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COMPUTING – CUSTOMISED
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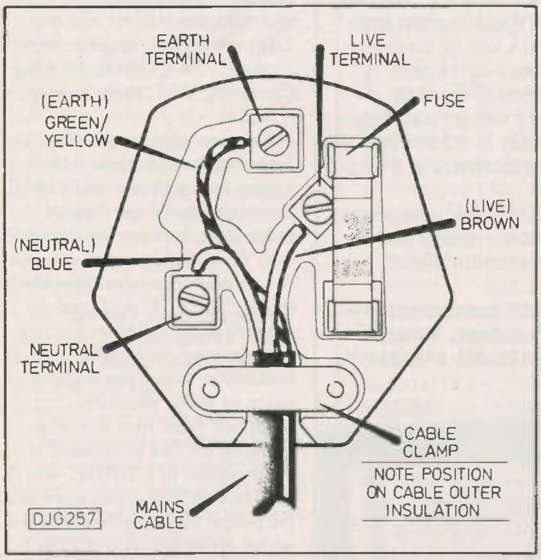
EXPERIMENTAL ELECTRONICS
AND PRACTICAL APPLICATIONS – EXCITING DESIGN IDEAS

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

PRACTICAL ELECTRONICS

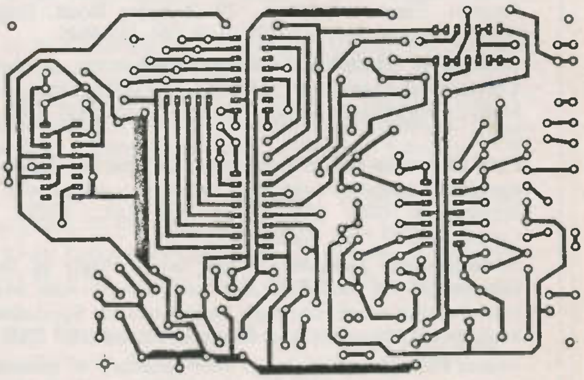
PE VOL 24 NO 5 — MAY 1987

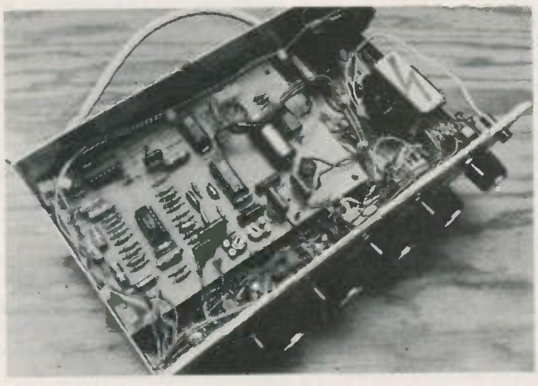
CONSTRUCTIONAL PROJECTS



SPECIAL FEATURES

REGULAR FEATURES





NEXT MONTH . . .

You really shouldn't miss the JUNE issue of PE.

Look at some of what we have in store for you –

MODERN TV RECEIVERS • FREQUENCY SYNTHESISERS • SYNTHESISING AF SIGNAL GENERATOR • INFRA-RED TRANSCEIVERS. • DIGITAL AND ANALOGUE SIGNAL TECHNIQUES • POLYWHATSIT! • PRINTING PE •

NOT ONLY ALL THIS, BUT ALSO our regular top line features of Spacewatch, Leading Edge, Industry Notebook, plus lots more exciting experimental ideas, and all the latest product information from our advertisers.

PE JUNE 1987 ISSUE ON SALE FROM FRIDAY MAY 1st

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

CATALOGUE CASEBOOK

Last month we received details of the following catalogues and literature:

Cambridge Kits. Kit News leaflet of ideas, tips and **new budget priced kits,** etc. Cambridge Kits, 45 Old School Lane, Milton, Cambridge. 0223-860150.

British Amateur Electronics Club. News letter and **circuit ideas** January 1987. Cyril Bygod, B.A.E.C., 26 Forrest Road, Penarth CF6 2DP. 0222-707813.

Electronic Organ Constructors Society. February 1987 magazine of **news, views and ideas.** R. Williams, EOCS, The Mill House, Mill Lane, Wheaton Aston, Stafford, Staffs. 0785-840860.

Electrovalue. February 1987 60 page **catalogue of quality components,** for which they claim to be Britain's leading supplier. Electrovalue Ltd., 28 St Judes Road, Engleford Green, Egham, Surrey TW20 0HB. 061-432 4945.

Institute of Electrical Engineers. Publication of the **1987 Thesaurus** is announced. INSPEC, Marketing Dept., Station House, Nightingale Road, Hitchin, Herts SG5 1RJ. 0462-53331.

PMD Chemicals have a new product brochure of **chemical and equipment ranges** for the PCB industry, together with much applications data. PMD Chemicals Ltd., Broad Lane, Coventry, CV5 7AY. 0203-466691.

Semiconductor Specialists. Their list of **'state of the art' components** for bonafide club members is now available (membership proof required). Semiconductor Specialists, 159 High Street, Yiewsley, West Drayton, Middx UB7 7XB.

Swains Packaging have issued their February '87 **extensive list of polythene bags,** sheeting and tubing. Over 15 million bags in 300 different sizes are stocked. Swains Packaging, Brook Road, Buckhurst Hill, Essex IG9 5TU. 01-504 9151.

Teledyne Philbrick Microcircuits have issued a new short form catalogue that provides a **mass of worthwhile information** on op-amps, D-A, A-D, V-F converters and other products. Components Division, MCP Electronics Ltd., 26–32 Rosemont Road, Alperton, Wembley, Middx HA0 4QY. 01-902 1191.

Verospeed have a comprehensive new product catalogue of **over 13000 lines** for electronics, computers, tools, cables and production equipment. Verospeed, Stanstead Road, Boyatt Wood Industrial Estate, Eastleigh, Hants SO5 4ZY. 0703-641111.

Versatec Electronics Ltd, (a Xerox company). Brochure highlighting **advantages of the new Versacolour** fast, high resolution thermal plotter. Versatec Electronics Ltd., 8 Oxford Road, Newbury, Berks RG13 1QD.

WHAT'S NEW

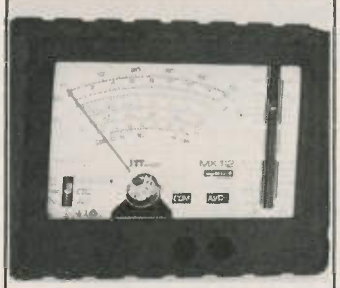
Shock Proof Meter

ITT Instruments have introduced an analogue multimeter fitted in a rubber shock-absorbing surround for greater resilience in field work. The MX 112's ease-of-use design provides a mere two input sockets for all functions and ranges, and full protection up to 200V on all ranges, including the 10A current range.

The instrument has eight multimeter functions on forty two ranges, as well as capacitance and decibel measurement, and a dwell meter function for carrying out measurements on car engines. A.c. and d.c. voltages up to 1600V and current from 50μA to 10A can be measured, and resistance up to two meohms. Sensitivity is 20 kilohms per volt on a.c. ranges. D.c. accuracy is $\pm$2 per cent of full scale deflection, a.c. $\pm$3 per cent.

The MX112 also incorporates shockproof movement and a parallax correction mirror behind the dial.

Contact: ITT Instruments, 346 Edinburgh Avenue, Slough, Berks SL1 4TU. Tel. 0753 824131.



A Good Year for Grilles

ADAM Hall Supplies, manufacturer and distributor of flightcase and cabinet fittings and major distributor of Celestion loudspeaker, have had a successful year, and are pleased to announce that they are taking on more staff to improve service to their customers.

Among Hall's main lines are Palmer passive crossovers, and filters from Germany. However, to cut costs, Hall's own audio division, 3rd generation, has produced its own range which they will be showing at this year's Frankfurt Music Fair. Now into its fifth year, 3rd Generation is also plugging a new range of slim Mosfet slave amps as a follow up to their successful power amps, and also a new range of small mixers.

Adam Hall Supplies manufactures selected cabinet fittings including speaker grilles (chrome plated) and stacking corners (plastic), as well as supplying a comprehensive range of other manufacturers' fittings, and is now moving into the American market.

Contact: Adam Hall Supplies Ltd., Unit 3, The Cordwainers, Temple Farm Industrial Estate, Sutton Road, Southend-on-Sea, Essex SS2 5RU. Tel. 0702 613922.

COBOL Core Classes

TWO world experts in the business-oriented programming language COBOL are joining forces with Micro Focus, a company with a decade in developing COBOL compilers and software development tools, to found a COBOL training company called, appropriately enough, The COBOL Training Company. Well, they thought of it first.

The two experts involved are Jerome Garfunkel, the American author and organiser of COBOL seminars, and John Triance, researcher, lecturer and author, who now manages a development group within Micro Focus. The CTC will base its courses around Micro Focus's applications development tools and will be aimed particularly at users of those products, but the company feels that it is now drawing on "an unrivalled core of expertise in COBOL" which goes beyond the application of a particular set of systems into the wider applications of COBOL programming. Garfunkel particularly has contributed to the evolution of COBOL in business through his work on various COBOL standardisation committees.

The three types of training which the CTC is offering are product training workshops, specifically relating to Micro Focus, key topic seminars, with expert-led discussions relating to the state of the art in COBOL, and skills acquistion workshops. Using one of the Micro Focus toolsets for in depth tuition aimed at professional programmers. The company has already begun holding product training workshops on the continent, and plans operations in the UK and USA.

Contacts: John Triance, Newbury, U.K. Tel. 0635 32646; Jerome Garfunkel, Connecticut, U.S.A. Tel. 0101 203 567 8555.

Sea And Shore

THE Radiocommunications Division of the Department of Trade and Industry has made two announcments of interest to radio users in January.

The first concerns the radio licensing of shipping. The new

Ship Radio Licence has replaced the former Ship Licence, the Hovercraft Licence and the On-Board Ship Wireless Licence. The Ship Radio (VHF) Licence has also been updated. Another major change is the issue of a Licence Display Slip which must be displayed on the vessel to indicate possession of a current licence. (The DTI's announcement did not say whether it should be displayed on the windscreen, or not.)

Under the Wireless Telegraphy Act 1949 a licence from the Secretary of State is necessary for the use or installation of any radio, including handhelds, on a vessel. The Licence costs £50 a year, and authorises use of all international maritime bands (l.f., m.f., h.f., v.h.f. and satellite), as well as radar and lifeboat radio equipment. The Ship Radio (v.h.f.) Licence, which is aimed at small vessels and only permits use of the international v.h.f. band, costs £17.50 a year. All equipment must meet the Department's type Approval Specifications, and all operators must hold the appropriate certificate of competance.

The second announcement concerns the re-issue of lapsed Amatuer Radio licences with the original call signs.

The Department has decided on the basis of several individual cases to allow previously held licences to be re-issued to their original and legitimate holders, even where the original qualifications were not based on the current City and Guilds Radio Amateur Examination syllabus. The only exception involves the G5 plus three letter series, which has already been withdrawn for re-use.

Prior to this decision, policy only allowed the re-issue of old licences where a pass in the post-1958 City and Guilds of London Institute syllabus had been obtained. This meant that amateurs who kept their licences current held on to them despite the revised syllabus, while those who did not were not allowed to re-commence radio operation without sitting a second examination.

This concession follows another recent concession (in June 1986) which extended a pass in the radio morse test to lifetime validity, in line with the RAE itself.

The Department's obvious and acknowledged appreciation of the fact that a radio call sign is not just a 'name, rank and number' to its owner, but a personal signature by which he or she is know to other amateurs, puts a pleasantly human face on a government department which is often seen only through its regulations and fine print.

Former amateurs wanting to reclaim old call signs must themselves provide incontrovertible proof of their identity and title to the call sign, for instance, the orignal licence or a copy of it, and all details concerning the lapsed licence and its issue.

Full details can be obtained from the **Department of Trade and Industry, Radiocommunications Division, Amateur Radio Section, Room 613, Waterloo Bridge House, Waterloo Road, London SE1 8UA.**

CAD Captured

COCAD Ltd., which supplies specialist software for computer aided engineering, is the worldwide distributor of ESP, a circuit diagram capture software tool for use with IBM PCs and DEC VAX computers, preferably in conjunction with a high resolution colour graphics monitor.

ESP was designed to meet the need for a technically advanced capture tool with local support, and a set of interfaces to popular simulators and routers. COCAD will be able to provide total support capability, including custom interfaces and consultancy on systems integration.

ESP is a 'very intelligent' schematic capture tool for analogue and digital design, including gate array and cell-based i.c. design. Unlimited levels of hierarchy in the system allow circuit functions to be represented by a functional block or series of blocks, each of which can contain any number of further blocks. Design can proceed from concept down to gate level uninterrupted by undue shuffling of files. Signal integrity right through the hierarchies is checked out by the program. Extensive editing facilities allow horizontal or vertical movement of cells or groups of cells, with connections correctly maintained. All labelling texts can be entered from the keyboard and justified and located under user control.

ESP supports drawings up to AØØ (65.5in) and multi-sheet drawings. A parameter file allows the user or system manager to customise some aspects of ESP to individual requirements.

Contact: COCAD Ltd., Ashford House, Tufton Centre, Ashford, Kent TN23 1YB. Tel. 0233 43445.

CAD Captured

COUNTDOWN

If you are organising any electronic, computing, electrical, scientific or radio event, big or small, drop us a line. We shall be glad to include it here. Send details to COUNTDOWN, Practical Electronics, 16 Garway Road, Bayswater, London W2 4NH.

PLEASE NOTE: Some events listed here may be trade only, or restricted to certain categories of visitor. Also, please check dates, times and other relevant details with the organisers before setting out as we cannot guarantee information accuracy.

Apr-Jun. Series of software training courses by Ericsson Information Systems Ltd. Birmingham. 01-422 3442.

Apr 6-10. Saturn Workshops (several residential computer courses). Ludgrove Hall, Cockfosters, London. 0969 50449.

Apr 8-9. Laboratory Manchester. New Century Hall, Manchester. 0799-26699.

Apr 13-16. Acoustics '87 (IOA). Management Centre, Portsmouth Polytechnic. 031-225 2143.

Apr 24-26. Homvention '87. Dayton, Ohio, USA. 0101-603-878-1441.

Apr 28-29. Electronic Data Interchange Conference. Barbican Centre, London. 01-868 4466.

Apr 28-30. British Electronics Week '87 (incorporating All Electronics, ECIF show, Automatic Test Equipment, Circuit Technology, Communications). Olympia, London. 0799-26699.

May 12-15. Automan. National Exhibition Centre, Birmingham. 01-891 5051.

May 13-14. Laboratory Cambridge. Cambridge. 0799-26699.

May 13-15. EDS '87. Las Vegas, Nevada, USA. 0101-313-648-1440.

May 26th. Developments in Instrumentation and Computation in Acoustics (ICA). Society of Chemical Industry, 14-15 Belgrave Square, London. 031-225-2143.

May 30-June 2. Summer Consumer Electronics Show 87, Chicago, Illinois, USA. 0101-202-547-8700.

Jun 2-3, Intel exhibition and conference. Wembley. 0793-696000.

June 2-5. British Manufacturing Technology Week (incorporating CIM). 01-891-3426.

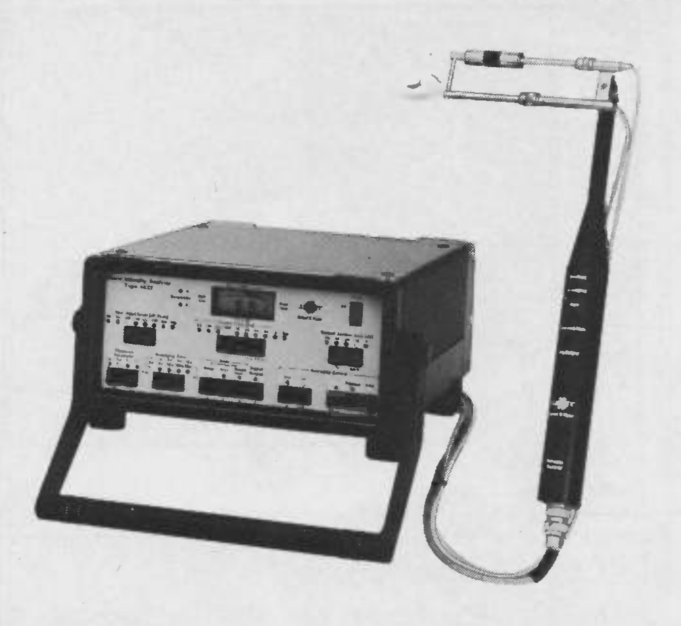
POINTS ARISING

Fibre Optic Light Pen (Mar 87) Page 37, Fig.2. TR1 and TR2 labels should be exchanged.

Telephone Bell Repeater (Mar 87) Page 35, Fig.3. Bridge Rectifier BR1, top right hand pin should be a.c., bottom right hand pin should be negative. C2 left hand pin is positive.

30 + 30 Amplifier (Mar 87) Page 49, Fig.1. R124 (middle LHS) should be R144. C32 and C132 go into spare holes alongside IC2 and IC102 respectively. R15 goes into spare holes below C5, C8 then goes where R15 is marked.

Vigilante – see page 29.



Sound Intensity

BRUEL and Kjaer (UK) Ltd. have released a portable Sound Intensity Analyser, the Type 4433, which weighs only 12lbs and is battery powered.

The 4433 is easy to operate, with an automatic scan for sequential octave analysis and automatic ranging. There is a choice of three microphone sensitivites, and 200V, 28V or 0V microphone polarisation voltages.

Using sound intensity, sound power determination can be done quickly and without special screening or isolation. Measurements made at points over a surface are automatically averaged; a figure for the surface area then being entered into the analyser for calculation of the sound power. Corrections accounting for air density variations are automatically calculated from user-entered temperature and air pressure values.

Two sound intensity probes, type 3519 and type 3520, are available. These are both two-microphone probes using pressure gradient techniques. The 3520 includes a remote control handle. The phase and amplitude matched pair of microphones include newly developed phase corrector units. Very close and stable phase matching is maintained between the measurement channels to allow accurate measurements to be made in difficult environments.

One application of the device will be sound intensity mapping to locate noisy components among groups of components.

Contact: Brüel & Kjaer (UK) Ltd., 92 Uxbridge Road, Harrow, Middx HA3 6BZ. Tel. 01-954 2366.

Computer Cameras

REFLEX Ltd. of Maidenhead has introduced three new computer cameras recently, two from Focus Graphics Inc. and one from General Parametrics.

The Focus Graphics cameras, Imagecorder 4520 and 4526, can be connected to the majority of v.d.u.s, terminals and personal computers via TTL or RS170/RS343 RGB video inputs. The cameras can also work with IBM Enhanced Graphics Adapters.

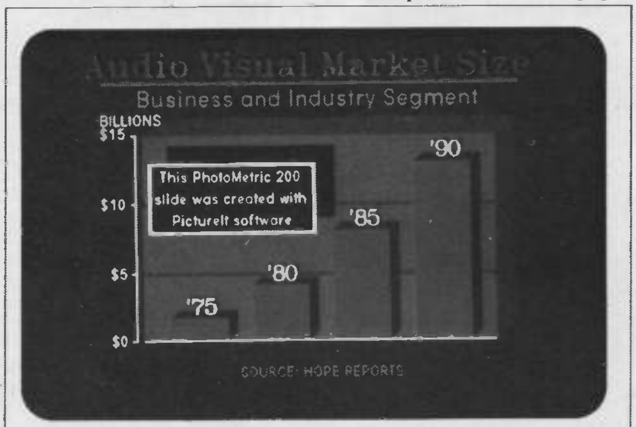
A range of interchangeable modules allow screen images to be recorded on different film types, including 35mm colour transparencies, Polachrome instant slides, 4 x 5 colour and B/W instant prints, 8 x 10 trannies and individual 16mm cine frames.

The Imagecorder's system is fully automatic and does not require photographic skills.

The 4520 has a maximum resolution of 820 by 630 pixels, a video bandwidth of 22MHz and a horizontal line rate of 15.7 to 20kHz, while the 4526 has a resolution of 1024 by 768 pixels with a bandwidth of 32MHz and line rate of 20 to 26kHz.

Both models have a seven inch previewing/recording CRT, analogue and digital signal processing, raster fill and some special effects.

The General parametrics model is specifically for use with the VideoShow 160 presentation system. Essentially a 35mm slidemaker, the camera, called PhotoMetric 200VS, can make slides with a simulated 2048 by 2048 pixels in up to 1000 different colours. Slides can be previewed, and all the camera's functions are automatic. The PhotoMetric 200 is compatible with most popular graphic packages including Lotus 123, Freelance, Chartmaster etc. as well as the VideoShow Picture It package. A version for stand-alones is expected shortly.



For more information contact **Reflex Ltd., Viewpoint, Gardner Road, Maidenhead, Berks SL6 7RJ. Tel. 0628 771414.**

On a slightly different track, Facit Ltd. is marketing a video interface from Kone Instruments Ltd. which converts video graphics into full colour hard copies from the Facit 4544 high speed colour flexhammer printer.

The unit boasts one of the fastest screen data capture times around. It takes a few seconds to store a screen picture in memory, removing the need to freeze the image before transmitting it. The user can then output as many copies as he likes of the stored picture.

The interface accepts standard RGB signal from a wide range of video monitors. The Kone 5791 has a video memory of 512,000 samples, and copy time is two to five minutes, depending on picture density and printing height. The interface has manually adjustable picture width, four selectable heights and remote control. Colour response and print format are also adjustable, and an optional serial data input allows the same printer to be used for video hard copies and normal text without switching.

Contact: Facit Ltd., Northgate, 72 Northolt Road, Harrow, Middx. HA2 0HE. Tel. 01-4222 3442.

Soldering stations, OK.

OK Industries has launched three new low price soldering stations. The cheapest model is the SA-20-230, at £59.00, a fixed temperature unit factory adjusted to 700 degrees F. It has a thermocouple sensor and burn proof cord, and operates at 24V, 48W.

The SA-3-230 is adjustable between 210 and 930 degrees F, has analogue temperature indication, and operates at 24V, 48W.

The top of the range model is the SA-10-230, a tri-temperature station with colour coded ranges: 850 degrees F (red), 750 degrees F (green) and 650 degrees (yellow). The control switch can be made operator secure, and the tips supplied operate over the complete range of temperatures. Also a 24V, 48W model, this one costs £98.63.

Contact **OK Industries, Barton Hill Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants SO5 5RR. Tel. 0703 619841.**

Don Yeates, Education Director of Datasolve, and Dr Janet Larcher of the Spastics Society demonstrate a touch-sensitive computer to twelve year old Adam King, a pupil at the Society's Thomas Delarue School in Tonbridge.

Award to aid handicapped research

A new award scheme to encourage the use of technology to help children with cerebral palsy has been launched by computer services company Datasolve, a Thorn EMI Technology company.

The aim of the awards is to attract recognition, and ultimately funding and development, to inventive work now being done by individuals and small groups to help child palsy victims. As is often the case where ways of applying new technologies to educate and stimulate, or simply make life easier for, mentally or physically handicapped children, ideas are often devised by people working directly with children, or closely related to a handicapped child. It is hoped that the awards will attract commercial funding where it will do most good.

To attract the attention of the media and industry, the winning ideas will be unveiled in front of several hundred representatives from British computer companies at the 1987 Computer Industry Charity Ball on 11th June. Datasolve is the chief sponsor of this event, which in 1986 raised over £40,000 for Spina Bifida victims. The money raised by this year's ball will go to the Spastic's Society to provide customised accomodation for young palsy victims. Amdahl (UK) is co-sponsoring this year's event.

The scheme is setting a manufacturing cost limit of £1,000 on ideas submitted. Typical ideas could include low cost eye-movement detectors for use with a computer, or a speech recognition device which would translate speech which is hard to understand into easily recognisable words. The winning inventor will receive a Thorn EMI Liberator portable computer from Mr Douglas Shepherd, Chairman of the Spastics Society.

Cerebral palsy is a movement disorder which appears when the victim is young, and is caused by damage or impaired development of the vital area of the brain which controls movement. Symptoms vary from person to person, and range from barely perceptible impairment to almost complete immobility.

However, with the help of a microcomputer and a customised interface (a conventional keyboard is too complicated) many children with cerebral palsy can communicate and learn for themselves. The ability to control and interact with the computer helps to build the children's self-confidence and their ability to make the most of their potential.

Since every child is affected differently by cerebral palsy, some able to control the movement of their arms, while some can only control their eyes, a wide range of specialised interfaces is needed to help them.

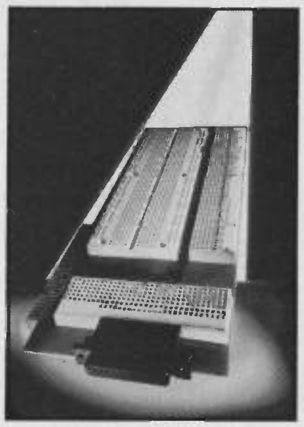
Entry forms for the Award Scheme are available from **Mary Painter at Datasolve Ltd., 61–73 Staines Road West, Sunbury-on-Thames, Middx TW16 7AH. Tel. 0932 785566.**

Satellite receiver

A new satellite TV receiver, the model RSR 30P, is being added to its range by Rediffusion Satellite Systems. This is an upgraded version of the receiver which they introduced in 1986, with a number of additional features.

The new receiver allows full remote control of polarity and skew, programmable into memory using an infra red remote control handset, and can be automatically recalled on individual channel selection. A new polaritor, designated RPR1, is being released to work with the new receiver's remote control facilities. This has been designated to be simple to mount.

Various complete receiving systems are available from Rediffusion at the **Satellite Systems Division, Rediffusion Radio Systems Ltd., Unit 9, Mole Business Park, Randalls Road, Leatherhead, Surrey KT22 7BA. Tel. 0372 379620.**



IBM PC breadboard

The PB-88 Protoboard is a 1680 point breadboarding card, which plugs directly into an IBM PC card slot to enable the user to design interfaces. The bus strip allows breaboarded circuits to be connected directly to all the PC's signals, controls and data lines.

The breadboarding area consists of two solderless bread-boarding sockets permanently attached to the base of the board. Each socket can take up to eight 14-pin d.i.l. i.c.s with four tie points per pin, and eight power rails with twenty five tie points each. All IBM signals are connected to a solderless interface socket, and an external DB-25 connector is provided for interfacing. Signals are labelled on the IBM bus and on the DB-25 interface sockets.

The PB-88 is supplied by **Global Specialities, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ. Tel. 0799 26699.**

Technomatic Special Offer

Technomatic, one of the country's leading suppliers of components and equipment, have a special offer available to PE readers only. They are offering a 10% discount on all TTL and CMOS devices. A selection of their large range will be found on page 11 of this issue.

Technomatic Ltd., 17 Burnley Road, London NW10 1ED. Tel. 01-723 0233.

Radio teletext

Six weeks of test transmissions in the London area, starting on 8 January, have been carried out by the Independent Broadcast Authority (IBA) in preparation for the launch of the UK's first radio teletext service. The data is broadcast using the Telerate data system, from the IBA's v.h.f./f.m. transmitter on 97.3MHz. Another six week test period wil be carried out on the Telemet UK Ltd financial data service on the IBA's other v.h.f./f.m. transmitter in London on 95.9MHz.

Radio teletext uses techniques already well established in the USA, but only experimentally used in the UK up to now.

CHIP COUNT

This month's list of new component details received.

BLT90 series – 900MHz Cell Radio Power transistors (ML).
BTA140 series – High current motor ctrl triacs (ML).
BTV60D seeries – low cost Gate Turn Off thyristors (ML).
Cescom 10375 – VME fast data comms switch (CS).
HM66203-4 – 1M-bit (world's largest) SRAM modules (HT).
IMS T800 – UHP 2.25 Mflop Transputer (RP).
ITEM4000 – 60 MF lop transputer eval. module (IN).
LGA63645 LCD driver for IBM PC (HT).
LM215XB – 'all round' viewing angle LCD (HT).
PAL32VX10 – High speed-density PAL (RP).
PCF8582 – 2KBit CMOS EEPROM with I²C bus interface (ML).
PLHS501 – 3rd generation PML Random Logic Unit (ML).
WS5901 – CMOS 4-bit HS m-processor (RE).
WS5901A – CMOS m-program controller (RE).
WS59032 – CMOS 32-bit HS m-processor (RE).
WS59520.1 – CMOS multilevel pipeline reg. (RE).
ZL30 series – High Speed PLD progammers (RP).

Manufacturers, and contact telephone numbers for further details. (CS) Cescom, 01-534 7613. (HT) Hitachi, 0923-46488. (IN) INMOS, 0454-616616. (ML) Mullard, 01-580 6633. (RE) Rastra Electronics, 01-748 3143. (RP) Rapid Silicon, 0494-442266.

THE LEADING EDGE

BY BARRY FOX

The technology behind the products

Can electro-magnetism help your health? Will it, charge your brain, or just your credit card?

OVER the years I have seen several patents for methods of healing broken bones by enveloping the plaster cast in an a.c. magnetic field. The patents all claim that this speeds regrowth of the bone. It's not the kind of claim you can test too easily for yourself. There are, however, some other ideas that can more easily be put to the test – although the tests are unlikely to be conclusive.

Both magnetism and air ionisation are supposed to be good for us. The snag is that the ailments they may cure are non-specific; like aches, pains and general listlessness. As a doctor told me years ago "if you tell someone that standing on their head will make them feel better, it probably will; and there's no way of knowing whether they would have felt better anyway".

The magnetism-makes-you-feel-better craze is now big business in America. The original idea was that a necklace did the trick. Now it's bracelets. In the Far East there are even magnetic sticking plasters to help heal wounds.

The magnetic necklace craze hit in Britain 10 years ago but petered out because the makers, TDK of Japan, were plainly rather embarrassed by the sale of their trinkets by a third party importer. TDK was at the time busy building up its business image as a reputable tape manufacturer. There was no place in TDK's tape marketing strategy for magnetic black magic.

TDK has started selling magnetic necklaces in Japan because the Japan Medical Journal published the results of research at the Isuzu hospital in Tokyo, and the Tokyo University medical faculty. The researchers concluded that magnetism is good for humans because the earth's magnetic field is decreasing at a rate of 0.05% per year and this creates a "magnetic field deficiency syndrome". Doctors hung powerful cobalt magnets round the necks of patients suffering from shoulder stiffness, lumbago, constipation, insomnia, dizziness and chest pains. A similar number wore dummy necklaces. More people wearing magnets felt better than those with dummies.

Magnetic sticking plasters are claimed to relieve pains in much the same way as the TDK necklaces. One theory is that they work by attracting blood – which contains iron compounds – to the scene of the wound.

Recent adverts for magnetic bracelets placed in popular American newspapers by a firm in New Jersey claims that they are in "unprecedented demand on the Continent – thousands upon thousands of Europeans now wear them". At $15 a time the bracelt is "scientifically designed . . . 100% magnetically operational".

"The moment you put on your bracelet" readers are assured "you will feel a magnetic force field penetrate your body . . . feel a surge of energy". For why? Because the bracelet "will activate magnetic waves that give off charged energy signals to the brain . . . that is the start of the new life that lies ahead".

In the past some designers have increased the drive voltage to around 6 or 7 kilovolts, in an effort to increase efficiency. The ioniser may then produce ozone which is bad news for the human respiratory tract and may also kill plants. High voltages also produce nitrous oxides.

Professor Ronald Pethig of the Industrial Development Department of the University College of North Wales, has studied the technology.

"Cheap machines are unlikely to produce ozone", he says, "because their components could not cope with the high voltages needed. But, some early machines were so clumsily made, with diodes connected the wrong way round, that they produced positive ions instead of negative!"

Do ionisers work? "I approached the subject with an open mind" says Professor Pethig "and I now know there is definitely something in it. Around 40% of the population are sensitive to ions – they get headaches when there is a positive build-up before a thunderstorm".

Others may benefit because any ions, positive or negative, clean the air by precipitating dust. Particles attract to earth, the walls and the floor. See how dusty it gets inside a TV set. Industrial plants use electrostatic charges to clean dust out of the air by clumping particles together.

Four disadvantaged Europeans agreed to wear one. Believe it or not (and some may find it hard) one made a fortune, another landed a dream job, a third gained a great love life and a fourth became the picture of health.

Feeling tired, irritable and depressed, with criminal and suicidal tendencies and aching bones? Want to supercharge your body, increase mental awareness, make sleeping easier and speed plant growth? Then, if you believe what you read in other US adverts, and watered-down versions in the UK, all you need is an ioniser.

Ions form naturally in the atmosphere when energy, from natural radio activity or cosmic rays, displaces an electron from an air molecule. The displaced electron joins another to form a negative ion and the stripped molecule becomes a positive ion. Polluted air in the cities neutralizes the ions, especially those with a negative charge. Natural winds, like the Fohn in Germany and Santa Ana in California have the same effect. The air becomes positively charged and people start feeling irritable and off colour.

The same thing happens before a thunderstorm. The air becomes positively charged and people start getting headaches. After a storm the air is exhilarating, because lightning has generated negative ions.

Home ionisers produce negative ions by feeding a high voltage (several thousands of volts negative continuous or pulsed DC) to the tip of sharp needle electrodes. The trick is to make and keep the tips so sharp so that a supply of around 3.5 kilovolts can produce a high enough charge density to ionise the surrounding air. If the electrode is blunt, or of poor quality metal which erodes, the charge density falls and the gadget produces no ions.

"If you are doubtful about the benefits" advises Pethig "buy an ioniser which guarantes your money back if it does you no good".

Old sci-fi films had the villain generating sound waves to drive the victim mad. Maybe it wasn't so crazy.

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THE VITAL TRIANGLE

A healthy magazine depends heavily on the relationship between its advertisers, its readers and itself. The importance of this vital triangle cannot be overstressed.

In particular, the relationship with advertisers deserves considerable emphasis. The primary objective of any advertiser is to sell his products. Naturally he must advertise products that people want, using an attractive technique, and in the magazines that produce the best return on investment. Several factors dictate magazine selection, and their effect is cyclic.

Firstly, the type of readership should be compatible with the nature of the product. Then, a sufficient number of readers must exist for the value of sales to be potentially high. With high sales, manufacturing or buying-in costs are proportionally reduced, enabling retail prices to be held down. This has the knock-on effect of affirming public confidence, which in turn can enhance sales and profitability. Make no mistake, profit is the essential end product for any company.

Readers buy magazines for two basic reasons. The most obvious being that they are interested in the subject matter published. Consequently, a magazine has to ensure that its articles are written by good and interesting authors, and have the right degree of sophistication. Secondly, it is well established that many people buy magazines as much for adverts, as for articles, and whether they want components or complete units, they turn to the magazines containing adverts related to their needs.

In one sense then, a magazine is simply a meeting point for advertisers and customers. However, it too needs to be profitable. Magazines derive their income from selling copies and advertising space. Selling more issues not only relatively reduces publishing costs, but also provides advertisers with a wider shop window potential. As more advertisers recognize a viable market place, so a magazine receives greater advertising revenue. With a higher profit margin, it can invest more heavily in ambitious articles and features, to the benefit of an increasing number of readers, and without having to raise the cover price too frequently, which any magazine is extremely reluctant to do.

Obviously then, a good magazine like PE, has to look after the interests of its readers and its advertisers alike. Without either it cannot survive. I have first hand experience of all sides of the equation, and as Editor, I am determined that the relationship with advertisers is given the prominence it deserves. With this policy I believe that everyone benefits – advertisers from a good market place, readers from a wide variety of products, projects and articles, PE from a strong distribution, and for me personally, from the satisfaction of helping PE to maintain its lead.

Advertisers, readers, let me know your thoughts.

THE EDITOR

OUR JUNE 1987 ISSUE WILL BE ON SALE FRIDAY, MAY 1st 1987 **(see page 2)**

CONSTRUCTIONAL PROJECT

VERSATILE AUDIO A-D-A UNIT

BY JOHN BECKER

The first of two articles on a digital sound signal processor

A home computer can be used to process an audio signal to make a plethora of standard, strange and sampled sound effects. In all cases the signal must be converted from analogue to digital form, and back again. This interface works with audio units, any 8-bit I/O computer, and dedicated sound processors, such as the Polywahtsit!

REGULAR readers of PE will be aware that a home computer can be used for considerably more than playing games and general computing, and that a vast range of audio effects can also be computer created and controlled. Indeed some effects can only be created by a computer or equivalent digital memory storage unit.

Many of these effects require an original audio signal to be fed to the memory unit, stored, retrieved and returned after a suitable delay. In this way standard effects such as echo, reverb, phasing and flanging can be created with suitable software. Other stranger effects can also be produced, such as pitch change, reverse tracking (playing backwards), repeated looping and robot voices, to name but a few examples.

For all of these effects it is necessary to convert the original audio analogue signal to a digital form that the computer or memory can accept, and to subsequently reconvert the digital representation back to an analogue signal. Since the basic requirements for A to D and D to A will be pretty much similar for most digitally produced effects, this project has been designed as a general purpose interface unit that can be used between audio units (such as musical instruments, high output microphones and recordings), and vertually any computer providing that it has a normal 8 bit input-output socket, such as the Commodore Pet series, C64, and the BBC etc. Additionally, and equally important, the board can also be used as the interface for digital processing units that are dedicated to particular sound modifications. An example of such a unit will be described in a second article, in the next issue.

From the block diagram of the unit (Fig.1.),it will be seen that the project caters for most of the pre- and post digital processing requirements for effects modification. The basic facilities here are a variable level and gain pre-amp, feedback and feed forward mixing, and gated analogue converters, both of which can be controlled either internally or externally. Modulated filter and amplitude control is not included since this can be performed by a separate analogue unit.

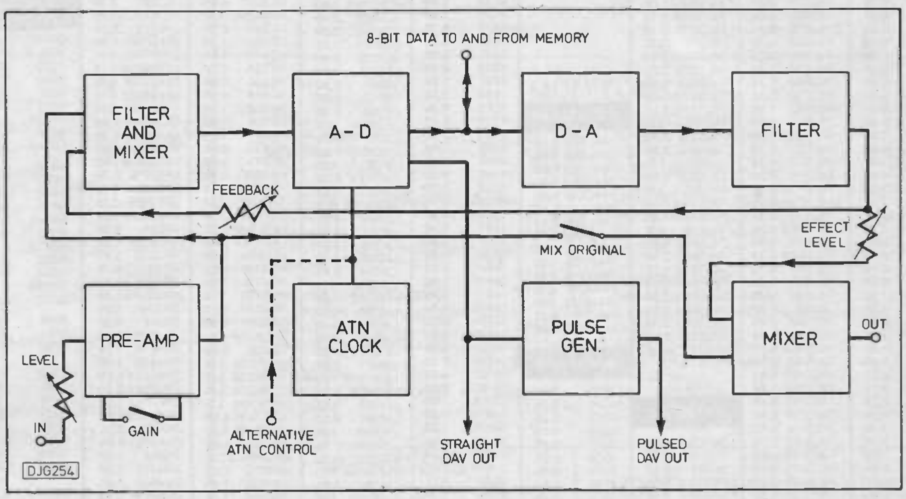


Fig.1. *Block diagram of Audio A-D-A Unit.*

ANALOGUE TO DIGITAL

For audio signal processing the analogue to digital conversion needs to be a continuous process, repeatedly sampling the level of the signal and converting it to a digital representation. For a reasonable degree of accuracy the digital number should be represented by at least eight binary bits, any of which can be high or low, with a total combination of 256 variations. A higher bit count of 12 or 16 would produce greater accuracy, but since most computers available to the home user are designed as 8 bit machines, the coverter used here also generates an 8 bit number.

The chip used for the conversion, IC2, (Fig.2.). has an internal oscillator, operating at about 1MHz as set by the value of C10. Upon receipt of a positive going transition (ATN) on its Convert input, pin 4, the oscillator clocks the conversion process through 8 steps. At each step the chip decides whether the associated bit should be high or low, depending on an internal comparison with the analogue signal level. After about 8 microseconds, once all bits have been set, the output at pin 1 goes from low to high. This transition can be used to tell the computer or other digital equipment that the conversion is complete.

During the conversion it is usually preferable for the outputs of IC2 to be in a high impedance state so that other circuits connected to the same output data lines are unaware of the conversion process. IC2 pin 2 controls the outputs, holding them closed in the presence of a high level, and opening them for a low level. The inverter IC4a is included between pins 1 and 2 so that the outputs are always closed during the conversion, and open only upon its completion. A link wire is included on the PCB so that this can be omitted and pin 2 controlled instead from the computer or other source. The maximum level on the audio input pin 6 that will produce the maximum binary output number of 255 is determined by an internal 2.5v reference voltage supplied from pin 8 to pin 7, in association with R14 and C11. Each binary step thus represents approximately 10mV of signal level.

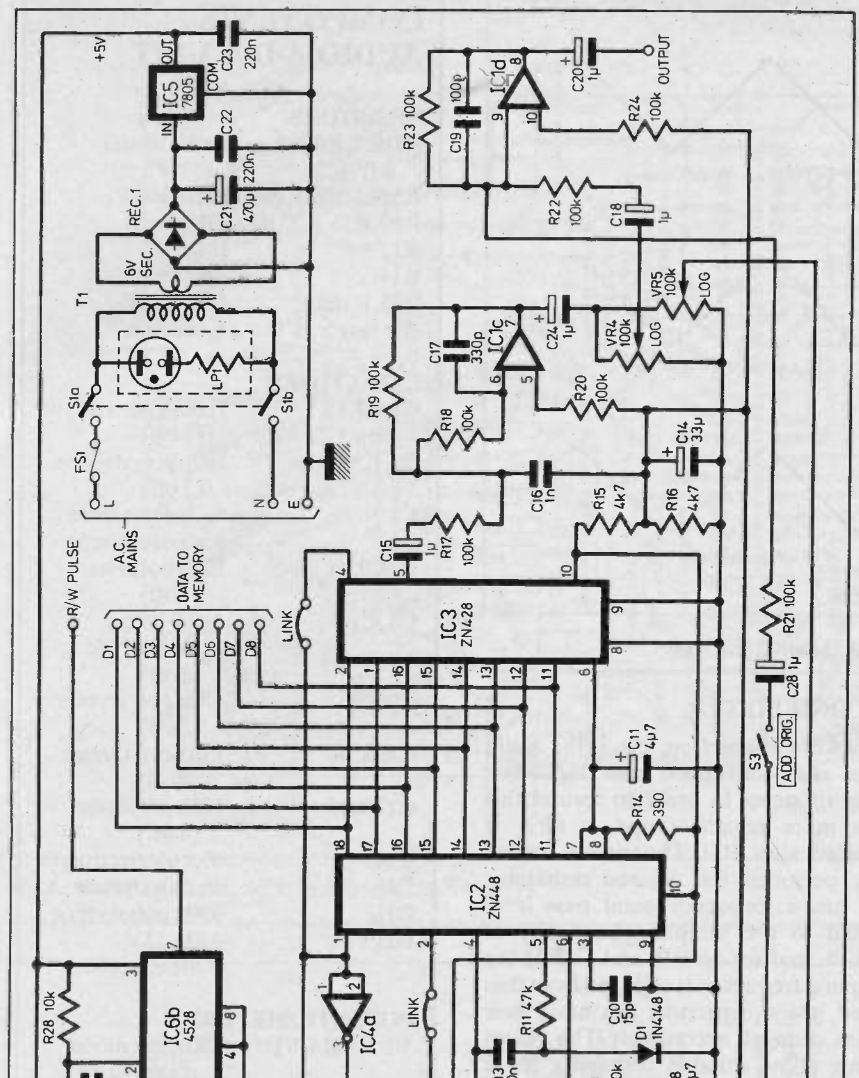


Fig.2. *Circuit diagram of Audio A-D-A Unit.*

DIGITAL TO ANALOGUE

The data lines from IC2, to and from the computer are also those that feed to the digital to analogue converter IC3. For any binary number from 0 to 255 this chip produces an equivalent voltage output. Since its reference level is the same as that supplying IC2, this will also lie in the range of 0v to 2.5v. As it is normally undesirable for the output of IC2 to be transferred to the output of IC3, the latter is latched so that the data passing through can be suitably synchronised to the data coming from the computer or processing unit, rather than from the A to D chip. The latch control here is normally directly coupled to the IC2 pin 1, so that when the outputs of one are closed, the outputs of the other are open. By omitting the link wire on the PCB between IC3 pin 4 and IC2 pin 1, the computer or other unit can alternatively be used to control this latching via IC3 pin 4.

A-D CONVERT CONTROL

IC4b-d form an oscillator with its frequency set by the value of C9 and R26 to about 18kHz. This square wave output repeatedly triggers the A to D conversion, and is also used to generate a negative voltage level that is simultaneously required by IC2 pin 5, and derived in association with C13, D1 and R11. The PCB has been designed with another link wire between this oscillator and IC2. If the link is omitted the conversion can alternatively be controlled by the computer or other source. If the internal oscillator is retained, its frequency could be made variable by the inclusion of a potentiometer between R26 and the junction of R13 and C9. The value of R26 can also be changed to give a different maximum frequency, but its value should preferably not be lower than 10k.

DATA VALID SIGNALLING

For use with a computer, the output of IC2 pin 1 can be used to signal that the conversion data is now valid (DAV) and that the output can be read. This changing voltage level can also be used to step the counter on any other digital processor, or to perform other synchronised functions. However, some equipment may prefer to have a short delay between a counter controlled address change, and the writing of the signal data into its memory. IC6 is consequently included, configured as two monostablesin series. The first, IC6a is triggered by the positive going edge of the output from IC2 pin 1. The output at IC6 pin 10 at once goes high and remains so for about 4.5 milliseconds as set by the value of C25. At the end of the delay, the negative going edge from pin 10 triggers IC6b which immediately produces a negative going pulse at pin

7, lasting for approximately 1 microsecond as set by C26. This output can be used to control the Write mode of any other memory circuit. Pin 6 of IC6 could alternatively be used for its positive going pulse.

INPUT CONTROL

The audio signal to be processed is brought into the level control VR1, and then to the inverting stage around IC1a. With S2 closed, the gain is set at unity, but with S2 open R12 is brought into circuit, which the value shown gives a gain of about 13 to the audio signal. This allows for medium and high level signals to be catered for, but low level signals should be preamplified before being brought to the unit, in order to retain good signal to noise characteristics. Since IC2 will only satisfactorily process signals upto 2.5V peak to peak, the maximum level seen at IC2 pin 6 should not exceed this, otherwise clipping will occur. It is also preferable that the overall signal level should be fairly close to maximum so that a reasonable digital conversion representation can result. If the signal is too low, too few bits will be set resulting in low level distortion and noise. The original signal itself should also be as free from noise as possible.

FIRST FILTER AND MIXER

Since the A to D coversion is clock controlled, the maximum signal frequency that can be sampled satisfactorily is limited by the clocking rate. Ideally this should be at least three times as fast as the audio frequency. Frequencies above this rate are liable to result in sub-harmonic generation. The amplitude of upper audio frequencies is consequently given attenuation prior to the A to D conversion. This occurs at IC1b, with the upper limit set by C5 and C6. These are set to give a reduction to half level at 3.5kHz, and progressively more above this frequency. Since the main power in most audio frequencies is usually below 3kHz, the attenuation can be regarded as normally unnoticable. To offset the effects of the second filter, pre-emphasis is given to mid range frequencies by R4 and C4, with bass frequencies effectively dropping to half level at about 120Hz. This stage also serves as a mixer for feeding back processed signals for such effects as echo and reverb. VR2 presets the maximum level of feedback.

The output of IC1b goes to the analogue input of IC2 via C7. VR3 is used to supply an optimum bias to IC2 pin 6 so that the audio signal swings evenly to either side of this level, so maintaining an even waveform through IC2 at peak levels. In the absence of a signal, the output of IC2 will be at approximately half level, of 128 decimal.

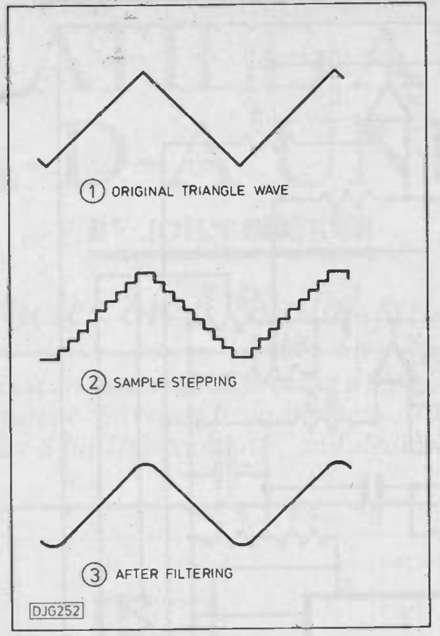


Fig.3. *Sample filtering.*

SECOND FILTER

As will be seen from Fig.3, the audio signal after conversion from digital is a series of steps. In order to restore this to a more regular shape, a filter is required after IC3. The circuit around IC1c performs this filtered reshaping, and has a frequency band pass level related to the sampling frequency of IC4b-d, and set by C16 and C17. If the sampling frequency is changed from that stated, these capacitors can have their values changed accordingly. The values shown allow suitable reshaping for a sampling rate as low as 9kHz.

From IC1c, the reconstituted signal can be fed back to IC1b via the elvel control VR5, or to the output stage IC1d, the original unprocessed signal can be mixed in via S3. If panel space permits, another level control could be inserted here, taking the output of IC1a via the coupling capacitor C3 to the pot, and then to C28. From IC1d the mixed signal can go to any ordinary amplifier. If panel space still permits, a master output level can be inserted immediately after C20.

POWER SUPPLY

The maximum voltage level acceptable by IC2 and IC3 is 5 volts d.c., and this is supplied to the full circuit by the stabilised mains power supply shown in Fig 2. It can deliver about 300mA, of which about 50mA is drawn by unit, leaving a healthy margin for driving other circuits as well.

SETTING UP

Fig.4 and Fig.5 show the p.c.b. and control wiring connections. The choice of internal or external control of the A to D and D to A chips will depend on the purpose to which the unit is put. Whatever that purpose is, VR2 and VR3

COMPONENTS AUDIO A-D-A UNIT

RESISTORS

R1-R4,R6-R9, R17-R24	100k (16 off)
R5,R11,R25,R26	47K (4 off)
R10,R13,R27,R28	10K(4 off)
R12	1M
R14	390
R15,R16	4K7 (2 off)

All resistors ¼w 5% carbon

CAPACITORS

C1,C3,C15,C18, C20,C24,C28	1µ 63V electrolytic (7 off)
C2,C5,C19	100p polystyrene (3 off)
C4	4n7 polystyrene
C6	56p polystyrene
C7,C22,C23	220n polyester (3 off)
C8,C11	4µ7 63v electrolytic (2 off)
C9,C25	470p polystyrene (2 off)
C10,C26	15p polystyrene (2 off)
C12,C13	100n polyester (2 off)
C14	33µ 6V electrolytic
C16	1n polystyrene
C17	330p polystyrene
C21	470µ 25V electrolytic

POTENTIOMETERS

VR1,VR4,VR5	100K log mono rotary (3 off)
VR2	250K skeleton
VR3	100K skeleton

SEMICONDUCTORS

D1	1N4148
REC1	1A bridge rectifier
IC1	324
IC2	ZN448
IC3	ZN428
IC4	4011
IC5	7805
IC6	4528

SWITCHES

S1	min d.p.d.t.
S2,S3	min s.p.d.t. (2 off)

MISCELLANEOUS

Fuseholder, PCB clips (4 off), 1A fuse, knobs (3 off), mains neon, printed circuit board 251A, 14-pin i.c. socket (2 off), 16-pin i.c. socket (2 off), 18-pin i.c. socket, Mono jack socket (2 off), Transformer 2 x 6VA 6V secondaries.

THE PRINTED CIRCUIT BOARD AND A FULL KIT OF PARTS IS AVAILABLE FROM PHONOSONICS. SEE ADVERT.

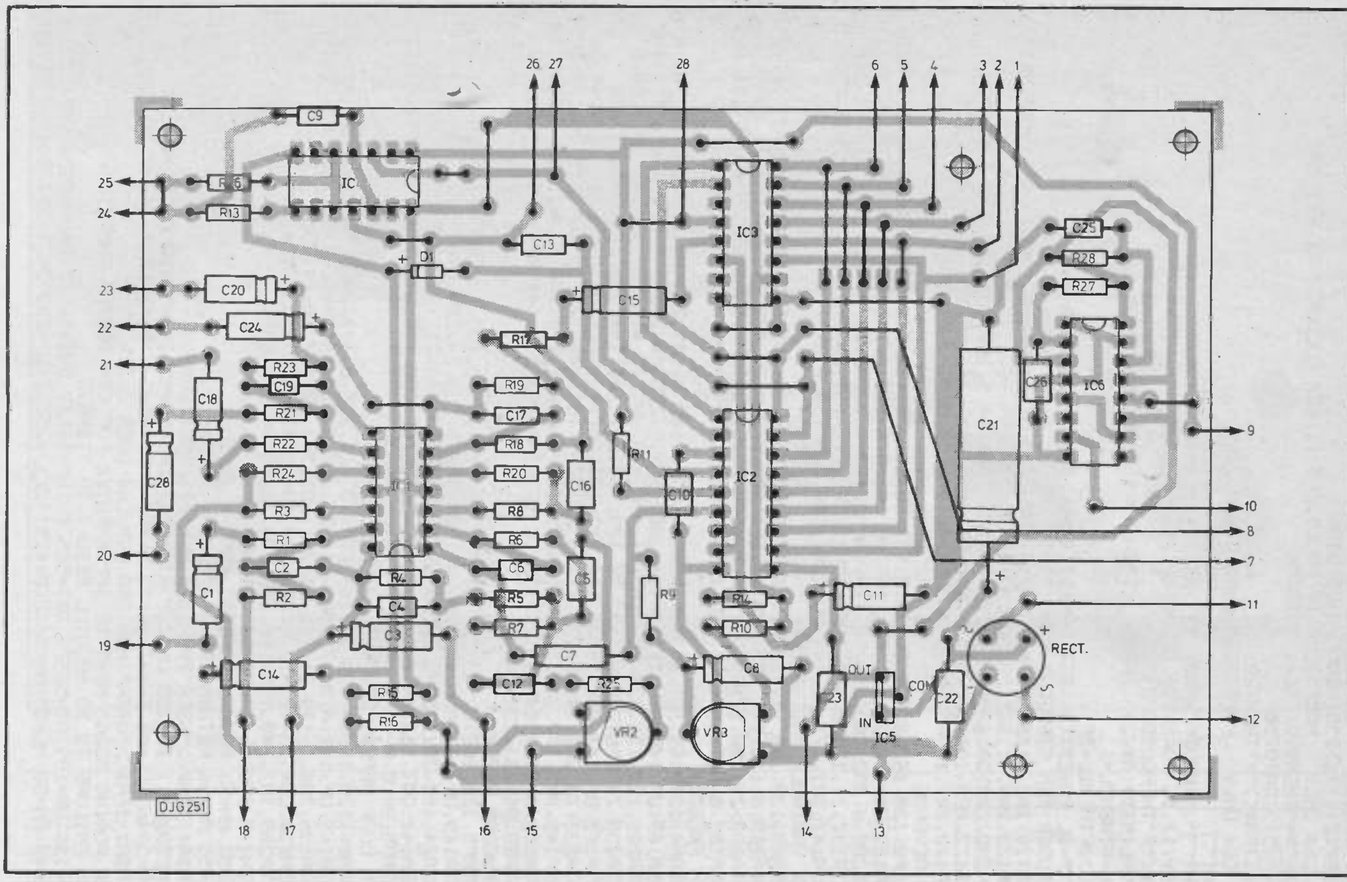
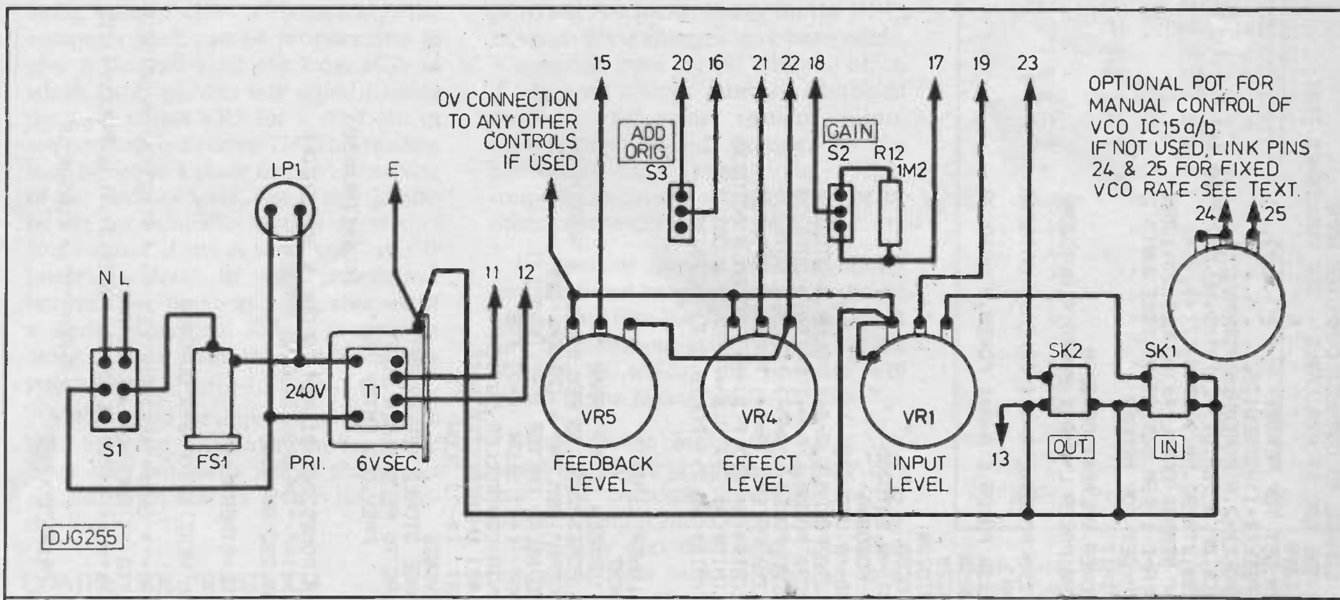


Fig.4. *Printed Circuit Board component layout.*

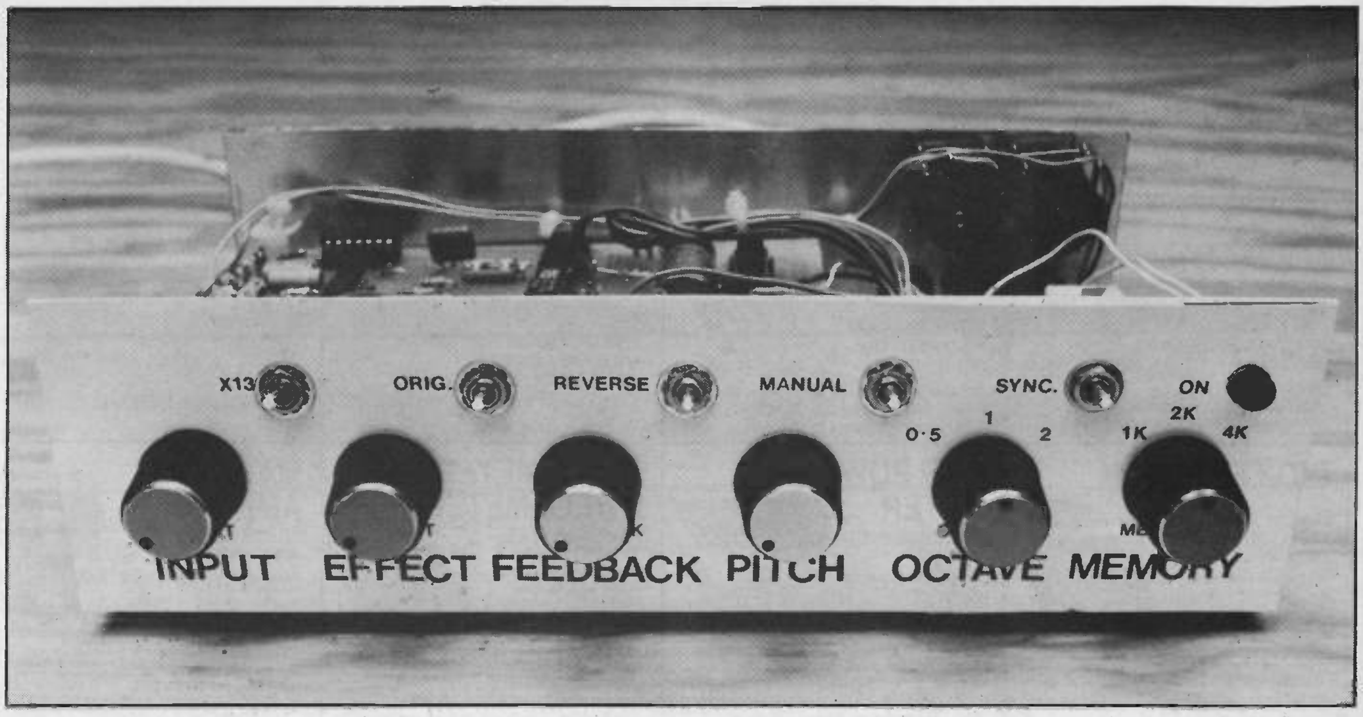


OTHER PCB PIN CONNECTIONS (SEE TEXT)

PCB PINS	1-8 data inputs/outputs in order (1 is MSB)		
PIN 9	DAV output (Synchronised)	PIN 27	Access to PIN 2 IC2 (A-D Read Enable) (IC4 must be omitted if used for external input control)
PIN 10	Pulsed DAV output (Delayed)		
PIN 14	+5v output		
PIN 26	Access to PIN 4 IC2 (Convert Trig) (link wire to PIN 11 IC4 must be omitted if used for external input control)	PIN 28	Access to PIN 4 IC3 (D-A Read Enable). Link wire to PIN 1 IC2 must be omitted if used

Fig.5. *Wiring diagram for Audio A-D-A Unit.*

```
100 PRINT"]PROG251 ADA DELAY CONTROL AUG86":REM "]" = CLEAR SCREEN
110 DATA1-PET USER:REM 2-C64 - CHANGE TO CORRECT COMPUTER NAME
120 REM A SEPARATE LISTING FOR THE BBC IS AVAILABLE - SEE PUBLISHED TEXT
130 READA$:ONVAL(A$)GOSUB1300,1310
140 B=PEEK(MH)*256+PEEK(ML):REM GET TOP MEMORY
150 GOSUB1290:IFPEEK(B+2)*256+PEEK(B+1)=BTHEN170
160 B=B-3:GOSUB1290:POKEB+1,L:POKEB+2,M:POKEMH,M:POKEML,L
170 CLR:DIMA,B,D,L,M,AT,BO,BT,CR,DF,DL,DN,DT,FL,FH,MD,ML,MH,TP,UP,VL
180 DIMDAV,DRT,INP,OUT,SET,A$,B$,BT(20),MD(3),P(6),Z(4),V(4)
190 PRINT:PRINT"LOADING MEMORY":READB$:ONVAL(B$)GOSUB1320,1350
200 D=PEEK(FH)*256+PEEK(FL)+10:A=D-1:REM GET START FREE RAM
210 B=PEEK(MH)*256+PEEK(ML):REM GET TOP MEMORY
220 GOSUB1290:TP=M-1:REM MAX LIMIT
230 READA$:A=A+1:IFA$<"A"THENPOKEA,VAL(A$):GOTO230
240 IFA$="ATN"THENB=AT:GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
250 IFLEFT$(A$,1)<>"A"THEN270
260 B=D+VAL(MID$(A$,2)):GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
270 IFLEFT$(A$,3)<>"JMP"THEN290
280 B=D+VAL(MID$(A$,4)):GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
290 IFA$="DN"THENPOKEA,DN:GOTO230
300 IFA$="UP"THENPOKEA,UP:GOTO230
310 IFA$="SET"THENPOKEA,SET:GOTO230
320 IFA$="TOP"THENPOKEA,TP:GOTO230
330 IFA$="BOT"THENBT=BT+1:BT(BT)=A:GOTO230
340 IFA$="DRN"THENDT=A:POKEA,0:GOTO230
350 IFA$="MID"THENMD=MD+1:MD(MD)=A:GOTO230
360 IFA$="DAV"THENB=DAV:GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
370 IFA$="DRT"THENB=DRT:GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
380 IFA$="INP"THENB=INP:GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
390 IFA$="OUT"THENB=OUT:GOSUB1290:POKEA,L:A=A+1:POKEA,M:GOTO230
400 IFLEFT$(A$,1)="P"THENB=VAL(MID$(A$,2)):P(B)=A+1:POKEA,0:GOTO230
410 IFLEFT$(A$,1)="V"THENB=VAL(MID$(A$,2)):V(B)=A:POKEA,0:GOTO230
420 IFLEFT$(A$,1)="Z"THENB=VAL(MID$(A$,2)):POKEA,Z(B):GOTO230
430 IFA$="END"THEN450
440 STOP
450 B=A:GOSUB1290:BOT=M+1:REM LOWER LIMIT
460 FORB=1TOBT:POKEBT(B),BOT:NEXT
470 DF=TP-BOT-1:B$="NIL":PRINT"]":REM DELAY RANGE
480 REM C64 ONLY : POKE53280,6:POKE53265,155:REM COLOUR & SCREEN ON
490 PRINT"■":PRINT"SAMPLER PROGRAM":REM "■" = CURSOR HOME
500 PRINT:PRINT:PRINT"LIVE ECHO DELAY FACTOR 1 -";DF;" [?]
510 PRINT:PRINT"LIVE - [+?] FAST  [-?] SLOW  [←?] RVS
520 PRINT:PRINT"LIVE IRQ ONLY VIA CONTROLLER SWITCH
530 PRINT:PRINT"LOOP - [*] & [*0] UNCORRECTED RATE
540 PRINT:PRINT"     - [*?] FAST  [*-?] SLOW
550 PRINT:PRINT"     - [*←] REVERSE
560 PRINT:PRINT"[=] IRQ TO CHANGE STORED REPLAY RATE
570 PRINT:PRINT"[OTHER KEYS] IRQ TO RECORD NEW LOOP
580 PRINT:PRINT"['?' = NUMBER]    PREVIOUS ENTRY "B$"          "
590 PRINT:PRINT"                                          ":IFCR=1THEN690
600 INPUT"]WHICH";A$:B$=A$
610 REM C64 ONLY : POKE53280,16:POKE53265,11:REM COLOUR & SCREEN OFF
620 DL=ABS(VAL(A$)):IFLEFT$(A$,1)="-"THENPOKEDT,202:GOTO840
630 IFLEFT$(A$,1)="+"THENPOKEDT,232:GOTO840
640 IFLEFT$(A$,1)<>"←"THEN680
650 DL=ABS(VAL(MID$(A$,2))):IFDL=0THENDL=1
660 IFDL>DFTHENDL=DF
670 FORB=1TOMD:POKEMD(B),BOT+DL:NEXT:SYS(P(2)):GOTO480
680 IFLEFT$(A$,1)<>"*"THEN850
690 DL=ABS(VAL(MID$(A$,2))):IFA$="*"ORA$="*0"THENPOKEV(3),1:POKEV(4),0:GOTO720
700 IFMID$(A$,2,1)="-"THENPOKEV(3),1:POKEV(4),DL:GOTO720
710 DL=DL*20/19:VL=INT(DL/20):DL=DL-(VL*20):DL=20-DL:POKEV(3),VL+2:POKEV(4),DL
720 IFCR=1THEN770
730 PRINT"]                                  ":REM "]" = CURSOR UP
740 PRINT"]WAITING",:SYS(P(4)):PRINT"LOOPED"
750 GETA$:IFA$<>""THEN800
760 IFPEEK(Z(1))<>255THENCR=0:GOTO480
770 REM C64 ONLY : POKE53280,16:POKE53265,11:REM COLOUR & SCREEN OFF
780 IFB$="*←"THENSYS(P(6)):GOTO750
790 SYS(P(5)):GOTO750
800 CR=0:IFA$<>"="THEN720
810 REM C64 ONLY : POKE53280,6:POKE53265,155
820 PRINT"]                                  "
830 PRINT"]";:INPUT"CHANGE TO";A$:CR=1:B$=A$:GOTO480
840 POKEV(1),DL:POKEV(2),DL:SYS(P(3)):GOTO480
850 IFA$<"A"THENGOTO870
860 DL=VAL(MID$(A$,2)):IFP(DL)<>0THENSYS(P(DL)):GOTO480
870 IFDL=0THENDL=1
880 IFDL>DFTHENDL=DF
890 DL=TP-DL:POKEBT(3),BOT:POKEBT(4),DL:SYS(D):GOTO480
900 DATAUSER:REM STRAIGHT ECHO
910 DATA120,162,0,169,DN,45,ATN,141,ATN,169,UP,13,ATN,141,ATN,160,0,140,DRT
920 DATA173,DAV,41,SET,208,6,200,240,2,208,244,96
930 DATA232,208,30,238,A75,172,A75,192,TOP,144,5,160,BOT,140,A75,238,A83
940 DATA172,A83,192,TOP,144,5,160,BOT,140,A83,173,INP,157,0,BOT,160,255
950 DATA140,DRT,189,0,BOT,141,OUT,24,144,169,0,0
960 REM REVERSE
970 DATAP2,120,162,0,160,0,169,0,133,Z0,133,Z2,133,Z4,169,BOT,133,Z1,169,MID
980 DATA133,Z3,169,DN,141,ATN,169,UP,141,ATN,169,0,141,DRT,173,DAV,41,SET
990 DATA208,4,232,208,246,96,170,198,Z2,230,Z0,208,18,198,Z3,230,Z1,169,MID
1000 DATA197,Z1,176,8,169,BOT,133,Z1,169,MID,133,Z3,173,INP,145,Z0,169,255
1010 DATA141,DRT,177,Z2,141,OUT,208,188,240,186,0,0
1020 REM VARIABLE FAST SPEED
1030 DATAP3,120,169,V1,133,Z1,160,0,162,0,134,Z0,169,DN,141,ATN,169,UP,141,ATN
1040 DATA169,0,141,DRT,173,DAV,41,SET,208,5,230,Z0,208,245,96,133,Z0,200
1050 DATA198,Z1,208,5,169,V2,133,Z1,DRN,232,173,INP,153,0,BOT,169,255,141,DRT
1060 DATA189,0,BOT,141,OUT,208,197,240,195,0,0
1070 REM FREEZE
1080 DATAP4,120,169,BOT,133,Z1,160,0,162,0,169,0,133,Z4,141,DRT,169,DN,141,ATN
1090 DATA169,UP,141,ATN,173,DAV,41,SET,208,5,230,Z4,208,245,96,133,Z4,173,INP
1100 DATA201,123,176,225,169,DN,141,ATN,169,UP,141,ATN,173,DAV,41,SET,208,5
1110 DATA230,Z4,208,245,96,133,Z4,173,INP,201,180,144,225,169,DN,141,ATN
1120 DATA169,UP,141,ATN,169,0,141,DRT,173,DAV,41,SET,208,5,230,Z4,208,245,96
1130 DATA133,Z4,200,208,8,230,Z1,165,Z1,201,TOP,240,32,173,INP,145,Z0,169,255
1140 DATA141,DRT,177,Z0,141,OUT,201,136,176,9,201,120,144,5,232,240,6,208,188
1150 DATA162,0,240,184,165,Z1,133,Z2,173,INP,169,255,141,DRT,169,255,133,Z1
1160 DATA88,96,234,234
1170 REM LOOP REPLAY
1180 DATAP5,120,169,0,133,Z0,169,BOT,133,Z1,169,0,133,Z4,160,0,169,DN,141,ATN
1190 DATA169,UP,141,ATN,173,DAV,41,SET,208,5,230,Z4,208,245,96,133,Z4,173,INP
1200 DATA24,165,Z0,105,V3,133,Z0,165,Z1,105,0,133,Z1,197,Z2,240,17,177,Z0
1210 DATA141,OUT,162,V4,240,3,202,208,253,234,208,197,240,195,169,255,133,Z1
1220 DATA88,96,0,0
1230 REM LOOP REPLAY REVERSE
1240 DATAP6,120,169,0,133,Z0,169,TOP,133,Z1,169,0,133,Z4,160,0,169,DN,141,ATN
1250 DATA169,UP,141,ATN,173,DAV,41,SET,208,5,230,Z4,208,245,96,133,Z4,173,INP
1260 DATA136,208,8,198,Z1,165,Z1,201,BOT,144,23,177,Z0,141,OUT
1270 DATA234,234,234,234,234,234,234,234,234,234,234,234,234,234
1280 DATA208,197,240,195,169,255,133,Z1,88,96,0,0,END
1290 M=INT(B/256):L=B-(M*256):RETURN
1300 ML=52:MH=53:RETURN:REM PET MEMORY TOP
1310 ML=55:MH=56:RETURN:REM C64 MEMORY TOP
1320 READA$:IFA$<>"USER"THEN1320:REM PET USER CODES
1330 POKE59467,1:DN=205:UP=237:AT=59468:DRT=59459:INP=59457:OUT=59471:SET=2
1340 DAV=59469:FL=46:FH=47:ML=52:MH=53:FORB=0TO3:Z(B)=B:NEXT:Z(4)=5:RETURN
1350 READA$:IFA$<>"USER"THEN1350:REM C64 USER CODES
1360 REM POKING 53265 MUST BE IMPLEMENTED FOR C64 DURING SAMPLING
1370 REM FAILURE TO DO SO WILL RESULT IN VIBRATO
1380 DN=195:UP=199:AT=56576:DRT=56579:INP=56577:OUT=56577:DAV=56589:SET=16
1390 FL=49:FH=50:ML=55:MH=56:Z(0)=251:Z(1)=252:Z(2)=253:Z(3)=254:Z(4)=2:RETURN
```



Photograph of complete Audio A-D-A Unit, also incorporating the Polywhatsit! Circuit to be described next month.

can be set whilst listening to the output, starting off with them both in midway position. VR3 is then adjusted around its midway point until no distortion is heard at signal levels just below maximum. Alternatively if the unit is being used with a computer, the computer itself can be programmed to give a decimal read out from IC2, in which case, without any signal passing through, adjust VR3 for a read out of approximately decimal 128. This reading may be set to a place or two either side of the midway level, but it should also be set for minimum output noise that could result if the A to D converter is hovering close to the changeover between two numbers in the absence of a signal. This final setting is actually more critical than the exact midway point setting.

VR2 should be adjusted so that with VR5 fully up for maximum feedback, howl does not occur. Adjust this preset for maximum echo or reverb just below the howl point.

COMPUTER PROGRAM

The computer program listing shown on the previous page is an example of the type of control functions that can be created by coupling the Audio ADA unit to a computer. The listing is in Basic, but also consists of its own relocatable machine code mini-assembler. It has been written in PET Basic, but it additionally has data incorporated in it enabling the Commodore C64 to be used as the controlling micro. The difference between the PET and C64 as far as this type of program is concerned is minimal.

This is largely true for the BBC computer, and very little change is needed for the program to be translated for it. The main differences are in the memory location codes used, and in a few dialect changes needed within the body of the program. A separate listing for the BBC, in which these changes have been made, is available from the PE editorial office if you send a large stamped addressed envelope (overseas readers please enclose one pound sterling, or the equivalent in international reply coupons, to cover postage). Listings for other computers are not available.

When using the unit with a computer and the listed program, a switch should be inserted into the DAV line, to switch out the synchronisation pulse, in the absence of which, the program will return to the menu options display.

Study of the listing will show the versatility of the program and the ADA unit. The principle functions are to sample an input audio signal, store it for a particular period of time, and then return the data back to the unit as a delayed signal. The amount of time for which it is stored determines the delay factor, and the method of reading it back sets the other functions. In this way, straight echo can be produced, or more complex functions such as replay speed variation, so increasing or decreasing the pitch. It will also be seen that the sampled signal can be frozen, or looped, and that the direction of signal replay can be reversed, in effect playing it backwards. Use of the panel controls can then help create some really remarkable effects.

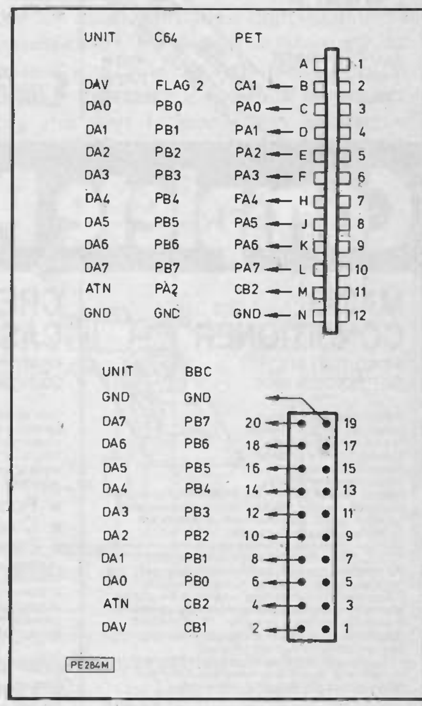


Fig.6. *Computer port connections for the BBC, Commodore C64, and PET Computers.*

DEDICATED CONTROLLER

Next month's issue describes a practical electronic example of one possible circuit that can be used with this unit in place of a computer, providing frequency shifting, reverse tracking, together with double tracking, echo and reverb. It is a highly versatile addition, and goes by the astonishing name of Polywhatsit! P.E.

EXPERIMENTAL ELECTRONICS

BY THE PROF

Biofeedback measurement circuits.

"Biofeedback" has been used in lie detectors. The more nervous the subject becomes, the higher the meter rises. But these measurements can also be used to control the body's nervous reactions, with beneficial side effects such as a lower heart rate, a more relaxed posture, greater confidence – and possibly even greater intelligence and reduced hair loss. Would we lie to you??!!

WITH the seemingly ever increasing pace of modern life, and the increased stress that we all seem to suffer, there is growing interest in the subject of biofeedback. In case this term is new to you, it basically involves having a device of some kind, but usually electronic in nature, which gives an indication of how relaxed (or otherwise) the monitored person happens to be. The idea is for the subject to try to relax, and the monitoring device will provide an indication of some kind if he or she is successful. Then, by continuing to act in the same way, an ever deepening state of relaxation can, in theory at any rate, be achieved. It thus helps to relieve stress in those who otherwise find it very difficult to relax, and it does not require the use of any drugs which could be potentially addictive or in some way harmful in the long term. Although there is no electronic feedback path, this system is a genuine feedback type in that the user responds to the results indicated by the monitoring device, and forms part of a positive feedback loop.

There are various ways of measuring relative stress in the human body, and in this article we will consider three types of these 'strain gauges'. The circuits featured in this article are designed to monitor relative skin resistance, skin temperature, and heart rate. I am not making any great claims as to how effective these devices are or are not when used as aids to relaxation, but they are certainly interesting to experiment with, particularly the heart rate monitor circuits. All the circuits are reasonably simple and inexpensive to build, and are quite viable as projects to build just for the fun of it.

SKIN RESISTANCE

Many circuits for devices which respond to changes in skin resistance have been published in the electronics press, and these have most often been put forward as 'Lie Detectors'. The theory behind this has it that when the subject tells the truth he or she remains relatively relaxed, but they become exposed to increased stress when they tell a lie. Stress causes increased perspiration, which in turn results in increased resistance between two electrodes positioned on the subject's skin. Devices of this type seem to be virtually useless as lie detectors in that many people are able to fool them, and practically anybody can be trained to do so. Also, with any form of lie detection the method of questioning has to be more subtle than just asking a few questions and expecting reliable truth/lie indication. Despite its limitations for lie detection, a device of this type does represent an attractively simple introduction to the subject of biofeedback.

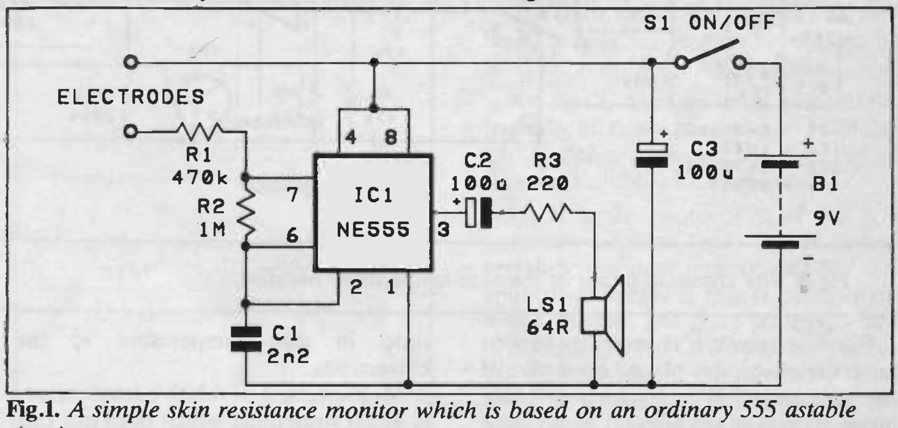


Fig.1. *A simple skin resistance monitor which is based on an ordinary 555 astable circuit.*

Obviously, measuring resistance does not provide a particularly difficult technical challenge. The resistance between the two electrodes is likely to be quite high at several hundred kilohms, and possibly as much as several megohms. This is within the capabilities of the average multimeter, and probably most readers could experiment with this type of sensor without building up a special monitor circuit. One word of warning though, for reasons of safety you should not try this with a mains powered multimeter, or any mains powered device, unless some form of isolation circuit is included between the electrodes and the measuring device.

There are alternatives to having meter indication, or to having any form of visual indicator come to that. A simple but effective approach is to have a circuit which produces a tone that increases as the subject's skin resistance decreases, and a state of deep relaxation is therefore induced by obtaining the lowest possible tone from the unit. The circuit for a monitor of this type is provided in Fig. 1.

There is nothing remarkable about the circuit, which is basically just a faithful old 555 astable driving a high impedance loudspeaker. R3 is used to attenuate the output somewhat so as to give a volume level that is quite low, which avoids having the unit induce stress instead of aiding relaxation. The skin resistance is placed in series with R1, and it consequently forms part of IC1's timing resistance. Thus, the lower the skin resistance, the higher the output frequency from the unit. The tone varies from a sub-audio 'clicking' sound with a skin resistance of many megohms to an audio tone of a few hundred Hertz with a short circuit between the electrodes. However, by changing the value of C1, the tone range can be altered if desired.

For the unit to stand any chance of functioning reasonably well, it is essential to have electrodes which operate effectively and reliably. Simply holding a couple of small metal electrodes, one in each hand, is unlikely to give good results. The problem here is simply that the tone would then vary over a wide range of frequencies depending on how hard the electrodes were gripped. It is possible to buy proper electrodes complete with conductive jelly, and these are taped in place. This type of electrode does not lend itself well to the present application though, as the conductive jelly would ensure a relatively low resistance between the two electrodes regardless of how stressed or relaxed the subject happened to be. Taping the electrodes in place does seem to suit this application well though, and two small pieces of practically any sheet metal should suffice as the electrodes.

If you use aluminium, which most readers will probably have available in the spares box, it will not be possible to solder a lead direct to each electrode unless special aluminium solder is used. The alternative is to fix a soldertag to each electrode and then make the connections via these, but this type of electrode is likely to prove a little uncomfortable for the user, and the direct soldering method is preferable. The electrodes do not need to be very big, and anywhere in the region of 100 to 500 square millimetres should suffice.

quickly. Changes in the opposite direction seem to be somewhat less spectacular, and this is presumably because the subject produces increased perspiration almost immediately when introduced to increased stress, but reduced sweating takes a while to become apparent as any perspiration already present must first evaporate to some extent. This slightly devalues this type of device in a biofeedback application, but with practice it is still probably quite usable.

SKIN TEMPERATURE

I suppose that there is no obvious reason for skin temperature to vary according to the amount of stress to which one is subjected, but this does apparently occur. Although you might expect that under stress a faster heartbeat would result in increased blood flow to the bodies extremities and, just possibly cause increased skin temperature in the fingers and toes, this is in fact the opposite of what happens. Apparently stress results in reduced circulation despite any increase in the rate of one's heartbeat, and this can be detected as a

form of an audio tone. This reduces in pitch as the subject's skin temperature falls. The idea is to try to obtain an output which is as high in pitch as possible, or if TH1 and R4 are swopped over, for the lowest possible output tone.

IC1 acts as the basis of the sensor part of the circuit, while IC2 operates as a voltage controlled oscillator which will operate over a wide control voltage range. Taking operation of the sensor circuit first; TH1 is a negative temperature coefficient device, and its resistance therefore decreases if the applied temperature is decreased. As TH1 is connected in a potential divider across the supply lines, it provides an output voltage which increases as the applied temperature is raised. Although thermistors are quite sensitive when compared to many other types of electronic temperature sensor, the change in output voltage is still only a small fraction of a volt per degree Celcius. IC1 is therefore used as a non-inverting amplifier to slightly boost any voltage changes produced by the sensor circuit. VR1 is initially adjusted to give an output at roughly mid-supply voltage.

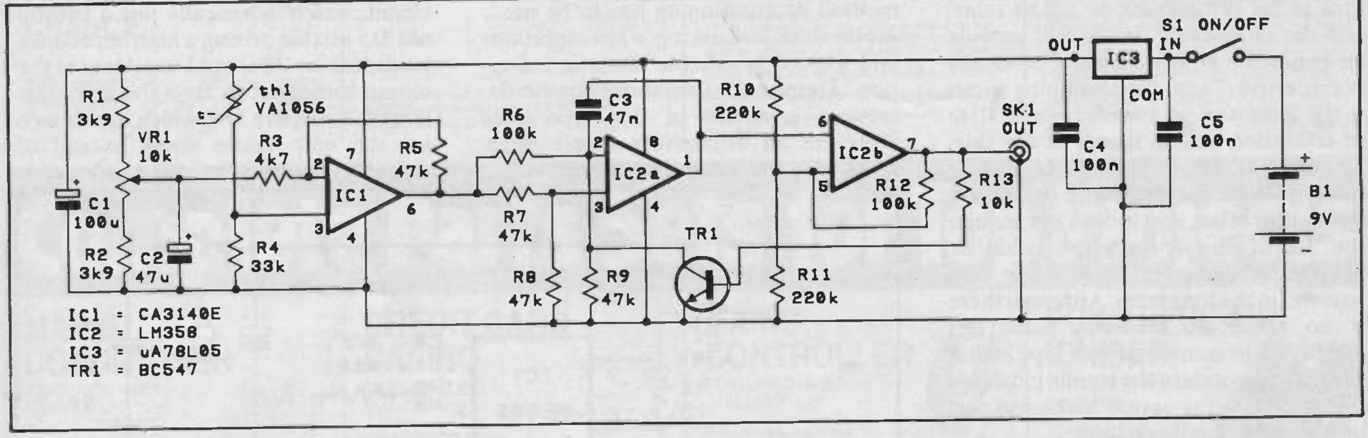


Fig.2. *The circuit diagram of the skin temperature monitor.*

For best results it is probably best to have the electrodes placed on a part of the anatomy that is likely to provide large changes in the amount of perspiration present as the mood of the subject alters. The obvious place is the palms of the hands. I obtained quite good results by fixing one electrode on the palm of a hand and the other on the back of the same hand with a rubber band to hold them in position. You may find that there is a problem with 50 Hertz mains 'hum' being picked up in the connecting wires to the electrodes, and in the body of the user. This can modulate the output of the unit and make it difficult to detect small changes in pitch. Adding a capacitor of about $1\mu F$ in value in parallel with the electrodes seems to effect a cure here, if necessary.

This type of device certainly seems to respond to changes in the subject's state of stress, and any sudden increase in stress will normally show up quite

drop in skin temperature at the extremities.

Measurement of relative temperature is again something which does not provide a great technical challenge, but things are not quite as straightforward as one might think. There have been plenty of designs over the years for temperature detectors and electronic thermometers, but few of these would work well in the present application. The main difficulty with a montior of this type is that it must respond to quite small changes in temperature if it is to stand any chance of success. A typical electronic thermometer circuit with a range of 0 to 50 degrees Celcius is not likely to be of any use at all, and one with a response range of something more like 25 to 30 Celcius has a much better chance of success.

The circuit of Fig. 2 is for a simple narrow range temperature change detector which gives an output signal in the

The oscillator is almost a standard Miller Integrator/Schmitt Trigger type, but the configuration has been modified to operate as a voltage controlled oscillator. This gives a wide output tone range which varies from zero to 0 volts input, to a few hundred Hertz at +5 volts input. The value of C3 can be changed if a different tone range is required. The squarewave output at SK1 is used to drive a crystal earphone, or in this application where high volume is not really needed or desirable, the output signal could simply be connected to a ceramic resonator, such as the popular PB2720 type. Incidentally, triangular output signal is available from pin 1 of IC2.

It is important that the supply is fairly stable as any significant changes in the supply voltage would almost certainly give a shift in the output tone and therefore give misleading results. IC1 provides a well stabilised 5 volt supply from the 9 volt battery supply.

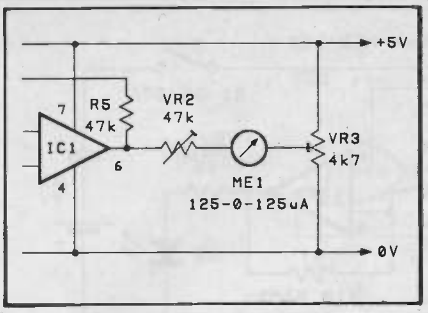


Fig.3. *Adding meter indication to the skin temperature monitor.*

METER OUTPUT

If meter indication is preferred to the audio tone method, the voltage controlled oscillator section of the original circuit (Fig. 2) can be replaced with the simple meter output circuit of Fig. 3. This is just a basic bridge type circuit with VR3 being used to provide a reference voltage of just under half the supply voltage. VR2 is the sensitivity control, and this is adjusted so that with VR1 in the original circuit adjusted to set the output of IC1 fully positive, and then fully negative, ME1 is driven to full scale. A little trial and error will probably be needed with the setting of VR3 in order to get the meter drive symmetrical, although it does not really matter if things are not quite perfect in this respect, and that in order to set VR2 to fully drive the meter in one direction, a small overload can be produced in the other direction. In fact you may prefer to set VR2 for quite high sensitivity, which will then leave the meter open to an overload in either direction. This is reasonably safe in that there is little risk of an overload occurring in normal use, and modern meter movements can take quite severe overloads without sustaining any damage. There is no need to use an expensive meter for ME1, and a cheap 'tuning' meter is perfectly acceptable in this application where it is relative and not absolute measurements that are involved. It is not essential to use a 125-0-125 microamp type either, and any sensitivity from about 50-0-50 microamps to around 1-0-1 milliamp should be perfectly alright.

There should be no difficulty in taping the thermistor in place on a finger, but there is a potential problem with the metal terminator at each end of this rod style thermistor coming into contact with the user's skin. This would place the user's skin resistance in parallel with the thermistor's resistance, and could have an adverse effect on results. This can be avoided by painting over any exposed metal at each end of the component, and insulating the leadout wires with P.V.C. sleeving as well if necessary. Incidentally, the circuit should operate using virtually any thermistor provided the value of load resistor R4 is changed to suit the particular component used. However, self heating types such as the RA53 are obviously unsuitable, as are types which have very low resistances, which would result in a large current flow through the sensor circuit.

Of the three types of monitor circuit I tried, this one seemed the least effective, although it did seem to respond to changes in stress to some extent. Possibly the ambient temperature effects results, and some means of insulating the non-skin side of the thermistor from the surrounding air might produce more reliable results. Placing the thermistor close to the finger tip also seems to give best results. Raising the value of R5 to give increased sensitivity might also be an avenue worth pursuing.

HEART RATE

Perhaps heart rate monitors are the most interesting type of biofeedback circuit for the experimenter, and possibly this is the type of monitor which gives the best results. There must be numerous ways of detecting the heartbeat, but there are two normal electronic approaches to the problem. One is to detect the electrical signal in the body that is associated with the heartbeat, and the other is to use a photoelectric system. We will deal with the latter first, and the general idea is to use a sensor of the type outlined in Fig. 4. This method of sensing is known as photoplethysmography (now you know why they call me the 'Prof').

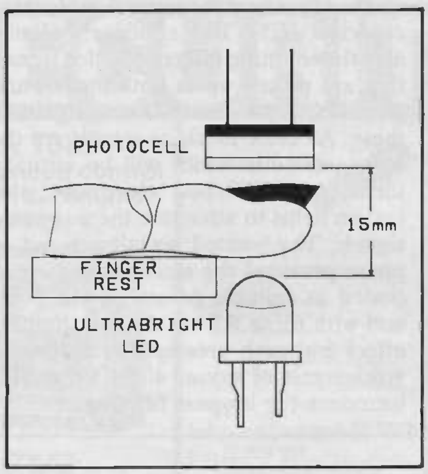


Fig.4. *Simple optical heart-beat sensor.*

In theory everything is delightfully simple, with a light emitting diode shining a light beam through the finger tip, and a photocell on the opposite side of the finger then detecting the amount of light passing through. The blood-flow in the capillary bed of the finger causes variations in the amount of light received by the photocell, and these result in small changes in the resistance of the photocell. With suitable circuitry these resistance changes can be converted to small voltage pulses and then amplified to give a usable signal level.

In practice things are not quite as straightforward as this, and there are problems with such a simple set up. The first problem is getting a strong enough light source to transmit a significant amount of light through the finger-tip. Until recently it would probably have been necessary to resort to a small filament bulb, but these days ultra-bright light emitting diodes are available, and these seem to give good results if they are operated at a reasonably high current. The main problem is that of getting consistent results. It is quite easy to produce a set up that will give reliable pulses for a few seconds, produce a few glitches, operate properly for a short time again, glitch some more, and so on, but it is much more difficult to produce a senor that will operate reliably for a reasonable period of time.

The first requirement is some form of finger rest to help keep the user's finger perfectly still, as any slight movement here can produce signals that are far stronger than those generated by the heartbeat. It is also important to have the smallest possible gap between the light emitting diode and the photocell, and this means a separation of only about 15 millimetres. The gap must not be so small that the finger-tip is wedged in place, as this would almost certainly prevent the unit from working at all. It is also important that the light emitting diode, photocell, and finger rest are all firmly fixed together so that these do not move significantly relative to one another. Finally, the light level received by the photocell is not likely to be very high, and as far as possible should be shielded from any ambient light.

As far as the circuit is concerned, basically all that is needed is an amplifier and a Schmitt Trigger circuit. Fig. 5 shows a suitable circuit diagram.

PCC1 is the photocell, and this is a cadmium sulphide type. This is almost certainly the best type of cell for this application where a fast response time is not needed, but good sensitivity is a decided asset. An ORP12 is suitable for the PCC1 position, but any fairly sensitive type should also be satisfactory. D1 is the light source, and this must be an ultra-bright type (not a standard or high brightness type) if the unit is to operate well. In fact the circuit is unlikely to work at all using an ordinary l.e.d. in the D1 position. The amplifier is a two stage type which has IC1 as an inverting amplifier and IC2 as a non-inverting type. The bandwidth is limited to only a few Hertz by the inclusion of C5 and C6, and this helps to give a low noise level while not attenuating any signal frequencies. Bear in mind that the heartbeat is at a frequency that will normally be little more than 1Hz. IC2b operates as a Schmitt Trigger which provides output pulses at the monitored heart rate. D2 flashes in sympathy with the user's heartbeat, but obviously the output pulses at pin 7 of IC2b can be fed to a pulse counter of some kind if preferred.

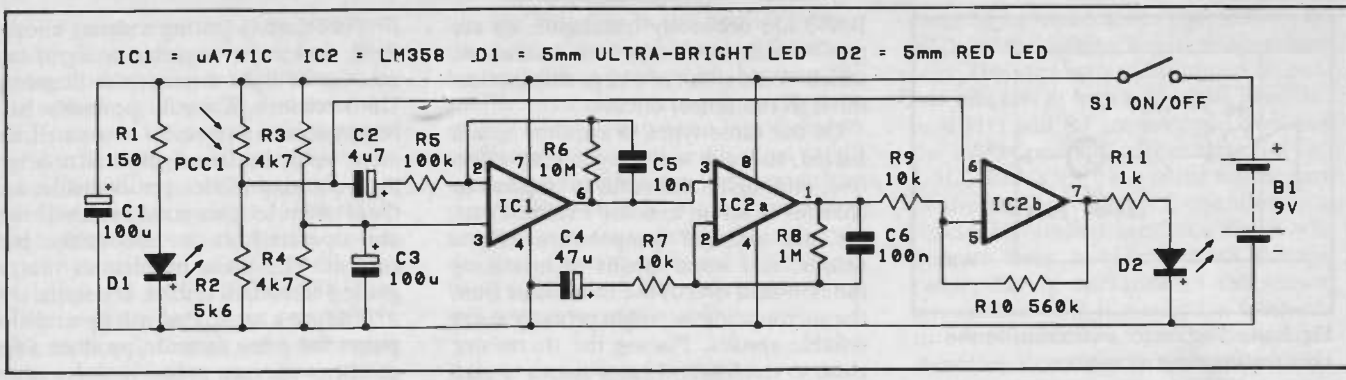


Fig.5. *A circuit to provide photoelectric monitoring of the heart-beat.*

ELECTRODE METHOD

Monitoring the heartbeat by using electrical signals within the body as the signal source, is not as complex as many people seem to imagine. There are difficulties associated with this type of heart rate monitor, but they are far from insurmountable. There are numerous points at which the electrodes can be positioned, but for simple heart rate monitoring an electrode on each hand is quite sufficient. The signal levels involved are quite low, being typically less than a millivolt peak to peak, but there is no difficulty in amplifying them so as to give a more usable signal level.

There is a problem in obtaining reliable electrical contact with the skin. Use of the special electrodes and conductive jelly referred to earlier overcomes these problems, but although the electrodes and jelly are available to amateur users they are quite expensive. An inexpensive alternative which seems to work quite well is to use pads of cotton-wool soaked in a strong salt solution, and the connections to the pads can be made via crocodile clips.

Another problem is that of electrical interference which is picked up in the leads running to the electrodes, and more particularly, the electrical signals actually picked up in the body of the user. These signals are predominantly 50 Hertz mains 'hum' and radio frequency signals, and as the wanted signals are at frequencies of about 4 Hertz or less, these interfering signals can be considerably attenuated by lowpass filtering. The use of balanced input techniques can also contribute to rendering them insignificant.

Fig. 6 shows the circuit diagram of the heart rate monitor, and this consists of two preamplifiers (one for each electrode) driving a differential amplifier and a Schmitt Trigger output stage. IC1a and IC1b operate as the preamplifiers, and these are identical non-inverting types. The feedback arrangement is a little unusual in that a common shunt resistor (R7) is used for both stages, and it connects between the two inverting inputs, rather than having one side earthed by way of the series d.c. blocking capacitor (C5). This effectively eliminates the shunting effect of R7 for signals that are picked up at both inputs, and gives only a low level of voltage gain on these. As these in-phase signals are the hum and noise which will be virtually identical at the two electrodes, this system helps to attenuate the unwanted signals. The wanted signals are out of phase provided the electrodes are positioned at suitable points on the body, and with these R7 has the full shunting effect and each preamplifier exhibits a voltage gain of around 40dB. C6 and C7 introduce the lowpass filtering.

IC2 combines the two output signals, and this is a standard differential amplifier circuit, and it is followed by a conventional operational amplifier Schmitt Trigger circuit. C10 introduces a further stage of lowpass filtering. D1 is a l.e.d. indicator which flashes on and off in sympathy with the monitored heartbeat. The output pulses can be taken to a pulse counter circuit if required.

A little experimentation with the positioning of the electrodes should soon produce good results with reliable flashing of D1 at the correct rate. Once the electrodes are in place it will take a few seconds for the circuit to settle down and start to function properly though, and you must give it time to do so. Do not worry if D1 does not flash at a stable rate, as it is quite normal for the beat rate to vary slightly, and the heart rate when inhaling is different to that when exhaling for example. If D1 simply flashes more or less randomly though, this would suggest that the unit is faulty or, more probably, that the electrodes are not achieving good and consistent contact and that further experimentation is needed here. Note that although three electrodes are shown in Fig. 6, in most cases only electrodes 'A' and 'B' will be required. Electrode C is only needed for some of the more exotic electrode placement arrangements which are not normally needed for simple heart

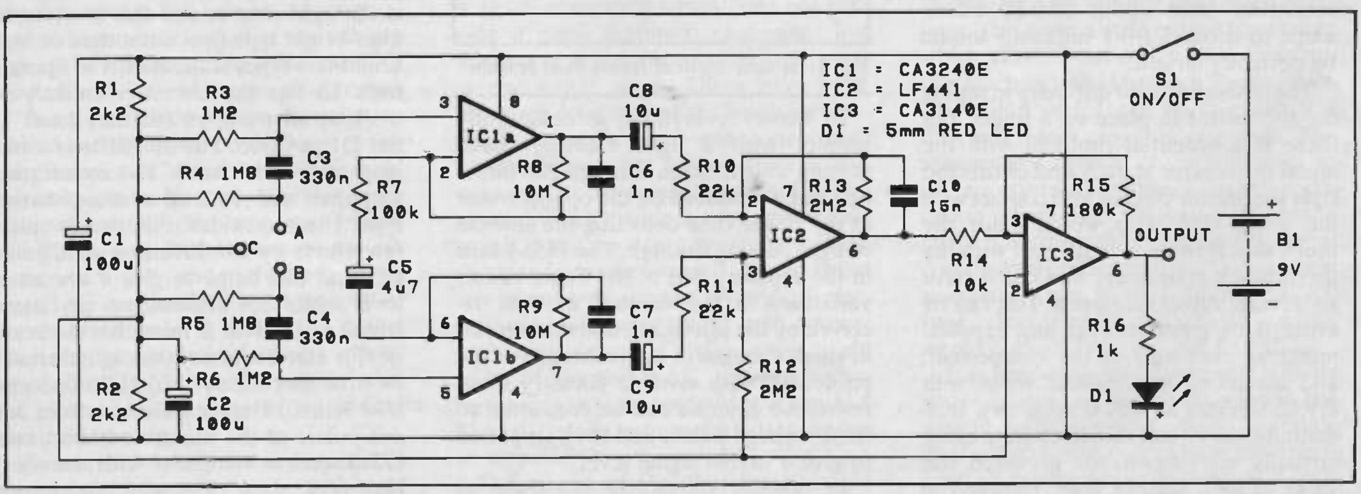


Fig.6. *The circuit diagram of the electrode heart- rate monitor.*

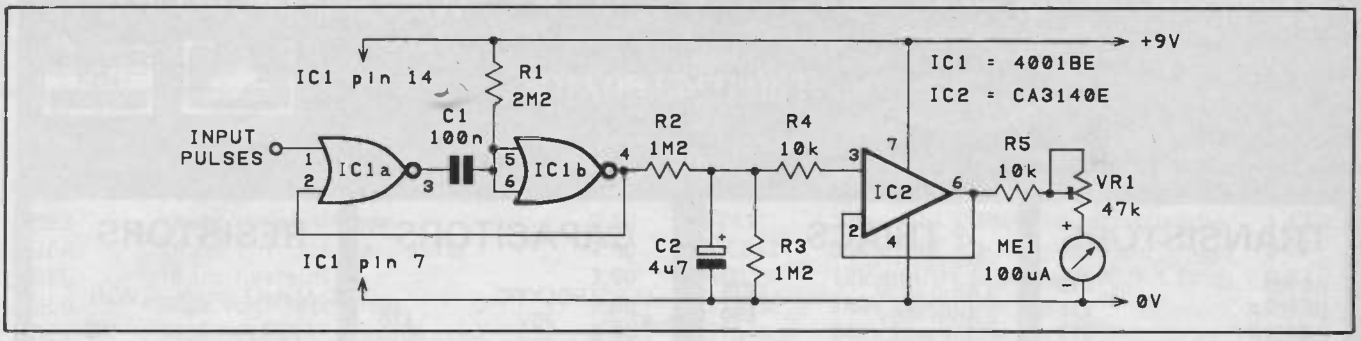


Fig.7. *A simple pulse counter circuit.*

rate monitoring, and which will not be discussed here.

The purpose of this series of articles is to present circuits which are worth building for their interest value if nothing else, and this is one which I would recommend as one of the most fascinating type of circuit. It is well worth a try, and costs very little to construct. This circuit can easily be breadboarded if you do not wish to construct it using more permanent methods.

PULSE COUNTER

For biofeedback purposes the heartbeat monitor circuits are far more useful if they are fitted with a pulse counter circuit, and a suitable circuit appears in Fig. 7.

This is just a non-retriggerable monostable multivibrator based on IC1, a simple smoothing circuit comprised of R2, C2, and R3, and a buffer amplifier to drive the meter circuit. The output pulse duration from the monostable is constant, and the average output voltage (which is what the meter registers) therefore rises and falls as the input frequency increases and decreases. VR1 is given any setting that gives a strong deflection of the meter in normal use, but does not result in it being driven beyond full scale at high heart rates. It is not necessary to use an expensive meter in the ME1 position, and an inexpensive battery state meter or something of this type is perfectly suitable. However, many of these have sensitivities of about 200 to 500 microamps for full scale deflection, and they might need the values of R5 and VR1 to be reduced slightly in order to give adequate deflection.

IMPROVEMENTS

For anyone wishing to develop these circuits further, the heart rate monitors provide the greatest scope. The pulse counter circuit shown here is quite a crude type which does not give particularly stable readings. Better stability can be obtained by increasing the value of C2, but the circuit then becomes relatively slow at responding to changes in heart rate. One way of improving things would be to use a multi-stage active filter in place of this basic single pole type. Another approach would be to use a digital readout, with the pulse counter circuit measuring the duration between heart beats, or perhaps the time taken for a certain number of beats to be completed. This could give good accuracy with an instant response time. PE

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0010110010111101001111101111001000010001111000110010111101001011001
0100111011001011110001111111110101100101001111001110100100111011011
00111011101010010001011001010110011001111100100111111110011101110010
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20 A$=STR$(ABS(D>0))+A$:NEXTB:PRINT VAL(A$),:NEXTA:PRINT
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OSCILLATORS

BY ANDREW ARMSTRONG

Circuits which warble and hoot

Oscillator circuits are a basic frequency source for applications from radio frequency transmitters to the clock signals in microprocessor systems. Here we look at the most frequently used classes of oscillator, with some adaptable circuits.

OSCILLATORS come in many varieties, and are used in more applications than you might think. Calculators, radios, digital multimeters, electronic musical instruments, oscilloscopes, are a few examples of items which rely on them. The oscillator circuits in these applications may be very different, but they all use the same basic principle.

Simply stated, the rule is that for oscillation to occur there must be a condition at some frequency where feedback occurs with a net phase shift of 0 or any multiple of 360 degrees and a loop gain of unity, and that condition must be frequency dependent.

This may seem surprising – surely some oscillator circuits have much more than unity loop gain. If not, how could the oscillation start? Well, nobody said that the gain had to be linear. The classical idea of an oscillator is of something producing a perfect sinewave, and exhibiting good frequency stability. In this case a linear gain of unity is helpful. If an oscillator is designed without special attention to control of the gain, then it will control its own gain by oscillating at an amplitude sufficiently above the clipping level so that the average gain is unity. The unity gain here may be composed of a gain of 100 in the linear(ish) region, and zero when clipping occurs.

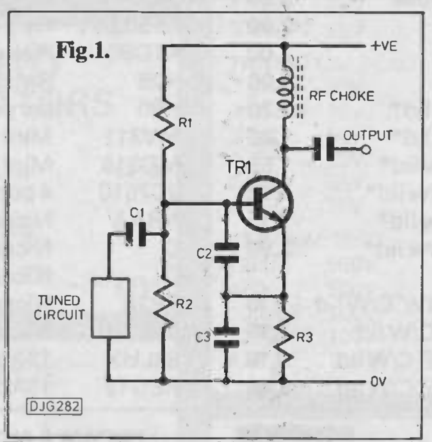
There are often exceptions to such simple rules, and this rule is no exception in that respect. The relaxation oscillator, to name the only one I can think of, does not seem to fit perfectly, though with a little mental contortion it is possible to see how its fits. It can be viewed as employing an extremely non-linear negative resistance device, always running at clipping level.

OSCILLATOR DESIGN

How, then, shall we design an oscillator? The cynics among you may answer "Design an amplifier and it is sure to oscillate." This is largely true, of course, because an oscillator must incorporate an amplifier whether or not it is recognisable as such, and it is often difficult to avoid unintended feedback in amplifier designs.

For most practical purposes, it is unnecessary to design an oscillator circuit from scratch for your application.

Fig.1.



There are innumerable standard circuit configurations whose characteristics are well documented. It is only necessary to choose the component values or make minor adaptations for your equipment design. If you pick out the aspects of oscillator performance that are most important in your design, there is likely to be a suitable circuit configuration to use.

Here we will look at some examples of different oscillators with different applications, ranging from RF to logic. Microwave oscillators will be left out, though, because this subject has been covered recently.

RF OSCILLATORS

For the most part, radio frequency oscillators can be divided into those using a crystal, and those using an LC tuned circuit. Adjustable LC oscillators are not greatly used now, except in ordinary radio receivers, but in the times before the widespread use of synthesizers, the VFO (variable frequency oscillator) formed the heart of many an amateur radio transmitter. Even now, there can be useful applications in receivers where close in phase noise is of paramount importance. A reasonably well built VFO still outperforms all but the very best synthesizers.

Fig.1. shows a typical configuration for a radio frequency oscillator using one transistor. If the tuned circuit is serial tuned then the configuration is called a Gouriet-Clapp oscillator, if parallel tuned it is called a Colpitts oscillator. In this circuit, power is fed to the tuned circuit from the emitter of the transistor, then back from the tuned circuit to the base of the transistor. The loop gain provided by the transistor is current gain, not voltage gain. The tuned circuit acts like an autotransformer to give a higher voltage, lower current output than that fed to its tapping. The ratio of the voltage increase is determined by the ratio of the impedances of C2 and C3.

The frequency stability of this type of circuit is determined partly by the stability of the components forming the tuned circuit, and partly by its loaded Q. In this context, the loaded Q gives a measure of how much influence the transistor has on the waveform on the tuned circuit on a cycle to cycle basis. If the energy stored in the LC circuit is very much greater than the energy being transferred from emitter to base of the transistor per cycle, then little change can occur per cycle regardless of what the transistor does.

Conversely, if the losses in the tuned circuit are high, and the transistor has to replace a large proportion of the stored energy per cycle, then variations in transistor opening parameters can affect the oscillation dramatically. This type of effect could be manifest as a transistor radio drifting off tune as its battery voltage falls, for example.

The circuit shown in Fig.1. will not give a sinewave output (save by sheer luck), but the circuit shown in Fig.2. will do so. Here an extra transistor is used to stabilise the amplitude of oscillation so that clipping does not occur. This sort of technique can be useful to provide a stable and clean local oscillator for a receiver.

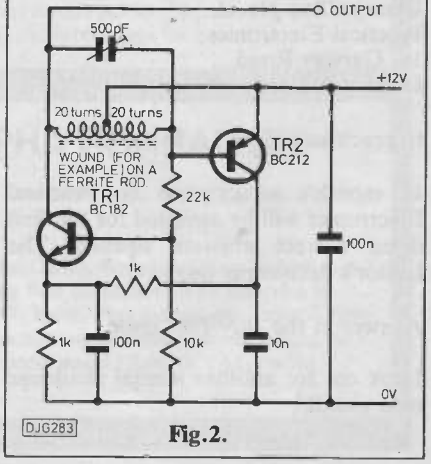


Fig.2.

Many other LC oscillator configurations are possible, but most of them are just variations on a theme, and it is a theme of limited application now.

CRYSTAL OSCILLATORS

In both RF and logic applications, the crystal oscillator is widely used where a stable, well behaved frequency source is required. A number of the standard LC oscillator circuits can be adapted as crystal oscillators, and in the case of overtone crystals, the original LC tuned circuit may also be retained. A quartz crystal has the major advantage over an LC circuit in that its Q is much higher.

Quartz is a piezoelectric crystal, which is to say that it deforms on application of voltage across its faces. When used as an oscillator element, the oscillation is mechanical in nature, with the coupling of the signal in and out of the crystal being electrical. The angle of cut of the crystal determines the precise nature of the deformation, and affects whether the crystal is more suitable for use on its fundamental frequency, or on an overtone (harmonic) of the fundamental. Overtone operation allows use of crystals at frequencies higher than can be obtained otherwise, because it enables the thinnest crystal which can be manufactured to behave as one still thinner. Fig.3. illustrates normal crystal resonance and overtone resonance.

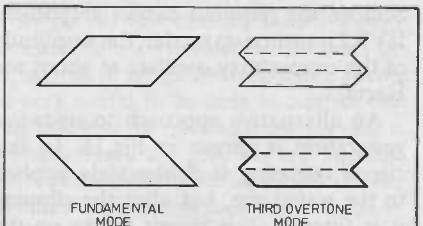


Fig.3.

The cut of the crystal affects its temperature coefficient, and certain cuts can exhibit almost no frequency change over a certain limited temperature range. This is of particular interest in digital watches, for example. The reasons for this are a specialist subject of their own, but it is worthwhile to remember that different temperature coefficient curves are available when selecting a crystal for a particular use.

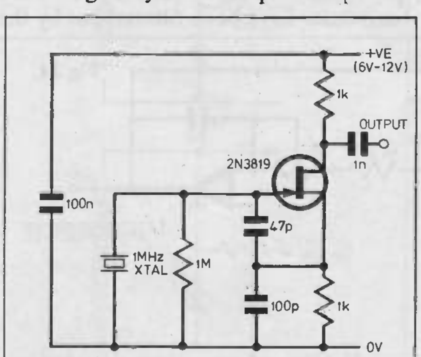


Fig.4.

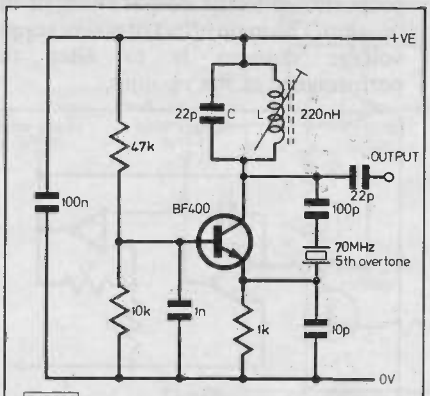


Fig.5.

A fundamental mode crystal oscillator may be made very simply by taking, for example, a Clapp oscillator and replacing the LC circuit with a crystal as illustrated in Fig.4. It is more difficult to make a crystal function on an overtone, even though it may be designed to do so. One approach is shown in Fig.5. In this circuit, the collector load is a tuned circuit resonant on the required output frequency. The crystal forms a frequency selective feedback element between collector and emitter of the transistor. As the inductor of the tuned circuit is adjusted through resonance, the circuit will burst into life, then as adjustment is continued the frequency will alter very slightly, and then stop oscillating again. The LC circuit does not affect the frequency of oscillation very much, it only affects whether it occurs at all.

If there is significant stray capacitance across the crystal, it is possible for a spurious mode of oscillation to take place, in which the crystal itself is irrelevant. In this case, the circuit becomes yet another standard form of LC oscillator, controlled by the tuned circuit in the collector.

LOGICAL OSCILLATORS

At present, probably the majority of crystals are used to provide clock signals in microprocessor systems. Current microprocessors cause no problem in this respect, you simply connect a crystal and a capacitor across the requisite two pins and think no more of it. There are occasions when a crystal is needed as a frequency reference in logic systems other than a microprocessor. In this case it can be difficult to get the result you want.

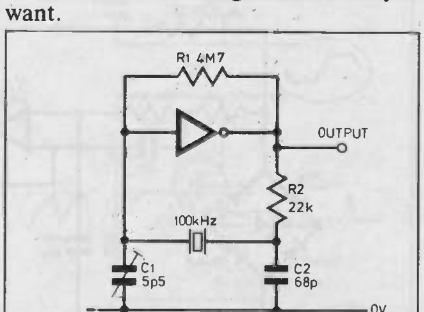


Fig.6.

Fig.6. shows a crystal oscillator circuit which is fairly dependable with 4000 series CMOS, and which should work well with 74HC00 series as well. In this circuit, R2 and C2 provide a phase shift which depends on the frequency, and thus sets the approximate frequency of operation of the circuit. The crystal is only allowed to operate near to its resonant frequency, thus spurious modes of oscillation are prohibited. R2 and C2 should be chosen to give about 45° phase shift at the required frequency, which occurs when the magnitude of the capacitive reactance equals the resistance.

Some crystals, in particular 32768Hz watch crystals, still exhibit spurious modes. The problem can be solved by reducing the value of R2 and adding an inductor in series with it, so that the approximate series resonant frequency is equal to the desired operating frequency. It is even possible to get overtone crystals to work on their correct overtone in this way. The value of R2 should be chosen partly by experiment, but a good starting point is to use a Q of about three, where $Q=2x\pi xFxL/R$. Q values used should be in the range of 1 to 10.

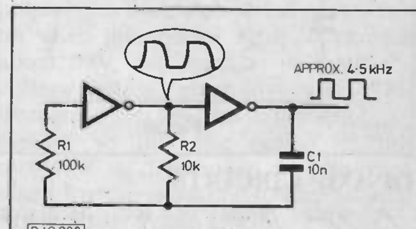


Fig.7.

R-C OSCILLATORS

In applications where the frequency stability is not quite so important, R-C oscillator circuits are common. Fig.7. shows a typical CMOS clock oscillator circuit. The frequency is approximately 1/(2.2xR2xC1). The frequency depends on the gain of the inverters to some extent, as you may deduce from the rather soggy looking waveform shown as typical of the output from the first inverter. Fig.8. shows a circuit which avoids this problem, though it is not always superior. Because it uses three inverters rather than just two, there is more propagation delay, which lowers the maximum frequency of operation.

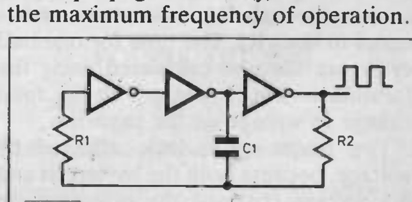


Fig.8.

R1 in each circuit does not affect the operating frequency significantly, as long as it is of a high enough value. Fig.9. shows the oscillator waveforms, and shows the voltage on the junction of R1, R2 and C1 going outside the supply rails.

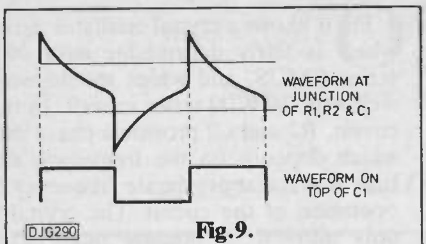


Fig.9.

The function of R1 is to prevent the charge on C1 being dumped rapidly into the input protection diodes of the first inverter. To minimise this effect, R1 should normally be chosen to be ten times R2. This can result in the impedance on the input of the first inverter being very high, in which case stray capacitance can cause spurious oscillations on the edges. This manifests itself as a double bounce on each clock edge, and only matters if the output of the circuit is used to clock a counter, which will merrily count all the edges it receives. A 100PF capacitor in parallel with R1 prevents this from happening.

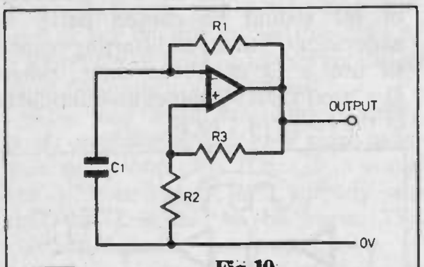


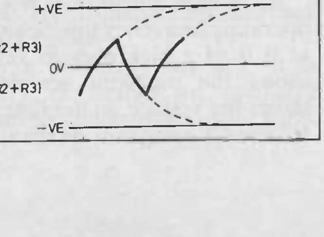
Fig.10.

OP-AMP CIRCUITS

A wide range of RC oscillator configurations is possible using op-amps. Fig.10. shows the simplest useful oscillator circuit using an op-amp. In this circuit, C1 charges between voltages set by the positive and negative power supplies, and R2 and R3. If the supplies are equal, and the output voltage gets equally close to each of them, then the waveform will be symmetrical. Otherwise the mark/space ratio will not be 1:1. The waveform on the capacitor is a section of an exponential waveform, as shown in Fig.11., but if the ratio of R2 and R3 is chosen to restrict the voltage range on the capacitor to a small proportion of the output swing of the op-amp, then a good approximation can be made by assuming that the charging current through R1 is constant, and is equal to Vout/R1. The time for one half cycle can then be calculated using the formula t=VxC/I where V is the total change in voltage on the capacitor.

The frequency is little affected by voltage, because both the hysteresis and the voltage charging the capacitor are proportional to the output swing of the op-amp. The main effect of power supply voltage changes is to alter the performance of the op-amp.

Fig.11.



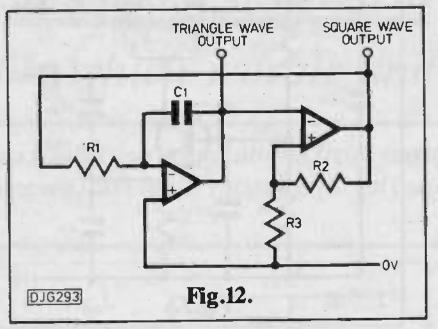


Fig.12.

Even with a restricted voltage swing on the capacitor, the sawtooth waveform on the capacitor still has rather bendy sides. A proper triangle wave can be generated by the circuit shown in Fig.12., where an integrator is used to ensure that the charging current of the capacitor is constant. The charging rate of the integrator, and the voltage range over which it works, both depend on the output swing of the second op-amp, so again the frequency is nominally independent of the power supply voltage. Assuming that the op-amp gives symmetrical output, the time for one cycle is:

t=4xTxR3/(R2+R3) where T is the integrator time constant, R1xC1

If good quality components are used, and the op-amp is not asked to run near to its maximum speed, then good frequency stability is possible.

If a sinewave is needed, several approaches are possible. One method is to build an oscillator which would produce a sinewave if only it did not clip, and then control the gain so that it does not clip. Fig.13. shows an example of this approach. The Wien bridge network forming the frequency dependent feedback has zero phase shift (not 360 degrees) at the frequency of oscillation. Unlike a straight piece of wire, however, it has a phase shift both above and below the operating frequency, and it is this phase shift which is the frequency determining factor.

The gain of the network at the zero phase shift frequency is 1/3, so that to maintain oscillation an op-amp gain of three is needed. With a gain of exactly three, oscillation could not start, but could continue if it had already started. Any tiny disparity in gain would cause oscillation to die away or build up to clipping level. The circuit of Fig.13. uses a junction f.e.t. as a variable resistor to adjust the gain according to the amplitude of the oscillation.

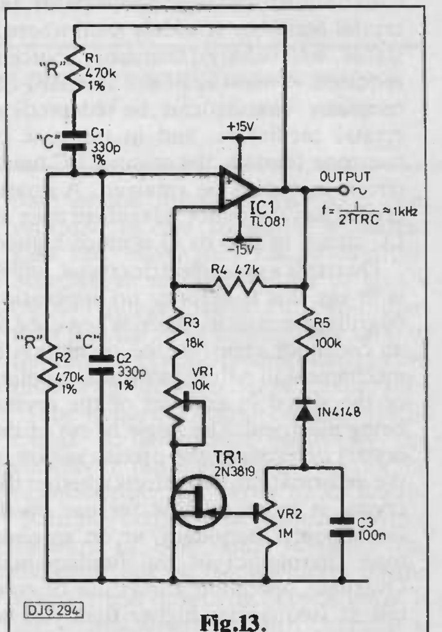


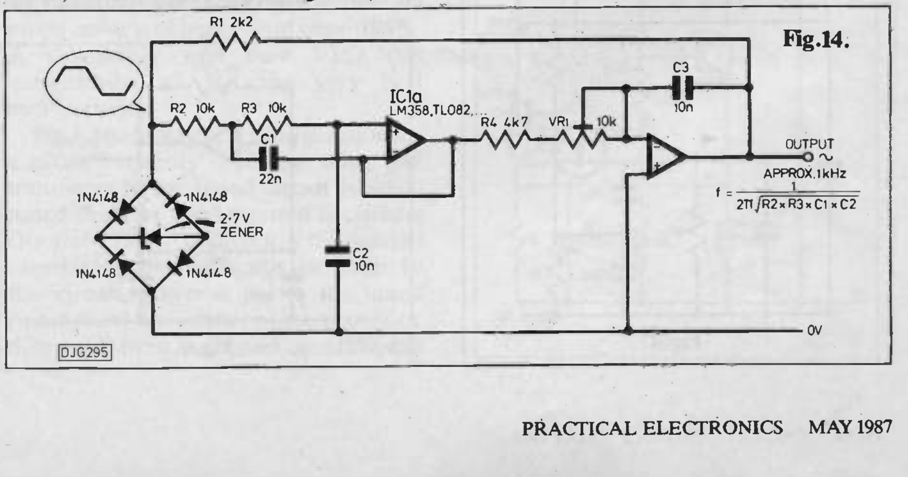
Fig.13.

To adjust this circuit, set VR2 to its mid point, and VR1 to maximum resistance. Then reduce VR1 until oscillation starts, and adjust VR2 to achieve the required output amplitude. If VR2 is turned up too far, the amplitude of the output may oscillate at about ten Hertz.

An alternative approach to sinewave generation is shown in Fig.14. In this circuit, clipping is deliberately applied to the waveform, but after the clipping it is filtered. This circuit works on the basis of 180° frequency dependent phase shift, and an inversion.

IC1A is connected as a second order filter, which will give a phase shift of 90° (delay) at its nominal corner frequency, where it will give about 3dB attenuation. IC1B is used to integrate the resulting waveform. This always produces 90° phase delay, but its output amplitude depends on the integrator time constant and the frequency. This stage also inverts the waveform. Its output is a good quality sinewave, in which almost all the harmonics have been filtered out by the

Fig.14.



second order filter and the integrator.

The output sinewave is clipped by the zener diode in the bridge, so configured to give symmetrical clipping. Unmatched back to back zeners could work at slightly different voltages and add second harmonics to the signal. The gain of the integrator, and hence the amount of clipping, may be adjusted by VR1. The less the signal is clipped before being filtered, the fewer harmonics there are to filter out, and the cleaner the resulting sinewave. If good quality components are used, the output frequency can be very stable.

Another means of generating a sinewave is to generate a triangle wave, and then convert it to an approximation to a sinewave by means of a non-linear network. Such a network would have to give symmetrical progressive limiting of the waveform, so that the triangle shape of the waveform is bent into a piecewise linear approximation to a sinewave. If the circuit of Fig.12. is used for this purpose, then sine, square, and triangle wave outputs will be available and we have a function generator. This will not be covered in more detail here because it is slightly at a tangent to the subject of oscillators in general, but a function generator project is planned to appear soon.

VOLTAGE CONTROLLED OSCILLATORS

So far all the circuits shown would require the use of variable resistors or capacitors to adjust the frequency. It can be very useful to be able to control the frequency of an oscillator by varying a voltage. Some applications are: to tune or frequency modulate an RF oscillator; to make a phase locked loop; to allow digital control of a signal generator, or to make some types of electronic musical instrument.

The frequency of an LC oscillator can be controlled by using a varicap diode instead of, or as well as, a variable capacitor. The trouble with varicap diodes in oscillator circuits, where there may be a substantial signal level, is that

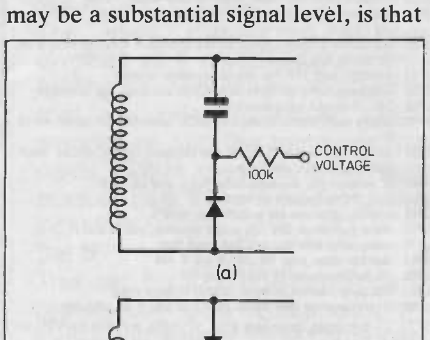


Fig.15.

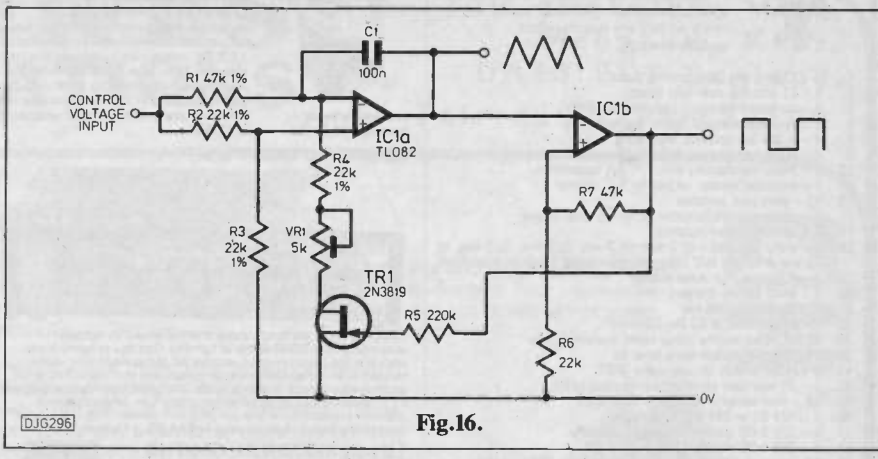


Fig.16.

the capacitance changes significantly during the oscillatory cycle. This distorts the cycle and generates harmonics. The solution is to use back to back varicaps as shown in Fig.15. The change in the capacitance of one varicap is almost exactly compensated by an equal and opposite change in the other.

A totally different method of frequency control is suitable for op-amp based RC voltage controlled oscillators. In the circuit of Fig.16., IC1A forms an integrator which integrates the d.c. control voltage input to produce a ramp. The direction of the ramp is controlled by TR1 switching on or off a resistor from negative input to 0V.

At all times the non-inverting input of the op-amp receives half the input voltage. When the f.e.t. is off, the integrator input receives the full input voltage, which means that C1 has to discharge at a current of $\frac{1}{2}V_{in}/R1$ to keep the op-amp in balance. When the f.e.t. is on, the input to the integrator is equivalent to 1/3 of the input voltage fed through 1/3 the value of R1. This equivalent integrator input is now below the voltage on the non-inverting input, so the output of the integrator rises and the capacitor charges. The equivalent input voltage is $(1/2 - 1/3)V_{in}$, and the effective input resistance is R1/3, so the charge current of the capacitor is the same as the discharge current calculated above.

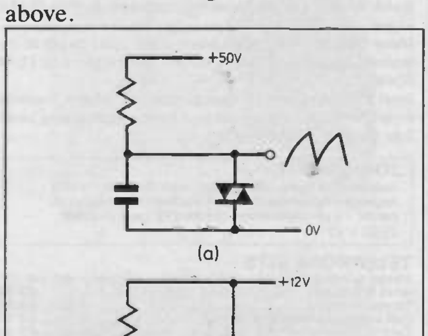


Fig.17.

The symmetry of the waveform is dependent on correct resistor ratios, so VR1 is included in the circuit to allow accurate adjustment. If there is not an oscilloscope available to carry out this adjustment, then VR1 can be replaced by a 1k5 resistor.

RELAXATION OSCILLATOR

Having mentioned the relaxation oscillator earlier, it deserves further description. Fig.17. shows two possible relaxation oscillator circuits, the first using a diac and the second using a unijunction transistor. The diac switches on when the voltage across it exceeds about 30V, and remains on until the voltage falls to about five volts. This discharges the capacitor to five volts very rapidly, so that the period of this oscillator is determined by the time taken for the capacitor to charge from five to thirty volts.

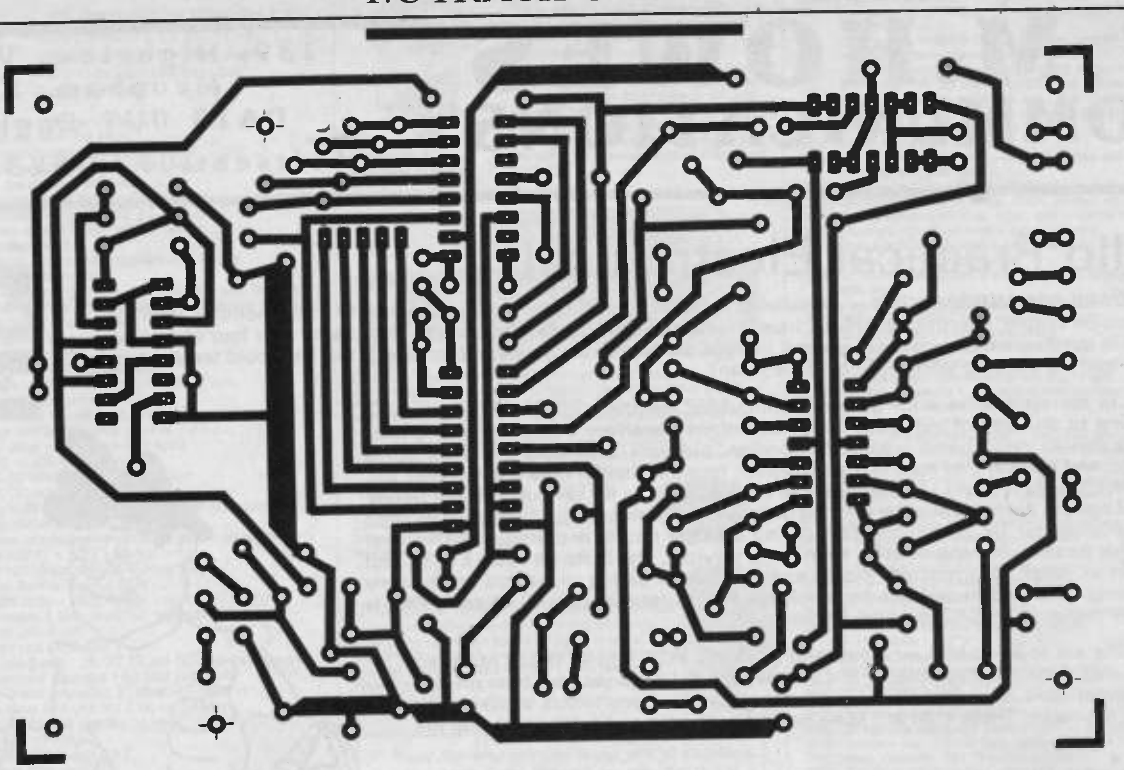
The unijunction circuit works similarly, but the firing voltage is lower. Again the discharge is very fast, so that the oscillator frequency is largely determined by the capacitor charge time.

We have examined here a wide range of types of oscillator, and I hope that there is something to fit almost every constructor's needs. Most of the circuits have been shown with example component values, and they will work if built as shown. If there is any problem in adapting a circuit for a particular requirement, then it might be worth building the circuit as shown first and then modifying it. PE

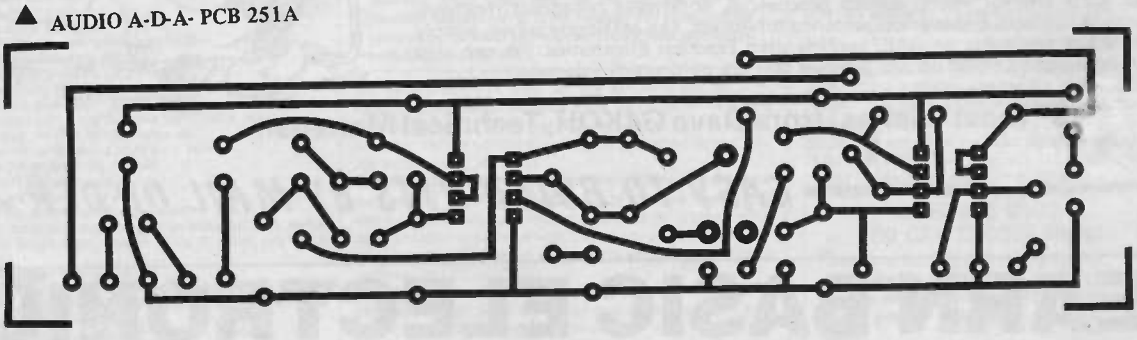
POINTS ARISING

Vigilante Car Alarm (Apr 87).

Gremlins crept in overnight on pages 24 and 25! Anybody who is puzzled about the wording continuity should send a stamped addressed envelope for a copy of the pages as they ought to have been.



▲ AUDIO A-D-A- PCB 251A



▲ PE 145

HOW TO USE THESE TRACKS

FIRST MAKE TRANSPARENT COPY

(We regret that we cannot supply transparent copies of PCB track layouts.)

STUDIO COPY METHOD

Ask local photographic studio to produce high contrast 1 to 1 positive transparency.

HOME PHOTOGRAPHY METHOD

Using even, bright illumination, photograph track onto fine grain black and white negative film. Develop film for high contrast. Photographically enlarge image up to lifesize, and print onto high contrast lithographic cut film, such as Agfa Copyline HDU 3P Type 2. Develop in Agfa Litex G90T litho developer, or similar.

PHOTOCOPY METHOD

Ask local photocopy shop to make a good contrast copy onto acetate film. (Some copiers are better than others – shop around.) Then touch up tracks with dense black ink, or photographic opaque ink.

ISODRAFT METHOD

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in accordance with supplied instructions. **ISOdraft** is available from **Cannon & Wrin,** 68 High Street, Chislehurst, Kent. Tel: 01-476 0935.

PAINSTAKING METHODS

Draw image by hand onto clear film or drafting film using dense black ink. Draw direct onto copper surface of PCB fibreglass, using etch-resist inking pen. Use etch resist PCB tracks and pads, taping direct to copper surface, or onto drafting film.

NEXT PRINT ONTO PCB

Place positive transparency onto photosensitised copper clad fibre glass, cover with glass to ensure full contact. Expose to Ultraviolet light for several minutes (experiment to find correct time – depends on UV intensity).

Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

(PCB materials and chemicals are available from several sources – study advertisements.)

*** CAUTION – ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.**

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CONSTRUCTIONAL PROJECT

BRIGHT FUZZ

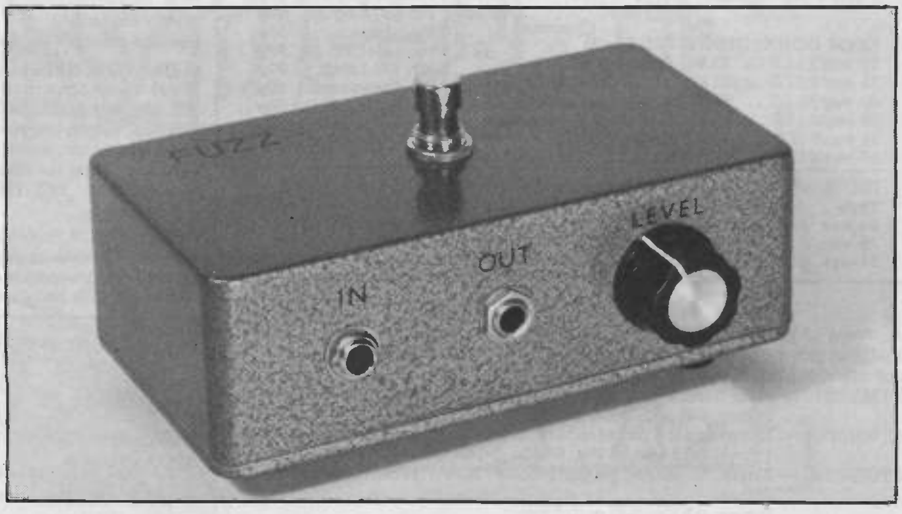
BY "BOBBY ROCKETT"

Plug it in and grind it out!

Fuzz or distortion is a classic effect for guitarists. This unit incorporates filtering to give a "bright" sound which can be used with poly phonic inputs, and a distortion control to give a variety of effects from a 'natural' guitar distortion to heavy over-drive.

THE term "fuzz" seems to be going out of fashion and is being replaced by "distortion", but whatever name is used the sound produced by an effects unit of this type is exactly the same, and is generated by clipping the input signal. Clipping is a very simple electronic process, and it simply entails preventing the signal from exceeding a certain voltage, and a voltage that is below the normal peak level of the signal. Distortion units normally process both half cycles of the signal, and give symmetrical clipping as shown is Fig.1. As far as the sound is concerned, the clipping generates strong signals at harmonics (multiples) of the fundamental input frequency, giving a harsher and brighter sound due to the increased high frequency content.

This is the classic fuzz effect, and there have been many attempts to give an improved effect, or what could perhaps be more accurately described as variations on the basic distortion sound. These include simple modifications such as the use of soft clipping, where the signal is allowed to increase in amplitude to some extent once the clipping level has been reached, and the inclusion of filtering, such as a lowpass filter to remove the higher harmonics and give the so called "thick" distortion sound. More complex types include units which have envelope shapers to retain the normal dynamic characteristics of the guitar. Simple clipping tends to give a sort of sustain effect, with practically no variation in the volume of each note from its beginning until the output of the guitar has practically decayed to zero. With another form of up-market fuzz the output of each pick-up coil is processed separately. This avoids the intermodulation distortion that occurs if two notes are fed into a single clipping circuit, and the consequent non-harmonically related (and rather discordant) frequencies that would be generated. Most fuzz units are only suitable for monophonic use.



The completed bright fuzz unit.

SYSTEM OPERATION

This distortion unit falls into the "improved" effect category, and the block diagram of Fig.2. helps to explain the way in which the circuit functions.

A buffer stage at the input gives the circuit a suitably high input impedance to match a guitar pick-up, and the output from the buffer is spilt two ways. Part of the signal is fed to one input of a mixer stage, and it is from here that the output signal is taken. The main output signal is therefore just the unprocessed input signal.

Some of the output signal from the buffer stage is fed to a clipping circuit which generates the "distortion" signal in the usual way. This signal is then processed by a highpass filter which removes the fundamental signal and the lower harmonics. If two or more notes are played simultaneously, the highpass filter also results in most of the intermodulation products being removed. The filtered signal is fed to the mixer via a gain control, and a controlled amount of distortion is added to the straight-through signal.

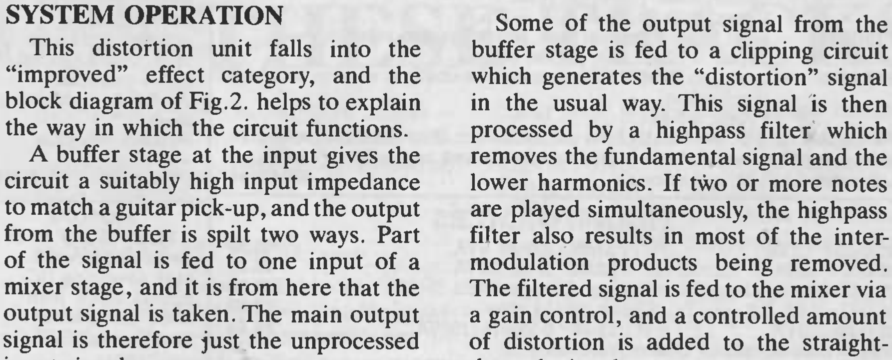


Fig.1. *The standard "Fuzz" effect is produced using symetrical clipping, as shown here.*

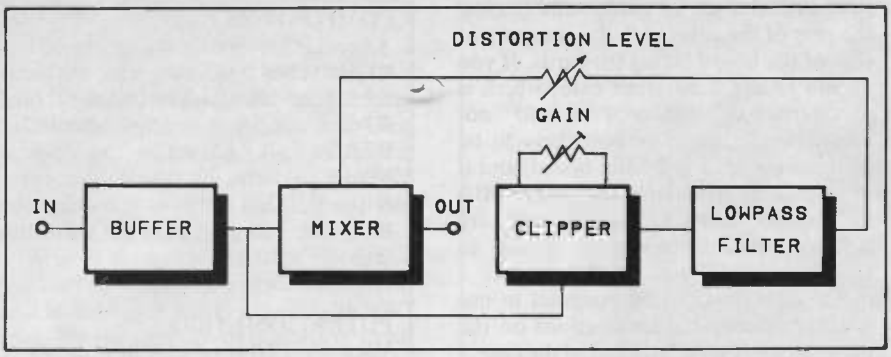


Fig.2. *The distortion unit block diagram.*

Although this system may not seem to be much diffferent to the standard type of fuzz unit, it does in fact give a somewhat different effect, and is not without its advantages. One of these is that the envelope shape of the original guitar signal is largely retained since much of the output signal is simply a buffered version of the input signal, but the circuit does not involve the complication and expense of an envelope shaper. The original envelope shape being retained is dependent on only a moderate amount of distortion signal being mixed into the straight-through signal. With a large amount of distortion added to the signal the fuzz effect is much stronger, and as the amplitude of the distortion signal is reasonably constant, this also gives a sustain type effect. The effect can therefore be varied from a mild distortion type, with the guitar's envelope being retained, through to a strong fuzz effect with sustain.

This gives a much more versatile and controllable effect than a conventional fuzz effect unit. These usually include a gain control which enables the degree of clipping to be controlled, but in practice it does not give much control over the effect. This is primarily due to the fact that there is little difference in the sounds produced by mild and heavy limiting. In either case the degree of distortion is severe, and although heavy limiting does generate stronger harmonics, much of the additional harmonic output is in the ultrasonic range and is therefore inaudible. Also, both mild and strong clipping give a marked degree of sustain. With the system used in this design, the distortion level can be set accurately at any desired level, from normal levels right down to zero.

The highpass filtering is not an essential feature, and it results in a fairly "bright" rather than a "thick" distortion effect. The reason for its inclusion is that be removing the low and medium frequency intermodulation products, it enables quite good results to be obtained if the unit is used with a polyphonic input. However, when used in this way it is advisable to keep the degree of distortion at no more than a moderate level, as otherwise the distortion tends to mask the fundamental frequencies and the music.

CIRCUIT OPERATION

Fig.3. shows the full circuit diagram of the unit. Although based on operational amplifiers, the circuit has a single 9 volt supply rather than a dual balanced supply rails. R1, R2 and C1 are used to provide a centre tapping on the supply rails, and which is used for biasinig purposes.

ICla acts as the input buffer stage, and this is a simple unity gain, non-inverting amplifier with R3 providing bias, and setting the input impedance at 220k. IC1b is the mixer stage, and this is a conventional summing mode type. R4, R5, and R6 all have the same value, and this gives nominally unity voltage gain from each input of the mixer to the output.

The clipping amplifier is built around IC2a, and this is basically just a non-inverting amplifier circuit. The voltage gain of the circuit is controlled by negative feedback, and this has R7, R8, and VR1 as its main elements. The voltage gain is equal to the total value of all three resistances, divided by the value of R7. VR1 therefore enables the voltage gain to be varied from two times at minimum resistance, to around 50 times at maximum resistance. This ignores the effect of D1 and D2, which are connected in parallel with the total resistance of R8 and VR1. These are silicon diodes, and as such they do not conduct significantly until supplied with a forward bias of about 0.6 volts. Increasing the bias voltage above this level results in the resistance falling very rapidly.

Provided the output voltage of IC2a does not exceed about 0.6 volts peak, neither diode has any significant effect on the negative feedback circuit. In practice though, the signal from the guitar will drive the circuit to the point where this level is easily reached. This brings D1 into conduction on peaks of negative going half cycles, and D2 into conduction on peaks of positive going excursions. When brought into conduction, the diodes greatly reduce the feedback resistance, and thus also the voltage gain of the amplifier. This introduces the required symetrical clipping and distortion.

The highpass filter is a three stage (18dB per octave) type. In other words, below the cutoff frequency a halving of frequency causes the gain to be reduced by a factor of eight. The circuit is a conventional active type which has IC2b as the unity gain buffer stage. The cutoff frequency is in the middle of the audio band at about 1kHZ, which is above the normal fundamental frequency output of a guitar. Consequently the output from IC2b is mainly harmonics (both the natural harmoic output of the guitar and those produced by the clipping).

The output from IC2b is coupled to

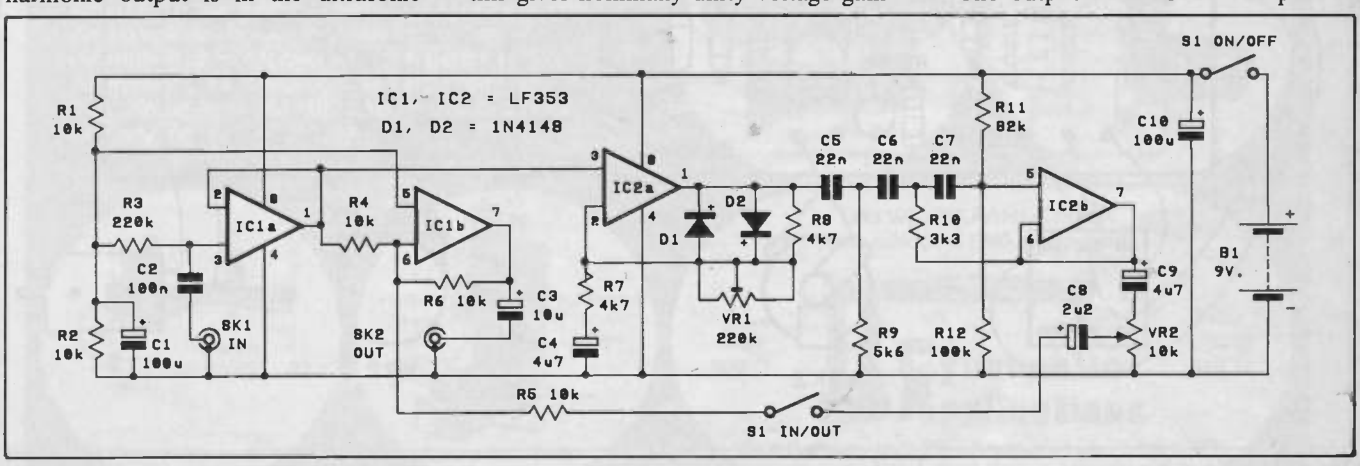


Fig.3. *The distortion unit circuit diagram.*

VR2, which is a volume control style variable attenuator, and it is this control that is used to set the required distortion level. From here the signal is coupled via S1 to one input of the mixer stage. S1 can be used to break the signal path and cut off the distortion.

Power obtained from a 9 volt battery, and a small type is adequate as the circuit has a current consumption of only about 7 milliamps.

CONSTRUCTION

The printed circuit track pattern and component layout are shown in Fig.4. IC1 and IC2 are FET input devices, but as they are JFET rather than MOSFET types, no special handling precautions are required. On the other hand, they are not the cheapest of components and the use of (8 pin DIL) integated circuit holders is recommended. Do not overlook the single link wire which fits just above VR1. The board is designed to accept miniature capacitors, and it is important to use the specified types or physically similar components. Otherwise, there could be difficulty in fitting the components onto the board, and in fitting the completed board into the case. There are a number of connections to off-board components to be made, but at this stage only fit pins on the board at these points.

A stong case is needed for a project of this type, which is likely to receive a certain amount of rough treatment in normal use. A metal type is also well suited to an application of this nature where electrical screening can help to prevent stray pick up of mains hum and other electrical noise. A diecast aluminium box is ideal as it provides both good screening properties, and great physical strength. The printed circuit board is designed to fit into a standard 150 by 80 by 50 millimetre diecast aluminium box, and it simply slots into the set of guide rails nearest the rear of the case, with the component side of the board facing forwards. If you decide to use a different case, which is a course of action I would not recommend, there are not likely to be suitable guide rails for the board, and it must then be bolted in place. M3 or 6BA fixings are suitable, and there are suitable vacant areas of board to accommodate these. If the case is a metal type it would be essential to use spacers to keep the connections on the underside of the board clear of the case.

The case is effectively used up-side-down, with the removable lid becoming the base panel, while S1 is mounted on the top panel of the case. S1 must be a heavy duty push button type so that it can be operated by foot. Ordinary push button switches are not recommended for this application as they would be unlikely to last long, even if used carefully. If a switch having SPST contacts proves to be difficult to obtain, then two contacts of a DPST or DPDT type will do just as well. S2 is a set of make contacts on SK1, and in common with many effects units, the device is automatically switched on when the jack plug is inserted into SK1, and switched off again when it is removed. This method is one which helps to avoid accidentally leaving the unit switched on. It might prove to be impossible to obtain a socket which has just one set of make contacts, but a type with DPDT contacts will suffice, with four tags simply being left unused. Of course, if preferred it is quited acceptable to use a separate on/off switch.

In order to complete the unit there is a certain amount of hard-wiring to be added, and details of this are included in Fig.4. Pieces of ribbon cable give a neat finish and are easy to fit, but ordinary multistrand PVC covered connecting wire is perfectly suitable. The battery fits into the space between VR2 and the printed circuit board. Some foam material can be used to keep it in place and to prevent it from rattling around inside the case.

COMPONENTS

RESISTORS

R1,2,4,5,6	10k (5 off)
R3	220k
R7,8	4k7 (2 off)
R9	5k6
R10	3k3
R11	82k
R12	100k

All resistors ¼w 5% carbon

POTENTIOMETERS

VR1	220k submin hor. preset
VR2	10k log.

CAPACITORS

C1,10	100μF 10V radial elect (2 off)
C2	100nF carbonate
C3	10μF 25V radial elect
C4,9	4μ7 63V radial elect (2 off)
C5,6,7	22nF carbonate (3 off)
C8	2μ2 63V radial elect

SEMICONDUCTORS

IC1,2	LF353 (2 off) dual bifet op amp
D1,2	1N4148 (2 off) silicon signal diode

MISCELLANEOUS

SK1	Standard jack with DPDT contacts (S2)
SK2	Standard jack socket
S1	SPST heavy duty push button switch
S2	Part of SK1
B1	9 volt (PP3 size)

Diecast aluminium box 150 x 80 x 80mm, printed circuit board, two 8 pin DIL IC holders, battery connector, control knob, Veropins, wire, etc.

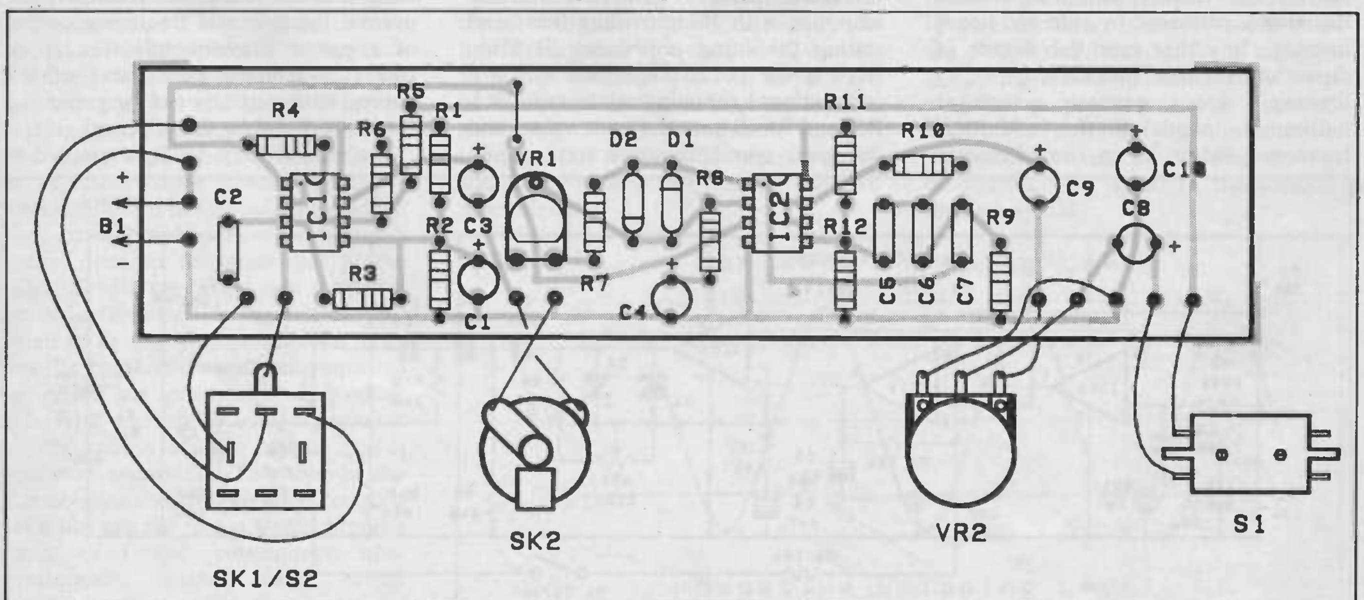
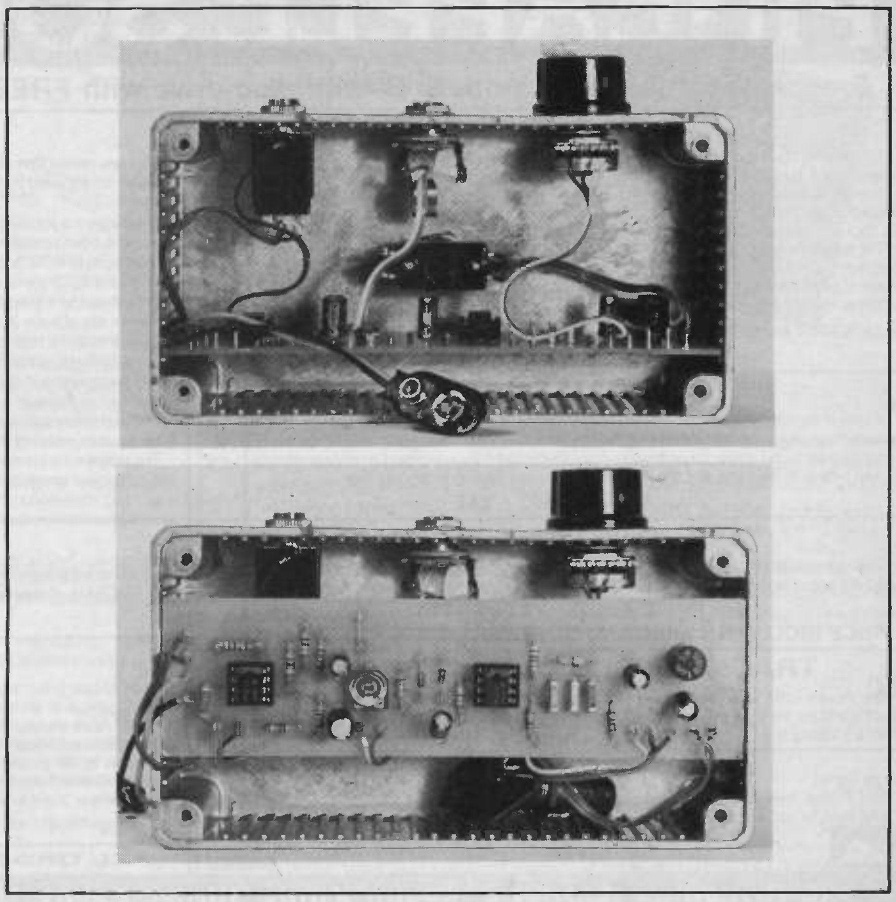


Fig.4. *Details of the printed circuit board and wiring.*

IN USE

The guitar connects to SK1 using a standard jack lead, and a second jack lead is needed to couple the output from SK2 to the input of the guitar amplifier, mixer, or whatever. As explained previously, plugging a jack plug into SK1 automatically switches the unit on, and removing the jack plug switches it off.

With S1 set to switch in the effect and VR1 set at a roughly central setting, the unit should give a fuzz effect, with VR2 enabling the amount of distortion to be varied from zero to a high level. With a fairly low output guitar pick-up VR1 must be set for a high level of gain (set well in an anticlockwise direction). Inadequate gain will manifest itself as the distortion dying away quickly after a note has been played, or no distortion being produced at all. With a high output pick-up VR1 must be set for a low level of gain, or any slight vibration of a string will tend to give a strong output from the clipping circuit and give unwanted output signals. Finding the best setting for VR1 is really just a matter of trial and error, and with some experimentation a suitable setting should soon be found. There is a fair amount of latitude here. The unit should have sufficient gain available to suit even very low output pick-ups, but VR1 could be raised in value to give even higher maximum gain if necessary. PE



Interior views of bright fuzz unit showing component mounting details.

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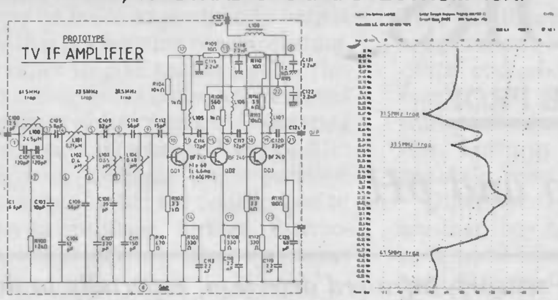

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SENSORS

PART 2 BY THE PROF

Platinum, pyro and pH

The second part of this series takes a look at temperature sensors, infra-red detection, especially in the longer wave lengths, and alkaline/acidity measurements.

The effects of temperature on electronic systems are something that often have to be guarded against, with problems such as drifting in oscillators and precision d.c. amplifiers being quite common. As temperature affects practically any electronic device to some degree this makes it relatively easy to sense. In fact there are several types of temperature sensor in common use, and the thermistor type is one of the most common. These are constructed from a substance, such as a compound of nickel magnetite, which produces a large change in resistance for a given temperature change. All the thermistors that I have ever encountered have been negative temperature coefficient (NTC) types. In other words, increased temperature produces a reduction in the component's resistance. Positive temperature coefficient thermistors do exist, but do not seem to be available to amateur users.

Thermistors can be used in temperature measuring applications, but their linearity over a wide temperature range is not equal to that of many other types of temperature sensor, and they are perhaps most used for temperature compensation. A typical application of this type would be as the bias stabiliser in the class B output stage of an audio power amplifier. The fact that these components provide true resistance and have a relatively high sensitivity, makes them well suited to applications where simplicity rather than great precision is called for. As an example of the sort of sensitivity that these devices achieve, the VA1066 rod type thermistor has a typical resistance of 47k at 25°C, but this falls to only about 940 ohms at 150°C.

Not all thermistors are intended for temperature sensing, and there are glass encapsulated devices of the so called 'self heating' variety. These are really current rather then temperature sensors, and a current flowing through a device of this type results in it heating up slightly, which in turn produces a reduction in its resistance. To aid their efficiency the glass envelope is often evacuated so that there is no air to conduct heat to, or from, the encapsulation. Probably the most popular application for this type of thermistor is in high quality audio signal generators where they are used to stabilise a sinewave oscillator so that it is maintained below the level at which clipping occurs. The R53 and (seemingly identical) RA53 types are intended for this type of circuit.

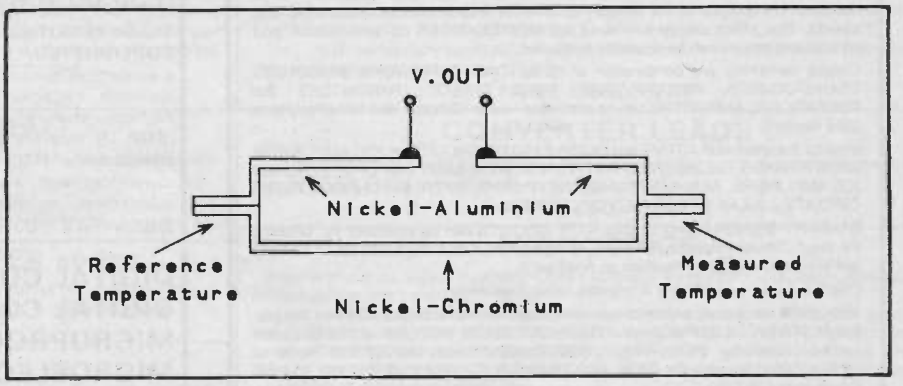

Fig.1. *The arrangement used in a thermocouple.*

PLATINUM SENSORS

A more up-market form of temperature sensor uses a grid of platinum wire as the sensing element. Pure metals offer quite high temperature coefficients and are consequently well suited to temperature sensing applications. In the case of platinum types, the fine wire is these days more likely to be in the form of a track deposited on to a substrate made from an insulating material. Note that this type of sensor is a positive temperature coefficient type, and that increased temperature produces higher resistance. The main attraction of sensors of this type is their wide operating temperature range, with −100 to +500 degrees Celcius being quite typical. An ac-curacy of around 0.1% can be achieved over the greater part of this range.

These sensors are mostly of open construction, and care needs to be taken to avoid damaging the sensing element. The sheathed type, which are in the form of a stainless steel probe assembly, are more suitable for general and experimental use, but unfortunately this style of sensor seems to be substantially more expensive than the open construction type.

The usual type of circuit for this form of sensor is a standard four element bridge. This arrangement does not produce a very large output voltage per degree Celcius, and the exact voltage obviously depends on the supply voltage fed to the bridge circuit, and on the sensitivity of the particular sensor used. Typically a 100°C increase in temperature would give a rise of around 40% in the resistance through the sensor. A modest supply potential of a few volts is generally sufficient to give an output of around 1 millivolt per degree Celcius. Although this may not seem very much, platinum temperature sensors are often used over quite wide temperature ranges, and the total output voltage swing over the full temperature span of the circuit could be several hundred millivolts. Also, the source impedance is generally quite low at around 100 ohms. This gives an output which is capable of directly driving many high quality digital voltmeter circuits. Direct driving of an ordinary (analogue) panel meter would also be feasible, but a good digital instrument is really needed in order to fully utilize the accur-acy provided by this type of sensor.

THERMOCOUPLES

A thermocouple is one of those devices which practically everyone has heard of, but relatively few people have actually ever used. Like strain gauges, they are a standard form of sensor for industrial use, but are relatively little used in home constructor designs. In fact I can only recall seeing one home constructor project which included one of these devices.

Operation of a thermocouple relies on the fact that the number of free electrons in a metal is dependent on both the composition of the metal and its temperature. Two pieces of dissimilar metal can therefore be made to produce an output voltage that is a function of temperature, but in order to give usable results, this type of sensor has to utilize a differential arrangement rather than truly operating as an absolute temperature sensor. The trouble with a simple single junction thermocouple is that the connections to the device produce further thermocouples which seriously affect the output voltage.

Fig. 1. shows the basic arrangement used in a practical thermocouple, and in this form one soldered connection balances out the effect of the other. Unfortunately, the output from one thermocouple junction also balances out the signal from the other, and it is because of this that the differential approach has to be adopted. One end of the device must be kept at a stable reference temperature while the other is used for measuring purposes, giving an output voltage that is proportional to the temperature difference.

temperature sensor are incapable of operating at temperatures anywhere near this figure. Linearity at these high temperatures is extremely good. At the other end of the scale most thermocouples will work down to –50°C, and some will operate at –200° C or even less. Linearity at low temperatures is generally relatively poor though.

Other points in favour of these devices are that they can be made very robust, or if made from fine wire, can have fast response times. Fast in this context means about 0.1 seconds, which is actually very slow by normal electronic standards, but compares well with the response time of several seconds which is associated with most other types of temperature sensor. They are available in a variety of styles ranging from bare wire types to enclosed and insulated probe assemblies. The output voltage is quite low at only about 40 microvolts per degree Celcius of temperature difference, and thermocouples have to be used in conjunction with high gain d.c. amplifiers having low levels of drift.

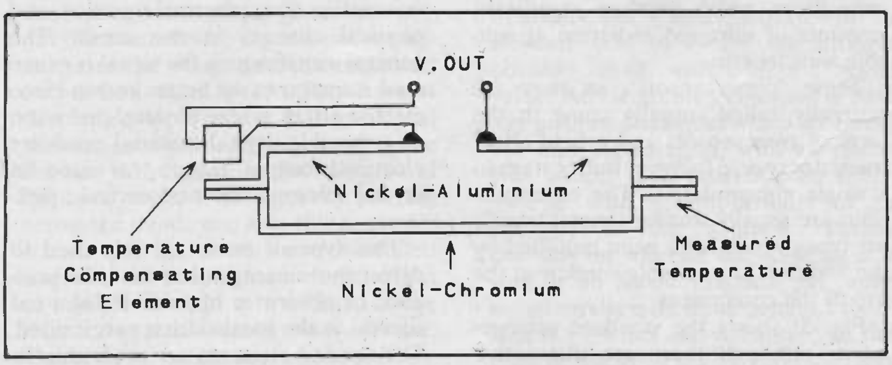

Fig.2. *A compensated thermocouple arrangement.*

In practice, the refined set up of Fig. 2. is more common, and here the reference end of the sensor is allowed to take up any temperature, but it is monitored by a compensating element. This effectively adjusts the output voltage to compensate for changes at the reference end of the device, so that the output voltage then becomes a function of the absolute temperature at the measuring end. This system is likely to be less accurate than maintaining the reference junction at a fixed temperature, but is generally much more convenient. Obviously a thermocouple is only well suited to the measurement of temperature that are substantially different to the ambient temperature, so that a reasonable temperature difference is present between the two junctions.

Thermocouples can operate well over very wide temperature ranges, and it is their ability to function at very high temperatures which makes them popular for many industrial applications. Devices which will operate at up to 600 or 700° Celcius are quite common; and types which will work at up to 1000° are readily available. Most other forms of

Anyone wishing to experiment with these devices could do worse than refer to the excellent 'Thermocouple Interface' article in the June 1986 issue of 'Practical Electronics'. This project uses a modern integrated circuit to take the hard work out of interfacing these devices.

SEMICONDUCTORS

Semiconductor temperature sensors are now very popular in both home constructor and industrial applications. There are numerous sensors for both temperature measurement and control, and these all take advantage of the fact that the voltage across a forward biased silicon semiconductor junction varies with applied temperature. In other words the basic sensing element is just an ordinary silicon diode used in a configuration of the basic type shown in Fig. 3(a).

The voltage developed across a forward biased silicon junction is in the region of 0.65 volts, but the exact figure depends on the particular device and the junction temperature. The voltage reduces at a rate of approximately 2 millivolts per degree Celcius of temperature increase. For an instrument which is to cover a wide temperature range this gives what will often be a large enough output voltage to directly drive a digital or analogue panel meter. Where necessary, the standard bridge and differential amplifier configuration of Fig. 3(b). can be used to give a boosted output voltage with the offset potential removed. Although a humble 5p silicon diode may seem to be an unlikely sensor, it does in fact give reasonable accuracy over a wide temperature range (typically 1% over a 100 degree span). This is not adequate for the most demanding of applications, but is adequate for many other purposes.

There is now a wide range of integrated circuit temperature sensors available, and some of these provide a boosted output voltage (typically 10 millivolts per degree Celcius), but leave a large d.c. offset on the output voltage. In fact some devices are temperature dependent current sources rather than voltage generating devices, although they only require the addition of a load resistor at the output in order to convert them to temperature dependent voltage sources. Some of the more recent devices include a differential amplifier which removes the d.c. offset to give an output of so many millivolts per degree Celcius. The LM35DZ for example (Fig.3(b).), is a three terminal device in a standard T0-92 plastic encapsulation which gives an output of 10 millivolts per degree Celcius over an operating range of 2 to 100 degrees Celcius.

The accuracy of semiconductor sensors is generally not as good as that provided by platinum types, and it has to

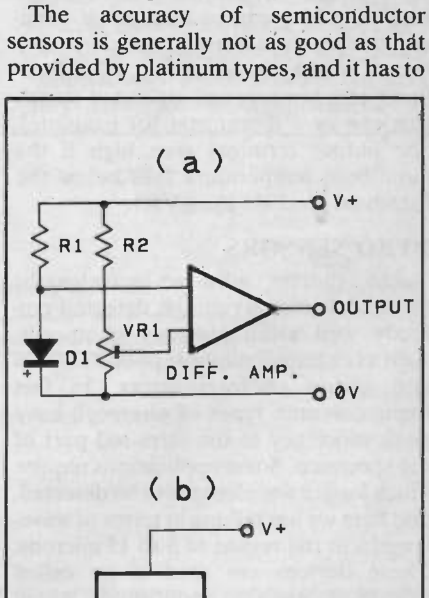

Fig.3. *(a) Using a silicon diode as the basis of a thermometer.*
(b) The LM35DZ provides an output of 10mV/°C.

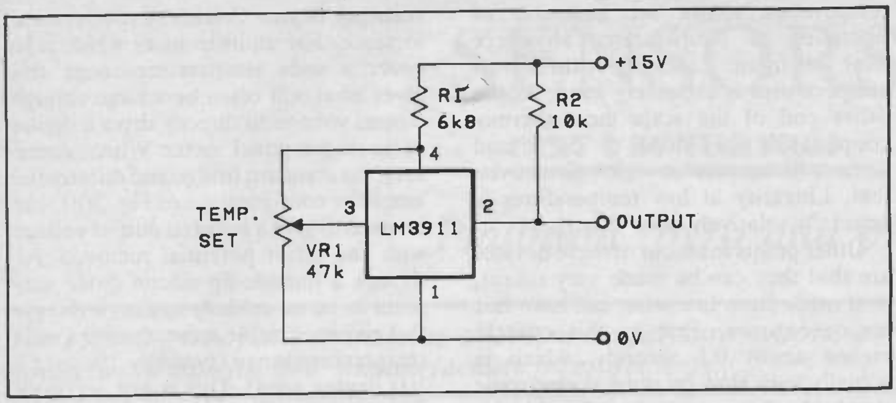

Fig.4. *The LM3911 as a simple temperature activated switch.*

be remembered that the component at the heart of even the more up-market of these devices is still only a forward biased silicon junction. Even where there is a facility to trim the device for optimum linearity, the accuracy is unlikely to be much better than ±1% over a wide temperature range, although a much higher degree of accuracy can be obtained over restricted temperature ranges. Where high accuracy over a wide temperature range is required, a platinum type sensor would normally be more suitable than a semiconductor type.

Semiconductor temperature sensing devices are not restricted to simple temperature to voltage/current converters, and there are devices which include further circuitry on the chip. Perhaps the best known of these is the LM3911 which can be used as an ordinary temperature sensor, or when connected in the circuit of Fig. 4., it functions as a temperature operated switch (for use as a thermostat for example). The output terminal goes high if the monitored temperature falls below the threshold level set using VR1.

PYRO SENSORS

The shorter infra-red wavelengths (around 1 micron) can be detected perfectly well using ordinary photocells, such as cadmium sulphide photoresistors and silicon phototransistors. In fact many common types of photocell have peak efficiency in the infra-red part of the spectrum. Some applications require much longer wavelengths to be detected, and here we are talking in terms of wavelengths in the region of 5 to 15 microns. These devices are used in so called 'presence' detection applications, where the presence of a human or humans within the monitored area must be detected. Applications of this type include automatic lighting, automatic doors, and burglar alarms.

There are alternative methods available, such as ultrasonic and radar doppler shift systems, but these passive infra-red detectors are generally accepted as offering a very good compromise between cost and complexity on the one hand, and reliability and performance on the other. Note that these are passive devices which detect body heat, and not infra-red that has been transmitted to the target object and then reflected back to the receiver unit. It is this factor that helps to give these systems good reliability as they will not detect any object which moves across the monitored area, only those which produce significant amounts of infra-red radiation at suitable wavelengths.

These 'pyro sensors', as they are generally called, usually come in the form of twin sensors and a field effect transistor source follower buffer stage in a single encapsulation. The encapsulations are usually standard metal transistor types which have been modified by the addition of a suitable window at the top of the component.

Fig. 5. shows the standard arrangement, although there are alternative configurations available, including single sensor types, and devices which require an external source load resistor (RB). The sensors are made from a ceramic material such as lead zirconate titanate, and each one consists of a thin slice of the material with metal electrodes deposited on both sides. The ceramic material does not naturally have the required characteristics, and must be processed to give the desired effect. The crystals in the material act as small electrical dipoles, but they are normally just arranged randomly. They are made to line up by heating the material to a critical temperature (just below the Curie temperature, at which the crystals have no dipole moment), and then applying an electric field. Once the material has cooled the electric field can be removed, and the crystals will remain aligned.

Changes in the polarisation of the material cause small voltages to be generated across the electrodes, and changes in the amount of heat received by the device result in similar changes in polarisation. This can be caused by more than one factor, including an increase in the randomness of the dipoles orientation due to thermal agitation, and physical changes in the sensor. The general way in which the signal is generated is similar to the better known Piezo electric effect, where physical distortion of a suitable crystal material produces electrical output signals (as used in crystal microphones and ceramic pickups).

This type of sensor is only used to detect movement, rather than the presence or otherwise of suitable infra-red signals, as the bandwidth is very limited. The sensing elements are made thin so that they respond reasonably rapidly to changes in temperature, but a –12dB

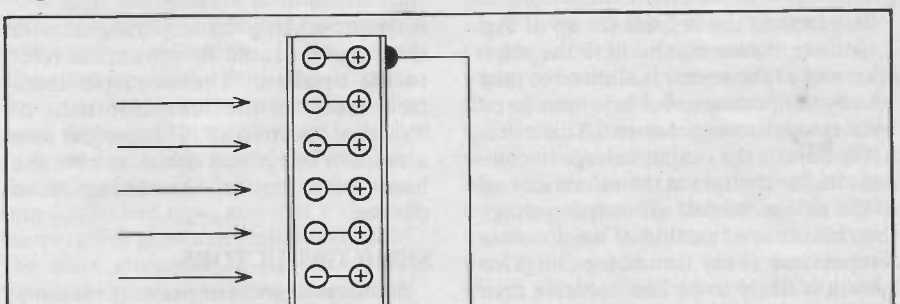

Fig.5. *The internal arrangement of a twin sensor pyro detector.*

point at 3Hz would be quite typical. At the other end of the frequency response curve things are limited by the load impedance on the sensor. This tends to leak away the charges generated by the device, and even using a high value gate bias resistor (RA) in the buffer stage the –12dB point at this end of the response is generally at about 0.3Hz. Although very restricted, this range of frequencies is well suited to the detection of someone moving across the monitored field.

The output level from the sensor is not likely to be very high, and around 70dB of voltage gain is normally needed in order to boost the signal to a usable level. Noise is the main limiting factor on performance, and restricting the bandwidth of the amplifier helps to minimise noise problems. Noise generated by the sensor itself is still something of a problem though, and this limits the useful amount of gain that can follow the sensor. Noise due to changes in the ambient infra-red level can also produce difficulties, and it is for this reason that twin sensors are often used. These are connected in anti-phase so that the output from one device cancels out the signal from the other, and the combined output from them is zero. This assumes that both devices receive the same signal simultaneously, which will normally be the case with changes in the background infra red level. With someone moving across the monitored area things are different, and the sensors are orientated such that the heat signal is directed first to one sensor then to the other as the infra-red beam sweeps across the device. This gives an output first of one polarity, and then of the other, effectively adding the two signals together and giving twice the output level of a single sensor.

In order to obtain a reasonably large field of view, the sensor must be used in conjunction with a fresnel lens which breaks up the monitored area into zones of high and low sensitivity. With a wide-angle system having good optics, a range of at least 10 metres can be achieved. A passive infra-red detector unit was described in the July 1986 issue of PE, and provides more information for those who are interested in building a unit of this type. Where low sensitivity is required a simple grating in front of the sensor will give adequate results, or an ordinary convex lens can be used if a narrow corridor of high sensitivity is required. Perhaps 'ordinary' is not the right word, since here we are dealing with wavelengths that are far removed from the visible light spectrum. The optics (including any window material) therefore have to be constructed from suitable materials that have good transmission efficiency at these long wavelengths. On trying some glass and plastic lenses in front of a pyro sensor, most were found to be practically opaque to long infra-red wavelengths.

pH MEASUREMENTS

Measurement of pH is something many readers will be familiar with, having encountered it in school physics or chemistry experiments. This is not to say that it is something that is of purely academic interest though, and accurate measurement of pH values is something that has become increasingly important in a number of fields, including colour photographic processing, agriculture, the food and drink industry, and scientific establishments in general. The standard school method of measurement is using paper, where the colour change of specially treated paper dipped into the solution is used to give an indication of pH value by comparison with a colour chart. This method involves subjective judgement, and is not suitable where really good accuracy is essential. Using electronic means, an accuracy of better than 0.1% can be achieved.

For those who are unfamiliar with pH measurement, it is basically a measure of the concentration of hydrogen ions in a solution, or in other words, a measure of acidity. The scale runs from 0 for the ultimate acid to 14 for the strongest possible alkali, with 7 as the neutral value. An electronic pH sensor is basically just two electrodes which are immersed into the solution, with an electrolytic action then providing an output voltage that is proportional to the strength of the solution. Polarity depends on whether the solution is an acid or an alkali. Practical pH probes are generally a bit more complex than a couple of wires and a handle, as they must be designed to give good long term reliability, and a typical probe would be along the lines of Fig. 6.

in these days of MOS operational amplifiers this does not represent any real difficulty. Two points which should not be overlooked when using this type of sensor are that the output voltage depends to some extent on the temperature of the solution, and the response time can be quite slow when measuring strong solutions (in excess of one minute in fact).

THE FUTURE

The trend in temperature sensors perhaps shows the way sensor technology is likely to develop. With these devices there has been a tendency towards the inclusion of as much of the circuit as possible on the same chip as the sensor, and the same tendency is also apparent with Hall effect devices. Of course, these are examples of semiconductor sensors where placing the processing circuit on the same chip poses relatively few problems. With other types of sensor this type of thing might not be feasible, although there are now pressure transducers which use integrated circuit techniques to produce the bridge resistors for what is basically a standard full bridge strain gauge. There is even a device from Motorola (the MPX100) which includes an evacuated chamber beneath the sensing elements so that barometric pressure can be sensed. Semiconductor sensors which might seem unlikely now could see the light of day in the future.

Where semiconductor sensors are not feasible at present, it is not uncommon for special signal processing integrated circuits for conventional sensors to be produced. Devices for use with thermocouples, and which provide the necessary temperature compensation and

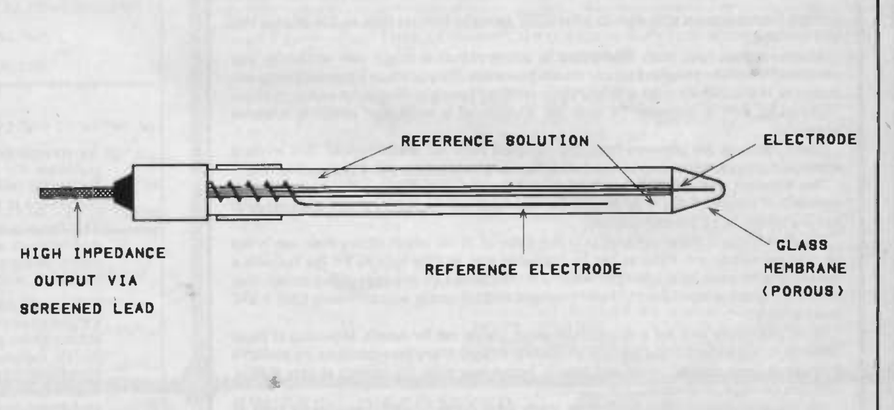

Fig.6. *Typical construction of a pH probe.*

The output voltage from the probe, although never more than a fraction of a volt, is quite respectable, but the available current is very limited. The output impedance of a pH probe is generally of the order of a few tens of megohms. It must therefore feed into an ultra-high input impedance buffer amplifier, and

amplification are an example of this. Another trend is towards devices that provide a high degree of guaranteed accuracy so that calibration is greatly simplified, or in some cases is rendered totally unnecessary. This is a trend that seems likely to continue, with ever greater accuracies being offered. PE

SPACEWATCH

BY DR PATRICK MOORE OBE

Our regular look at astronomy

Probes are reaching further into and beyond the Solar System. Now a probe may be sent out to the Oort Cloud, more than a light year away.

FOLLOWING the successful soft-landing of probes on the surface of Venus, it has been generally assumed that the prevailing colour is bright orange. However, new studies carried out by Russian and American investigators seem to show that this may not be the case. Standard colour chips were included with the pictures from the Soviet Veneras; and using these, scientists at Brown University in the United States have found that the general hue is more grey than orange. Mars is red because of the presence of ferric oxide (Fe_2O_3), but it seems that on Venus the fiercely hot temperature removes the colour from this material by reducing its reflectivity in long-wave regions of the spectrum. It is generally believed that much of Venus' surface is covered with basalt, produced by volcanoes there.

According to NASA, their next Shuttle flight will take place on 18 February 1988. A full schedule has been issued, with five missions in 1988 and another ten in 1989. Flight No. 9, due in November 1989, may be either devoted to the Galileo mission to Jupiter, or to the ESA/NASA Ulysses probe which will fly over the poles of the Sun. But we have to admit that nothing is certain, and many NASA observers are dubious whether the next Shuttle really will fly in less than a year's time. Meanwhile, astronomers all over the world are impatiently waiting for the launch of the HST or Hubble Space Telescope. Let us hope that military projects will not cause further lengthy delays to the scientific space programme.

Tremendous interest has been generated by the discovery of a vast cool shell of 'dust' surrounding the remarkable variable star R Coronæ Borealis, which is normally on the fringe of naked-eye visibility but which sometimes fades down to below magnitude 15. The 'shell', detected by studies of IRAS results, seems to be about 8 parsecs in diameter, so that if it were centred upon the Sun many other stars – including Sirius – would be inside it. The origin and nature of this shell is a matter for debate, and I will have more to say about it in the near future.

All astronomers have been saddened by the death of Dr Richard van der Riet Woolley, the last Astronomer Royal who was also Director of the Royal Greenwich Observatory. Woolley, a great administrator, was also a leading astrophysicist who achieved much valuable work. Yet, ironically, he may be most remembered for his off-the-record comment in the 1950s that space travel was 'utter bilge'. This was said in the heat of the moment when he was being questioned by journalists after a long and tiring flight – and it is significant that later on he contributed largely to space programmes.

PROJECT TAU

Only a few decades ago it seemed futuristic to talk about sending probes to the Moon. Today we have explored the Solar System out as far as Uranus, and by the end of the 1980s only Pluto of the main planets will remain unvisited (assuming that Pluto merits true planetary status, which is becoming more and more doubtful). We have also carried out rendevous missions with two comets.

The Sky This Month

APRIL skies are not really rich in planets. Venus is the exception; it remains a brilliant object in the morning sky, and cannot be mistaken. Telescopically it is, unfortunately, an unrewarding object. Its phase is now over 80 per cent, and virtually no markings can be made out. Jupiter and Saturn are also morning objects, but are as yet badly placed, while Mercury is even more elusive – though on the 19th it may be located slightly south of Jupiter.

This leaves Mars, which remains visible in the western sky after dusk. The apparent diameter is now less than 5 seconds of arc, so that powerful telescopes are needed to show anything much on it; but earlier in the year the Martian atmosphere was very clear, and with my own 15-inch reflector during January and February I was easily able to draw the main dark features. There had been earlier reports of dust-storms, but I could see no sign of them.

The Moon is full on the 14th and new on the 28th. On the 14th there is a penumbral lunar eclipse, but the most that we can expect is a very slight dimming.

We have now virtually lost Orion and the brilliant winter star-groups, though part of the Hunter's retinue remains visible aftr dark – notably Procyon, Capella and the Twins, Castor and Pollux. Ursa Major, the Great Bear or Plough, is not far from the zenith, which means that the W of Cassiopeia is low in the north, though from Britain it always remains above the horizon. In the South Leo, the Lion, is high, and the curved line of the Sickle, led by the first-magnitude Regulus, makes it very easy to identify. Following it round is Virgo, the Virgin, with the bright Spica and the 'bowl' which marks an area remarkably rich in faint galaxies. Also on view is Arcturus in Boötes (the Herdsman), a lovely orange star which is actually the brightest in the northern hemisphere of the sky; it is surpassed only by the southern Sirius, Canopus and Alpha Centauri, of which the last two never rise above our horizon.

Closer to the southern horizon is a wide area which is very efficient in bright stars. This is the constellation of Hydra (the Watersnake), actually the largest in the entire sky, but with only one conspicuous star – Alphard, which is of the second magnitude and is clearly orange. It is often nicknamed 'the Solitary One' because of its relative isolation. To identify it, first find the Twins and then use them as guides; a line from Castor, passed through Pollux and extended, will lead straight to Alphard.

But even so, the idea of probing as far as the Oort Cloud still seems more like fiction than fact. We may soon have to revise our thinking!

The Oort Cloud, named after Jan Oort, is believed to be a 'reservoir' of comets orbiting the Sun at a distance of more than a light-year. No doubt the present Pioneers 10 and 11 and Voyagers 1 and 2 will reach it eventually, but not for a very long time, and the chances of keeping in touch with them at such distances are nil. However, a new project, Tau, may alter the whole situation.

Tau stands for Thousand Astronomical Units. It has been formulated by scientists at the Jet Propulsion Laboratory in California, and involves what is in effect a robot space-craft which will travel out far beyond the known planets and may even reach the Oort Cloud. Its main task will be in astrometry – the positions, movements and distances of the stars and star-systems. If it can provide images of star-fields taken from a distance of a thousand astronomical units, we will have an immense 'base-line' which will be able to provide parallax measurements of objects so remote that their parallax shifts are undetected by our present techniques. (One astronomical unit is the distance/between the Earth and the Sun; approximately 93,000,000 miles or 150,000,000 kilometres.)

The problems are tremendous. The main telescope will have an aperture of 1.5 metres, and will be only one of many instruments; but what about propulsion? If we are to send Tau out to such distances in a reasonable time, we must have something far better than our present rocket motor. The JPL design involves a low-thrust ion propulsion system, using some 25,000 pounds of frozen xenon fuel and slowly accelerating Tau to a peak speed of 225,000 mph in ten years – after which the unit will be jettisoned and Tau itself will continue to 'coast'.

We will also need a nuclear reactor capable of supplying enough electricity to power ten thousand 100-watt light bulbs, plus a laser communications system which will be able to pump data across a distance of six light-days. Moreover, since the active lifetime is planned at 50 years, everything possible must be done to ensure against failure of even a single component.

All these considerations involve major advances in techniques, and any thought of launching Tau before the end of the century is discounted. However, the JPL team believes that it will be possible by around the year 2005. This is a mere eighteen years in the future – but look back at the situation as it was eighteen years ago, in 1969. At that stage a Moon landing was still no more than imminent, and even the nearer planets seemed out of range for soft-landing probes. If progress continues at a comparable rate, then the date for Tau starts to look a great deal more reasonable.

There is, of course, the undoubted fact that the team which sends Tau on its way will have no hope of seeing the results of all the work put into the planning and instrumentation. But astronomy has always been a science which looks ahead beyond single lifetimes; after all, Edmond Halley knew, when he predicted the return of 'his' comet for 1758, that by then he would no longer be alive.

Whether or not Tau will actually be built remains to be seen. But the JPL planners are confident that it will; and by the year 2087 we may well have the results sent back from as far away as the Oort Cloud. PE

ELECTRICAL SAFETY

BY RAY STUART

How to become unshockable

Electricity can be dangerous if it is not treated with respect. The way to avoid electrical risk to yourself and others is to construct all mains-operated projects to the proper safety standards before bringing them into use. This is not difficult, and, here is how to do it:

CONSIDER the following scenario. You have just finished designing your latest electronic masterpiece. You have successfully built the circuit board and to your delight and surprise it works first time. You have a bird's nest of switches, pots, connectors and lamps spread all over the kitchen table and you are threatened with divorce if you don't move it within ten seconds.

Your immediate thought is to put it in a case as soon possible. You drill a hole for the mains lead, but forget to deburr it; you could not find a rubber grommet, so you push the mains cable through the metal box and tie a knot in it to stop it pulling out. The mains plug came fitted with a 13 amp fuse, so you use it, and in your rush to use the equipment you exchange earth and neutral. The circuit consumes 10 amps but the cable is only rated for three. When you turn it on for the final test the cable catches fire, the main fuse blows and the house is plunged into darkness.

The above may sound somewhat exaggerated, but it serves to illustrate how easy it is to make equipment unsafe. Now ask yourself how much consideration you give to safety when you design and construct mains powered equipment. We are all guilty of ignoring safety to some extent from time to time, perhaps without even realising it!

STRESSING THE OBVIOUS

The above example has safety errors of such obvious magnitude that PE readers should recognise them immediately. However, there are a number of areas where safety can be compromised and it is to these that this article will address itself. Remember that it is not only the constructor's safety that is at stake, but also that of other unsuspecting persons.

The purpose of this article is to inform the reader of the importance of adopting a safe attitude to electrical work and the techniques that should be employed.

I make no apologies for stating the obvious even though experienced constructors may feel that this is teaching them to 'suck eggs'. The importance of electrical safety cannot be stated too forcefully. I hope the experienced will regard this as a refresher course, and the newcomer as a useful reference.

MAINS PLUG

The most obvious safety factor related to mains plugs is to ensure that the correct colour coding is used, as shown in Table 1 and Fig. 1.

TABLE 1
Earth – Yellow/Green
Live – Brown
Neutral – Blue

The earth lead is bi-coloured to allow easy identification by those who suffer from colour blindness.

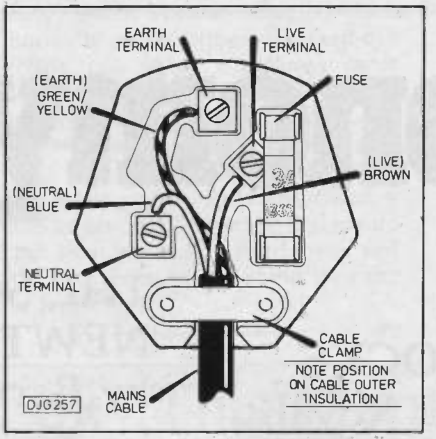

Fig.1. *Typical mains plug with cover removed.*

The second thing to ensure is that the leads are cut to the correct length. These are sometimes shown on a data card supplied with the mains plug, and serve two purposes. Firstly they allow easy installation and secondly, and more importantly, they ensure that, should the lead be pulled from the plug, the Earth lead is the last to be removed.

There are two types of terminals commonly used, those with insert holes and those with wrap around terminals. When using the insert type it is important to ensure all the conductor strands go into the hole so that there are no loose strands that could short to other terminals. One should also ensure that the insulation covers any exposed conductor, and that the terminal screws are tightened sufficiently to hold the cable in place. In the wrap around type the conductor strands are wrapped around a screw post and a combined washer/nut assembly is used to clamp the conductor. The length of the exposed conductor should be such that it will create about one turn when wrapped around the post. In addition the conductor should be fitted in a clockwise direction around the post to ensure that the cable is drawn into the assembly when it is tightened.

Should the cable diameter be too small for the cable clamp to grip, the diameter should be increased until a suitable fit is achieved. This can be achieved by adding the outer covering from a larger diameter cable, or by using layers of heatshrink sleeving (or similar) until the required diameter is achieved. It should be noted that this technique can also be used for cable glands and plugs/sockets clamps (see below).

Mains plugs are fitted with cable clamps of varying designs. All are designed to prevent the cable from being pulled out. It is important that these are adequately tightened and that the clamp rests against the outer covering of the mains cable; another reason for cutting the leads to the specified length.

Mains plugs should be fitted with a fuse appropriate to the equipment with which it is being used. It is now common for plug manufacturers to fit 3 amp fuses as standard.

Mains plugs come in a range of shapes, colours and prices, and the old addage 'you only get what you pay for' is true. Ensure that the plugs you use conform to British Standard BS1363, which should be displayed on the plug.

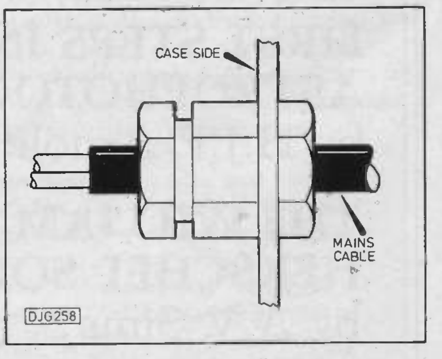

Fig.2. *Cable entry using gland as grommet and strain reliever.*

CABLE ENTRY/EXIT

There are two methods generally used for mains cable entry into equipment. The first, and most elegant method is to use a plug/socket arrangement such as an IEC connector. This provides automatic earthing, and a version of this connector contains a mains filter, especially useful for digital equipment.

The second method (Fig. 2.) is to pass the cable through the case and make connections inside. One should ensure that any burrs are removed from the entry hole and a grommet inserted to prevent the metal cutting into the mains cable. Provision should be made to secure the cable to the case, thus preventing the cable being pulled out thereby exposing live conductors. There are several devices available that clamp the cable, such as strain relief bushes and cable glands. One method sometimes seen is a knot tied in the cable (Fig. 3.). This is totally unacceptable as it can damage the cable which could cause the earth conductor to fracture and allow a metal case to become live under a fault condition.

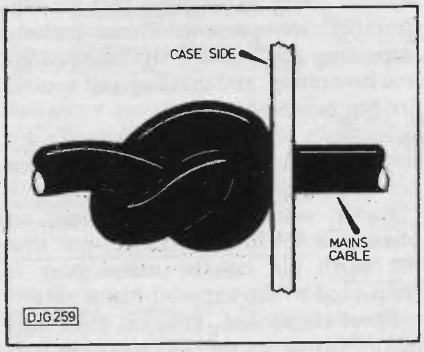

Fig.3. *Incorrect cable entry.*

EARTH CONNECTION

It is absolutely essential that exposed metal parts on equipment are earthed. Obviously it is easier to use a metal case as only one earth connection needs to be made. However, if a plastic case is used any metal parts that pass through the case, such as transformer mounting bolts etc, should be earthed. This may require the use of earthing straps as shown in Fig. 4. It should be noted that the earth connection to the case should have its own mounting screw and not rely on the mounting screw for another component.

FUSES AND FUSEHOLDERS

It is quite common to fit a small value fuse in a piece of equipment when the 3 amp fuse in the mains plug is too large, or when one wishes to fuse the d.c. side of the power supply. In these instances a panel mounted fuseholder is used such as that shown in Fig. 5. It should be noted that the feed to the fuse should be to the rear of the fuseholder rather than the side. If the side terminal were used there is the possibility that one

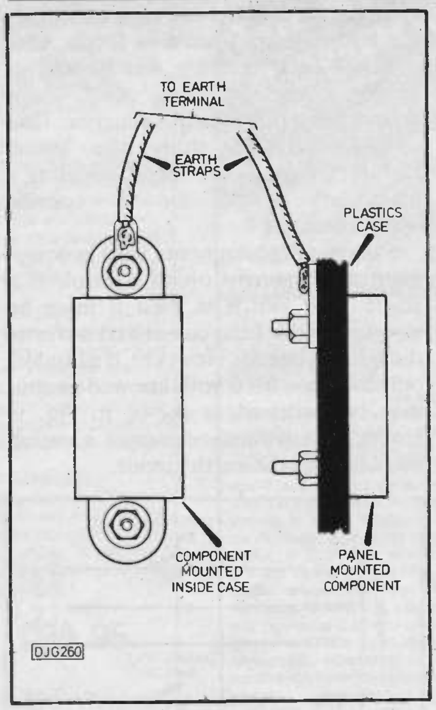

Fig.4. *Use of earth straps in plastic case.*

could get a shock as the fuse is removed. This is because a finger could touch the top of the fuse whilst the other end of the fuse touches the side terminal. It should also be noted that there are two types of fuseholder available, finger and screwdriver release. Some types of finger release types are not suitable for mains operation on domestic equipment as defined in the Electrical Equipment (Safety) Regulations 1975–76. Reference to manufacturer's catalogues should indicate these types.

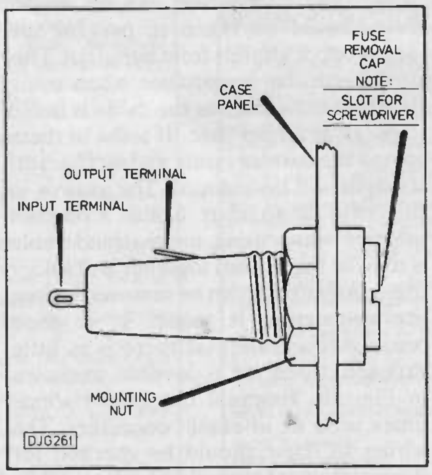

Fig.5. *Panel mounted fuseholder.*

The purpose of a fuse is to protect equipment from serious damage arising from large currents due to fault conditions, for example line and neutral shorted together. If these currents were allowed to persist there is a strong possibility that a fire could occur, especially in the mains supply lead. The fuse should therefore be rated below that of the mains cable.

Another important aspect to note when a fuse is placed in the mains circuit, is that it should be fitted in the Line lead, not the neutral lead.

PLUGS AND SOCKETS

If it is necessary for mains to be supplied by equipment to external devices such as motors etc, a plug and socket arrangement provides an elegant solution. However it should be noted that not all types are suitable. Reference should be made to manufacturers's catalogues to ensure that the types chosen are rated for the current and voltage that are to be used. Plugs and sockets that can be opened without the use of a tool should not be used for mains voltage. I prefer the IEC mains output connectors for use with currents up to six amps. The convention that must be adopted is that sockets *supply* power, whilst plugs *accept* power.

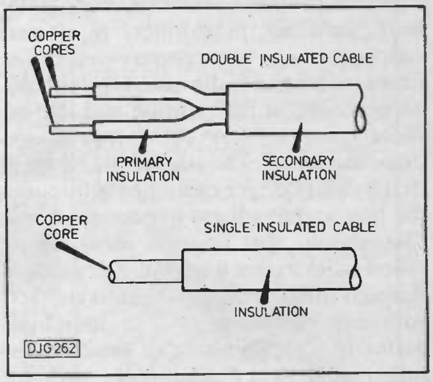

Fig.6. *Single and double insulated cables.*

CABLES

There are two basic types of cable available, single and double insulated (Fig. 6.). Doubled insulated cables should always be used outside equipment, and it should be ensured that the inner insulation is not exposed when connection is made to plugs and sockets etc (Fig. 7.). Cables can be categorised by their current rating, by cross sectional area, or by the number of strands in the core and their diameter. Table 2 shows the relationship between these factors for single core equipment cables that comply with BS 4808 part 2. Note that the current ratings are for 70°C.

Wherever possible the cable used should be suitably colour coded as shown in Table 1. This helps to prevent

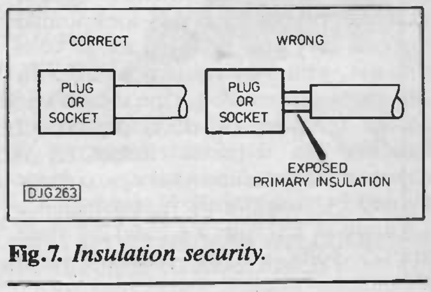

Fig.7. *Insulation security.*

TABLE 2

Current amps	Strands/ diameter no/mm	area mm^2
1.8	1/0.6	0.28
1.4	7/0.2	0.22
3.0	16/0.2	0.5
4.5	24/0.2	0.75
6.0	32/0.2	1.00

errors and makes checking easier. Single stranded cables tend to crack much easier than multistranded cables. This is especially true when the single strand is slightly cut during stripping. For this reason I prefer the use of multistrand cables. *The cable used should have a higher current rating than the maximum current required by the equipment.*

VENTILATION HOLES

When constructing equipment containing components that generate heat, such as transformers in power supplies, it may be necessary to include ventilation holes in the case. Care should be exercised in the position and size of these holes as they could lead to an unsafe situation. The size should be such that a child's finger cannot pass through the hole and touch any live components. One should also position these ventilation holes so that a screwdriver pushed through them cannot come into contact with live components. It is therefore better to use a number of small holes rather than one large hole, and to include a cover plate behind the holes as shown in Fig. 8.

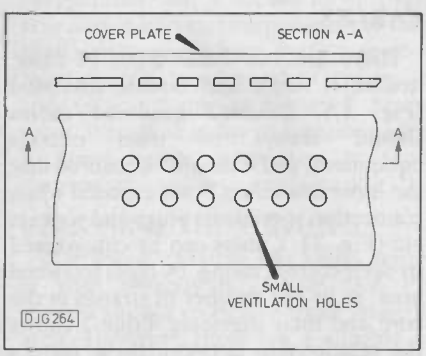

Fig.8. *Ventilation.*

SWITCHES

Although most switches appear to be adequate for mains use, closer examination may suggest otherwise. For example, two switches may look similar but one may only be rated for 50 volts d.c. use, whilst the other is suitable for 240 volt a.c. operation. One should also ensure that the switch is capable of handling the required current. It is common for switches to have two ratings quoted by manufacturers, for instance 1.5 amps at 250 volts a.c., and 2.5 amps at 125 volts a.c. In addition some switches have different current ratings for inductive and resistive loads. One switch I used recently was quoted as having a current rating of 16 amps resistive and only 4 amps inductive. One should therefore study the manufacturer's data sheets before selecting a particular switch for a specific application.

Switches are commonly used in equipment as the mains on/off control. If a single pole switch is used it must be inserted in the Line circuit and never in the neutral circuit. However, if a double-pole switch is used both line and neutral may be switched as shown in Fig. 9. Under no circumstances must a switch be placed in the earth circuit.

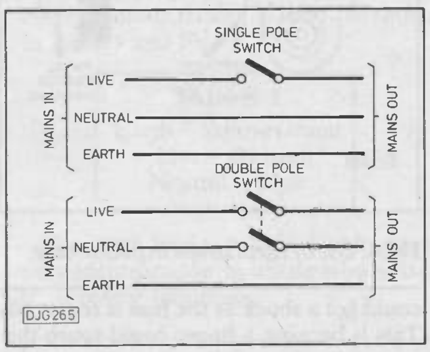

Fig.9. *Single and double pole switch circuits.*

WIRING

Having decided which components and wire types are to be used, you can proceed with the actual wiring up. This is probably the area where the greatest number of mistakes can occur.

First the cable has to be stripped before any connection can be made. Care should be taken to prevent the inner copper strands from being cut. This is of particular importance when using single strand cable, as the cable is liable to break at a later date. If some of them are cut the current rating and mechanical strength will be reduced. The answer in this case is to start again. Common practice when using multi-strand cable is to twist the strands together and solder them. Any excess can be removed before the connection is made. It is good practice to ensure that there is as little exposed conductor as possible, as shown in Fig. 10. Terminal blocks are sometimes used as internal connectors. The wiring to these should be checked for stray strands that could short to earth, or to others from adjacent cables. In addition the terminal's clamp should rest on the strands, not the insulation.

Cable runs not only look more professional, but are easier to trace later, if they are neatly routed. This can be achieved by planning the routing before you start and using cable ties to keep them together. Where possible colour code the cable and use the standard colour code for mains cables.

CASES

There are some aspects regarding safety that should be considered in the choice of a case. Generally there are two options available, metal or plastic. Metal cases may not be as attractive as some plastic cases, but they can have advantages. They are naturally conducting, thereby only requiring one earth connection, and can be mechanically stronger. Plastic cases are not normally conductive which means that, in order to earth any exposed metal components, a number of internal earth straps have to be provided. Exposed metal parts includes things such as mounting screws on transformers, as shown in Fig. 4. No matter what type of construction is used for the case, if it contains mains it should not be possible to open it without the use of a tool. This prevents it from accidentally being opened thereby giving someone an electric shock.

SAFETY CHECKS

When the construction is finished, conduct a few simple checks to ensure that the final system is safe. Firstly, give a visual check to establish that no silly mistakes are present. These include inspecting the mains plug connections and fuse rating, and that line and neutral are not reversed.

Secondly a few tests with a meter are required, which must be undertaken before plugging into the mains.

Earth continuity test. Using an ohmmeter set to a low range, test that the earth pin on the mains plug is connected to the exposed metal parts.

Short circuit test. Position the mains on/off switch to the ON position and connect the voltmeter across the line and neutral pins of the mains plug. The meter should show a high resistance value, indicating that line and neutral are not shorted.

When these prove satisfactory connect the equipment to the mains, and enjoy the satisfaction of having completed a successful and electrically safe project.

CONCLUSION

Safety is something that is not difficult to understand or implement, and is to a large extent a matter of common sense. But even when you know what should be done, you still require a positive safety attitude and the will to implement it. PE

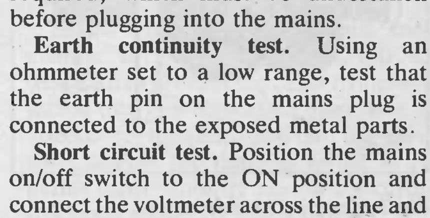

Fig.10. *Insulated tagging.*

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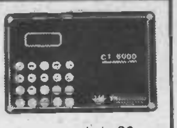

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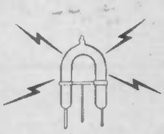
This kit includes all components (+ transformer) to make a sensitive IR receiver with 16 logic outputs (0-15V) which with suitable interface circuitry (relays, triacs, etc – details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits.
Supply: 240V AC or 15–24V DC at 10mA.
Size (excluding transformer) 9 x 4 x 2 cms.
The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

MK12	IR Receiver (incl. transformer)	£14.85
MK18	Transmitter	£7.50
MK9	4-Way Keyboard	£2.00
MK10	16-Way Keyboard	£5.95
601 133	Box for Transmitter	£2.60

POWER STROBE KIT



Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz. this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator.
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BETTER USE OF BATTERIES – UPDATE

BY ROD COOPER

Better use of battery chargers

Following on from his articles in the June and July 1986 issues of PE, Rod Cooper discusses a few arising points.

SEVERAL queries were received about the dry-cell charger. I was surprised that some readers thought that the timer section of the charger could be disposed of in order to reduce cost. The photographs of overcharged cells in the July issue were meant to show that there was a safety factor in overcharging, not that unlimited overcharging of the sort that could be done with a timer-less charger was permissible. Zinc-carbon cells are generally regarded as not being gas-tight, so gases from decomposed electrolyte due to overcharging escape to leave the dry cell even drier – and defunct of course.

On the other hand, alkaline cells are gas-tight and trying to stuff too much charge into them will result in the safety seal rupturing and the jelly-like electrolyte will ooze out. Being caustic, this can cause quite a mess. A timer is therefore essential not just to stop charging at the point where overcharge starts, but well before that. This is because the type of charger described gives essentially a constant-current charge. This is very safe as a short-circuit across the cell terminals caused by clumsy handling does no damage, but unfortunately it means that there is no significant reduction in the charging rate as the cell approaches full charge, which is what a dry cell requires. So, it is best to stop short of full charge even if it means missing a small amount of capacity.

The component value given will give a satisfactory charge to the average zinc-carbon dry cell, which is what the charger design was primarily intended for. With alkaline-manganese cells, it is necessary to estimate the charge required, and experience will show what length of time is required for the particular type being used. The stripboard layout showed IC2 holder pins removed so that the track could pass under the holder and so that R15 could be conveniently connected to pins 1, 14 or 15 as required, and adjusting the timing period as needed. If you find you are unable to judge the charge required, then it is better to leave these cells alone and stick to zinc-carbon.

Some of those who made a charger went to measure the current through the cells, or at least tried to! Although your meter scale may be showing readings in 'r.m.s.', the chances are that the scale is only true for sine-waves over a very restricted frequency range. Most inexpensive meters rectify the a.c., take the mean average deviation and display this – but with r.m.s. values showing on the scale because this is usually the value that people want to use. This is fine for sine-waves, but useless for any other waveform because there is then no fixed relationship between m.a.d. and r.m.s. values.

Just try taking a reading with such a meter on a square-wave and you will see what I mean. Even my Solartron 7045 (a d.m.m. costing over £400) is average-reading r.m.s.-calibrated, and gave fictitious readings with the waveform shown in Fig. 7 on Page 16 of the July issue, which is anything but a sine-wave. The only way to measure such a waveform is with a true r.m.s. reading meter, and these are usually based on converting the a.c. to heat and then measuring the temperature rise, a method which is substantially independent of both frequency and waveform. I used a thermocouple-type instrument, and the reason the current values were not published was because I supposed (correctly, as it turned out) that few constructors would have one of these.

The current can be calculated by an indirect method, though. You can measure the peak value of voltage across R7/R10 by connecting a 'scope across this resistor and taking a reading, but be careful about earthing arrangements if you do this. You can then work out the r.m.s. value, take an average by assuming approximately equal on and off times, and then use Ohm's law to find the effective current through the resistor, and thus the cell. There are inaccuracies in this method, but it is better than using a false-reading meter. However, it is tedious.

The mains transformer used in the charger was a critical component. It was specified as the RS 207-627, available from Magenta or Electromail. Regrettably, this vital information did not get into print, and constructors who used other transformers had variable results. This is because transformers vary in their regulation. A good quality component from a British manufacturer may have a regulation of 5%, whereas a cheap Far Eastern import may be as bad as 20%, and this has a disproportionate effect on the charging current. The specified transformer was chosen because it was the lowest-voltage commercially available type with a reasonable regulation (10%) and availability. As the dissipation varies as to the square of the working voltage, a low voltage was considered an advantage.

At least one constructor connected the diodes D7 to D10 so that the large pulse of Fig. 7 (July issue) was the wrong way round, thus mysteriously causing the cells to come out with less charge than when they went in! Unfortunately the stripboard layout did not make it clear which way the diodes were inserted, although the circuit of Fig. 9 makes it quite clear. You can check with a 'scope that the cell is receiving the large pulse in the right direction for charging by connecting across R7/R10, and that the small pulse is in effect discharging the cell.

Now to the Verkon dc/dc converters described in the June issue which stepped up the 1.5V of a single cell to either 8V or 12V. Most users seem to have had great success replacing expensive NiCd and layer-type PP3 batteries with these cost-saving devices. However, it was inevitable that some converters were used for applications which were unsuitable or difficult, for example a.m. radios, where r.f. interference gave problems. The V6 and V12 are both switch-mode power supplies, so it is obvious some r.f. is going to be present, although the manufacturers have gone to the extent of putting the device inside a steel can. The leads, capacitors, etc will all carry r.f. interference, so if you are going to use any dc/dc converter for an a.m. radio then you will need extra screening. It is very easy to construct an r.f. shield which will enclose the cell, converter and other components from tinplate. There is plenty of literature around about r.f. screening so I won't repeat the standard text here except to say, on a purely practical note, that the rectangular cans of Colman's mustard make excellent r.f. shields with no extra work! Also, it helps if the converter is placed well away from the r.f. sensitive parts of the circuit, like the ferrite rod aerial. After all, no-one making an audio amp would put the mains transformer next to the phono input, and exactly the same principles apply even if you are using an r.f. screen. The leads from the converter should have small ferrite-type chokes in series, and these must have a low d.c. resistance and be enclosed along with the cell, the decoupling capacitors and all the other converter components inside the shield.

These problems occur with a.m. radio, but f.m. does not pose the same amount of difficulty. I have used Verkon converters on c.b. transceivers like the ones shown in the photo in the July issue, which were of course the legal f.m. type. I have also successfully used Verkons with no extra screening for replacing the PP3 battery in a resistance-capacitance bridge, a portable electronic thermometer, an AVO meter (for the resistance ranges), a frequency meter and for driving the 6v motor in a cassette mechanism, so it is safe to say that for most uses screening is not needed. PE

Photo 1. *Cells 1 to 4 are different types and make of cell which have been overcharged by a factor of ten times to show how safe it is. The recharge current was 1 amp (five times that recommended) for 24 hours (twice as long as that recommended). To make the test more severe, plain smoothed d.c. was used. Result: no sign of leakage, no sign of splitting or bursting. Cell No. 2 developed a slight bulge after 8 hours but nothing further happened. This cell was sectioned and compared with an uncharged cell.*

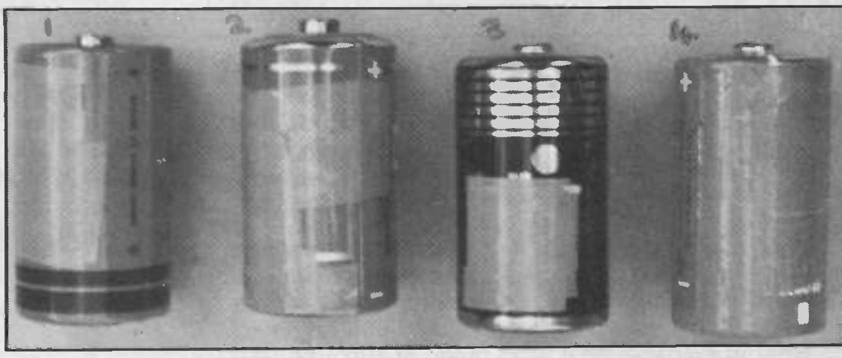
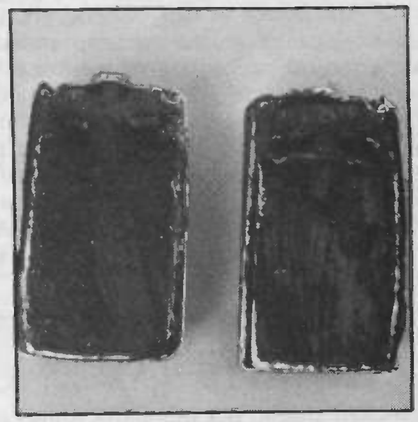


Photo 2. *Another set of cells was charged at 0·2 amp using PCR for **5 days**, an overload of* ten times *the recommended rate. No sign of leakage or splitting of the case was seen. A sectioned view of one of these cells shown below on the right compared with an uncharged cell on the left, confirms no distortion of the case or internal components.*

As all these tests have been repeated many times it is safe to say that recharging with PCR at 1/10 of the charge rate used is harmless provided the rules set down in the text are adhered to.



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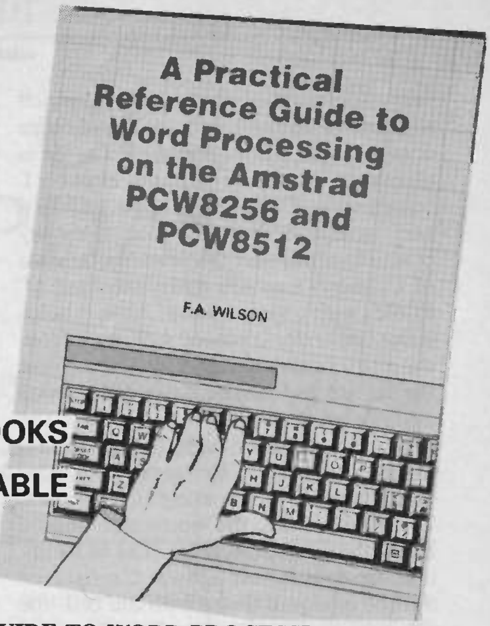

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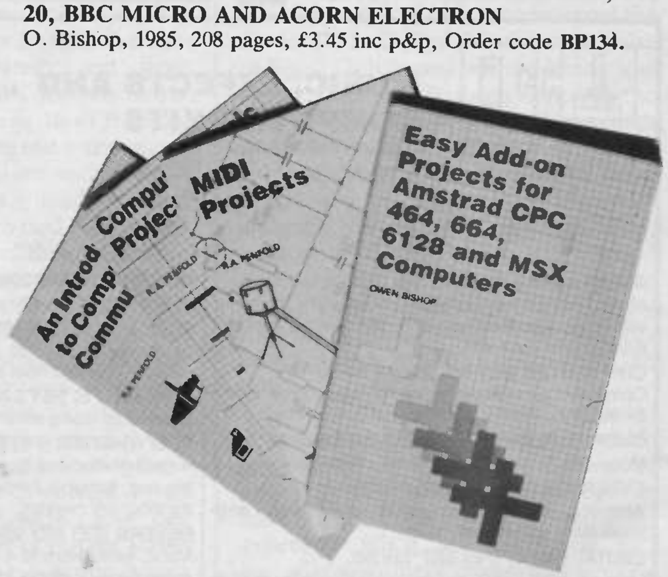

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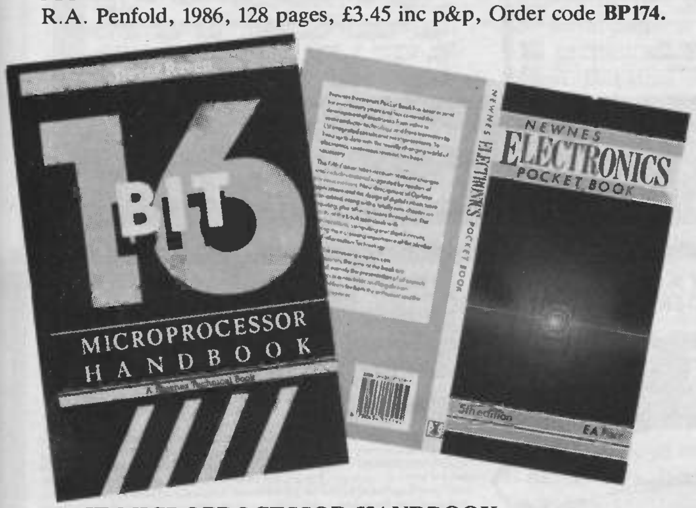

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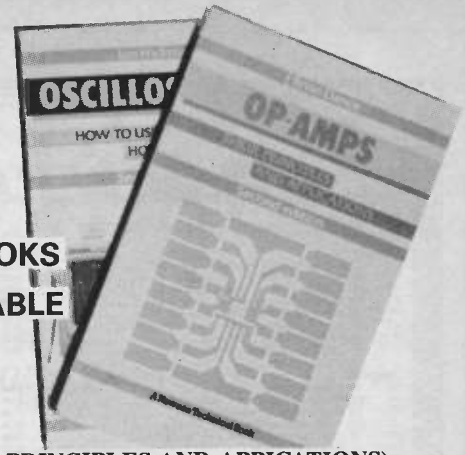

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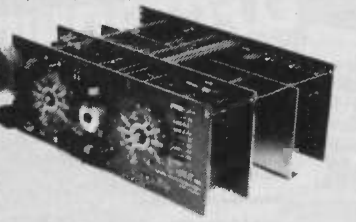

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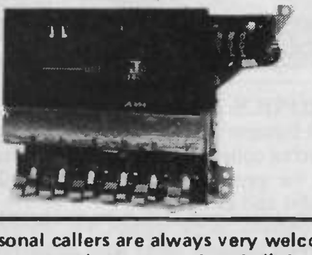

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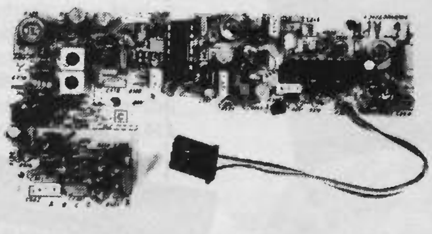

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INDUSTRY NOTEBOOK

BY TOM IVALL

Keeping the Juggernaut going

The shadow of 1984, and society's addiction to consumerism, is never far away in the electronic age, despite all its benefits.

A recent series of articles called 'The British and the Box' in *The Observer* was based on the premise that television has enormous power and an influence that is all-pervasive. It pointed out that tv can cause churches to change the times of their services, can boost the sales of books, turn images of anonymous persons into national figures and inspire the launch of national campaigns. We also know that individuals and governments can get very worked up about it. Programmes are accused of political bias, inciting young people to violence, undermining national security, inculcating all kinds of dangerous ideas, and so on. Earlier this year the police raided BBC offices over the Zircon spy satellite affair. Looking abroad, whenever there is a revolution or military coup one of the first things the insurgents do is to capture the tv broadcasting station.

All this could be cited as one example of how electronics, through television engineering, has an effect on society at large. The programmes couldn't exist without the electronics hardware – the broadcasting and receiving equipment – so the electronics industry is ultimately responsible. A parallel case could be set out for the powerful effect of electronic computers on our lives. One could instance the spread of cheaply manufactured computers into homes and schools, their use in small businesses, the data banks holding dossiers and official information on individuals, the computerised robots and expert systems taking over from human specialists, and so on.

In both these very public manifestations of electronics the sensitive element seems to be ideas and information – the domain of mental activity. Electronics is largely concerned with transmitting and processing information (in the communication theory sense) and is therefore involved with the semantics – the matters that affect our feelings and thoughts – carried by the information. Reflective people are worried by these intrusions into their private mental worlds.

But I do not think these influences are fundamental to the way we actually live from day to day. Psychological security is certainly important to all of us, and anything that seems to be influencing our normal perceptions of the world and our place in it, our beliefs and prejudices, we might feel to be a threat. But such influences have been at work for centuries, through preachers, gurus, teachers, artists, writers, minstrels, actors and all their various media of communication. Now we have the electronic media, but all they provide is a big increase in the volume. The effect, whatever its nature, is on the superstructure of society.

Modern industrialised societies are built on capital and mass production assisted by technology, working together. Even communist countries are following the same basic principle. A characteristic of mass production is that it has an in-built necessity to keep going. Factories are initially set up to make goods. But eventually a reverse process takes place. The public is pressured to keep buying the goods, which they may not necessarily need, in order to keep the factories running – and, of course, the workers in jobs, the managers managing and the shareholders benefiting from their capital investment. It is even useful to give unemployed workers money to help maintain demand.

Without this permanent pressure for consumption the whole system would collapse. So expedients like planned obsolescence of products are brought in to help. Karl Marx thought that capitalism would be ended by an inner contradiction – the increasingly exploited workers eventually rising up and overthrowing the owners of the capital. This didn't happen, of course, but there are now other contradictions to be seen.

Electronics is coming into motor vehicles more and more to improve their efficiency and convenience – and, of course, to provide further outlets for electronic products. In a comparable way this technology of information processing is insinuating itself, like the growth of a nervous system in a living embryo, into the structure of industrial production and the societies formed around it. As such it is helping to sustain and strengthen the Juggernaut, this apparently unstoppable, self-fuelling vehicle which is lumbering along, full of the most extraordinary contradictions.

For example, as already mentioned, a characteristic feature of mass production is planned obsolescence. But planned obsolescence means that the ultimate purpose of production is waste. Peacefully we're manufacturing equipment for warfare. Skilfully we're designing machines to abolish skill. High intellects are turned to the creation of trash; and great bodies of technical knowledge, built up over centuries, to bringing forth more ephemera. We develop products to satisfy demands which don't yet exist, and sell these products to rich minorities in the midst of a poverty-stricken majority. Workers suffer intense boredom to produce goods, the images of which are used through advertising to excite and stimulate other workers. Worst of all, in pursuing endless consumption we behave as if we didn't know that the Earth's minerals and sources of energy cannot be renewed.

Electronics helps to keep these contradictory processes going, sometimes playing a central role. Through them it has a much deeper effect on the way we live than any amount of watching television, using computers, or accepting the benefits of the various domestic devices like microwave ovens and programmable washing machines. The inherent contradictions, looked at afresh, are sometimes quite crazy. But in industrialised societies the continual rise in the material standard of living anaesthetises us to accept them without question. Some people have become completely stoned, understanding human life solely in terms of getting and spending. So large populations live docilely with what an observer from another planet might find completely imcomprehensible. PE

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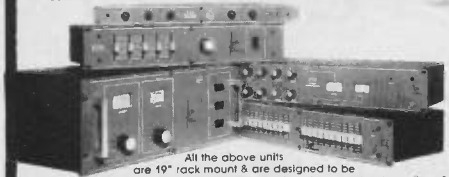

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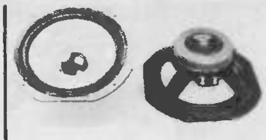

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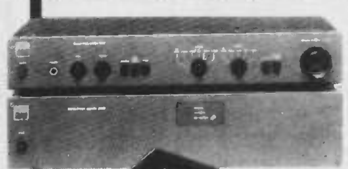

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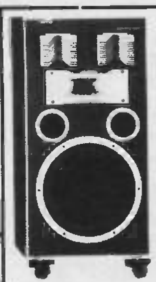

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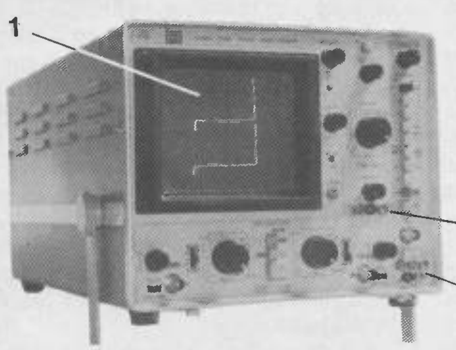

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