximate cost)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipboard</td>
<td>£5.00</td>
</tr>
<tr>
<td>Hardwood</td>
<td>£2.00</td>
</tr>
<tr>
<td>Cabinet cloth</td>
<td>£5.50</td>
</tr>
<tr>
<td>Wood glue</td>
<td>£1.00</td>
</tr>
<tr>
<td>Screws and nails</td>
<td>£2.00</td>
</tr>
<tr>
<td>Cabinet feet</td>
<td>£0.50</td>
</tr>
<tr>
<td>Paint</td>
<td>£3.00</td>
</tr>
</tbody>
</table>

**Grand Total**

for single complete speaker from kit

£54.95
**TRAVELLER’S AERIAL AMP**

Keen caravanner Keith Brindley finds poor television pictures a bind. With this project he’s guaranteed a good picture wherever he parks his van.

Campingers and caravanners alike will know the difficulties in picking up a strong enough signal to ensure good television reception when touring around the country. The main problem is, of course, that the typical touring aerial you use hasn’t the same sort of gain which permanent aerials have. Permanent aerials can have gains up to 20dB, depending on size and the number of elements. Touring aerials, if you’re lucky, give around 4dB.

What’s more, your aerial at home is sitting at rooftop level — your touring aerial is at best stuck on the top of a caravan, at worst a tiny set top box, inside the van or tent.

Aerial pre-amplifiers are available but most are mains-powered — fine for home use but not so fine for touring where your only source of power is often a car or caravan 12V battery. Those which allow low-voltage operation have limited gain anyway — no more than about 10dB usually — so pictures can often be so marred if you happen to have pitched for the night in a location with poor signal reception.

The aerial amp featured here on the other hand gives a remarkable 23dB gain so even with a limited touring aerial and situation, you should be watching acceptable television pictures when you’re on holiday in next to no time.

The main component in the project is a thick-film hybrid IC, Mullard’s OM335. It features an extremely wide bandwidth (wide enough that you can use it for amplifying VHF radio broadcasts, too) and wide operating voltage (around 9-28V). These make the IC ideal for the purpose here, although it can also be used to advantage as a masthead, set-back, or MATV preamplifier in the home or laboratory.

**Construction**

Construction couldn’t be simpler. With the grand total of three — yes only three — components mounted on the circuit board, the project ideally qualifies for 1st Class category. Nevertheless, a number of points need to be made and certain precautions must be taken to ensure the project works.

![Fig. 1 Internal circuit of the Mullard OM335 thick-film hybrid IC](www.americanradiohistory.com)
Start with the case. In our prototype, an aluminum alloy diecast box was used. This not only gives a suitably tough enclosure for portable use but also allows total electrical screening of the internal circuit. The PCB (see Fig. 3) was designed for use with this case so it makes sense for you to use an identical one but anything larger will also do.

First, drill the case for the two co-axial aerial sockets and power input lead. The aerial socket fixing holes must be drilled at about 45° angles to allow the bolts to pass through the case without touching the threaded supports inside the case at each corner. Fit a grommet into the power input hole.

Next, file the PCB (without any components, at this stage) to fit the case between the two inside edges of the two aerial sockets. The board must be a fairly good fit, because it is to be held in position between the two sockets simply by soldering the sockets' terminals to the board.

Now solder the components into the board. Be extremely careful with the amplifier IC. It's not particularly fragile but it can be damaged by excessive heat. Solder it in one pin at a time, letting the IC cool in between. Pins should be soldered on both sides of the board (component side and underneath) so you'll need a fine-tipped soldering iron to avoid touching the IC when soldering on the component side.

Mount and solder the other two components (ensuring the diode is the correct way round) and solder in two PCB pins, to which the earth terminals of the two aerial sockets can be soldered. Solder in power connections. About an inch from the board, tie a knot in them to prevent them from being pulled out and feed them through the grommet. Now, insert the PCB between the aerial socket terminals (the components should be on the underside).

Solder the aerial socket terminals to the PCB at each end. Finally, earth the case to the PCB with a short connection from one of the socket mounting nuts and bolts to the board. For your own reference, mark the case so that input and output sockets cannot be confused.

No setting up is required, simply connect a power supply of 9-28V and plug in your aerial and television leads.
**LATEST MAIL ORDER CATALOGUE (100 PAGE) ONLY £1**

### "CLOSED-CIRCUIT" TELEVISION SYSTEM

**COMPRISES:**
- 1x CAMERA
- 1x MONITOR
- 1x CAMERA BRACKET

**ORDER CODE:** SEC/CCTV/KIT

**PRICE:** £150,000 (COMPLETE)

**ILLUSTRATIONS NOT TO SCALE. FOR GUIDANCE ONLY—ACTUAL ITEMS SUPPLIED MAY VARY FROM THOSE ILLUSTRATED.**

**PLEASE RING FOR FURTHER INFORMATION**

---

**SEPTEMBER SPECIAL**

**ONLY £5.25**

**ANTEX SOLIDNING & PACK OF SOLDER**

**IRON ALONE NORMALLY £5.80**

**£6.99**

**VISIT OUR RETAIL SHOPS**

- **WEM (MARCO)** The Maltings, High St. (0939) 32783
- **WOLVERHAMPTON (WALTON)** 90922 22038
- **BIRMINGHAM (SUPERTRONICS)** 65 Hurst St. (021) 666 6504

---

**12V RECHARGEABLE UNIT**

- **10 x SIZE NICADS (144) ENCAPSULATED IN A BLACK PLASTIC CASE. FUSE HOLDER. GIVES 12V OUTPUT WHEN FULLY CHARGED. EX EQUIPMENT—FULLY GUARANTEED.**

**£6.99**

**LOOK OUT FOR OUR NEW SPECIAL OFFER EVERY MONTH**

---

**ALARM BELL BOX**

**PRICE:** £6.99

- H 404mm W 266mm D 138mm
- THICK TONG POLYCARBONATE
- UNIT LOCKED YEL. RED.

**EQUIPMENT CASES LEATHER GRAIN**

**PRICE:** £4.99 + 45p

- COATED STEEL
- ALL ALUMINIUM

---

**BATTERIES**

**PRICE:** £5.80

- FOR AAA, AA, C, D AND/or NICAD BATTERIES

**BATTERY CHARGER**

**PRICE:** £6.99

- SUITABLE FOR AAA, AA, C, D AND/or NICAD BATTERY CHARGING

---

**SERVIS PRODUCTS**

**PRICE:** £6.99

- SUPA PROTECTOR
- SWIVET CLEANER
- FOAM CLEANER
- SUPER 40
- FIRE EXTINGUISHER
- PAPERHEAD CLEANER
- ANTI-STATIC SPRAY
- SILICON OIL
- PLASTIC SEAL

---

**MARCO KITS**

**PRICE:** £7.75

- CERAMIC G50 (125)
- ELECTRIC TUBE (100)
- FUSE 20mA x 6.80
- NUT & BOLT (800)
- PRE-SET POTentiometers (120)
- PRE-SET POTS VERT. (120)
- RESISTORS
- 0.25W POPULAR (100)
- 0.5W POPULAR (100)
- 0.5W T/P OFF (100)
- 1W OFF (100)
- 5W OFF (100)
- ZEROT DIODES 5 OFF (10)

---

**SOLDER AT A RIDICULOUSLY LOW PRICE!**

**ONLY £4.99**

- 500G ROLL OF 22 SWG MULTICORE SOLDER 60% TIN 40% ALLOY NON-CORROSIVE

---

**DISDORDERING PUMP**

**PRICE:** £2.99

**SPARE NOZZLE FOR ABOVE — 60p**

---

**EMALLENED COPPER WIRE**

**PRICE:** £10.99

- SOLDER PEOPLE's FAVOURITE
- LOW RESISTANCE
- HIGH DURABILITY
- STRONG ALLOY COATING

---

**CARBON FILM RESISTORS**

**PRICE:** £1.09

- 1% TOLERANCE
- 10WATTS
- 210 VALUES

**RESISTORS**

**PRICE:** £0.50

- 250 VALUES
- 1% TOLERANCE

---

**PARTS SHOP**

**PRICE:** £1.99

- BULK BOXES
- ELECTRONICS COMPONENTS
- 1,000 VALUES
- 1% TOLERANCE

---

**SERVIS PRODUCTS**

**PRICE:** £6.99

- SPARE TIPS FOR ABOVE IRONS

---

**CARTRIDGE LIQUID**

**PRICE:** £0.99

- FOR ALL MAKES OF CARTRIDGES

---

**ENCAPSULATED**

- +185p

---

**ANTEX SOLIDNING**

- C IRON 15 W £5.40
- C IRON 17 W £5.80
- XS IRON 25 W £5.80
- XS IRON 25W £5.80
- TSDU SOLDERING STATION £72.50
- SPARE TIPS FOR ABOVE IRONS £1.20

---

**DISDORDERING PUMP**

**PRICE:** £2.99

- SPARE NOZZLE FOR ABOVE — 60p

---

**EMALLENED COPPER WIRE**

**PRICE:** £10.99

- SOLDER PEOPLE's FAVOURITE
- LOW RESISTANCE
- HIGH DURABILITY
- STRONG ALLOY COATING

---

**CARBON FILM RESISTORS**

**PRICE:** £1.09

- 1% TOLERANCE
- 10WATTS
- 210 VALUES

**RESISTORS**

**PRICE:** £0.50

- 250 VALUES
- 1% TOLERANCE

---

**PARTS SHOP**

**PRICE:** £1.99

- BULK BOXES
- ELECTRONICS COMPONENTS
- 1,000 VALUES
- 1% TOLERANCE

---

**CARTRIDGE LIQUID**

**PRICE:** £0.99

- FOR ALL MAKES OF CARTRIDGES

---

**ENCAPSULATED**

- +185p
RECURRING DREAM

Those of you who have followed this project from the start may have noticed something missing from last month's construction article. Remember the lucid dream stimulator? It hasn't been overlooked.

Lucid dreams are those strange experiences that happen to many people from time to time, when they are able to take control of their own dreams. Psychologists with a particular interest in dreams are not content to wait until the lucid variety occur of their own accord and have devised a way to turn ordinary dreams into the more exciting type.

Lucid dream stimulation relies on the fact that if a sleeping person is disturbed during an ordinary dream, it will often turn into a lucid one. The stimulator must therefore be able to detect the onset of dreaming and then when the time is right apply the necessary disturbance, usually in the form of a very mild electric shock.

Detecting a dream sounds as if we need a mind reading circuit, but it's really much simpler than that. Dreams occur during a particular phase of sleep known as REM (rapid eye movement) sleep. The physical changes that occur in your body when you enter this phase of sleep include a change in your brainwave patterns, rapid movements of your eyes and...a speeding up of your breathing rate. You begin to see how it all comes together.

This month I'll be giving you, amongst other things, a circuit which will transform your breathing rate monitor into a lucid dream stimulator. Before I get onto that, there's some work to be done. The breathing rate signals inside the monitor will have to come out, so there's a socket to be fitted before you do anything else.

The Interface Socket

The signals you need are all available at the edge of the main PCB, and are the very same ones that drive the display board. In Fig. 3a of last month's article they are labelled J,K,H,L (G is not required), N,P,M,R and TV.SW. A ground reference is also needed — this can be taken from the unused pad just above the Y connection on the display board.

The most suitable type of socket to use, taking into account the number of connections and the space available for it in the case, is a 15-way D socket. The twelve signals and ground (battery —) can be wired to the pins in any order, so I won't draw a diagram. As long as you know which is which and can identify the signals at the other end, that's all that matters.

Since the display board and the socket both need the signals, the new cable between the main board and socket can be soldered to the rear of the main PCB. Otherwise, PCB pins can be soldered into the J,K...W holes and both cables can be taken to the pins. Yet another alternative is to connect both the main PCB and the display PCB to the socket. There's no difference electrically, so do whichever looks neatest or easiest.

Space inside the case is very limited, so it's a good idea to check the socket position very carefully before making the cut-out. If it fits on the top of the case, just above the battery compartment and below the display PCB. A suitable hole can be made by marking out a rectangle of a size suitable for the socket, drilling holes...
32

Fig. 2 The Lucid Dream Stimulator circuit diagram

around the inside, then removing the surplus plastic with a modelling knife. The flange of the socket will cover any rough edges.

Magnitude Detector
All the add-ons I'm going to suggest for your monitor involve detecting whether the reading is above or below a certain value, so the magnitude comparator of Fig. 1 is common to all. I have shown the 'fully upgraded' version with DIL switches to select any value whatsoever as a set point, but the circuit can be simplified considerably as I'll explain at the appropriate time.

The circuit needs little explanation. It simply uses three 4585 magnitude comparator ICs cascaded in the usual way. The comparator with the reference value is selected by the DIL switches. As long as the monitor shows a rate of, say, 15 breaths per minute, you can select a rate of 10, 20, or 30 breaths per minute. If the monitor rate equals the set rate, output Y will be high. If the monitor rate is above the set rate, output X will be high.

Values are selected in BCD, so, each switch can be set to a value from 0000 to 1001. The BCD switch is more suitable than DIL spc/o switches if the values are to be changed frequently.

Lucid Dream Stimulator
The circuit of the stimulator is shown in Fig. 2. It is almost the same as the stimulator suggested in May as an add-on for the Brainwave Monitor — why not? If a circuit works well, there's no point in changing it.

For the magnitude comparator you could use the entire circuit of Fig. 1, but you could save an IC and DIL switch by connecting the X, Y, Z outputs from pins 13, 6, and 12 respectively of IC2. Having selected a suitable trigger point you can also hardwire the switch inputs to IC2 and 3, saving two more switches.

The top three switch sections of SW2 are set (or wired) to 1, 0, 0. The bottom switch and all of SW3 are used to set a breathing rate above which the circuit will trigger. Set it a little below your normal resting breathing rate.

The 4521 is used as a timer to allow about half an hour for you to fall asleep. During this time the comparator will be looking for a breathing rate of above 80 per minute (since pin 14 of IC2 is high) and, unless there's something very odd about your breathing, it won't happen. After the half hour period, the comparator now looks at whether your breathing rate is above that set

Fig. 3 Circuit diagram for a training aid

www.americanradiohistory.com
by the switches. The circuit is armed!

When your breathing rate speeds up as you enter REM sleep and begin to dream, the comparator will detect this and trigger the 555 IC, which fires the shocker. This is set to give you a little tingle — just enough to disturb your sleep, but not enough to wake you up. At the same time as the circuit fires, it resets the counter for another half-hour delay to be ready for your next dream.

The shocker electrodes are connected to the output of Fig. 2 and taped to one arm or leg. Two 1p pieces will do — if you can afford it! Needless to say, the circuit must be run from a battery and not from the mains.

Training Aid
Last month I suggested a training program which involved raising your heart rate to 100 beats per minute with occasional peaks of 140. It could be that when you’re jogging along you’d prefer to look where you’re going rather than keep your eye on the heart monitor. Your training won’t do you much good if you end up running into a lamp post.

Reaching a level of 100 beats per minute is easy — unless you’re very fit already you can assume that a gentle jog will give at least this rate. For extra bursts of exertion however, it could be useful to know when you’ve hit the 140 target without having to look at the monitor. Figure 3 shows a little circuit which beeps briefly as you hit the right level. The comparator switches are of course set or wired to 140.

Baby Alarm
The chances of a new born infant dying for no apparent reason are alarmingly high. Much higher than I would have guessed if I didn’t know better. If there is no previous history of ‘cot death’ occurring in your family, the statistics give your child about 1 chance in 500 of dying inexplicably. If there have already been cot deaths, the chances of another are much worse — about 1 in 125.

Already there are gadgets available which detect a child’s breathing rate and sound an alarm if it should stop. The ETI monitor was not designed for this purpose but could certainly be used in this way. The circuit is trivial and is shown in Fig. 4.

The units used for this in hospitals are called Apnoea monitors and are based around a pneumatic sensor capsule. This is connected to a plastic cone lined with foam rubber, which is taped to the baby’summy. Respiration is monitored down a plastic tube connected to the cone, and the sensor supplies signals to the main unit. Unfortunately I haven’t yet discovered exactly what form these signals take, and some adjustment to the input stage of my circuit may be needed if such a system is to be used reliably and safely.

The commercial devices apparently sound the alarm after a breathing interruption of 30 seconds. Since the ETI monitor would take rather longer than this to register zero, the switches should be set to a rate of about half your infant’s breathing rate. You can check on the delay time by simply removing the sensor leads and waiting for the alarm to sound.

As long as the breathing sensor is properly arranged, the monitor can’t do any harm and may actually save your child’s life, so it’s got to be worth investigating.

Biofeedback
I can’t let this project go by without mentioning biofeedback. The reason I have not raised the topic before is that although conscious control of your heart rate is easy to achieve, there’s not really much point in doing it! However, there are a few snippets of information that may amuse, enlighten or bore you, and I’d like to take this opportunity to share them with you all, brothers and sisters.

The most bizarre experiment I have come across is the one conducted by Dr. Miller of Rockefeller University when he took it into his head to teach rats to beat their hearts slower or faster. The idea is wacky enough in itself but the good doctor went one stage further. Just so that the rats couldn’t cheat by having a crafty jog around the cage or a peek at Playboy magazine, they were injected with curare. This drug has the effect of knocking out the skeletal muscles, so the poor old rats couldn’t do a thing for themselves — they couldn’t even breathe.

To keep the rats in working order for the duration of the experiment, Miller attached them to little rodent respirators (I’m not making this up!) and rewarded the proper responses with joists of electrical ecstasy to the pleasure centres of their brains.

The outcome was that the rats could indeed control their heart rates, Miller’s students all got their PhDs, Dr. Miller eventually received a mention in ETI, and the rats were disposed of by the caretaker.

Humans, without the curare and respirators, can usually learn without difficulty to increase or decrease their heart rates quite significantly — around 20 beats per minute on either side of the resting rate is easily achievable. Being able to do this has clinical applications in the treatment of cardiac arrhythmias, but this really does require the guidance of a doctor and the aid of sophisticated heart monitoring equipment. The only point in doing it at home is just to see whether you can!

The increased awareness of your own heart could be beneficial if you were ever unlucky enough to suffer with some kind of heart trouble — you might well notice the signs and be able to have treatment earlier.

A veritable myriad of applications then, and no doubt readers will conceive more than a few more. Good luck, and sweet dreams!
Frequency meters are rather expensive things to buy. I don't need one every day of my life and can think of much better things to blow a hundred quid on. So I decided to do something about it. This meter uses cheap 74LS1ICs and works out to about £3 for each digit of the display and maybe £20 for the rest of the circuit.

The design is flexible enough to be expanded gradually or built as the full 8-digit version from the start. If you're looking for something to check frequencies into the gigahertz range then I'm afraid this design isn't the one for you as the response is limited by the TTL circuitry to 40-45MHz, which is fine by me.

If Mr. Leong of Harlow is reading (hello Mr. Leong), he may recognize a large chunk of the gating logic. This appeared as an ETI Tech Tip some years back and I've used it here since it worked best in pre-prototyping trials.

You can choose between using LEDs and incandescent displays — incandescents are probably a better bet if you can get them, as they do not need current limiting resistors and have a long life expectancy (50000 hours). Because of this option on the display there is no PCB to mount the digits, this would be an added expense in any case.

The prototype used stripboard to mount the incandescents with wires connecting to the main PCB. The wires were colour coded corresponding to the segment connected and I really would recommend this as the only way to avoid total confusion with 56 wires flying around. This way it isn't as daunting as it seems.

Construction

To keep costs down the main PCB (Figs. 2 and 3) has been made single sided. This means there are more links on the upper side of the board than is usual. Begin by fitting all links (insulated where there is a chance of shorting) not forgetting that some lie under 1C sockets. The short links under the 74LS75 ICs may be fitted on the track side if

HOW IT WORKS

The circuit diagram is shown in Fig. 1. IC2a is configured as a 1MHz clock oscillator and drives buffer stage IC2f. This clock signal is fed to the combination of IC3 and IC4 which together divide the clock by 10,000.

A reset pulse is output from IC4 back into IC3 to continuously enable this part of the circuit. A pulse is also output from IC5 pin 2 which clocks the three divide-by-ten ICs 5, 6 and 7. The four outputs at 0.1sec, 1s, 10s and 100s intervals are selected by SW2 and then applied to the gating logic.

IC6a is a "D" type flip-flop configured to divide by two. The output enables IC9a which is a monostable dependent on the time constant of the 2µ2/80k combination on its output side.

There is a further monostable between IC2 pin 6 and 5 which generates the main counter reset pulse. IC5 is a buffer stage to the LED on the front panel which indicates when the gate is open.

IC8b is an overflow indicator driver which is operated by a pulse from the MSD 74LS90. When this occurs, the LED is lit and the gate IC9b is disabled thus halting the count. The input into the pre-amp stage is by way of a BNC socket on the front panel feeding a switched attenuation stage via C1. Before D1 and D2 together with the combination of 180k/22µf also protect D1 from damage by high-voltage spikes.

D1 and D2 are connected as a high gain wideband amplifier. The output from the first pair of transistors is then fed to the darlington pair Q3 and Q4. The amplified signal is output from the emitter of Q4. The 1k preset pot in the drain lead of D1 sets the stage gain of the FET and thus the rest of the pre-amp.

IC1 is an XOR gate which, if fed from either +5V or OV changes the polarity of the square wave signal on its opposite input.

The main counter input is fed from IC1 pin 3. Each stage has three ICs — one to convert pulses into BCD, one latch to either pass the information on or not, and a third IC to drive the display. The third IC (74LS47) has "lamp test" and leading zero blanking facilities and both these are used. Note that the current limiting resistors R22-77 are only needed for LED displays.

Each stage in the counter is identical and accepts pulses on the input pin of each 74LS90, giving output pulses to the next stage in the series on pin 11. Thus the LSD counts units, the next tens, the next hundreds and so on.

The power supply is standard. Note that there are two regulators fitted, this is to obviate any overload situation which might arise. The larger rated 7805S device is mounted on the case of the instrument, necessitating a metal case. The rectifier is protected by a fuse as is the mains input to the instrument. All the circuitry with the exception of the pre-amp is on one PCB thus simplifying construction.

ETI SEPTEMBER 1988
Fig. 2 Off-board connections for the frequency meter

desired. Next fit throughboard pins at the appropriate places for off-board connections.
IC sockets are fitted next, then diodes, resistors and capacitors (noting polarity where appropriate), gradually building the height of components on the board. Last of the capacitors should be the pair of 220pF in the power supply and don't forget the transistor Q5 between IC7 & 8. The two 220R resistors for the LEDs are mounted on the display board.

At this point the main board should be finished by checking with a multi-meter for short circuits between power rails and between IC pins (except where these are supposed to be).

Don't Fit The ICs Until I Say So

For the display board (stripboard) you'll have to fly solo I'm afraid, since this all depends on the type of display you decide to use and anyway pin-outs differ from device to device. Whatever you use you should prewire the display now and check very carefully with a trusty multimeter as a single short circuit here can cause some pretty obscure faults. And write down the colour code you use (I used the resistor codes — black for segment a, brown for b, red for c and so on — so that in five years I'll still be able to understand).

If you are using LED displays you will need either SIL resistor packs or individual 180R or 220R resistors to the front edge of the main board. Two types of SIL packs are suitable, one with seven resistors and a cheaper one with eight. The cheaper one is just as good here, so remove the extra legs (pins 8, 9) and fit as for the other type.

If you are using incandescent displays then ignore the above paragraph and proceed from here.

Wire each display segment to the main board, the colours of which should run from right to left in this order (assuming the aforementioned colour scheme) — green (f), blue (g), black (a), brown (b).

BUYLINES

All components should be available from the normal suppliers except perhaps 01, available from STC on (0279) 628777. The PCB is of course available from the ETI PCB Service on 0442 41221.

PARTS LIST

RESISTORS (All ¼W 5% unless specified)
R1 8M2
R2 750k
R3, R4 150k
R6 120R
R7 100R
R8 39R
R9 1k
R10 470R
R11, R13 1k
R12 10R
R14 1M
R15, R18, R19, R21 100k
R16, R20 220R
R17 820k
R22-77 180R or 220R
RV1 1k min preset

CAPACITORS
C1, C16 100n 400V polyester
C2 47µ 35V tantalum
C3 220p min polyester
C4 4a7 35V polyester
C5 100p silver mica 5%
C7 22p min trimmer
C8 82p silver mica 5%
C9 2u2 35V tantalum
C10 2n2 min ceramic
C11 1n0 min ceramic
C12, C13 1n0 min disc
C14, C15 2200u 25V axial electrolytic
C17-C24 100n min disc

SEMICONDUCTORS
IC1 74LS86
IC2 4049
IC3 4020
IC4 4066
IC3-7 4017
IC8 4013
IC9 4093
IC10, 12, 16-31 74LS90
IC11, 14, 17-32 74LS75
IC12, 15, 18-33 74LS47
IC34 7805
IC35 7805
IC1 74LS06
D1 2N3906
D2 2N3906
D3 4B90
D5 2C548
D1-5 1N4148
LED1, 2 hi-brightness LED
LED3-10 incandescent or LED
digit displays

MISCELLANEOUS
BR1 6A bridge rectifier
FL1 1A fuse
FL2 3A fuse
L1 1mH wire wound choke
SW1 SP mains toggle
SW2 5-way, 2-pole
SW3, 5 1-pole C/O
SW4 3-way, 1-pole
SW6, 7 press-to-make
T1 9V 2.5A secondary
XTAL1 1MHz crystal
Case. IC sockets. Nuts and bolts.
Fig. 3 Component overlay for the main board
red (c), orange (d), yellow (e). This applies to all displays.

Assemble the pre-amp PCB (Fig. 4) using the same order of construction as for the main board there is only one link to fit. The only point to note here is that Q1 pads have been provided for either BF246 or 2SK40 FETs — the overlay shows a BF246 as this is the more common device.

The case depends on the transformer you use. The prototype used the transformer from a ZX81 which is fairly small for a 2.5V secondary (which is what you need). With this, everything fits neatly into the recommended case, but otherwise a larger case is recommended. Mark and drill the front and rear panels to suit the switches and displays you are using.

![Component overlay for the preamp board](image-url)
Testing
At this point it will be necessary to loosely wire everything together for testing purposes. Do not fit the main board into the case just yet.
Assuming you haven't got a bench power supply capable of giving 2.5A then proceed as follows. Mount the mains transformer, input fuse and mains switch in position being careful to cover exposed terminals with sleeving. Also mount the 78H05 regulator IC34 on the rear panel allowing enough room for the pre-amp and the 7805 regulator IC35 as well. Temporarily fit a heatsink to the 7805 regulator and mount it on the main board.
Ignoring the pre-amp for the time being, make connections between the 78H05 and the through board pin at the front of the main board. Temporarily link the case with the ground plane on the PCB and make the following tests.
Insert FS1 and apply power to the unit. There should be AC voltage on the secondary of the mains transformer. This can lie anywhere between 8V and 12V but should not be much lower than the power figure or the regulators may not work properly.
For DC at the 220pF capacitors C14, 15, the figure here will be somewhat higher, in the range of 10-15V DC. If it isn't, switch off before something catches fire and check, check and check again on your construction.
If all is well to this point, then you should have +5V on all the IC sockets (you didn't fit the ICs did you?) at the relative pins. If not, check for missing links, broken tracks or pins not soldered.
Remove FS3 and in its place fit a milliammeter, turn off the power and fit the logic ICs one at a time noting the current consumption as you go.
It should gradually increase from virtually zero to a couple of hundred milliamps, if there is a sudden change, power down quickly and investigate the cause.
If you have connected the two LEDs on the front panel one or the other may be lit. If the overflow is lit check it goes out when you apply +5V to IC8 pin 4.
If you make temporary links in place of SW2 the gate LED should light in response to where you make the link — if you connect IC8 pin 12 to IC8 pin 11 the LED should be lit for 1 second and extinguished for 1 second.
If these tests are good to this point, transfer the milliammeter to the output lead of the 78H05, after first checking to see if there is +5V on its output.
Power down and insert the 3 ICs for the LSD of the counter. As before note the current reading as you go and power down on anything which looks like a fault. Clear it and proceed to the next stage.
As each digit is checked the current should rise by some 60 to 80mA although individual ICs may consume more than others. If after inserting all the counter ICs you have not had any major disasters to this point, then grounding pin 3 on the 74LS47 ICs should light all segments. In this condition the 78H05 regulator will be supplying about 2.4A if all is well.
Remove the temporary heatsink from the 7805, drill the PCB for mounting and fit sticky stand-offs through these holes. Simply press the PCB into the bottom of the case et voila. The display board is mounted in the same way (you did allow for the extra length of course) and the remainder of the controls may now be fitted and wired up.
High brightness LEDs are recommended for the two panel mounted devices and if the overflow LED does not appear to be bright enough then an extra transistor Q5 may be included as a buffer.
Before the displays are finally mounted it is advisable to stick some contrasting material behind the aperture (in the case of LEDs this will obviously be red, but if incandescent are used then they can be any pretty colour you fancy).
Final Assembly
With the main PCB in the case, mount the pre-amp PCB on a bracket at the rear. The 7805 should also be mounted at this time.
Connect the attenuation switch on the front panel to the pre-amp board with a short length of screened cable. At this point the preset resistor on the pre-amp should be set up. To do this, monitor the voltage at the emitter end of R11. There should be approximately 1.5V at this point relative to ground — adjust the preset and re-adjust this later for optimum performance.
At this point it is the time to adjust the master oscillator using if possible a frequency standard. However if you cannot gain access to the above proceed as follows: construct on stripboard the oscillator in Fig 5. Depending on the frequency of the crystal used you should be able to read something close to the stated frequency.
A word here about crystals — have a chat with your local TV repair shop, they will probably be happy to part with a 4.4433619 device for a few pence (these are the ones used in all colour TVs but don't whatever you do go poking around in your TV).
Having built your test signal source apply power to it and inject the output into the BNC socket, noting that it is better to start with the attenuation switch in the 50:1 position to begin with. Trim the master oscillator on the counter by adjusting C7. If it won't quite make it to the stated frequency try altering the values of C6, C7 and C8.
All that remains to be done now is to box up the unit leaving it running for an hour or so and giving the trimmer C7 a final tweak.
In use, you may find that when investigating square waveforms that the counter refuses to count properly. Use of SW3 will enable you to choose the best edge to count on. A final word about performance — the pre-amp should be good for the worst case transformer in the design which is Q2 whose f1 is quoted at 150Mhz.
In the counter itself the upper frequency limit is imposed by the TTL itself, this being 40-45Mhz.
CONSTRUCTION SERIES SPEAKER KITS
Based on the famous Kef Reference Series, these three DIY designs give the home constructor the opportunity to own an upmarket pair of loudspeakers at a very down-to-earth price! With a Wilmslow Audio Total Kit it's easy — no electronic or woodworking skill is necessary. Each kit contains all the cabinet components (accurately machined from smooth MDF for easy assembly), speaker drive units, crossover networks, wadding, grille fabric, terminals, nuts, bolts etc.

Model CS1 is based on the Reference 101, CS3 is equivalent to the Ref. 103.2 and CS9 is based on the Reference 105.2 (but in a conventionally styled enclosure). CS1 £117 pair inc. VAT plus carr/ins £6
CS3 £143 pair inc. VAT plus carr/ins £12
CS9 £393 pair inc. VAT plus carr/ins £18

We also offer a kit (less cabinet) for Eletor PL301

Lightning service on telephone credit card orders!

WILMSLOW AUDIO LTD.
35/39 Church Street, Wilmslow, Cheshire SK9 1AS Tel: 0625 529599

Call and see us for a great deal on HiFi.
(Closed all day Mondays)

DIY Speaker catalogue £1.50 post free (export £6)

19" RACK CASES
Suitable for instruments, high quality amplifiers and many other applications that demand strength and professional finish. New improved construction and finish. Black anodised aluminium front panels. Separate front mounting plate, fixing screws in line on the front and the size of the enclosure. Heavy gauge front panels of brushed aluminium finish enhanced with two chrome Hansens. With ventilation slots and price ticket. Road box manufactured from 1.1mm sheet finished in black. Rack mounting or free standing. Comes in 6 sections for packaging spare front panels available.

Order Code: Panel Size Rear Box Price
1U-10 Width (inch) W Height D Weight Price
1U-10 19 x 1.75 17 x 5 x 12 3.3kg £25.50
3U-10 19 x 3.5 17 x 3.5 x 12 10.2kg £49.50
6U-10 19 x 5.25 17 x 5 x 10 3.3kg £26.50

TEST EQUIPMENTS

C550 8-DIGIT 550MHZ FREQUENCY COUNTER
- Auto channel selection
- Dual Decimal Points Indication
- Selection of Gate Times
- Complete with RF Cable and Technical Manual

SPECIAL INTRODUCTORY OFFER £79.50
offer ends 31.10.88

C550 550MHZ Frequency Counter
CR3A Digital Power Supply Voltmeter (0-35 Volts 1.5 A)
CR8A Digital Power Supply Voltmeter (0-35 Volts 1.5 A)
CR8A Function Generator (2 Hz to 200 KHz)
CR8A 60 MHz Counter/Timer
CR7A Autoranging Capacitance Meter (0.1 pF to 99.9 mF)
MV306 Metal main's detector

High quality test equipments at an incredibly low prices. Customers who have bought from us are delighted with the quality and found them excellent value for money. Place an order now, we will give you your money back if you are not completely satisfied to return the unit within 14 days. Please add £3.50 per pair item (50p for MV308).

To order send chequnier order , Cheque/PO available. Customers who require further information please send S.A.E. Trade and private orders welcome. Mail order only.

T.J.A. DEVELOPMENTS
Dept. ETI, 19 Welbeck Road, Harrow, Middlesex HA2 0RN.
**SPECTRUM EPROM EMULATOR**

It is a fact of life that when it comes to designing and debugging microprocessor based circuits, your old single beam valve oscilloscope and trusty Avo won’t get you very far. Microprocessors are tricky beasts to get going at the best of times and specialised development and support tools are really aimed at the professional engineer in industry, where the elevated price tag is of secondary importance.

One extremely valuable piece of microprocessor development equipment is an in-circuit emulator. This usually takes the form of a big box of tricks and a ‘pod’ on the end of an umbilical cable, which plugs into your target circuit in place of the microprocessor chip. From then on, the emulator pretends to be the processor, and if desired the memory too, simulating all the functions in real-time.

The emulator provides facilities to start and stop the processor, examine and change register values, and perhaps most importantly, examine and change the memory contents. Such systems provide an amazingly powerful development tool, cost many thousands of pounds and no, we’re not going to build one!

A few steps down in complexity from the in-circuit emulator but no less valuable, is the so-called EPROM emulator. Once again this provides a ‘pod’ at the end of a cable which plugs into the target board, this time in the place of the EPROM containing the operating software.

As far as the target board is concerned, the EPROM emulator is the EPROM - a block of read-only store. However, the emulator is in fact RAM and data can be put into it during code development, from some external source such as a home computer.

This means that changes to code can be made in seconds, without going through the hassle of erasing and programming EPROMs each time you discover a tiny bug in your software. It also means that short test routines can be quickly employed to test and debug new hardware, again saving time with EPROMs.

Such EPROM emulators have appeared in ETI before, so what is so special about this one? The major difference is in the method used to download the code into the emulator. Usually, having been compiled/assembled, the code is moved from the development computer into the emulator via a serial link. This requires a program to be running in the home computer to transmit the data, and some hardware in the emulator to receive the data and write it into the appropriate RAM locations. In this design all that is unnecessary.

**A Full Spectrum**

This emulator has been designed for use with our old friend the ZX Spectrum and simply plugs onto the expansion port at the back. The emulator RAM maps itself into the Spectrum memory as an 8K location block starting at address 49152.

The idea is that the Spectrum sees the emulator RAM as its own memory so that downloading data is handled automatically. However, the Spectrum’s memory map is full of its own RAM already.

In order to overcome this, the emulator RAM is configured as ‘Write-Only’ memory (WOM?) as far as the Spectrum is concerned. This means that if the Spectrum writes to these locations, the data is put into both its own RAM and that of the emulator. If the Spectrum reads from these locations, it sees only its own RAM contents. Thus the emulator will not affect in any way the operation of the Spectrum, yet manages to receive download data at the same time.

In this way we simply use the Spectrum BASIC ‘Poke’ command to put suitable data into the emulator. However, even more amazing is the possibility of assembling code into this area of memory. The mere act of assembling source code on the Spectrum writes executable code into memory, and in this case into the emulator RAM at the same time.

With an ordinary serially loaded EPROM emulator, getting executable code into the emulator RAM is a lengthy process. First, it is necessary to load the assembler into the computer, then load the source

---

Graeme Durant's Spectrum bears more than a passing resemblance to a development system's EPROM
HOW IT WORKS

The block diagram for the system is shown in Fig. 1. The EPROM emulator basically consists of a block of static RAM, its address and data lines being switchable between one of two external ports.

The port shown on the left is connected to the Spectrum address and data busses via the Spectrum's expansion slot. This port is write-only, and allows the EPROM data to be downloaded into it from the Spectrum.

The port shown on the right goes to the target system via a cable and EPROM look-alike pod. This port is read-only, and emulates the effect of the EPROM.

The switching of the RAM between these two ports is handled by some simple control logic — basically by the state of the power supply to the target board as sensed by the EPROM-pod power pin.

If the target board is turned off, the emulator is switched to its download mode. EPROM emulation starts as soon as power is sensed on the target board.

The emulator board itself is always powered from the Spectrum, via the 5V supply connection on the expansion slot.

The circuit diagram (Fig. 2) demonstrates operation in more detail. The heart of the emulator is IC4, an 8K x 8-bit CMOS static RAM chip. The switching of data and address lines to IC4 is achieved by means of the in-stateable 8-bit buffers IC1, 2, 3, 8, 9, and 10.

Looking first at the write-only port from the Spectrum, the incoming data and address signals arrive on the emulator board via edge connector SK1, and are buffered by IC1 and IC2, 3 respectively onto the data and address lines of IC4.

The 8K locations present in the emulator are mapped into the Spectrum's memory space by IC8b and so that they start at 49152 (dec). IC8b detects a memory write access by the Spectrum to one of these locations.

The write strobe to IC4 is derived from the output of IC8b and can be disabled in emulation mode by IC5a.

Looking now at the read-only port to the target system, the output data and the incoming address signals leave or enter the card via connector SK2, and are buffered by IC8c and IC9, or respectively from or onto the data and address lines of IC4.

This time there are only thirteen address bits coming from the port, so these all go to the RAM without decoding — any decoding will already have taken place on the target board.

The most significant address bit from the target system (A12) has a high value pull-up resistor RS connected to it. This is there to ensure that this line doesn't pick up noise when the board is emulating the smaller 4K EPROM (2732) with this address line floating unconnected. This does mean however that whilst emulating the 2732, data should be placed in the top half of the 8K RAM, starting at Spectrum address 53248 (dec).

It is worth noting too that the RAM address and data lines are not connected to the two external ports in the same order as defined by the manufacturer's data sheet. This dramatically simplifies the IC8 layout, and has no effect on operation providing that a data line from a port goes to a data line on the RAM, and an address line from a port goes to an address line on the RAM.

Each unique address combination will access a different RAM location capable of storing data; it does not matter where exactly this occurs on the chip! Naturally, the data and address lines on the two ports must match so that data put into a certain address from the Spectrum will be found at the same location on the emulation port.

As mentioned previously, the operating mode of the card is determined by the state of the power supply on the target board. This is detectable on the port by the voltage on the "EPROM" power pin, and is handled by IC1 and its associated biasing resistors. When the target supply exceeds about 3.5V, IC1 turns on the transistor voltage being set by R8 and R9. The state of IC1 is converted into TTL levels by Schmidt Inverter IC7a. An LED driven via IC7b indicates when the emulation mode is in operation.

The circuit diagram shows this voltage sensing taking place on pin 28 of the 2764 port. A second connection, via diode D1, comes from pin 26. This is for 2732 emulation, when the EPROM supply pin does not coincide with that of the larger device, and pin 28 is unused (diode D1 is present to protect the target system from a possible fault condition, if in the case of 8K device emulation, pin 26 of the EPROM socket is not open circuit as the 2764 pinout assumes).

Imagine first that the target board power is off, and the emulator board is thus in the download mode. Q1 will be switched off, and the output of IC7a will be low. The output of IC7c is always the complement of the output of IC7a, so will be high.

The low output of IC7a will directly enable buffers IC1, 2, 3 so that the Spectrum data and address signals will reach the emulator RAM. At the same time, the high output of IC7c will allow IC5a to pass write strobes from the Spectrum to the RAM, so that the downloaded information can be written into IC4. The high output of IC7c also disables the address buffers (via IC6a) from the emulation port IC8, 9, and 10, and disables the data output drivers in IC4 and the data buffer to the emulation port IC8.

After the download is complete, the target system power can be applied. Q1 turns on, sending the output of IC7a high and the output of IC7c low. IC7a disables the three Spectrum port buffers IC1, 2, 3, thus effectively decoupling the emulator from all the Spectrum's influence.

Similarly, IC7c enables the emulation port address buffer so that IC4 receives the required EPROM address signals from the target board. Any further write strobes from the Spectrum are stopped by the low signal on pin 1 of IC5b, so now the RAM is held in its read mode constantly. The logic is carefully arranged so that as long as the Spectrum is not trying to write data to the RAM at the time changing mode from download to emulation or back can never cause an erroneous write pulse to be sent to the RAM, which might otherwise
When the target board decided to access our 'EPROM', it pulls the CE and OE pins on the port low after supplying a suitable address. This function is controlled by IC6a and CE, and assuming emulation mode is in operation, the data output drivers (IC4) and emulation data bus buffer (IC8) will be enabled. The accessed data can then get from the RAM to the target board.

The timing specification for access is shown in the table on the right. The resistors R2 and R3 on the CE and OE lines of the port reduce the sensitivity of these signals to noise pickup when the target system is unpowered.

Finally, decoupling capacitors are distributed liberally about the board to ensure the supply to the emulator is noise free. A large value capacitor, C1, is also included near to the power connections from the Spectrum. This helps to avoid supply dropouts if the emulator is accidentally knocked, and also prevents problems due to the fact that the power supply is connected remotely.

### Timing Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address access time</td>
<td>180ns</td>
<td></td>
</tr>
<tr>
<td>OE to output valid</td>
<td>11ns</td>
<td></td>
</tr>
<tr>
<td>CE to output valid</td>
<td>11ns</td>
<td></td>
</tr>
<tr>
<td>CE to output High-Z</td>
<td>55ns</td>
<td></td>
</tr>
<tr>
<td>OE to output High-Z</td>
<td>55ns</td>
<td></td>
</tr>
<tr>
<td>Output data hold time</td>
<td>20ns</td>
<td></td>
</tr>
</tbody>
</table>

These timings make the emulated device equivalent to a 250-300ms part.
code. Once assembled, the object code must be saved, then the serial link download program must be loaded into the computer, after which the object code must be re-loaded in order to transmit it to the emulator. If a small change is required in the code, this whole process must be repeated. If you are working with floppy disks or worse still audio cassettes, all this loading and saving is painfully slow and very tiresome.

With the design described here, once the assembler has been loaded into the Spectrum, it can stay there, as can the source code. Code can be assembled into the emulator, the source code can be tweaked and then immediately re-assembled into the emulator for another try — all in seconds!

This design is capable of emulating the two industry standard EPROMs most commonly used by the hobbyist — the 2732 and the 2764 (4K×8 and 8K×8 respectively) and has an emulation access time equivalent to that of a 250-300ns device.

Thus it is perfectly suited for use with 4MHz 280A based target systems (such as ETI Spectrum Co-processor CPU card), and indeed any application requiring such a medium speed EPROM.

Construction

Construction of the EPROM Emulator should not prove to be difficult, particularly if the recommended PCB (Fig. 3) is used. This is a double-sided board and requires a number of interconnections to be made between the two layers. (The board is not a through-hole plated PCB due to the excessive costs involved.) Use tinned copper wire pushed through the appropriate hole in the board and soldered in on both sides.

Many of the required through connections are made via the IC pins themselves, each time a copper track is connected to an IC pin on the component side of the PCB. In these cases (48 in all) the ICs must be soldered in on both the top and underside of the board.

This is straightforward if you plan to put the ICs directly into the board but can create problems if you decide to put the ICs into DIL sockets. Sockets must be employed which provide access for soldering to the topside of the PCB. This really means DIL sockets of the 'turned-pin' variety, designed in such a way that the base of the pin is visible on the component side of the PCB.

To fit these sockets, solder into place as normal from the underside of the board. Then solder in on the component side of the board but not directly with a soldering iron (it would be very difficult to avoid melting the plastic socket frames). The pins should be heated in turn from the underside of the board whilst dabbing fine solder onto the topside of the pin, until solder flows to form a good joint.

Once the through connections and the IC sockets (if used) are in place, the rest of the components can be inserted. No particular order is necessary, but it is always wise to put the semiconductors in last of all. Remember to put the LEDs, Q1, D1 and C1 in the right way round!

All that remains now is to fit the two connectors SK1 and SK2. SK1 is the edge connector for the Spectrum port and must be fitted so that one row of its pins are soldered to the topside of the PCB, and the other row to the underside.

The two rows of pins will probably need to be squashed together a bit, before fitting the connector to the board. The pins do not go through holes in the PCB, they lay flat against its surface and are soldered down by flowing solder onto the copper pad associated with each pin. Squashing the pins together can be achieved either using pliers or more easily, using a small vice. SK1 should then be slid onto the edge of the PCB and soldered into position.

The other connector SK2 sits at the other end of the PCB and provides the EPROM emulation connections. The pinout used is shown in Fig. 4. This connector should be simply inserted and soldered into place. For extra reliability, it is recommended that M2.5 nuts and bolts are used through the PCB to fix the socket in position.

This completes the construction of the PCB itself, but now we must look briefly at the cable assemblies which connect the target system to the emulator. Basically, these consist of a length of ribbon cable with an IDC header socket at one end to plug into SK2, and an IDC DIL header at the other end to plug into
the target system EPROM socket.

A different cable assembly is used depending on which size EPROM is being emulated, so you may need to make up two types.

Figure 5 shows the pinouts of the two types of EPROM we are seeking to emulate. The 2732 is in a 24-pin package, whilst the 2764 is in a 28-pin package. The pinouts are so designed that if you put the smaller device in the larger device's outline, matching up the ground pins, the rest of the signals correspond perfectly.

Obviously, the 2732 does not need as many signal connections as the 2764 but if the emulator provides all the connections for the larger device then the smaller device simply uses a subset of these signals. So, it is possible to make the required emulation connections to either device by only changing the size of DIL pod on the end of the cable assembly — no further signal switching is required.

Figure 5 also shows the construction of the two cable assemblies. Care must be taken to ensure that the DIL plug and the IDC header socket are fitted exactly as shown, particularly the latter which has a number of unused socket positions.

The length of ribbon cable used should not be much more than about 200mm, since the signals travelling up and down it are ordinary TTL levels, and are at quite high speeds. Any longer and the emulation could become unreliable. If it were necessary to have a much longer cable, then high-speed twisted pair line drivers would have to be used, but this is really beyond the scope of this simple project.

To actually fit the connectors to the cable, you should ideally use one of the special presses designed for IDC work. Not everybody has one of these(!) but with a little care it is quite possible to use a small vice to do the same job.

First the IDC connector should be loosely assembled so that it sandwiches the end of the ribbon cable. Then the two halves should be carefully squashed together in the vice, to make a permanent connection to the cable. Before the permanent connection is made, you must be absolutely sure that the ribbon cable is correctly positioned in the connector, because it is not easy to go back after the connector has been assembled.

It is worth then plugging it into the emulator and testing the connections from the PCB to the DIL pod with a continuity tester to make sure that correct and reliable links have been formed. One this has been done, we are ready to test the Emulator itself.

### Testing

Before plugging the board into the back of your beloved Spectrum, it is wise to check that there are no potentially damaging short circuits between the emulator's power and ground lines, using a multimeter on the ohms range. If there are, make sure that the shorts are found and eliminated before moving on.

Then take the plunge and push the emulator onto the expansion port of your Spectrum. Apply the power. The power indicator, LED 2, should light up and LED 1 (the emulation LED) should be off.

### BUYLINES

There are no special parts needed to build the emulator, and your usual supplier should stock most of the components required.

The miniature axial ceramic capacitors used in this project are available from Verospeed as order code 52-500520. Verospeed can be contacted at Sunstead Road, Boyatt Wood, Eastleigh, Hants SO5 4ZV. Tel: 0705 644555.

Suitable DIL sockets for soldering on the topside of the PCB should be commonly available, but try the turned pin range from Maplin if uncertain. Maplin can also supply the Spectrum edge connector if required, order code FG23A.

The PCB is available from the ETI PCB service.
Fig. 4 IDC header plug pinout (viewed from pins)

If all is well, fit one of the emulator cable assemblies so that you can get at the 'EPROM' pin connections. Using a piece of wire or a croc clip, connect the Vcc pin on the EPROM pod (pin 28 for 2764, pin 24 for 2732) to +5V somewhere on the emulator card to simulate the power being applied to the target system. This should switch the emulator into emulation mode — LED1 should illuminate.

If the circuit has responded so far, the rest of the emulator can be tested (remove the test wire on the Vcc pin). Using Spectrum BASIC, poke a data value of 85 (dec) into the top location of the emulator (Spectrum address 57343). In binary, this data value has alternate one and zeros, and is thus great for finding stuck bits.

Next, put the emulator into emulation mode by reconnecting the Vcc wire. The data just loaded into the RAM can be looked for at the pod by pulling the 'EPROM' CE and OE lines low using further wires. At this point it becomes convenient to plug the pod into a solderless breadboard or similar to make the necessary connections. If you do not have such a thing plug the pod into an IC socket and solder test wires to the pins.

Since unconnected TTL input lines float at the logical high level, leaving the emulation address inputs open circuit on the pod will address the highest location in the RAM; this is where we put our test data previously. So, using a voltmeter or a scope, it should be possible to look at the data bits coming out of the emulator pod one by one, checking that they are correct.

If all is well, try loading a value of 170 (dec) into the same location (this value in binary is the same as the last but with the ones and zeros swapped), and check for the correct bits on the pod data pins. If you are using a plug-in breadboard to test the emulator, it is quite easy to check a few more addresses besides the top location — simply pull down some of the address pins on the pod to 0V, having picked suitable test data into the RAM. This is certainly worth trying.

After all this static testing the real proof that the emulator is working must be to try it in a real target system, after loading real executable code into it.

Use
Using the emulator in a real target system is very simple, so long as a few basic rules are obeyed. With the target system unpowered, and the emulator connected to both the Spectrum and the target board, code should be assembled/compiled into the appropriate area of Spectrum RAM.

For 2732 emulation, the starting address in the Spectrum should be 53248 (dec). For 2764 emulation, the starting address in the Spectrum should be 49152 (dec).

One vital thing to remember is that these starting addresses are equivalent to address zero in the...
EPROM — the whole 'EPROM' contents are offset in the Spectrum memory by an amount equal to these starting addresses.

If your assembler allows you to assemble object code into a different area of memory to the runtime locations, then you are lucky. Simply write the source code from the target system's point of view starting at address zero, and then assemble it into the Spectrum memory starting at the addresses listed above.

**PARTS LIST**

<table>
<thead>
<tr>
<th>RESISTORS (all Ω W 5%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, 8, 10</td>
<td>10k</td>
</tr>
<tr>
<td>R2, 3, 5</td>
<td>47k</td>
</tr>
<tr>
<td>R4, 11</td>
<td>220R</td>
</tr>
<tr>
<td>R8</td>
<td>330R</td>
</tr>
<tr>
<td>R9</td>
<td>68R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAPACITORS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>47µF 10V axial electrolytic</td>
</tr>
<tr>
<td>C2, 3</td>
<td>100µF miniature axial ceramic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEMICONDUCTORS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1:3, 8, 10</td>
<td>74LS244</td>
</tr>
<tr>
<td>IC4</td>
<td>6264 — 150ns Bx h CMOS sRAM</td>
</tr>
<tr>
<td>IC5</td>
<td>74LS10</td>
</tr>
<tr>
<td>IC6</td>
<td>74LS27</td>
</tr>
<tr>
<td>IC7</td>
<td>74LS14</td>
</tr>
<tr>
<td>IC8, 2, 3</td>
<td>8051</td>
</tr>
<tr>
<td>LED1, 2</td>
<td>Green/Red LED 3mm diam</td>
</tr>
<tr>
<td>LED3</td>
<td>74HC14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MISCELLANEOUS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1</td>
<td>Edge connector for Spectrum</td>
</tr>
<tr>
<td>SC2</td>
<td>34 way PC mounting right angled IDC header plug</td>
</tr>
<tr>
<td>SC3, 4</td>
<td>38 way PC assembly, EPROM, PCB</td>
</tr>
<tr>
<td>SC5, 6</td>
<td>Copper wire for through connections M2.5 nuts and bolts for PCB</td>
</tr>
</tbody>
</table>

Unfortunately, the majority of software development tools for the Spectrum cannot handle such complicated concepts (!), being much less powerful than proper professional development software (though of course much cheaper!).

The only problem this does create concerns the assembler generated addresses in the executable code. Obviously, you must assemble the code into the Spectrum starting from the addresses listed above. As far as the target system is concerned, all the absolute addresses generated by the assembler in the resulting object code will have an inbuilt offset equal to that starting address. If you are able to make your code relocatable by using only relative addressing, then there is absolutely no problem. However, if you are forced to use absolute addresses in your program, then it will be necessary to correct them by hand, subtracting the Spectrum start address before download.

This whole problem could have been overcome during the hardware design, by mapping the emulator into the area of Spectrum memory starting at zero instead of where it is. Unfortunately, most assemblers for the Spectrum will not allow assembly into that part of the memory map, since that is where the Spectrum operating system EPROM sits. Despite the problem with offsets, the actual method used at least guarantees that the assembler will work!

Once the code has been assembled, the power can be applied to the target system and (assuming that the program is correct) it should spring to life. Further downloads can then be achieved by simply repeating the above process again.

One interesting possibility worth noting concerns EPROM programmers. Once the final working version of your software is available, having developed and tested it using your EPROM emulator, it is possible to use the emulator as the source of the data for an EPROM programmer. After downloading the code into the emulator, the pod can be plugged into the programmer and the data read out, just as if you were copying a real EPROM. This provides an easy means for the transferral of code from the Spectrum to the programmer, without using messy serial links and the like.

Just one extra reason for building this simple but effective development tool!
Digital Train Controller

This is a pulse type train controller that is primarily intended for computer control. Although the range of available speeds is rather limited (stop, full speed, and two intermediate) the transition from one speed to the next has been made very gradual to avoid any unrealistic jumps in speed. The circuit can easily be modified to provide a greater range of speeds if desired.

The unit provides a variable average output voltage by varying the mark-space ratio of the output signal. Provided a suitable output frequency is used, this type of signal is suitable for driving DC electric motors. In fact, it gives very good results, fine speed regulation and immunity from stalling at slow speeds.

This circuit uses a standard pulse width modulator with IC1 to provide the triangular clock signal, and IC2 operating as the voltage comparator. The clock frequency is just over 200Hz, which seems to give good results with any small DC electric motor.

With the voltage at the non-inverting input (pin 2) of IC2 half way between the peak to peak voltages of the clock signal, the output signal is a square wave having a perfect 1:1 mark-space ratio. Taking this input voltage higher results in it being exceeded by the clock signal for a smaller percentage of the time, and the high output period becomes longer than the low output time. Reducing the input potential has the opposite effect. This gives the desired result, with an average output voltage that is proportional to the control voltage.

Q1 and Q2 form a complementary emitter follower output stage that enables the unit to handle output currents of up to a couple of amps. Q2 is not strictly necessary but with D1 it helps to suppress voltages generated by the motor when Q1 is switched off. As Q1 operates in a switching mode, it only requires a small bolt-on heatsink. Q2 does not require a heatsink at all.

For straightforward manual control a potentiometer circuit to drive pin 3 of IC2 is all that is required. For computer or digital control it is needed, and a very simple and inexpensive 2-bit circuit can be used.

The state of the signals at inputs 1 and 2 alter the resistive network determining the signal fed into IC2, and therefore the speed of the train. With both inputs at 0, Q3 and Q4 are off so that R8 and R9 provide a high enough control voltage to keep the controller output continuously high.

Applying a logic 1 signal to input 1 or input 2 shunts either R10 or R13 across R9, giving a lower control voltage and a lower average output voltage. As R10 and R13 have different values, the two logic inputs provide different speeds. Taking both inputs to logic 1 produces a very low average output voltage, and the train halts.

More transistor drivers and shunt resistors can be added to give a greater range of speeds. The transition time between speeds is proportional to the value of C4 and is easily changed.

A reasonably smooth and stable 15V supply, with current limiting to protect the unit against the inevitable short circuits on the output, is provided by a simple smoothing and regulator circuit fed from the 'raw' 12V DC output of a train controller. Direction control can be provided manually via a DPDT switch, or under computer control via a relay and driver circuit.

Two-colour Signal

This two-colour red/green signal is automatically operated by the train via sensors on the track. There are several ways of sensing the train as it passes but the two most simple and reliable methods are to use micro or reed switches.

I prefer reed switches positioned just under the track, activated by a magnet mounted just above the track level on one of the pieces of rolling stock. Sometimes the DC motors used in locomotives will activate the reed switches but in most cases a small bar magnet must be added to each train by the constructor. Note that the reed switches are activated when parallel to a bar magnet and not when one pole of a magnet is applied to them. Switches should be mounted lengthwise along the centre of the track, with the magnet mounted lengthwise along the middle of the floor of a piece of rolling stock. The distance between them probably needs to be about 10 millimetres or less — this should be possible without continual
derailment.

The purpose of the sensors is to set the signal to red as it is passed by a train and then to reset it to green when the train has progressed to some point further along the track. The circuit is basically just a S-R flip-flop built around IC1b and IC1c. The other two gates of IC1 are wired as inverters and used as buffers at the outputs of the flip-flop.

SW1 is the red switch near the signal and when this is activated it sends the output of IC1a high. This switches on Q1 and the red signal LED1. SW2 is further along the track, and returns the output of IC1a to the low state. It also sends IC1d high activating LED2, the green signal.

Two-tone Horn

This sound effects unit is designed to simulate the sound of a two-tone horn, as used on many diesel and electric locomotives. This is the type of horn that goes up about a fifth in pitch (about 50% higher in frequency) after the initial tone. The basic sound is not just a simple tone, and is actually a quite complex signal.

Accurately simulating an intricate sound of this type is far from easy but results here are about as good as you are likely to obtain from a simple circuit and loudspeaker of about 65mm in diameter! Unless you are a steam only fanatic, it should certainly add a bit more realism to your model railway layout.

The basic audio signal is generated by a 555 timer (IC1) used in the standard astable circuit. It drives a miniature high impedance loudspeaker via common emitter amplifier Q2. L1 must have an impedance of 64Ω to 80Ω and must not be a low impedance type. The oscillator’s operating frequency works out at approximately 550Hz but we are using frequency modulation applied via pin 5 of the device and it does always operate at this frequency.

The horn starts fractionally flat, and moves up in normal operating pitch over a period of around 910ms, regulated by C1 charging up through R1.

Problems with spurious triggering due to switch bounce or stray electrical noise in the connecting cables are counteracted by R4, C2 and R6, C3. If manual override is required, add push-button switches in parallel with SW1 and SW2.

It should be possible to control a ready-made signal, but LED types will probably incorporate current limiting resistors and R1 and R8 will then be unnecessary. The unit should also be able to control sub-miniature 12V filament bulbs in the same way, but the bulb current should not exceed about 200mA.

A 9 or 12V battery is the easiest source of supply. IC2 and C4 to C6 are only needed if the unit is fed with the raw 12V DC output of a train controller.

Pin 5 of IC1 must be pulled lower in voltage in order to raise the output frequency and give the two-tone effect. This is provided automatically just under a second after switch-on by IC3, a quad 2 input NOR gate which has three of its gates connected to operate as a monostable with an output pulse duration of around 800ms. This is triggered at switch-on by C7 and R8 but, as it provides a negative output pulse, Q2 is initially switched off. It is turned on when the output pulse ends and it then pulls pin 5 of IC1 lower in voltage by an amount that is controlled using RV2. In practice RV2 is adjusted ‘by ear’ to give the correct second tone from the unit. C5 gives a smoother transition to the higher pitch for a slightly improved effect.

The second 555 oscillator is used to enrich the sound and its output is mixed with the main tone signal at a much lower level. Frequency modulated in exactly the same way as the main tone generator. It is probably best to initially leave one terminal of R9 unconnected so that RV2 can be adjusted with only the main oscillator driving the loudspeaker. With R9 connected, RV1 can be adjusted for the best effect. This will probably be with the second oscillator just slightly off-tune from the main one, or perhaps with the second oscillator set about a fifth higher.
Three-colour Signal

This signal is similar to the two-colour type but controls a three-colour (green, amber and red) signal and requires an additional track sensor.

The signal changes from green to red as the train passes the sensor next to the signal. The sensor further along the track sets the signal to amber, and a third sensor still further along the track brings it back to green again. Like the two-colour signal, the sensors can be micro or reed switches.

Cycling Three-colour Signal

Similar to the three-colour signal, this circuit cycles continuously under the control of a built-in clock oscillator, and it does not use track sensors at all. It is not so much a matter of the train activating the signal as the operator having to control the train so that it obeys the signal. The colour sequence of the signal is slightly different, with a green — amber — red — amber — green sequence. In order to avoid a lot of inactivity (and boredom) the signal has the colours weighted in favour of green.

Again this circuit is based on a 4017BE one of ten decoder (IC2). In this case though, all ten outputs of the device are utilised. Outputs 0 through to 5 drive the green LED1, outputs 6 and 9 drive the amber LED2, and outputs 7 and 8 control the red LED3. This gives the required colour sequence with heavy weighting in favour of a green signal. Rewiring diodes can alter the weighting or colour sequence if desired.

A low-frequency clock signal is required, and this is provided by a standard 555 astable circuit. RV1 enables the clock frequency to be adjusted from a little over 1Hz to under 0.25Hz. This equates to a complete cycle time of between about 10 and 40 seconds but a longer cycle time can be achieved by making C2 higher in value. Note that C2 must be a high-quality (low leakage) type due to the high timing resistance values used in the circuit. Any plastic foil type should be suitable but electrolytics are not recommended.

The notes on power sources for the two and three-colour signals apply equally to this design. RV1 may have to be a large preset, as sub-miniature types in this value (4M7) can be difficult to obtain.
Points Controller

Some model railway points are purely mechanical but electric points are now a standard accessory. These are mostly very basic and are really just a manual point with the addition of a couple of solenoid mechanisms giving the option of manual operation or electric remote control using a form of changeover switch plus a 12V DC supply.

The points have three terminals, one of which is a common terminal wired to one supply rail. The other terminals are wired to the other supply rail via the changeover switch which selects the desired solenoid. By alternating this switch the points can be repeatedly set and reset.

The changeover switch is slightly non-standard in that it is spring-loaded to a central off position, so that ordinarily it does not supply power to either solenoid. This is an important point, as the solenoid currents are quite high. Applying power for more than a second or two risks burning the solenoid out. These points are not always totally reliable in operation and the addition of a simple capacitive discharge circuit improves this and totally removes the risk of applying excessive power to the solenoids in an attempt to force operation.

In this points controller circuit the input supply is fed to a high value capacitor C1 by way of current limiting resistor R1. R1 keeps the current at no more than about 25mA, which should be well short of the current needed to cause over-heating. It is also well short of the current need to drive the point from one setting to the other! This does not matter though, because C1 will charge to virtually the full input supply voltage, and can supply a large enough burst of current to reliably operate the points. The extremely low source impedance of a capacitor means that the large pulse of current normally removes any tendency for the points to stick.

The solenoids can simply be driven from across C1 by way of the changeover switch. However, things can be refined a bit further, as in this circuit. The switch selects one of two Darlington power devices (Q1 or Q2) which control the solenoids. R1 and R3 limit the base currents and result in the switch only handling very small currents. This eliminates any problems with contact sparking reducing the operating life of the switch. A miniature toggle type which is spring-loaded to a central off position is perfectly suitable for SW1.

D1 and D2 protect Q1 and Q2 against any high reverse voltage spikes generated across the solenoids as they are switched off. Q1 and Q2 do not require heatsinks. Also note that it takes a second or so for C1 to recharge after the unit has been used and that the controller cannot function until C1 has almost fully recharged.

---

NO HOLDS BARRED

The bar code competition in the July issue attracted a large number of entries. We never knew so many readers were fluent in checkout-speak and baked-bean-ian. The lucky winner was Jim McCarthy of Wokingham who correctly decoded the bar and guessed the secret message held therein. A year's free subscription to ETI goes to Mr McCarthy. The explanation of the bar code is given below.

The bars were encoded in the standard EAN 13-digit code as used on baked bean cans in the supermarket. This is in two sections with six figures in each section and a barrier code (101 or bar-gap-bar) between them and at each end. The pattern of figures in the first section gives an additional figure at the beginning of the code. The last figure is a checksum.

---

ETI SEPTEMBER 1988
FREE READERS' ADS

Buy, sell or exchange through our free service to readers

RS COMPONENTS STE BUS computer system. Five cards with 19in instrument case and PSU. All untested. £200. Tel: Jnr 041-334 0802.

WANTED: Modern dual beam oscilloscope minimum 15MHz and mono headphones with impedances - 1k to 4k. Phone D. E. Jones 01-249 4829.

TANGERINE DISK SYSTEM wanted. Also Tanram. Good price paid. Tel: (0786) 852939 after 6.00pm.

ONYX COMPUTERS bits, software, books wanted. Please contact Nick Hacking, 9A Bowmont Terrace, Glasgow G12 9LP. Tel: 041-339 1575. Thank you.

FISHER hi-fi cassette (single) with Dolby £39 ONO. Also Goodmans turntable; semi auto only £39 ONO. Ring David (0924) 498248.


OSCILLOSCOPE Hameg HM204, dual trace, DC-20MHz triggering; DC to 50MHz, component tester, sweep delay. As new £330. Essex (0375) 84759.

C64 and 1541C drive plus software. Computer needs some repair. Both for £175. Contact R. Nicoll, 40 Ridgehill Avenue, Sheffield S12 2G1.


SUPERB QUALITY PSU. Ex-equipment, easily upgradable to 5A @ 7A, -12V @ 2A, plus additional 18V 7A AC. Cardframe. WWPCB, UART, 17025, RS232. £35. Tel: (0892) 83590.

OLIVETTI MICRODOLES COMPUTER program £49. Advance dual trace 10MHz scope £150. Quantity TV/hifi video manuals, as new £100. 01-897 9603.

COMMODEOR + 4, drive, printer, many extras. VGC £250 ONO. Phone 021-422 3344 (after 6pm).

WANTED - RML 380Z boards/keyboards in working order. Phone 021-422 3344 (after 6pm).

WATFORD, 'LE MODEM' communications modem, suit BBC computer etc. complete in original packing with manual, disk. £65. Ring Woking 72120.

CAPACITY AND RESISTANCE BRIDGE, Hunts, also checks insulation and leakage resistance, good working condition. Ring Woking 72120.

SIGNAL GENERATOR, RF. Advance model E2, 100kHz to 100MHz, internal 400Hz modulation. Fine/ coarse attenuator. Clean condition. £30. Phone Woking 72120.

OSCILLOSCOPE, doublebeam, Scopex 4D10A, 10mV sensitivity, 10MHz bandwidth, TV field and ext. Trigger. Clean, working condition. Phone Woking 72120.

COMPUTER TERMINAL Televideo 970, RS232 coms, printer port, software setup via menu, only £80. Tel: (0206) 845450.

WANTED: UK101 disk drive, DOS and manual, also Bas 3 with improved garbage routine. Steve (0803) 842166, after 6.00pm.

CIRCUIT DIAGRAMS, PCB foils, Vero layouts, etc, wanted on electric guitar effects, preamps. A Tiffany, 9 Grange Park Avenue, Raheny, Dublin 5, Ireland.

DIABLO SERIES 30 15in front loading hard disk drives 3 @ £10 each. Disks 50p each. Waterloo Ive (0705) 266856 evenings.

IC DATA WANTED: HA11711, AN214, SH, Mordi PO Box 17445-165 Tehran, Iran.

SOLARTRON DVM CT469 laboratory precision voltmeter with many features but needs recalibrating. Not a pocket model £15. Ring Bradford 736106.

LENSO TRANSCRIPTION TURNTABLE variable speed. 18-87 RPM. Phone Nuneaton (0203) 327341.

REQUEST INFORMATION wiring diagram for Tandberg language system, 5000 (student tape deck) any costs met. Ring William Angus Ashington (0670) 855135.

ADVANCE TYPE F MODEL 1 A/F generator Triplet 1632 sig. Gern 200 kHz, 120MHz frequency meter, BC221AH leak trough line tuners. Offers. Tel: (0308) 897625.

WANTED: Circuit diagram for GEC Soundec music centre. 5 Spectrum power supplies, 9V 1.4 amps £15. J Bakewell. 21 Newhams Rd. Barrow-in-Furness, Cumbria LA13 9SG.

CLEF ELECTRONIC PIANO six octave, fully touch sensitive, complete with integral amplifier, £495. Tel: (0786) 661391.

GEORGE BRAY limited brass encased elements 240V 650W, 9in x 5in dia (trade price £42 47 + VAT). New for sale £50. Tel: (0274) 593382.

WANTED: SUPERBRAIN computer for spare drives. Must be cheap, any offers? V. O. Loan, 8 Springwood Avenue, Stirling.

SPECTRUM 48K, LMT68FX2 keyboard, Swiftdisc drive, joystick, printer port, books, magazines. Over £1000 software on disk, £320 ONO. Twickenham 01-894 3982.


EDDYSTONE 730/4 communications receiver 480kHz-30MHz with BFO, includes manual, ideal for SWL. £100 ONO. Tel: John 01 397 7931 evenings.

NON-WORKING CALCULATORS. Keypads suitable combo-lock project (ETI April 88) £1 including postage. Dave Edwards, 5 Vulcan St., Aberystwyth, SY23 1JH. Tel: (0970) 624671.

TOA 100w PA system, 6 horn speakers, mike, £100. Also XY recorder £75. ONOs. 021 426 1197.

WANTED old wireless set in Balakite cabinet. Need not be in working order but cabinet must be in VGC please. Phone (0752) 671277 evenings.

AVO Mk8 MULTIMETER 31 scales complete with probe set £80 Phone (0359) 50634.

Ads should be 20 words or less including the address and/or telephone number. Please write in black block capitals or type in the grid provided on this form or a photocopy.

Send the form to: FREE READERS' ADS
Electronics Today International 1 Golden Square London WIR 3AB

Enter your advertisement below

CONDITIONS
- These ads are only for ETI readers not engaged in buying or selling the same items or services on a commercial basis.
- Ads will be inserted as and when space permits. Insertion in a specific issue cannot be guaranteed.
- ETI reserves the right to alter or refuse ads whenever this is judged necessary.
- All ads are accepted in good faith. Neither the magazine nor its publishers can be held responsible for any errors in the reproduction of ads, nor for untrue or misrepresentations, nor for the activities of advertisers or respondents.
- Advertisers submitting ads for this section shall be deemed to have accepted these conditions.

ETI SEPTEMBER 1988

www.americanradiohistory.com
ETI PCB SERVICE

Miss out the mess with ready-made pre-drilled PCBs for ETI projects

Use the form (or a photocopy) for your order. Please fill out all parts of the form.

Make sure you use the board reference number. This not only identifies the board concerned but also tells you when the project was published. The first two numbers are the year of publication and the next two the month. The number after the dash indicates the particular project in that issue.

Terms are strictly payment with order. We cannot accept official orders but we can supply a pro forma invoice if required. Such orders will not be processed until payment is received.

Please make cheques out to ASP Ltd. Payment can also be made through Access and Visa cards by telephone on (0442) 41221.

Send your order to:
ETI PCB Service, ASP Readers Service, 9 Hall Road, Hemel Hempstead HP2 7BH

<table>
<thead>
<tr>
<th>Price code</th>
<th>Price (inc. VAT)</th>
<th>Price code</th>
<th>Price (inc. VAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>£1.80</td>
<td>N</td>
<td>£13.10</td>
</tr>
<tr>
<td>D</td>
<td>£2.50</td>
<td>O</td>
<td>£15.80</td>
</tr>
<tr>
<td>E</td>
<td>£3.25</td>
<td>P</td>
<td>£17.90</td>
</tr>
<tr>
<td>F</td>
<td>£4.00</td>
<td>Q</td>
<td>£21.80</td>
</tr>
<tr>
<td>G</td>
<td>£4.75</td>
<td>R</td>
<td>£23.90</td>
</tr>
<tr>
<td>H</td>
<td>£5.50</td>
<td>S</td>
<td>£25.90</td>
</tr>
<tr>
<td>J</td>
<td>£6.62</td>
<td>T</td>
<td>£29.00</td>
</tr>
<tr>
<td>K</td>
<td>£7.20</td>
<td>U</td>
<td>£32.20</td>
</tr>
<tr>
<td>L</td>
<td>£8.80</td>
<td>V</td>
<td>£35.80</td>
</tr>
<tr>
<td>M</td>
<td>£10.60</td>
<td>X</td>
<td>£40.70</td>
</tr>
</tbody>
</table>

Price (inc. VAT)

Please supply:
Quantity Ref. no. Price Code Price Total Price

Post and packing £0.75
Total enclosed £

Please send my PCBs to:(BLOCK CAPITALS PLEASE)
Name
Address
Postcode

ACCESS and VISA credit card orders can be taken on (0442) 41221 during office hours.

ETI SEPTEMBER 1988

www.americanradiohistory.com
Printer Buffer (November 1987)
The listed software for the EPROM has three errors. The byte at 039A should be 2D, at 039B it is 14 and at 0492 30 (all hex). Connections to 21c and 22c in the circuit diagram disagree with Table 1. The table is correct. C3-28 are 10nF as listed in the parts list and not 10n as in Fig. 2. C1 is orientated with the positive terminal to the right.

Dream Machine (December 1987)
The transistors used in this project are ST1702 BC108s can be substituted.

Heating Management System (December 1987)
A 4116 is not a suitable alternative to the 6116 specified. A 4016 RAM chip will suffice. In Fig. 1 the junction of R1/D5 should connect to D1/4/C1 and not cross. The zener diodes above the temperature sensor ICs (IC16-19) should be deleted. C4 should be 220n and not 22u. C7-10 should be 10µ. Q2-7 should be 2N3904 and not BC3904.

RGB Auto-Dissolve (January 1988)
In Fig. 5 there are marked two D6s. The right hand one should be D5 (they are both 1N148S anyway). In the text the reference to zener diode D5 should read D1.

Power Conditioner (January 1988)
There is confusion between the values of R7 and R8 in the Parts List and Fig. 1. These should be: R7 27k, R8 10k and not as given in the Parts List. In addition ZD1 is incorrectly orientated in Fig. 3. The positive terminal should be at the southern end.

Passive Infra-Red Alarm (January 1988)
Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

Transistor Tester (February 1988)
The foil pattern for the main board was printed reversed left-right on the foil pages.

Spectrum Co-processor (March 1988)
Mogul Electronics, given in the Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Dynamic Noise Reduction (May 1988)
The LM1894 is no longer available from the sources listed but it can be obtained from the author, Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

QL Output Port (Tech Tips May 1988)
Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pins 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.
PCB Foil Patterns

The frequency meter main board foil pattern
**Hi-Tech Adhesives**

**Your Chance to Try Out a Range of Modern Adhesives at Bargain Prices**

**Hi-Tech Adhesives**

**Trial Pack of 5 Types at Bargain Price £9.95 + P&P**

**Thin Cyanocrylate**

Low viscosity instant adhesive bonds rubber, plastic, metal, wood, etc.

*20 gram bottle.*

**Thick Cyanocrylate**

Higher viscosity instant glue, good gap-filling properties.

15-20 second setting time.

*20 gram bottle.*

**Flexi Epoxy**

Totally new type of adhesive, has good vibration absorbing properties and just a little 'give'.

*40 gram twin pack.*

**Rapid Epoxy**

Class C fret-set (10-15°C min) epoxy tough enough to use as general purpose adhesive.

*40 gram twin pack.*

**Threadlock**

General purpose threadlocker, compound prevents screws, nuts, etc. from vibrating.

*20 gram bottle.*

To: A.S.P. Readers Services, 9 Hall Road, Maylands Wood Estate, Hemel Hempstead, Herts. HP2 7BH. Telephone: 0442 41221

Please send me Adhesive Packs ADH @ £9.95

U.K. Inland Postage: 50p

I enclose cheque/P.O. payable to A S P Ltd

Please debit my Barclaycard/Access Account Number ____________

---

**Henry's**

Electronics for Trade, Industry, Export, Education and Retail

*Instruments*
- Scopes
- Counters
- Digital Multimeters
- PSUs
- Generators etc.

*Communications*
- Intercoms
- CB radio

*Security*
- Panels
- PIRs
- Sirens
- Doorphones
- Strobes

*Public Address*
- Speakers
- Amplifiers
- Mixers
- Mics etc.

*Components*
- Huge stocks also
- Tools
- Cables etc.

*Accessories*
- TV-Video amplifiers
- Audio
- TV/video security
- CB radio accessories

**Free! Illustrated Catalogues with Retail Discount Vouchers**

Please state Trade/Education or Retail/mail order and enclose 9" x 4" SAE £1.00 each or £1.50 for both.

Henry's
404 Edgware Road, London W2 1ED

Tel: 01-724 0323

Also at Audio Electronics 301 Edgware Road W2 01-724 3564

Sales Office 01-258 1831 Telex 298102 Fax 01-724 0322

**A.S.P. Readers Services**

A.S.P. Readers Services, 9 Hall Road, Maylands Wood Estate, Hemel Hempstead, Herts. HP2 7BH. Telephone: 0442 41221

Hi-Tech Adhesives

Your chance to try out a range of modern adhesives at bargain prices

To: A.S.P. Readers Services, 9 Hall Road, Maylands Wood Estate, Hemel Hempstead, Herts. HP2 7BH. Telephone: 0442 41221

Please send me Adhesive Packs ADH @ £9.95

U.K. Inland Postage: 50p

I enclose cheque/P.O. payable to A S P Ltd

Please debit my Barclaycard/Access Account Number ____________

---

www.americanradiohistory.com
CLASSIFIED

Heather Wust
01-437 0699 Ext 292
Send your requirements to:
Heather Wust, ETI Classified Department, ASP Ltd.,
1 Golden Square, London W1.
Lineage: 54p per word VAT inclusive (minimum 15 words)
Semi Display: (minimum 2 cms)
£12.80 per single column centimetre + VAT
Ring for information on series bookings card (available on request)

SPECIAL OFFERS

CASSETTE MOTORS large and small 2 for £1.00. Mono and stereo cassette tape heads. 2 for £1.00. Microphone small for cass. tel, etc. 2 for £1.00. Telephone buzzers at £2.50 each. Please add 75p p&p no VAT. Access card accepted. Golden Orange Supplies, Brockhall

FREE MEMBERSHIP to the NATIONAL COMPONENT CLUB
For details and a free gift of components worth over £10 send only £1.00 pp to: Higher Asford, Castle Carv, Somerset BA7 7JQ

SECURITY ALARMS. Power amplifiers £5.10W @ 12V/1m and 40W @ 40V/150m2 reliable + circuit!! 100W slave £10. built: KIA-8, Cumilffe Rd. Ilkley LS29 GIVEAWAY NEXT MONTH ... IT'S AMAZING!!

J.P.G. ELECTRICALS
Resistors 1/4%, 5%, carbon, 1W. Pack £4,4 or 4/1W 5%, metal film £1 per 50, includes delivery, current of order 1000. £9.00 1.25% Res. 0.25W. £16.50 1/4W.
Bipolar Transistor £1.75. Top. £1.85. £9.50 R7400. £5.75 10N50-9R2/10N14-9R2 FREE on order. Filters £1.50.
70mm Disc Rolls: £1.25 each, £13.00 for mixed £5.00 or 30p each.
COOKS, Mode-outp national components FREE (02572) 2400. £9.50 4x12, £16.40 3x14. £29.00 8x15, £54.00 5x16.
Stagger meter 4 phase £1.75 each 50V/200a. 85p. £9.50. SAA, E/DY piping over 20m. 65p. 50p.
Mineral PM Transformers: 100. £600. £800. QTY quality control. Incl. delivery. £6.50 each. £17.00 R10N5. £17.45 for 10NE
1W free pack.
Used Spares.
Useful Components for triodes with 3/4W/6. £1.45
Hunt card order: 50G.
Automatic Switchgear wire copper £3.65
SPECIAL OFFERS:
Coaxial plate capacitors with 3/4W terminations 16000p at £1.40. £8.00 £1.00 30p. £15.00 £1.40 75p. £35.00 £2.40 FREE on order.
Stagger meter 2 phase £1.25 each 50V/200a. £8.50. £9.50. SAA, E/DY piping over 20m. 65p. 50p.
Mineral PM Transformers: 100. £600. £800. QTY quality control. Incl. delivery. £6.50 each. £17.00 R10N5. £17.45 for 10NE
1W free pack.
Automatic Switchgear wire copper £3.65

FROM DINKY TWEETERS TO MASSIVE WOOFERS
They are all in our latest illustrated catalogue of quality speakers and accessories. Send today only 75p (refundable against first order). Fail by return service.

STRACHAN ELECTRONICS (ET55), 9 Croall Place Edinburgh EH7 4LT

TO ADVERTISE HERE
01-437 0699

FOR SALE

GWM RADIO LTD, 40/42 Portland Road, Worthing, Sussex BN11 1QN. Tel: (0903) 34667. Special purchase powers. Some-one international series type HS15 - 1.5A output 15 VDC at 1.5A, unassembled with spec sheet, open frame case, £15 inc pp. Goul Ecometrix type EX5-20n, open-frame - switch mode - output 5V at 20A, unassembled with spec sheet, £30 inc p&p.

TO CLEAR. Part stripped equipment, ex-government. Hobby books, manuals, etc. Ring Chorley 75769 (02572) 24 hrs.

THE SCIENTIFIC WIRE COMPANY
811 Forest Road, London W17
Telephone 01-531 5588
ENAMELLED COPPER WIRE
SWG 18 16 8 4 2 oz
9.94 30.3 40.3 60.3 80.3
35.3 33.0 33.0 33.0 22.0
30.0 27.3 27.3 27.3 20.9
40.0 30.6 30.6 30.6 23.3
48 19.6 16.8 16.8 16.8 13.0
SILVER PLATED COPPER WIRE
14 to 30 10 to 15 5 to 10 TINNED COPPER WIRE
14 to 30 10 to 15 5 to 10 50p Free Postage & P+P of 10. Orders under £10.00 50p
SAA for all of copper and tinned wire.

S.H. COMPONENTS presents 18 pages of very competitively priced semiconductors, switches, optoelectronics, etc. plus sample, send 85p to: 17 Beeley Road, Grimsby, S. Humberseide

NEIGHBOURHOOD WATCH
BURGAL ARM A.L.Y. KIT
will offer a professional system at a DIY price
Ham mini beam 10, 15, 20 metres. Parts integrated circuits, transistors, diodes, valves, resistors, etc.

Service Manual and parts for Spectrum and Amstrad
Send a 8" x 5" SAE for list.
M.J. SEAWARD (Mail Order)
Dept (ET), St. Olafs Road, Stratton, Nr. Bude, Cornwall. Telephone: 0288 4892

NEGLIGENCE SURPLUS EQUIPMENT

ANCHOR SURPLUS LTD.
The Cattlemarket, Nottingham NG2 3GY Tel 0602 864902
The UK's Largest Genuine Government Surplus Dealer

Always a large stock of Radio, Test, Service and General Equipment in stock. Pye, Racal, Marconi, Tek Rediton, Plessey, Mullard.

SPECIAL: Edcstone 730/4 1-30MHz RX £75 - £110. Pye PF2 LB FM from £25. Phone Rob (G4ROB) For Details.

GWM RADIO LTD, 40/42 Portland Road, Worthing, Sussex BN11 1QN. Tel: (0903) 34667. Special purchase powers. Some-one international series type HS15 - 1.5A output 15 VDC at 1.5A, unassembled with spec sheet, open frame case, £15 inc pp. Goul Ecometrix type EX5-20n, open-frame - switch mode - output 5V at 20A, unassembled with spec sheet, £30 inc p&p.

TO CLEAR. Part stripped equipment, ex-government. Hobby books, manuals, etc. Ring Chorley 75769 (02572) 24 hrs.

THE SCIENTIFIC WIRE COMPANY
811 Forest Road, London W17
Telephone 01-531 5588
ENAMELLED COPPER WIRE
SWG 18 16 8 4 2 oz
9.94 30.3 40.3 60.3 80.3
35.3 33.0 33.0 33.0 22.0
30.0 27.3 27.3 27.3 20.9
40.0 30.6 30.6 30.6 23.3
48 19.6 16.8 16.8 16.8 13.0
SILVER PLATED COPPER WIRE
14 to 30 10 to 15 5 to 10 TINNED COPPER WIRE
14 to 30 10 to 15 5 to 10 50p Free Postage & P+P of 10. Orders under £10.00 50p
SAA for all of copper and tinned wire.

S.H. COMPONENTS presents 18 pages of very competitively priced semiconductors, switches, optoelectronics, etc. plus sample, send 85p to: 17 Beeley Road, Grimsby, S. Humberseide

NEIGHBOURHOOD WATCH
BURGAL ARM A.L.Y. KIT
will offer a professional system at a DIY price
Ham mini beam 10, 15, 20 metres. Parts integrated circuits, transistors, diodes, valves, resistors, etc.

Service Manual and parts for Spectrum and Amstrad
Send a 8" x 5" SAE for list.
M.J. SEAWARD (Mail Order)
Dept (ET), St. Olafs Road, Stratton, Nr. Bude, Cornwall. Telephone: 0288 4892

NEGLIGENCE SURPLUS EQUIPMENT

ANCHOR SURPLUS LTD.
The Cattlemarket, Nottingham NG2 3GY Tel 0602 864902
The UK's Largest Genuine Government Surplus Dealer

Always a large stock of Radio, Test, Service and General Equipment in stock. Pye, Racal, Marconi, Tek Rediton, Plessey, Mullard.

SPECIAL: Edcstone 730/4 1-30MHz RX £75 - £110. Pye PF2 LB FM from £25. Phone Rob (G4ROB) For Details.
COURSES

ELECTRONICS TECHNICIANS FULL-TIME TRAINING

(ALL TIME COURSES APPROVED BY THE BUSINESS & TECHNICAL EDUCATION COUNCIL)

2 YEAR
BTEC National Diploma (OND)
ELECTRONIC & COMMUNICATIONS ENGINEERING
(Electronics, Computing, Televisions, Video, Testing & Fault Diagnosis)

1 YEAR
BTEC National Certificate (ONC)
ELECTRONIC ENGINEERING

1—INFORMATION TECHNOLOGY
(Electronics, Satellite TV, CD, Networks, Telecomms)

2—ELECTRONIC EQUIPMENT SERVICING
(Electronics, Televisions, Video, Cassette Recorders, CCTV, Testing & Fault Diagnosis)

3—SOFTWARE ENGINEERING
(Assembler, BASIC, PASCAL, CAD/CAM)

4—COMPUTING TECHNOLOGY
(Electronics, Computing Software, Microcomputer Testing Methods)

10 MONTHS
BTEC Higher National Certificate (HNC)
COMPUTING TECHNOLOGY & ROBOTICS
(Microprocessor Based Systems, Fault Diagnosis, A.E, Robotics)

ALL COURSES INCLUDE A HIGH PERCENTAGE OF COLLEGE BASED PRACTICAL WORK TO ENHANCE FUTURE EMPLOYMENT PROSPECTS

NO ADDITIONAL FEES FOR OVERSEAS STUDENTS

SHORT-TERM COURSES OF 6-12 MONTHS CAN BE ARRANGED FOR APPLICANTS WITH PREVIOUS ELECTRONICS KNOWLEDGE

O.N.C. 19th September 1988
FULL PROGRAMME FROM

LONDON ELECTRONICS COLLEGE (Dept EE)
20 PENNYWERN ROAD, EARLS COURT,
LONDON SW5 9SU. Tel: 01-373 8721.
DEADLINES

Next copy Deadlines are:

NOVEMBER ISSUE 19th August 1988
DECEMBER ISSUE 20th September 1988

TERMS & CONDITIONS

CLASSIFIED ADVERTISING

TERMS & CONDITIONS

Our terms for new advertisers (see below) are:
- Advertising is strictly non-returnable
- Minimum charge for display advertising - minimum charge for classified advertising
- Our minimum charge is advertised at all times. Rates are based on the size of the advertisement
- Rates: Lineage 54p per word (VAT inclusive) minimum 15 words
- Semi-display £12.80 per single column cm plus VAT
- No reimbursements for cancellations. All ads must be pre-paid.
- Name...........................................
- Address.......................................
- Daytime Tel. No................................
- Signature.....................................
- Date...........................................
- KITS...........................................
- PCBS.........................................
- OTHERWISE STATE

CLASSIFIED COUPON

ELECTRONICS TODAY INTERNATIONAL, CLASSIFIED ADVERTISEMENT DEPARTMENT, No. 1 GOLDEN SQUARE, LONDON W1R 3AB

PLEASE DEBIT MY ACCESS/BARCLAYCARD No.

□ FOR SALE □ COMPONENTS □ WANTED

Rates: Lineage 54p per word (VAT inclusive) minimum 15 words, Semi-display £12.80 per single column cm plus VAT. No reimbursements for cancellations. All ads must be pre-paid.

ETI SEPTEMBER 1988 61
OPEN CHANNEL

Within a couple of years or so (well, three to be precise) drivers in London should have access to an automatic route guidance system, which is fitted into the car's dashboard.

The Autoguide system will provide drivers with voice synthesised instructions regarding route at each junction, allowing drivers to miss busy spots and traffic hold-ups. In theory, the system will save hours of drivers' time at the wheel.

A network of infra-red beacons, linked to a central computer system with microwave links, and supplied with data at high speed, will ensure that the system is updated with traffic information, including accidents, hold-ups and roadworks.

Having spent many an hour fit to burst behind the wheel of my trusty rustbucket, I can appreciate the potential of such a product but I still have reservations. The system is planned with beacons only on main routes in the capital and if one route is blocked chances are the adjacent ones will probably be busy too (particularly if most other drivers receive the same instructions) so it may be of only minor efficiency.

Only the first drivers who chance to come upon a hold-up will benefit from the instructions to change route. After a few minutes the alternative route will be taking twice the traffic it normally does and so will be blocked itself.

It may be that the system would need to re-route drivers along routes normally unused (side streets) as well as alternative main routes to ensure congestion doesn't occur. But I suppose residents in those side streets might object to my suggestion.

HIGH-TECH COPS 'N' ROBBERS

The Police computer system is to be upgraded by 1990 with a new network. This will allow national access to an index of records incorporating photographs of convicted people, criminal records and so on. It looks as though the network will allow access to the Swansea computer which holds and vehicle licensing data, too.

HIGH-TECH PHONE

British Airways aims to commence customer trials of satellite-linked public telephone calls from transatlantic jumbo jets by the end of the year. Initial non-customer trials have been successful, routed via British Telecom's Goughnilly earth station in Cornwall.

EUROCRIPT — TOMB WITH A VIEW?

Agreement about an international standard for encryption of European direct broadcast satellite (DBS) television services has been reached — after much argument. The standard covers scrambling of the transmitted picture and conditional access of the signal by individual television receivers.

The agreement means that hardware manufacturers can now press ahead to develop receivers complete with chip sets for the European market, instead of purely national ones. The exception to this appears to be British Satellite Broadcasting (BSB) and its foreseen transmission standard D-MAC. All other countries will be using D2-MAC. Careful design, however, should ensure either transmission standard can function with the Eurocrypt conditional access system.

Meanwhile, BSB has been concentrating on placements of chip and module orders, in an effort to ensure they are available when manufacturers start to put together design plans for receivers. It has been reported that four million D-MAC transmission standard chips have been ordered from ITT subsidiary International (ITT already make the European-preferred D-MAC chips). An order has also been placed with General Instruments, to supply conditional access modules.

Instead of going for a brand new chip design, BSB has accepted that the General Instruments modules are to use existing technology. However, it doesn't appear to be clear why the BSB-chosen conditional access system follows the Eurocrypt standard if not, does it really matter?

What seems to be important is that BSB is taking its finger out nice and early, to ensure receiver manufacturers will have the goodies when they need them.

This is an important move by BSB itself merely a programming and organisational body and does prove a high level of commitment by them to ensure that British DBS television services are going to work, right from day one, and right on schedule.

BT/Mercury Can Work Together!

British Telecom and Mercury are starting work with France Telecom to lay the first fibre optic cable across the Channel! The cable will start full time operations next year. France Telecom is to own 50% of the cable, British Telecom and Mercury have 25% each. The deal marks the first international link by Mercury.

Linking Brighton to Dieppe, the cable will be the longest multi-fibre connection without signal repeaters.

Keith Brindley

PLAYBACK

Loudspeaker designers have a problem. The engineers use a controlled environment (anechoic chamber) in which to perform measurements but this is hardly representative of the average consumer's living room.

It may only be some months after a product's launch that a manufacturer can accurately gauge the broad compatibility (or otherwise) of a new loudspeaker.

Those innovative people at KEF are fully aware of this problem, having come unstuck themselves in days gone past. However they have re-examined a new drive unit technology under the banner of Uni-Q, an attempt to address the inherent difficulties of controlled speaker directivity.

Directivity (both horizontal and vertical) is the key element here for it is the off-axis response of the loudspeaker that determines how favourably the system will interface with a given environment.

There is little point having a smooth on-axis response if sharp discontinuities appear as soon as you listen slightly off-axis. Furthermore, any ragged off-axis signals that are reflected from neighbouring boundaries will mix and colour the perceived on-axis response.

Recent evidence suggests that vertical reflections from floor and ceiling tend to result in the most damming subjective colourations rather than the equivalent horizontal reflections occurring off nearby walls.

This may well be due to the relative ear dispersion symmetry — the brain judging quality through disparities between signals arriving at the ears.

As such it is the horizontal dispersion that influences the perception of stereo space and whether these reflections detract from absolute accuracy or not, any extra spatial effects are usually quite pleasing.

Anyway, though KEF have no control over the type of listening room used they have decided to at least minimise any unpleasant interactions by manipulating the off-axis characteristics of the speaker itself.

The Uni-Q driver adopts a co-axial construction but one that enjoys a truly coincident source. This has been achieved by placing a soft-dome high frequency unit in the throat of the main low frequency driver. KEF have therefore achieved a single physical coincidence of the drivers — close to the ideal point source. This technique avoids the uneven path lengths, subsequent time delays and crossover anomalies suffered by other two-way loudspeakers.

Tannoy's dual concentric driver has been used for many years now but its method of construction differs in several important respects. Here the treble unit is mounted behind the main driver and fires through several phase-compensating tubes machined out of the central pole piece. This is terminated in a concentric HF horn whose flare is continued by the exponential curve of the LF cone itself.

Tannoy then employs a 'phase coherent' crossover network to align the acoustic centres at one point on the axis. However, an electrical delay is only appropriate for on-axis correction. It is certainly no substitute for pure physical alignment.

KEF has achieved this goal by recourse to a new magnet material that offers up to 10 times the energy product of conventional ferrite, being machined into a motor assembly small enough to sit right inside the voice coil of the bass driver!

Composed of neodymium, iron and boron this very expensive alloy magnet is sourced from Sumitomo in Japan. The Delco Remy division of General Motors have a similar material on their books known as Magnemquench. It is apparently slightly cheaper but offers a lower total energy product.

A standard ferrite magnet is employed for the bass motor assembly while the cone is formed from BBC polypropylene, its curvature providing the optimum loading for the inset tweeter.

So in short KEF have succeeded in manufacturing the first coincident co-axial drive unit that offers a matched directivity throughout the crossover region and a carefully controlled directivity off-axis.

Four new loudspeaker models (£159-£599) incorporate the fruits of this Uni-Q technology — the C35, C55, C75 and C95 but the results of any listening tests will have to wait until a future issue...

Oh yes, KEF will be catering for the DIYer amongst you, the Uni-Q driver is seemingly ideal for home constructor projects.

Paul Miller
This month’s Blueprint request comes from S.A. Bowen of the Birmingham and Black Country Bat Group.

Bats emit ultrasonic sounds between 35kHz and 80kHz and we in the Birmingham & Black Country Bat Group would like to build our own detector to convert these frequencies into the audible range. There are detectors on the market but they cost around £150 which is beyond our price range.

There are three obvious methods to tackle your problem and they have different disadvantages. The most obvious is to record the sounds on a reel-to-reel tape recorder at a high speed and replay at a slower speed. This will decrease the frequency of the tones in proportion to the reduction in speed of tape. The duration of the times is also increased, of course, and you can’t listen until you have rewound the tape. In addition, most tape recorders cannot be modified to handle such high frequencies.

The second possible method is similar in concept. The sounds from the bats would be picked up by a microphone, buffered and fed into a bucket brigade delay line at high speed. When the delay line is full the signals would be read out at (say) 0.1 times the read-in speed. Thus 10ms of sound would be stretched to 100ms at 0.1 times the frequency.

The big disadvantage here is that the bats are only being monitored for 10% of the time. However, the technique is suitable for moderate frequency changes, for example to connect the sound of speech on a tape recorder played too fast. I may provide a project along these lines next year.

The third possible approach would be to heterodyne the frequencies down so that some of the range would be audible. This has two obvious disadvantages. First of all, the bandwidth of sounds used by bats is 45kHz, while the human ear is capable of hearing an absolute maximum of 20kHz. Secondly, harmonic information is lost in the conversion.

For example, if a 35kHz tone has a harmonic at 70kHz, the 2:1 relationship will be lost if the frequencies are reduced so that the 35kHz becomes 1kHz and the 70kHz becomes an inaudible 36kHz. This technique would, however, give immediate and continuous monitoring of the bats.

Fig. 1 shows a possible system to achieve the required frequency shift. This circuit produces sum and difference frequencies of the oscillator and the bat sounds but only the difference frequency is audible. A frequency of 45kHz would be converted to approximately 10kHz and 55kHz to approximately 20kHz, so the higher range of frequencies would be inaudible. However, if the higher range is needed then the low pass filter frequency and the oscillator frequency could be raised as appropriate — perhaps two switched frequencies would be useful.

Fig. 2 shows a possible circuit to do the job. I would emphasise that this circuit has not been prototyped and may require some alterations when tested but it should be workable in principle — the only piece of circuitry not similar to something I have tested is the multiplier. That is designed to conform to the information in the data book but what the data book tells is sometimes not the whole story.

In addition it is very easy to overlook a small point at the initial design stage, some experimentation with access to an oscilloscope covering 35-80kHz and an oscilloscope may be necessary.

This circuit is fed from the only way to implement the heterodyne system illustrated in Fig. 1 but it has the advantage that most parts of the circuit are conventional and should work with minimum difficulty. The integrator on the input could perhaps have been omitted because signals above 80kHz are unlikely to be present. An input buffer was needed so a filter has been included to minimise the chance of spurious frequencies causing interference.

The input stage is also configured to provide gain, the level of which is set by R1 and R5. The values chosen should work but if less gain is needed the value of B4 can be increased. The gains shown in the circuit is the maximum which is possible with the IC chosen, over the frequency range. If higher gain is needed then two resistors should be added to the circuit of IC2 (the high pass filter) to provide gain in the range as well.

It is necessary to provide enough signal at IC2 to give a good signal to scale ratio, without overloading the input of the multiplier. The gain needed can be determined by experiment and will depend on the microphone chosen. The multiplier uses the 3080 operational transconductance amplifier. This device provides an output current (rather than a voltage proportional to the differential input voltage) multiplied by the bias current led into pin 5. This is exactly what is required because zero output must occur at half scale bias current. To achieve this result, the input signal from the microphone is fed to the inverting input of the multiplier and a non-inverted signal is fed forward via R10 to cancel the inverted output signal at approximately half scale bias current.

The output stage is simply a current summing stage with frequency roll-off removed ultrasonic frequency.

The sinewave oscillator which provides the signal to multiply by the input signal is of a conventional design, using an integrator (which provides a 100° phase lag) and a lowpass filter which provides a 90° phase lag at the corner frequency, given by the formula 35kHz x R17 x R15 x C5 x C6. The component values in the integrator are chosen to give enough voltage gain at the operating frequency to provide about ±4V peak output. The amplitude of the sinewave is limited by D1 and D2 but the distortion products generated by these diodes are filtered out by the filter and the integrator, so the output is a clean sinewave.

The microphone must be able to respond to frequencies up to at least 50kHz to give a useful response and not all types will manage this. I can only suggest experimentation as a means of finding a suitable type but probably an electret microphone would be more likely to work.

No audio amplifier design is shown because audio amplifiers for small circuits are not commercially available. One suitable amplifier would be the Matchbox amplifier as published in the April 1986 ETI (photocopies from the ETI Photocopy Service folks).

Adjustment

First of all, RV1 should be adjusted to null out any offsets. The left hand end of RV2 (marked X1) should be temp-orarily connected to OV and RV1 set to provide 0V on the output of IC4. To adjust RV2, connect a signal generator providing about 40kHz to the input of the circuit and adjust RV2 (still connected to OV) for no output from IC4. It is best to use an oscilloscope for this although an AC volt-meter may be usable. If a signal generator is not available an output signal from the oscillator could be used. The signal level is much too large to feed to the input directly, so it must be passed down via a 10k ohm potentiometer.

When RV2 has been adjusted, reconnect it to IC6, and the circuit is ready for field trials. When there are bats to listen to, RV3 should be set to adjust the oscillator frequency to reduce the frequency of the bats by the correct amount. The unit should now be working.

Andrew Armstrong
The world of satellite television nears its head again this month with three new books on the scene. Interest here for both the newcomer to the subject and for STV die-hards.

Satellite and Cable TV Scrambling and Descrambling by Brent Gale and Frank Baylin. £19. Vincent Technical Books, 24 River Gardens, Purley RG8 8BX.

A tricky subject this one. Even the (American) authors note in the acknowledgements that all the other contributors wished to remain anonymous! However, it is debatable whether it is illegal to descramble STV signals not intended for your reception and it is certainly not illegal to read about it!

This is an excellent book with just one (major) downfall — it is very American. This is only meant if is written in that wearing style apparently loved on the other side of the pond but more importantly that few of the scrambling systems talked about have relevance in Europe.

Nevertheless, the book gives a good background to the whole subject and should be considered a useful read if you are contemplating building your own descrambler.

The first third of the book is devoted to the principles of television reception and display. Although this naturally concentrates on the NTSC system, much mention is made of PAL (and SECAM for that matter) and so it provides a good framework of reference.

The rest of the book is devoted to the principles and practices of encryption. The discussion of techniques used is quite fascinating. After reading 70 pages of the trials and tribulations of broadcasting and receiving a TV picture, to see all the methods used to louse up the process is almost amusing.

This section is very useful. Not only are the techniques of it all discussed in quite some detail sufficient for a competent TV engineer to go about designing a decoder but example screen pictures are given for many of the scrambling methods. This means that when you are presented with a moving mess on your TV screen you can have an intelligent stab at guessing the scrambling system being used.

Unfortunately, the rest of the book (and half) is devoted to discussions of the innumerable commercial scrambling and descrambling units available in the US. Much information is given, including numerous photos of the boxes concerned and interconnection details.

However, little of this is of any use to the European would-be viewer (although the various versions of MAC are well covered). Unless you are intending to try your hand at satellite TV DX-ing and grab some US TV, this is all largely wasted.

It is interesting to see how the theory of the earlier chapters has been put into practice by the manufacturers but otherwise there's not a lot here for us limes.

You are unlikely to find this book in your local library (although you could always try to persuade them to get it in for you) so the limited use that a read of it will give you is only available for the rather steep price of £19.

The Hidden Signals on Satellite TV by Thomas Harrington and Bob Cooper. £20. Vincent Technical Books, 24 River Gardens, Purley RG8 8BX.

This is another one aimed at an American audience. It is about two years old and is now available in this country through STV specialists Vincent Technical Books. This one came as something of an eye-opener for me. I had no idea there was quite so much going on up there anyone.

Everyone knows about the satellite TV transmissions (that's what you get a dish for in the first place). The same satellites can also carry non-video material such as radio, teletype data, telephone channels, teletext and who knows what else.

Many US satellites do indeed carry such information and this book goes into quite some detail of the technical methods of transmission of the data and the commercial (or otherwise) contents of these 'hidden' signals.

Much of the information in this book is by way of experimental data — a write-up of what the authors have found in many years of searching the frequency spectrum and investigating the signals they've found.

Of course, the authors haven't been looking at the same satellites as you and I have available above the horizon. This means all their findings are next to useless for UK readers or are they? Many of the techniques used for encoding the carrier signal with non-video data are used as much in this neck of the woods as in the US. Indeed, some services mentioned such as Reuters' news-view service — are international ones and can of course be received over here.

The big problem is that this book is entirely (well, except for a few brief paragraphs at the end) concerned with the C-band satellites which make up the majority of transmissions in the US. These are at a frequency of 3.7-4.2GHz as opposed to the 11.7-12.7GHz 'Ku-band' satellites which broadcast all the TV signals in this country and in Europe generally.

There are many C-band satellites above our skies too but you'll need a second LNB and probably a second dish to pick them up.

I am sure there are a good many hidden transmissions coming from the European Ku-band satellites too (text is standard on the Sky and Superchannel stations and a satellite radio channel has recently started, broadcasting on a secondary audio frequency from one of the main STV satellites) but these are a different kettle of fish and this book does little to encourage the weary newcomer to venture off his receiver's presetted settings.


At last the Babani stable is getting into satellite television with this eminently understandable and all-encompassing guide to the subject.

Intext, it's even a little over-encumbering. An awful lot seems to be standard chapters regurgitated with no real thought as to their relevance to STV enthusiasts. Do we really need sections on scientific notation or SI units? Are the internal technicalities of rocket motors or even amplifiers that relevant?

Where the book does concentrate on the subject in hand it does a good job. The prose is pleasantly readable and despite the vast number of mathematical equations and formulae, it remains for the most part unforeboding and positively encouraging for the newcomer.

Considering this is a Babani book, not enough emphasis is put on the DIY aspects of STV. It quite correctly points out that building an STV receiver is beyond all but the most dedicated (and knowledgeable) electronics enthusiast. However, only scant duty is paid to installation — an area where most ETI readers, for example, can easily not only save a bob or two but often perform a better job than many so-called professionals.

Nevertheless, like most Babani offerings, this volume does offer a solid grounding in the subject. Refreshingly it approaches the maths of it all neither skirting around the subject nor attempting the 'baffle 'em with science' approach.

Little is said about the material on offer or scheduled to grace our screens in the future. Although the preface points out that in a restaurant 'it is hardly necessary to understand the chemistry of cooking to enjoy the food', this whole book makes a meal out of the theory with few programmating appetisers.

For a basic reference work, as a clear tutor through the labyrinth of dish efficiencies, free space path loss and the like, this one is cheap and readable.

Martin Tame
STAN WILLETTS
37 HIGH ST, WEST BROMWICH, WEST MIDLANDS B70 6PB
Tel: 021-553 0186

PLEASE NOTE WE ARE INTERESTED IN PURCHASING ALL TYPES OF EQUIPMENT


2x4 SUPER PANELS = DFT — SERVO VIDEO — CROMA — STERITON, Meter-board, Modulator and Tuner, £5.99 p&p £1.00.

GRUNDIG REMOTE-CONTROL, £2.99 p&p £1.00.


VHS VIDEO TAPES: “VIDEOLAB” PREMIUM QUALITY brand, which we recommend and guarantee, one for one exchange, £1.99 p&p £1.00. TDK, SCOTCH, FUJI, £2.99; MEMOREX, £2.69.

VIDEO HEAD CASSETTE CLEANERS £1.99, with full instructions. VHS or BETA, p&p £1.00.

VIDEO HEAD CASSETTE DEMAGNETISER Electronic circuit, LED indication degausses one second. £79.99 p&p £1.00.

VIDEO RECORDER, SONY C5 AND C7 SANYO, etc., perfect working order, £39.99 (caller only).

THERMOMETER-COMPASS AND CLOCK (detachable), brand new. £1.99 p&p 75p.

FREQUENCY TRANSLATOR 8 Channel UHF and tunable mains voltage, used but in working order, £49.99 p&p £5.00.

ETI SEPTEMBER 1988
LINSLEY-HOOD CASSETTE RECORDER CIRCUITS

Complete records and replay circuits. See very high quality from noise shown cassette recorder. Circuits are optimised for our HS16 Super Quality Sendukst Alloy Head, Switched high and equilibrium up to carrier for ceramic and ferrite tapes. Very easily to assemble on all QRB-Complete with full instruction.

Complete Stereo Record-Play Kit £33.70
UV Meters for 24 Reprints of Original Articles £2.30 each
6000X Stereo Mic Amplifier £14.70

LINSLEY-HOOD 300 SERIES AMPLIFIER KITS
Superb integrated circuitised amplifier kit from John Linsley-Hood excels in all respects. Ultra easy assembly and set-up with sound quality to please the most discerning. High quality tape for domestic sound system. Quality guarantees to you. Buy the HCO kit and save pounds on the individual component prices.

K300-35, 35 Watt. Discount price for Complete Kit £26.79
K300-45, 45 Watt Discount price for Complete Kit £102.39
RE448 Repairs of Original Articles from HS1 to HS11. Note: £15.05 no VAT

STUART TAPE RECORDER CIRCUITS
Complete stereo record, replay and bias system for reel-to-reel recorders. These circuits will give studio-quality with a gold tape core. Separate sections for record and replay give optimum performance and allow a third head monitoring system to be used where the deck has this facility. Standard 250m input and output levels. These circuits are ideal for the 80s. For sale tape recorder back to life K994 Stereo Kit with Wound Coils and Twin Motor £6.07
RUB1. Reproduction Original Article £1.30 no VAT

LINSLEY-HOOD SUPER HIGH QUALITY AM/FM TUNER SYSTEM

Our very basic kit for the discerning enthusiast of quality sound and an exact level for lovers of designs by John Linsley-Hood. A combination of his ultra high quality FM tuner and stereo decoder described in "ELECTRONICS TODAY INTERNATIONAL" and the Synchroline AM receiver described in "Business Wire." The complete unit is a 300 Series amplifiers Novel circuit design in the FM section to include ready-built pre-amps and speech to keep the pre-amplifier down to DC and advanced simple and hold sounds decade together make a tuner which will produce the best sound the hifi market can offer. Thanks to HART engineering an integral easy key to bias. The Synchroline amplifiers provide very nice results from the standard range of TV systems to the highest fidelity quality sound this tuner is not cheap but in terms of its sound it is incredible value for money. To cater for all needs four versions are available with variations up to the largest range full AM/FM model, with any unit being upgradable at any time. Send for our fully illustrated details.

Tape Head Descriptions. Handy size charts various unit prevents head used from head unit instrumentation comparison on playback. £1.54
Current Price is the special price. £0.65

Send for your free copy of our LS535 Overseas please send 2 IRCs to cover surface Post or 5 IRCs for Airmail. Please add postage of post. packing and insurance as follows.

Overseas night £3.15, 5 IRCs over £4.68, 1 IRC over £8.32

For more detailed information on what goes inside. Full circuit diagrams and specifications are provided. And honestly, can you really use a computer effectively if you don't know what's outside and nobody will tell you?

Solid engineering construction something to be proud of. 19" 3U rack mounting, plus in compact boards and modular construction keeps obsolescence at bay.

Flourishing independent Users Group, and newsletter, Hundreds of programing on disk is all, and it's not just the Users Group. In program in machine code (Assembly), Basic, C, Forth, etc. Database, Word Processing, Scientific applications. Cassette tape operation or disk (up to 4 drives, 1 Megabyte 3.5" advanced, available from us, you can add 3", 5.25", 8" if you want). Disk operating system CP/M Plus. 64K RAM, 380 based at present with potential for expansion to 16 Megabytes address space and Zilog's latest Z8000 8088 Future. Needs no specialised knowledge to construct, and we will happily get you out of a jam if you get stuck into.

Availability of personal and individual after sales service, impossible to obtain from large companies, who are only after your money. Security of supply - from Greenbank Electronics, established in 1970.

Greenbank Electronics, Dept. (T9E), 460 New Chester Road, Rock Ferry, Birkenhead, Merseyside L42 2AE. Tel: 051-645 3391.

ETI SEPTEMBER 1988

www.americanradiohistory.com
**DISPLAY ELECTRONICS**

**COLOUR MONITORS**

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Resolution</th>
<th>Refresh Rate (kHz)</th>
<th>Price (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanyo</td>
<td>DVM2925</td>
<td>2560x1024</td>
<td>60</td>
<td>£349.95</td>
</tr>
<tr>
<td>Sanyo</td>
<td>DVM2953</td>
<td>2560x1024</td>
<td>60</td>
<td>£349.95</td>
</tr>
</tbody>
</table>

**PRINTERS**

<table>
<thead>
<tr>
<th>Printer</th>
<th>Brand</th>
<th>Model</th>
<th>Price (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epson</td>
<td>LQ2000</td>
<td>£119.95</td>
<td></td>
</tr>
<tr>
<td>Epson</td>
<td>LQ2050</td>
<td>£129.95</td>
<td></td>
</tr>
</tbody>
</table>

**POWER SUPPLIES**

- New 20" & 22" AV Specials
- Ultra Fast 240 cps NEWBURY DATA NDR 8840 High Speed Printers Only £449!!
- Special Offer: EXPIRERSMNTS PSU Only £16.95 (C)

**MONOCROME**

- NML1000 19" CRT back & white console chassis only £149.95
- IBM 215 7"" and 10"" surveillance monitor £150.00 (E)

**DISK DRIVE SCOOP**

- floppy drives from only £39.95

**RECHARGEABLE BATTERIES**

- Maintenance free, transportable LED ADC2000 £199.95
- RFE 1 x 14.3Ah £195.95

**COOLING FANS**

- Keep your computer protected with our range of COOLING FANS:
  - 5" FAN (40 x 40 x 25) £8.95 (B)
  - 6" FAN (120 x 120 x 25) £11.95 (B)
  - 8" FAN (120 x 120 x 30) £12.95 (B)

**SPECIAL INTEREST**

- BARGAIN-REDUCED real time, colour drafting PS2 output
- DEC VAX 11/750x 2mb RAM £995 (B) and full colour printing £1,295 (B)

- HP 5100A 8 pen digital A1 drum plotter with HP 1500A & HP 1500B
- CHEETAH Tactics machine £995 (B) & £1,079 (B)
- 500 watt INVERTER 240v to 12v £199.95
- SOLDERING SYSTEMS in lead roller torch systems £159.95
- CALLAN DATA SYSTEMS multi-user INTEL £1,195.00

**CUSTOMER SERVICE**

- We can design and supply all types of computer accessories and peripherals.
- SPECIAL ORDERS welcome.

**THE 'ALADDIN'S CAVE' OF ELECTRONICS & COMPUTER EQUIPMENT**
HOBBY VICE

Level operated suction cup base holds tightly to smooth non-porous surfaces. Ideal for holding small components and assemblies. Metal banded jaws 37 x 11mm, open to 36mm. Base 60 x 60mm. Height 36mm.

NEW LOW PRICE

SALES 0702 554161

UNBELIEVABLE PRICE

ONLY

DESMOND PUMP

Powerful pump action and plunger guard.

INcredible low price

NOW ONLY

£2 95

P. O. Box 3, Rayleigh, Essex, SS6 8LR.

Soldering Iron KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£4 59

£13 95

£11 95

SOLDERING IRON STAND

Suitable for most soldering irons.

SUPER LOW PRICE

£2 95

ALL PRICES INCLUDE VAT. PLEASE ADD 50p TOWARDS POSTAGE. IF ORDER BELOW 45p PLEASE ADD 50p.

ALL ITEMS SUBJECT TO AVAILABILITY

SOLDERING IRON KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDER by ADEPTO

INcredible low-price trial offer to launch our new brand

1/4kg reel 18 swg

£6 89

(=£5.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£4 99

(=£4.34 + VAT) PER REEL (SC20W price £99.80).

1/4kg reel 22 swg

£7 99

(=£6.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£5 74

(=£4.99 + VAT) PER REEL (SC21X price £114.80).

HOBBY VICE

Level operated suction cup base holds tightly to smooth non-porous surfaces. Ideal for holding small components and assemblies. Metal banded jaws 37 x 11mm, open to 36mm. Base 60 x 60mm. Height 36mm.

NEW LOW PRICE

SALES 0702 554161

UNBELIEVABLE PRICE

ONLY

DESMOND PUMP

Powerful pump action and plunger guard.

INcredible low price

NOW ONLY

£2 95

P. O. Box 3, Rayleigh, Essex, SS6 8LR.

Soldering Iron KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDER by ADEPTO

INcredible low-price trial offer to launch our new brand

1/4kg reel 18 swg

£6 89

(=£5.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£4 99

(=£4.34 + VAT) PER REEL (SC20W price £99.80).

1/4kg reel 22 swg

£7 99

(=£6.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£5 74

(=£4.99 + VAT) PER REEL (SC21X price £114.80).

"The finest soldering irons in the world." - Maplin recommend Antex.

Precision soldering irons that are a pleasure to use. Low leakage currents, ceramic element, shockproof handle. It all adds up to the number one soldering equipment for the hobbyist. Use CS type for very fine work; XS for general use.

SOLDERING IRON KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDERING IRON STAND

Suitable for most soldering irons.

SUPER LOW PRICE

£2 95

ALL PRICES INCLUDE VAT. PLEASE ADD 50p TOWARDS POSTAGE. IF ORDER BELOW 45p PLEASE ADD 50p.

ALL ITEMS SUBJECT TO AVAILABILITY

SOLDERING IRON KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDER by ADEPTO

INcredible low-price trial offer to launch our new brand

1/4kg reel 18 swg

£6 89

(=£5.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£4 99

(=£4.34 + VAT) PER REEL (SC20W price £99.80).

1/4kg reel 22 swg

£7 99

(=£6.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£5 74

(=£4.99 + VAT) PER REEL (SC21X price £114.80).

"The finest soldering irons in the world." - Maplin recommend Antex.

Precision soldering irons that are a pleasure to use. Low leakage currents, ceramic element, shockproof handle. It all adds up to the number one soldering equipment for the hobbyist. Use CS type for very fine work; XS for general use.

SOLDERING IRON KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDERING IRON STAND

Suitable for most soldering irons.

SUPER LOW PRICE

£2 95

ALL PRICES INCLUDE VAT. PLEASE ADD 50p TOWARDS POSTAGE. IF ORDER BELOW 45p PLEASE ADD 50p.

ALL ITEMS SUBJECT TO AVAILABILITY

SOLDERING IRON KITS

CS or XS Iron complete with stand, solder and How To Solder booklet.

IDEAL GIFT

£10 15

£9 95

£7 95

£5 99

£4 09

£2 95

SOLDER by ADEPTO

INcredible low-price trial offer to launch our new brand

1/4kg reel 18 swg

£6 89

(=£5.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£4 99

(=£4.34 + VAT) PER REEL (SC20W price £99.80).

1/4kg reel 22 swg

£7 99

(=£6.99 + VAT) PER REEL or in boxes of 20 reels (10kg)

£5 74

(=£4.99 + VAT) PER REEL (SC21X price £114.80).

"The finest soldering irons in the world." - Maplin recommend Antex.

Precision soldering irons that are a pleasure to use. Low leakage currents, ceramic element, shockproof handle. It all adds up to the number one soldering equipment for the hobbyist. Use CS type for very fine work; XS for general use.