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REGULAR FEATURES

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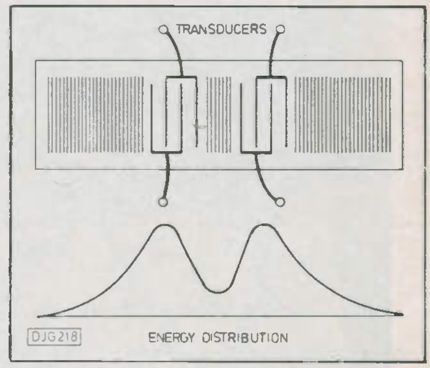

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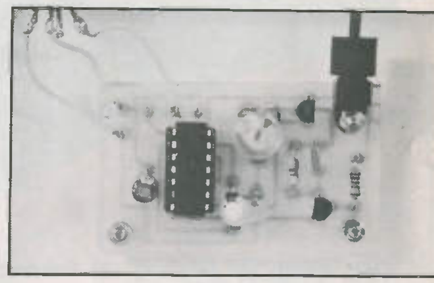

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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

WHAT'S NEW

CATALOGUE CASEBOOK

Last month we received the following catalogues and literature:

A four page leaflet from **Advanced Metalwork Supplies** (sister company to Advanced Power Supplies) detailing the companies **metalworking** capabilities.
Details from: **Advanced Power Supplies,** Raynham Road, Bishop's Stortford, Herts., CM23 5PF.

The **Micro Power Devices** catalogue from **Quarndon Electronics** featuring a range of low power chips of various types. Details from: **Quarndon Electronics** (Semiconductors) Ltd., Slack Lane, Derby, DE3 3ED.

The latest issue of the **Micropute** price list and catalogue detailing a wide range of **computer equipment** and supplies. Details from: **Micropute,** Catherine Street, Macclesfield, Cheshire, SK11 6QY.

Cricklewood Electronics' latest **components** and equipment catalogue containing a large list and prices of many devices, tools, components and electronic accessories.
Details from: **Cricklewood Electronics Ltd.,** 40 Cricklewood Broadway, London, NW2 3ET.

The **Handbook Of Electronics** from Chartwell Bratt. Details from: **Chartwell Bratt Ltd.,** Old Orchard, Bickley Road, Bickley, Bromley, Kent.

The 'Bigger Than Ever' **Maplins Buyer's Guide To Electronic Components** is now available through many good high street newsagents or direct from **Maplin.** Mail order.

Crofton Electronics **monitors, cables and connector catalogue** available from **Crofton Electronics.**

Lasercards

A 2MByte data store the size of a credit card will be available from British Telecom, following a licensing agreement with the Drexler Technology Corporation of California, the patent holders.

Known as LaserCard, the memory cards can hold up to 800 pages text or eight photographs. Data can either be imprinted photographically and supplied as part of the card, or alternatively written onto the card by the customer, using low cost laser equipment. Once written, the cards are 'intrinsically secure and difficult to corrupt either accidently or deliberately'. BT will also be the suppliers of the equipment for recording and reading the cards.

The cards have several advantages over floppy or hard disk storage for permanent records, the main ones being the relative indestructability of the data, and comparative cheapness of manufacture. BTis negotiating with one of the major London hospitals which is considering LaserCards for maternity records, as medical notes and photographs of x-rays, sonic scans, etc. can all be held on one card.

Applications in which the cards are being used in the USA, Europe and Japan include financial records, and secure data collection and distribution. Hardware manufacture is in the USA and Japan at present, but may come to the UK if there is sufficient demand for the system. Through its licensing agreement, BT joins a group of 25 international corporations operating in the information technology market.

The Drexler Technology Corporation is an optical data company best known for photo-production materials for the semiconductor industry.

Crystal printer

A co-axially driven computer printer which uses Casio-developed liquid crystal shutter technology is being marketed in the UK by You-data (UK) Ltd., a subsidiary of the machine's Danish manufacturers. The Ida 3270 LightWriter claims to be the world's first direct co-axial connection printer for IBM systems, allowing users to set up the printer either remotely from the host system, or through a 32-character menu-driven front panel display on the printer itself.

The printer has full APL/TEXT features in SCS and non-SCS modes. Specifications include high quality print of 240 dots per inch, nine page per minute print speed, vertical and horizontal print on the same page, a maximum of 132 columns, paper handling from postcard to B4 sizes, a choice of type styles, type sizes and barcode types, colour graphics, multiple font capacity and print on overhead projection foil and tracing paper. There is full IBM 3268/3287/4214 compatability allowing straightforward connection to IBM systems. The LightWriter accepts the same datastreams as used for IBM type printers, and connects to a variety of IBM and equivalent control units.

You-data's boast is that the LC technology used in the LightWriter gives a higher speed and quality of output with fewer moving parts, which in turn means a lower noise level and reduced machine wear.

The printer was launched in the UK in September, 1986 six months after its European launch, in the expectation that its unique qualities would be seen to increase the efficiency and quality of output from IBM-compatible mainframe-based electronic office systems. The company and its customers claim that the LightWriter is a significant improvement on other printers, including laser printers, evaluated. They expect LC technology to become established in this role in the next 12 months.

The LightWriter 3270 costs £4,850. You-data's parent company is a major supplier of IBM-compatible protocol converters in Europe, supporting a wide range of printers, plotters and bar coders.

Peaceful employment

Exchange Resources is an employment agency set up in July 1986 by Electronics for Peace, an organisation of some 250 electronics and computing engineers concerned to encourage the development of electronics for non-military and socially beneficial purposes.

MOD contractors are among the biggest employers in computing and electronics. People making a career in technical disciplines, from technicians to technical writers can be faced with a dilemma if they do not wish to work in a defence-related field. Exchange

Resources are concentrating on employment and personnel in non-miliary industries.

"Exchange Resources is not anti-defence but believes this country has far too much of its resources invested in an unnecessarily large and provocative system that has little to do with actual defence ... we are not aligned with or affiliated to any political party or any other organisation or their ideologies," they state. There is no doubt that there is a demand among technical people for non-military employment, a demand which is recognised to a varying extent by recruitment agencies, but Exchange Resources believe they are the first agency in this country to make this their primary aim.

Exchange Resources are presently looking for further finance to help them through the next year's operations. A loan of £20,000 is being raised through Mercury Provident plc, who are asking for £24,000-worth of guarantees, preferably in small amounts from individual guarantors. Alternatively, supporters are also being asked to open deposit accounts with Mercury "bearing whatever interest rate you need ... up to a limit of 8% gross per annum" for use specifically in financing Exchange Resources.

Maplin club card

Maplin Electronic Supplies, popular suppliers of electronic components, are in the process of issuing their new Maplin Club Card to their customers, starting with all buyers of the 1987 Maplin catalogue who responded to their free gift offer. Maplin expect that their card will have a wider circulation than any other electronics industry card.

The card will simply carry an identification number for each customer which can be quoted when ordering for direct keying-in to the Maplin computer. Maplin offer same day despatch for orders placed before 5pm, and hope that the ability to identify callers by number will streamline their system further.

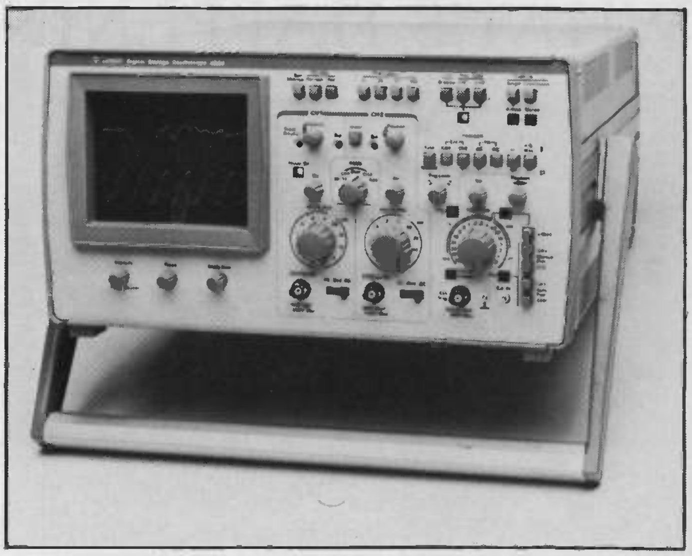
The Club Card is designed to fit into a wallet or puse so that Maplin's phone sales number and the owner's priority identity number will be available at all times. The reverse of the card, say Maplin, will carry much useful information such as metric measurements, resistor colour codes and tolerances and electronic data tables. They don't say whether magnifying glasses will be supplied as well – but no doubt they would if they thought it would tighten up their increasingly slick and versatile operation.

Low cost D.S.O.

Gould Electronics's established digital storage oscilloscope, the 4030, is being promoted by Gould as 'the only no-compromise performance DSO on the market for less than £1600' after a round of price cuts. The offered price is £1595 exclusive of V.A.T.

The dual converter, 20MHz machine has full speed performance and long store length on both channels. NATO-approved, the 4030 can operate as a real time oscilloscope, and to display repetitive signals which can at any time be frozen in its memory and automatically reproduced on an analogue recorder.

Dual channel simultaneous recording means that there is no phase displacement or loss of time resolution when two related signals are being perused. Individual channel-hold allows one signal to be stored as a reference for comparison with the second channel, simplifying set-up, drift-evaluation and test procedures.



Graph graphics

Kuma Contractors have enhanced their K-Graph business graphics package for the Atari ST, which is now released under the name K-Graph 2. The purpose of this business graphics program is to allow users to produce graphs and charts quickly and efficiently to a professional standard. The program makes uses the menu-driven GEM, which gives facilities such as the simultaneous display of up to four different graphs.

The chief new features in K-Graph 2 are mathematical and trig functions including sin, cos, tan asin, acos, stan, x and y values, log and log 10, exp, exp 10, exp 2, if, not, or, and, then, else, arithmetical functions, power and square roots, statistics including standard values, T and F tests and multiple regression, print and rename datasets, variable x and y origins, area graphs, texts in different fonts and colours, save graph to disk, custom desktop feature and various data manipulation features.

Features carried forwards from the mark 1 version include sideways printing option, enlargement and reduction, editable markers and line styles, automatic axis scales and legends, and free floating text and arrows.

K-graph 2 can be used with K-SPREAD or as a stand alone package, and is retailing at £49.95 including V.A.T. An upgrade of the original can be obtained for a fee of £10 by returning the master disk to Kuma.

Miracle Modem

Miracle Technology have developed a dedicated modem, the WS4000 and interface package for the Amstrad PCW8256 and 8512 word processors.

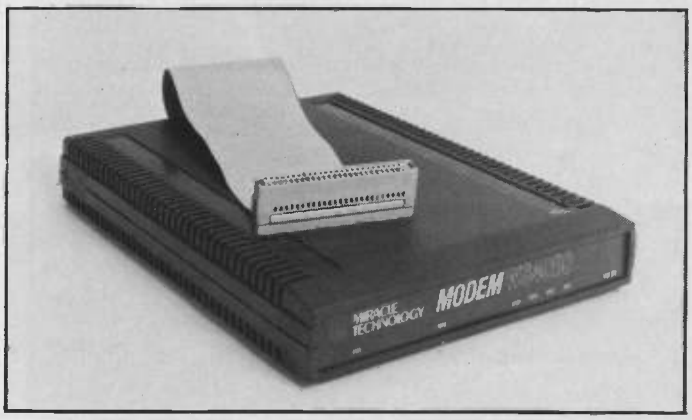
Developed on Miracle's standard WS4000 modem, the facilities offered by this package include autodial, autoanswer, full HAYES intelligence and an Amstrad serial interface incorporating all the necessary cables. The package is fully upgradable from standard V21/V23 to V22 and even (say Miracle) V22bis. Speeds from 300bps to 1200/75bps are therefore standard, with 1200 and 2400bps full duplex as optional extras.

No extra software is needed for users with Amstrad's built in MAIL232. Otherwise, the modem package is available complete with ChitChat comms software for £259.90, excluding V.A.T. No specialist computing knowledge is needed to use the modem, and a list of UK and international databases is supplied with every package, along with full instructions.

STV converter

Swedish Microwave of Motala, Sweden are introducing a low noise converter, the LNB 1115 HEMT, for satellite TV reception. This, they claim, is the first of its kind with a noise rating of 1.5dB within the 10.95GHz to 11.7GHz range. The converter uses h.e.m.t. (high electron mobility transfer) gallium arsenide transistors, a development from FETs using the same materials. The technique used exploits the fact that charge carriers in the transistor are confined to a thin layer, with resulting higher mobility. This is claimed to give h.e.m.t.s better noise readings and higher performance amplification of extremely high frequencies.

One advantage of the new design is that it can utilise a receiver dish 20 per cent smaller in diameter than conventional low noise converers, for instance 2.4m as opposed to the normal 3m dish. This, say the manufacturers, should allow smaller, less conspicuous and cheaper dishes to be accessible to consumers for STV reception.



WHAT'S HAPPENING

FIRM CONTACT

Further details of the products, services and companies mentioned in the News pages of Practical Electronics may be obtained from the following sources:

British Telecom Press and Broadcast Office, British Telecom Centre, Floor A3, 81 Newgate St., London EC1A 7AJ.

You-data (UK) Ltd., Frimley Business Park, Camberley, Surrey. (Attn. David Houston).

Exchange Resources, 28 Milsom St., Bath BA1 1DP, Avon. Tel. (0225) 69671/2.

Radio Regulatory Division report: free from The Library, Radiocommunications Division, Room 605, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Maplin Electronic Supplies Ltd., P.O. Box 3, Rayleigh, Essex SS6 8LR. Tel. (0702) 552911.

Matrix Systems, 35/36 Singleton Street, Swansea SA1 3QN. Tel. (0792) 476547.

Red Boxes available from: Electronic Fulfilment Services Ltd., Chesterton Mill, French's Road, Cambridge CB4 3NP.

Kuma Computers Ltd., 12 Horshoe Park, Pangbourne, Berks RG8 7JW. Tel. (07357) 4335.

Word Processing, P.O. Box 67, Wolverhampton, W. Midlands WV10 9HG.

Swedish Microwave AB, Box 230, S-591 23 Motala, Sweden. Telex 8155100.

Electronic Brokers Ltd., 140-146 Camden Street, London NW1 9PB. Tel. 01-267 7070.

Miracle Technology (UK) Ltd., St. Peter's St., Ipswich IP1 1XB.

Gould Electronics Ltd., Roebuck Road, Hainault, Essex IG6 3UE. Tel. 01-500 1000 (Chris Cook).

Rapid Terminals, Rapid House, Denmark St., High Wycombe, Bucks HP11 2ER. Tel. (0494) 21860.

Electronic & Computer Workshop, 171 Broomfield Road, Chelmsford, Essex CM1 1RY. Tel. (0245) 262149.

Lavell Electronics Ltd., Moxon Street, Barnet, Herts EN5 5SD. Tel. 01-449 5028.

Verospeed, Boyatt Wood, Eastleigh, Hants SO5 4ZY.

St. Cross Electronics Ltd., Unit 14, Mount Pleasant Industrial Park, Southampton SO2 OSP. Tel. (0703) 227636.

Epson (UK) Ltd., Dorland House, 388 High Road, Wembley, Middx. HA9 6UH.

J. Vincent Technical Books, 24 River Gardens, Purley, Reading RG8 8BX. Tel. (0734) 414468.

William Heinemann Ltd., 10 Upper Grosvenor Street, London W1X 9PA.

TK Electronics, 11 Boston Road, London W7 2SJ.

Technomatic Ltd., 17 Burnley Road, London NW10 1ED.

Cirkit Distribution, Park Lane, Broxbourne, Herts EN10 7NQ.

Magenta Electronics Ltd., 136 Hunter St., Burton-on-Trent, Staffs DE14 2ST.

New Epson drives

Epson (UK) are producing two new half height 5¼in floppy disk drives to industry standards to meet the increasing demand for IBM-compatible hardware.

The SD 621L is a 48 track, 500K drive with a 6ms track to track access time, a power consumption of a 4.3W while reading (1.1W in standby) and a simple level load/eject mechanism. The signal circuit uses one analog i.c. and one custom logic i.c., giving it 40 per cent fewer parts and a p.c.b. size only half that of its predecessor.

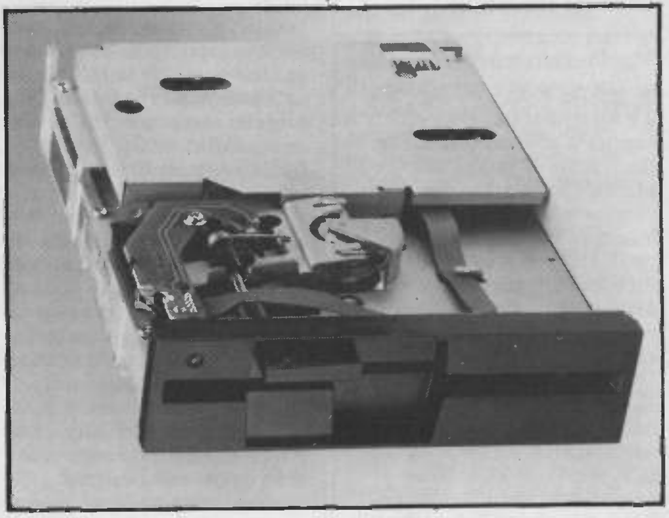
The SD 680L is a switchable 1MB/1.6MB drive with dual rotation speeds of 300 and 360 r.p.m. The drive has three modes of operation a) 1MB 300 r.p.m. 250KB/s data transfer rate b) 1MB 360 r.p.m. 300KB/s d.t.r and c) 1.6MB 360 r.p.m. 500KB/s d.t.r. Modes b and c are directly compatible which IBM PC/AT standards. Power consumption is 5.1W typical, and access time 3ms.

Radio Report

The Department of Trade and Industry has published a report from the Radio Regulatory Division, the DTI's radio frequency allocation and enforcement section. This first report coincides with the division's change of name to Radiocommunications Division, to encompass its present and future functions in promoting and regulating the use of the radio spectrum in the UK.

The division is effectively the only dispenser of radio bands in the UK, and the report, produced in response to a recommendation in the Merriman Report (Independent Review of the Radio Spectrum 30-960MHz, July 1983), is to familiarise present and future spectrum users with the RRD. It covers the division's activities in 1985/6, and includes future plans for the radio spectrum and background material on the international radio spectrum administrative framework.

Copies of the report are available free of charge from the Radiocommunications Division.



Ice warning

Electronic & Computer Workshop have introduced a new, inexpensive and reliable in-car ice-detection system as a kit.

The complete kit comprises simple electronics, a red l.e.d. and a front-of-car sensor to measure air temperature. The sensor is fitted in a metal housing with a mounting stud for easy fixing. All components and instructions are included in the mail order price of £12.88, with an assembled, ready-to-fit version for a modest extra charge.

The device's power requirement is from 10 to 15Vd.c.

Half height drives

Verospeed has now included three new half-height, double sided 5¼in disk drives by Mitsubishi. The new drives have gimbal head supports and high precision stepping motors in a compact chassis format.

The three models give a choice of 40, 80 and 40/80 tracks, with unformatted capacities of 500K, 1Mb or 1.6Mb. The 40/80 model can be switched in software as well as hardware.

Verospeed believe that the new models compare favourably in specification and reliability with much more expensive units.

WHAT'S TO COME

COUNTDOWN

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

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

The Which Computer Show, February 17th-20th, National Exhibition Centre, Birmingham, 01-240 1871.

Power UK – Enclosures '87, February 24th-26th, Kensington Rainbow Exhibition Centre, London, W.8, 0428-724 660.

Dexpo Europe, Olympia 2, London, March 3rd-5th, 01-486 1951

Southcon '87, March 24th-26th, Atlanta, Georgia, USA, 0101-212-421-6816.

Cadcam '87, March 24th-26th, Metropole Hotel, National Exhibition Centre, Birmingham, 01-608 1161.

Electronic Printing and Publishing, March 24th-27th, Olympia, London, 01-647 1001.

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

The Electronic Data Interchange Conference, April 28th-29th, The Barbican Centre, London, 01-868 4466.

British Electronics Week '87, April 28th-30th, (incorporating All Electronics/ECIF show, Automatic Test Equipment, Circuit Technology, Electronics Product Design, Fibre Optics and Satellite Communications), Olympia, London, 0799-26699.

EDS '87, May 13th-15th, Las Vegas, Nevada, USA, tel: 0101-312-648-1440.

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

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

Pen friend

Pen-Friend2 is a word processing utility ROM designed to accompany Wordwise Plus on the BBC Microcomputer. Its main function is to allow Wordwise Plus to be driven from drop down menus, circumventing the main packages's complicated command set.

The printer code menu inserts the necessary embedded codes into a text for underline, double-strike (bold), etc. To cope with different printers, the program has predefined sets for Epson dot-matrix printers and Brother daisywheels, but a further option allows a new set to be loaded from disk.

The status menu displays all details relating to the current cursor position, for instance, line and page, justification on or off, line length and margins, etc., from within the text, although Wordwise does not itself display the page layout. Variable parameters can be altered from this menu, and the appropriate commands automatically embedded in the text. A format page menu is also available to make pagination simpler prior to printing.

The address finder will locate any one or several addresses from a data file and insert them into the text area.

The function keys can be programmed from within Pen-Friend2 using a set of standard definitions provided.

Auto-load and auto-file display the directory and load with single keystrokes, checks new file names for duplication and saves the file with an optional backup copy to a second disk. A file saved double checks that the operation has been carried out.

Multi column format, label printing up to three columns, and first-line of segment display are available from menus. The package, which includes the program and a 30-page user manual, costs £18.95 all inclusive. The ROM is fitted in the same way as the Wordwise Plus ROM.

D.M.M.

A 4 digit Hung Chang hand-held d.m.m., the HC4510, has been added to Levell Electronics' roster of test equipment. The meter has d.c. ranges from 200mV to 1000V and 2mA to 10A with a basic d.c. volt accuracy of 0.05 per cent. The a.c. ranges are from 200mV to 750V and 2mA to 10A with a response from 45Hz to 1kHz. Resistance ranges are from 200ohms to 20ohms. Continuity test (with buzzer) and diode forward voltage drop are included, as well as a data hold switch to freeze the display. The HC4510 costs £69 including inland delivery but excluding V.A.T.

Bench p.s.u.s

Electronic Brokers has introduced the Thurlby PL series of lab bench power supplies capable of constant current or constant voltage operation, with simultaneous digital metering of voltage and current.

The PL series machines use digital readouts with a 3.75 digital scale length to give 0.1 per cent accuracy and a resolution of 0.01V and 0.001A. The wide angle 12.5mm l.e.d. display is designed to be free from parallax problems or scale interpretation error. A pair of digital meters displaying voltage and current eliminate the need for meter function and range switches. There is a damping switch to facilitate measurements of fast-varying load currents.

Coarse and fine voltage controls with a voltmeter resolution of 10mV allow settings to an accuracy of better than 0.05 per cent. A semi-logarithmic conductive plastic potentiometer allows the current level to be set down to the meter resolution level of 1mA.

A d.c. output switch allows voltage and current limits to be set before a load is connected protecting vulnerable circuitry from accidental overload. Integrated band-gap reference diodes stabilise voltage and current to a line stability of better than 0.01 per cent of the maximum output for a 10 per cent line change. A remote sense facility maintains current precision in the vent of output lead voltage drops due to lead resistance.

PL series p.s.u.s are designed to comply with IEC 348 Class 1 with an operating temperature range of 0 to 40 degrees centigrade.

CHIP COUNT

Over the last month we have received details of the following new components:

From Mullard, the PFC8582 2K-bit CMOS EEPROM with i.c. interface and two new ultra-high frequency power amplifier modules, the BGY96. The power amplifiers are designed specifically for use in the European and American cellular radio industry.

From Intel, military versions of its 80386 32-bit microprocessor (M80386) and military versions of various logic and memory devices.

The world's fastest 32-bit microprocessor from Inmos, the IMS T800, is now available. The 20MHz version is capable of 1.5MFLOPS (millions of floating point operations per second). An amazing 2.25 MFLOPS version is planned for later this year.

THE LEADING EDGE

BY BARRY FOX

Digital processing i.c.s have been developed which promise much greater flexibility in the use of TVs and video, but the benefits are being slow to reach the consumer.

ITT is now selling a TV set called Multicontrol. It lets the viewer watch two channels at once. One is a miniature 'picture-in-picture', set into the top right hand corner of the screen. The inset p.i.p. can be a second TV channel, or a surveillance picture from a video camera. In this way TV viewers watching one programme can keep an eye open for the start of a second programme on another channel, watch a baby asleep in another room, or see who has come to the front door. The inset image can be frozen as a still picture in a surprisingly small digital memory. Although the technology is clever, and points a way to the future, ITT cannot expect to sell many of the new 'Multicontrol' sets. The inset picture quality is poor, the still frame even worse and the system costs around £300 more than conventional sets.

ITT HAS SPENT £20 DEVELOPING A TV SET WHICH PROCESSES THE SOUND AND VISION SIGNALS IN DIGITAL CODE ...

ITT has spent £20 million over ten years developing a TV set which processes the sound and vision signals in digital code, rather than analogue waveform. This appeals to ITT as a manufacturer because seven chips do the job of 300 bulky analogue components. But slow sales of digital sets over the last two years have proved that the public does not care whether a TV set is working with analogue or digital signals, unless there is a perceived advantage. Multicontrol's picture-in-picture with freeze frame is the first perceptible advantage of digital processing.

The inset picture is one sixteenth the size of the main picture. It is built up from just 64 picture lines, around one tenth the number used for a conventional TV picture, so definition is relatively coarse. More resolution is lost when the inset picture is frozen in the digital memory. ITT's publicity photograph is a simulated picture, not a photograph from a TV screen. It makes the inset p.i.p. look far clearer than it really is.

Multicontrol contains only 12 kilobytes, or 98,304 bits, of computer RAM. This is surprisingly little for storing a TV picture, just one quarter of the memory in a budget computer like the Sinclair Spectrum. The TV set breaks up each line of the inset p.i.p. into 79 picture points and measures the red, green and blue picture content at each point. The 15,000 measurements are then described in 6 bit digital words, making a total of around 90,000 bits to be frozen. These fit easily into the 12 kilobyte memory.

This memory can also be used to store eight teletext pages. This lets a viewer call up a series of teletext pages with one command, and then switch immediately between them. This avoids the irritating delays normally caused by the slow rate at which a selected page is received off-air by a teletext TV set.

Frankly the p.i.p. and teletext page store features are unlikely to set the world on fire – just as the promise that the electrons in an ITT set are running round as digital pulses rather than analogue waves has predictably left the great British public completely unmoved. Equally predictably, the customer isn't the slightest bit interested in the fact that digitising TV sets makes life easier for the manufacturers and service engineer. There has to be something more than this . . .

And there will be.

ITT's German subsidiary Intremetall, in Freiburg, West Germany, has been modifying the TV chips for use in a video recorder.

Two chips replace several large circuit boards. This means the recorder can be made very small. More important, the chips process NTSC video signals (as used in Japan and America) in exactly the same way as SECAM (as used in France and the Eastern bloc) or PAL (as used in Britain and Western Europe). So one video recorder can handle tapes of NTSC, PAL or SECAM format. Although multi-standard video recorders already exist, they are expensive and need to be connected to a television set of TV standard which matches the tape. The ITT chips convert the signals before they leave the video recorder.

PEOPLE WILL BE ABLE TO EXCHANGE 'VIDEO LETTERS' ...

ITT engineers said over a year ago that their chips will make "the multinorm VTR a standard" and the VTR user will have "access to an increased variety of prerecorded cassettes".

People with friends and relations abroad will be able to exchange 'video letters'. But a multistandard video recorder also undermines copyright deals, whereby feature films are often released on home video in the USA long before Europe. It also makes life much easier for the pirates. Perhaps this is why the commercial wing of ITT still hasn't set a launch date for a VHS recorder made with the multinorm chips. Or perhaps the company has hit snags in chip production. Only time will tell, because if ITT doesn't do it, the Japanese will.

I spoke recently to a European TV set manufacturer which makes TV sets for a wide range of different countries. They were complaining about the production problems caused by different standards in different countries.

"Why don't you go digital, use the ITT chip set and make one set for all countries?", I asked.

"Believe us, we would" they said. "But we can't get the chips from ITT. They offer them, but they don't deliver."

PE SCIENCE AND TECHNOLOGY

VOLUME 24 No. 3
MARCH 1987
ISSN 0032 – 6372

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MY BIT AT THE BEGINNING – 8

Welcome to another issue of PE, especially if you're a new reader – and there's a fair chance that you are. I'm pleased to say that for various reasons we are increasing our UK monthly sales. Although I would like to say that it is due exclusively to the excellent variety and quality of our editorial, I know there is more to it than that. There is much evidence to suggest that the electronics hobby in general is once again beginning to enjoy the popularity it deserves. We haven't been too keen to publicise the fact, but for many years now our hobby has been in decline. Time taken with personal computers has, I feel, to a large degree been responsible for our misfortune but people are now either spending less time with computers or are realising that computers and electronics are complementary.

Many micro owners have, deliberately or otherwise, found that through their experience and knowledge of computers and software they have become familiar with basic electronics, in particular digital electronics. Much interest has been shown in developing interface and software based projects which has naturally led to a general interest in electronics and technology.

At the same time there has been additional emphasis placed upon technology (especially electronics and computing) subjects in schools. As I pointed out last month, new O and A level syllabusses recently introduced have generated a lot of interest in the practical side of electronics. This new found interest in electronics has begun to have some positive effects within the industry. Many well known electronics companies, especially those who deal with hobbyists and mail-order, are now reporting an up-turn in trading. According to the Greenwelds manager, the response to the catalogue, which was free with our December issue, has been extremely promising. A representative from Magenta reports that trade is generally good with sales of kits based upon PE projects getting better all the time. However, Mr. Jessa of Watford Electronics tells us that he is getting out of the electronic components business altogether and intends to concentrate purely on computer related equipment. Far be it from me to tell him how to run his business, but it does seem to be a case of closing the stable door when the horse is on its way back!

LCD COMPETITION

I would like to thank all readers who entered our l.c.d. competition which featured in our November 1986 issue of PE. All entries were of an exceptionally high standard – it's a shame there can only be one winner. A Citeven pocket TV is on the way to A. Auden of Hounslow for his ideas to use an l.c.d.s, not as displays, but for various electronic window applications.

EDITOR

OUR APRIL 1987 ISSUE WILL BE ON SALE FRIDAY, MARCH 6th 1987

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20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
FEMALE:				
St Pin	100	140	210	380
Ang pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
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2 × 43-way	395p	—
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2 × 32 way Ang Pin	275p	320p
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3 × 32 way Ang Pin	375p	400p
IDC Skt A + B		400p
IDC Skt A + C		400p

For 2 × 32 way please specify spacing (A + B, A + C).

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8 pin Video Connector 200p

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40 pin	200p	225p

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FOUR CHANNEL ENHANCER

BY THE PROF

Four-way sound is still around

There are several ways of designing a four-channel audio system so that stereo material gives an effective "sound around" effect.

I SUPPOSE it must be more than ten years ago now that quadraphonic hi-fi systems first became available, and not very much less than that since all the various systems became obsolete. Although it might seem that people who purchased quadraphonic hi-fi equipment were left high and dry when the systems all failed and were dropped by their respective manufacturers, things were not quite that bad. Apart from the fact that the four channel equipment was all usable as standard stereo equipment (albeit rather expensive stereo equipment for its specifications), most of it could be used to give a pseudo quadraphonic effect from an ordinary stereo source. Indeed, with some systems there seemed to be little subjective difference between the correct 4 channel encoded source material and many stereo sources. Thus, although quadraphonic equipment is officially dead and buried, there are still many hi-fi enthusiasts who use 4 channel equipment, with proper 4 channel sources where possible and with stereo sources to provide quadraphonic simulation the rest of the time.

The generally accepted reason for the demise of 4 channel systems was the lack of standardisation with three main systems being launched, and various other systems following on. To make matters worse there was no obvious front runner which looked a safe bet for anyone wishing to invest in a 4 channel system. Another deterrent to would-be purchasers was the problem of housing four loudspeakers plus the hi-fi units themselves. Fitting a stereo unit into the average lounge can be difficult, and with a 4 channel system things are that much worse. Certainly a lack of performance was not the cause of the failure, and even the most simple of pseudo 4 channel systems, given suitable stereo source material, can provide an effect which leaves ordinary stereo rather flat and lifeless. It would probably be an exaggeration to say that a pseudo 4 channel system (or even most genuine 4 channel systems) give a true 'just like you were really there' effect, but they are generally much closer to this than two channel stereo.

PASSING PHASE

Most of the obsolete 4 channel systems operated using a system of phasing to encode the four channels into two and then decode them back into four again. Systems of this type are less than perfect in that they only provide limited channel separation between certain channels, but they can still provide quite a good surround sound effect. They are based on the 'Hafler' method of 4 channel synthesis, and this uses the arrangement shown in Fig. 1.

This system is extremely simple, and requires nothing more than the addition of an extra pair of loudspeakers. The front pair of loudspeakers are connected to the amplifier in the normal way, but the rear speakers are wired in series across the non-earthy outputs of the amplifier with no connection to the earth output terminals at all. It should be pointed out that this arrangement will only work with amplifiers that have one output of each channel connected to earth (which the vast majority do). The normal 4 channel speaker arrangement is to have one loudspeaker in each corner of the room with the listener somewhere near the centre of the room, but there are other possibilities, and some people prefer a listening position well back, virtually between the rear speakers. The system will in fact operate with just one rear loudspeaker positioned behind the listener, but the effect is generally more satisfactory using the arrangement of Fig. 1.

On the face of it this system is not likely to give very good results, with little signal being fed to the rear speakers. The power fed to the rear speakers is indeed less than that fed to the front pair, since signals at the centre of the sound stage are produced by in-phase signals in the stereo channels. In-phase signals will produce little or no voltage difference across the non-earthy output terminals (depending on their relative amplitudes), causing the centre of the sound stage to be reproduced at greatly reduced volume. The sides of the sound stage are produced by signals in only the appropriate channel, and these will provide a strong voltage difference across the rear speakers. They are still reproduced at reduced power though, since the series impedance of the two loudspeakers is obviously double that of a single loudspeaker, giving only half the current flow and output power. What makes the system effective is the fact that some sounds are picked up by the microphones after being reflected off walls, or by microphones intended for other sounds. The point about these signals that are produced by accident rather than design is that they appear in only one channel or randomly phased in both channels. Some of them will therefore appear in both channels and out of phase. This effectively adds together the signal voltage in each channel so that a relatively strong output is produced across the rear speakers.

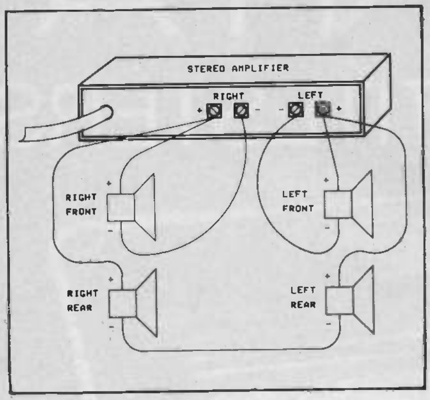


Fig.1. *The most basic 4 channel set-up*

The signal from the rear speakers is therefore a weaker version of the signal from the front speakers, but with severely attenuated 'middle' and increased ambience. There is zero channel separation from the rear speakers, but they are connected in antiphase which tends to spread the rear image out across the rear of the room rather than focussing it mid-way between the two loudspeakers. It is the increased ambience on the rear channel signals that gives the more spacious 'large hall' type sound, and the relative weakness of the rear signals is no great disadvantage as the signals reflected from the rear of a hall are much weaker than the direct sounds.

There are various improved versions of the system, such as the one shown in Fig. 2. Here a low value (and high power) variable resistance has been added from the junction of the rear speakers to an earth terminal on the amplifier. With the variable resistor set at maximum value there is very little current flow through it, and for practical purposes the system operates as a standard 'Hafler' style 4 channel system. With the variable resistance set at zero resistance the signals fed to the rear speakers are identical to the signals fed to the front speakers. Between these two extremes a compromise can be obtained with increased ambience but some degree of rear channel separation.

Both the systems described so far place additional loading on the amplifier, especially this second system, and are only to be recommended where an amplifier is normally used well within its maximum power rating. A safer way of doing things is to generate the rear signals using a differential amplifier and an inverter, and in conjunction with a second stereo amplifier this also the advantage of enabling the volume from the rear channels to be controlled.

ENHANCED SYSTEM

Synthesised 4 channel systems provide a lot of scope for the electronics experimenter, and it is a subject which I would recommend anyone interested in hi-fi to at least give a quick try out. The rear speakers do not need to be of equal quality to the front pair in order to give good results, and when upgrading the speakers or amplifier of a system it could be well worthwhile hanging on to the old equipment and using it for 4 channel experiments. It has to be emphasized that the effectiveness of a pseudo 4 channel system is largely dependent on how well (or otherwise) the programme source co-operates with the 4 channel synthesis process. Some programme material is much more effective than other material, and it is generally something like large scale orchestral works that give the best results. However, good results can be obtained with many types of stereo source material, including purely electronically generated music where artificial reverberation and similar techniques often help to give a good effect. The synthesised seagulls in Jean Michel Jarre's 'Oxygene' for example, can be very effective in pseudo 4 channel reproduction.

There are various possible ways of attempting to produce an enhanced quasi 4 channel effect, but these are mostly methods of producing artificial reverberation for use as the rear channel signals, or to be added to 'Hafler' style rear channels. A system which is reasonably simple but which can be quite effective, is to generate standard 'Hafler' rear channel signals, but to then delay these signals rather than feeding them direct to the rear channel amplifier. This is much the same as moving the rear speakers back, with the effective retreat of the loudspeakers depending on the delay used. Sound travels at roughly 1 metre every 3 milliseconds, and a delay of around 30 milliseconds would therefore be sufficient to give an effective shift of 10 metres. A delay of this order is not too difficult to obtain using a CCD (charge coupled device) delay line. The point of this system is that it overcomes the main problem of the basic system in that there is very little front to rear separation. Although the ambience signals are present and relatively strong on the rear channels, the straightforward front channel signals are also there and at quite a high level. The delaying of the rear signal does not greatly affect the ambience signals, but it turns the normal stereo signals at the rear into a sort of short echo signal, simulating the signals that are reflected to the listener after a single bounce off a wall or the ceiling of the concert hall.

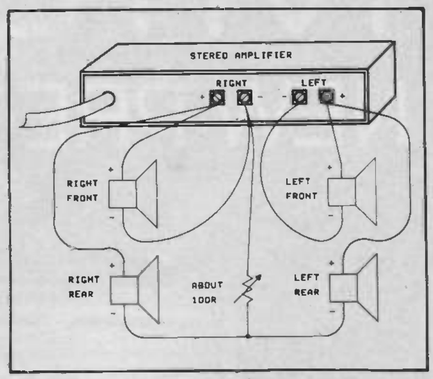


Fig.2. *An improved 4 channel arrangement*

The block diagram of Fig. 3 shows the general set-up required for an enhanced 4 channel system of this type. At the input there is a two input mixer with one input fed direct with the right hand channel signal and the other fed from the left hand channel via an inverter.

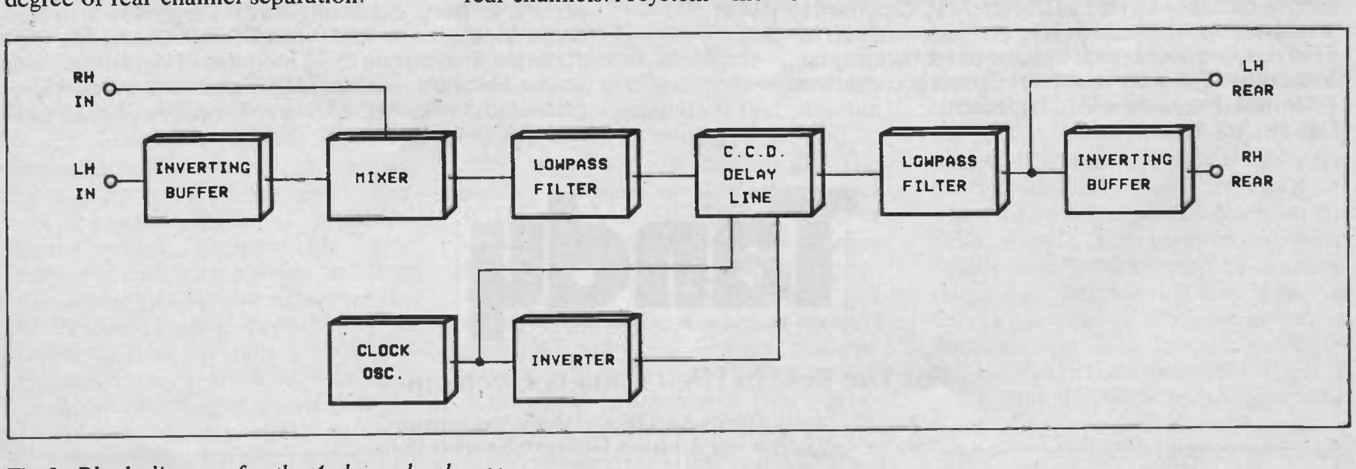


Fig.3. *Block diagram for the 4 channel enhancer*

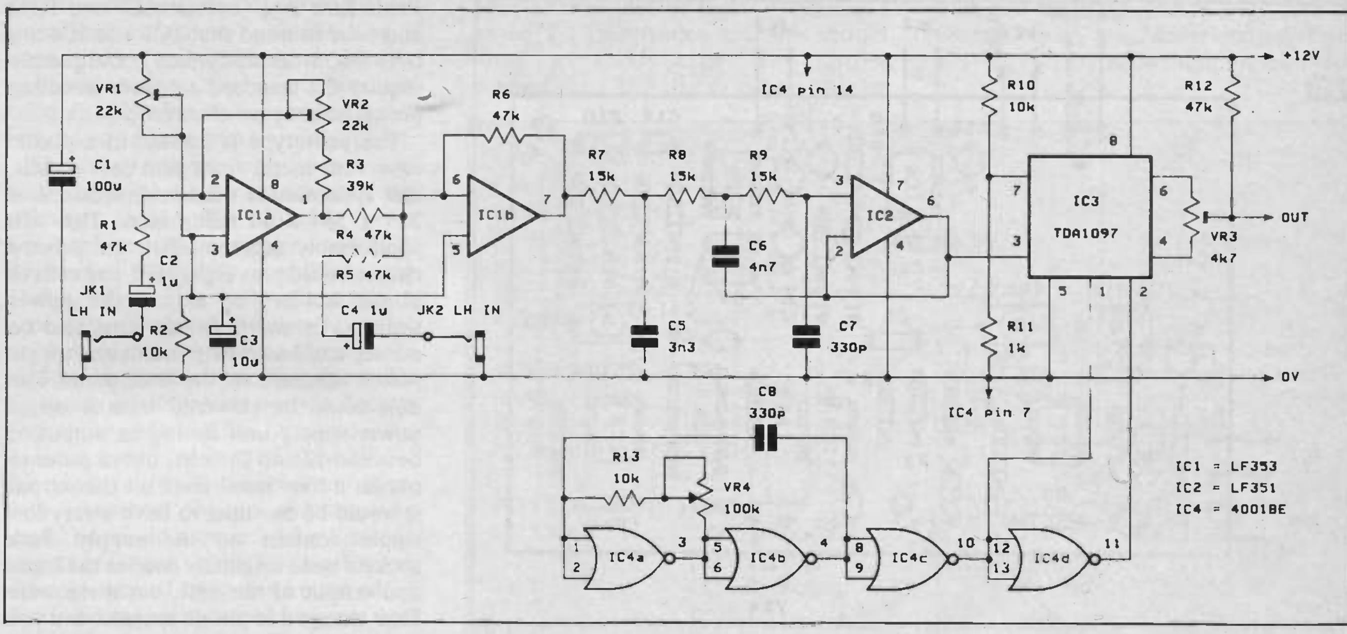


Fig.4. *The main circuit diagram for the 4 channel enhancer*

These form a differential amplifier which phases out the in-phase input signals and generates the basic pseudo 4 channel rear signal.

Of the remaining stages all but one are concerned with the delay line. At the centre of things is the CCD delay line chip itself, and this is a standard 'bucket brigade' type which uses a series of electronic switches to pass input samples along a chain of charge storage capacitors and eventually to the output. Operation of CCD delay lines is something that has been covered on more than one previous occasion in this magazine, and it is not something that we will consider in great detail here.

The delay time is governed by the number of stages in the delay line chip, and the rate at which the input samples are passed down the chain of capacitors (the latter being controlled by an external clock oscillator). The delay time is equal to the number of stages in the delay line divided by double the clock frequency. CCD delay lines require a two-phase clock signal, and do not normally seem to have any built-in circuitry to generate the second phase. An external inverter is therefore needed for this purpose.

The maximum input frequency to the delay line must be no more than half the clock frequency, and should preferably be less than one third of the clock frequency. This is necessary in order to avoid a severe form of distortion called aliasing distortion. It is also important to ensure that no high frequency signals (due to stray pick up of radio signals for example) enter the delay line as they could react with the clock signal or its harmonics to produce heterodyne tones. A lowpass filter is therefore used ahead of the delay line chip.

Another lowpass filter is used at the output of the delay line. This is needed due to the stepped nature of the output signal which switches straight from one sample voltage to the next. The output lowpass filter smoothes out the steps and also helps to keep any breakthrough of the clock signal to an insignificant level. The output filter is followed by an inverter which produces the out of phase signals for the second rear speaker.

PRACTICAL CIRCUIT

The main circuit diagram for a practical enhanced pseudo 4 channel unit appears in Fig. 4, with the circuit of output filter and inverter stages shown separately in Fig. 5.

Starting with the main circuit, IC1a is the unity gain inverting amplifier and IC1b operates as the mixer (which is a conventional summing mode type). VR2 enables the gain of the inverting amplifier to be trimmed to optimise the attenuation of in-phase equal amplitude signals. VR1 merely sets the quiescent bias level, and as the circuit is largely d.c. coupled it sets the bias level for several stages of the unit including the delay line. It is adjusted to give optimum large signal handling capability from the circuit as a whole.

The input lowpass filter is a three pole (18dB per octave) type based on IC2 and having a cutoff frequency at approximately 7.5kHz. This gives a bandwidth which encompasses considerably less than the full 20kHz audio bandwidth, but this is acceptable

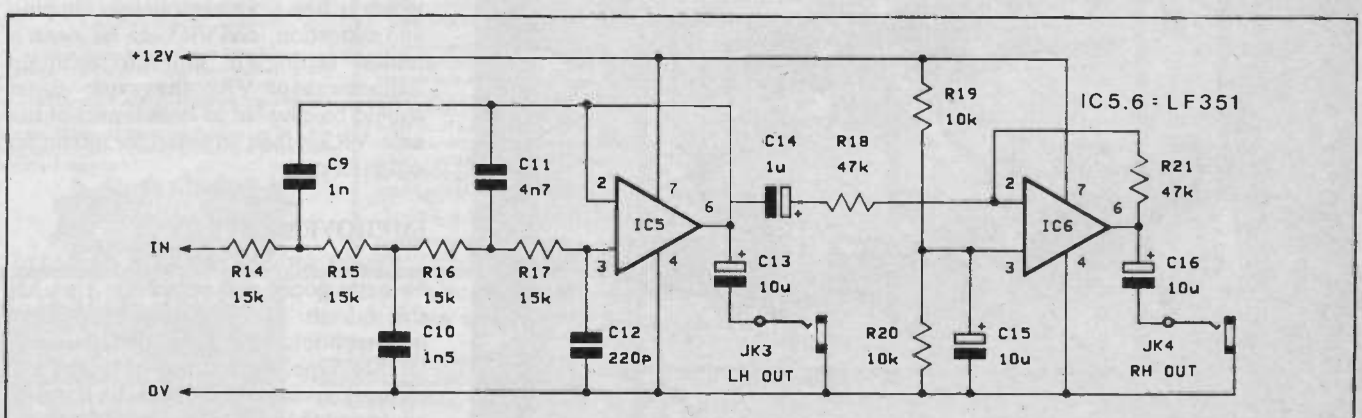


Fig.5. *The output filter and inverter circuits*

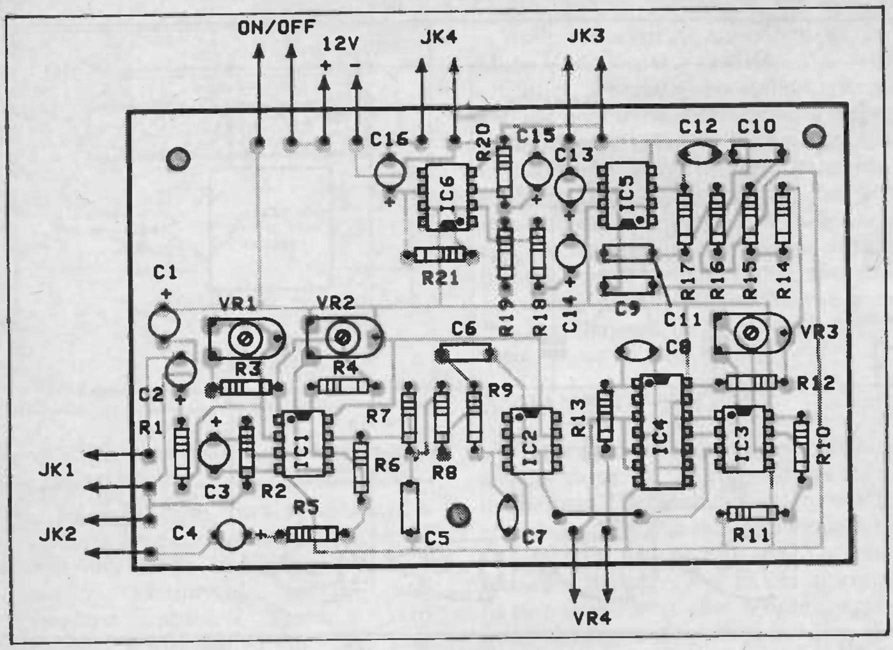


Fig.6. *Details of the printed circuit board*

in the present application. The high frequency sounds in a concert hall tend to be absorbed more than the lower frequencies during the reverberation process, and a reduction in the high frequency content on the rear channels is something that could be usefully introduced anyway.

In this case the main reason for setting the cutoff frequency quite low is to permit a fairly low clock frequency to be used. The clock oscillator is a standard CMOS astable circuit with a spare gate of IC4 being used as an inverter to generate the second clock phase. VR4 enables the clock frequency to be varied from around 16kHz at maximum resistance to over 100kHz at minimum resistance. IC3 is the delay line chip, and this is a TDA1097 1536 stage type. This gives a delay time which can be varied by VR4 from a maximum of about 48ms down to a minimum of about 6ms. The output from IC3 is taken from the final two stages with VR3 acting as a simple passive mixer to combine these two output signals. VR3 can be adjusted to balance out and minimise any clock glitches at the output.

Turning to Fig. 5 now: the output filter is a four pole (24dB per octave type having IC5 as the buffer stage and a cutoff frequency of approximately 7.5kHz. IC6 is the unity voltage gain inverting amplifier which generates the antiphase signal for the second rear speaker. In fact this stage is not strictly necessary, and if preferred the output from JK3 can be used for both rear channels with one of the rear speakers then being connected with reversed phasing.

CONSTRUCTION

As results with the circuit were suitably encouraging a printed circuit design for those who would like to try out the unit is provided in Fig. 6. Construction of the board is pretty straightforward, but do not overlook the single link wire (between C7 and R11) and bear in mind that IC3 and IC4 are both MOS devices which consequently require the standard antistatic handling precautions to be observed.

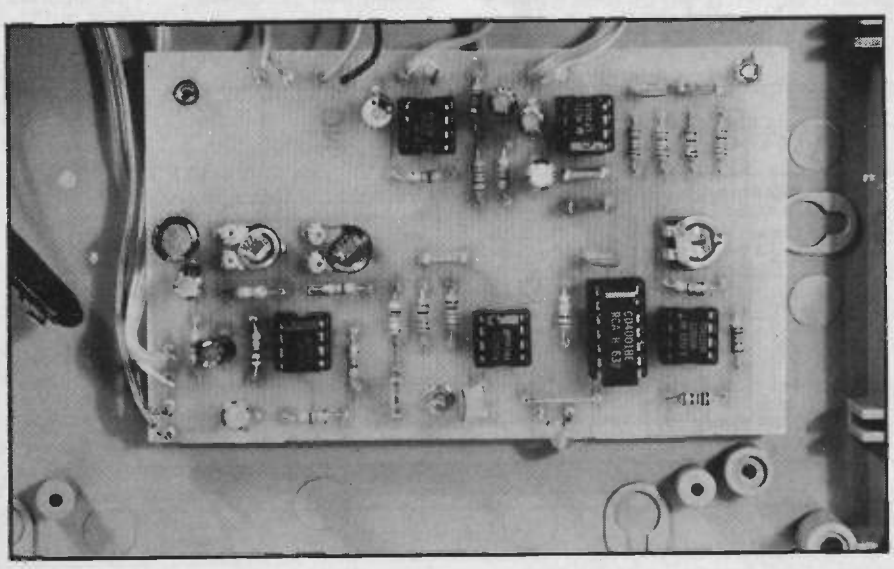
The prototype is housed in a plastic case with metal front and rear panels, and approximate outside dimensions of 205 x 140 x 40 millimetres. This will comfortably accommodate the printed circuit board plus eight HP7 size cells in plastic holders to act as the power source. An on/off switch must also be added, and I used a sub-miniature toggle switch mounted on the front panel. The unit could be powered from a mains power supply unit having an output of between 12 and 15 volts, but in order to obtain a low 'hum' level on the output it would be essential to have a very low ripple content on the supply. Jack sockets were originally used at the input and output of the unit, but these were later changed to phono sockets, and you should obviously use whatever type of socket will best suit your particular hi-fi set up. It might be helpful to add a pair of sockets in parallel with the input sockets, to act as front channel output sockets. This depends on the exact manner in which the unit is to be fitted into the hi-fi system. The circuit can accommodate a maximum input level of about 1.5 volts RMS, and in order to obtain a good signal to noise ratio it must be used with a signal level that is something approaching this figure. Most tape decks, compact disc players, preamplifiers, etc. provide a suitable output level, but the unit cannot be used successfully by feeding it direct from a low level source such as a magnetic cartridge.

ADJUSTMENT

If an audio signal generator and an oscilloscope are available, VR1 is adjusted to produce symmetrical clipping with an input level of around 1.5 to 2 volts RMS. VR3 is adjusted to minimise the clock breakthrough at the output. In the absence of suitable test equipment VR1 can simply be given any setting that gives an audio output signal which is free from any obvious clipping and distortion, and VR3 can be given a middle setting. In order to facilitate adjustment of VR2 the same signal should be coupled to both inputs of the unit. VR2 is then adjusted for minimum output signal.

IMPROVEMENTS

Results with the prototype seemed to be quite good, and personally I prefer this form of enhanced pseudo quadraphonic effect to the standard 'Hafler' type. A good way of testing a 4 channel system is to listen to it for a while and then cut off the rear channels. If it is working well this should cause the sound image to collapse around you



to an ordinary stereo type which will sound very unrealistic by comparison. It is an effect that is difficult to describe well, but once you have heard it you will know exactly what I mean, and may well be hooked on 4 channel systems for life.

The effect will probably sound at its best with VR4 set for maximum delay, although there will probably be a noticeable reduction in the noise level if it is backed-off slightly from this setting. The signal to noise ratio of the unit is generally quite good, but is not equal to the best of modern hi-fi equipment. An obvious improvement to the unit would be to use a compander noise reduction system around the delay line, and using a circuit based on an NE570 or NE571 this is not difficult to implement these days. Another obvious improvement would be to add a second delay line chip to permit longer delays to be achieved, although when I tried this I must admit that it did not seem to make a great deal of difference to the effect. The next stage of development would be to add more delay line chips to give what would effectively be a tapped delay line, and then with the appropriate feedback loops this could be used to give a complex reverberation effect. The RS data sheet for the TDA1097 (sheet No. 5516) includes a sound enhancer circuit built around four of these devices and an NE571 compander, and this should form a good basis for further experiment. The data sheet can be obtained from Electomail Ltd., free of charge, but a C4 size addressed envelope bearing two first class stamps is required.

PE

COMPONENTS . . .

RESISTORS

R1,R4,R5,R6, R12,R18,R21	47k (7 off)
R2,R10,R13, R19,R20	10k (5 off)
R3	39k
R7,R8,R9,R14, R15,R16,R17	15k (7 off)
R11	1k

All resistors 0.25W 5% carbon

POTENTIOMETERS

VR1,VR2	22k sub-min hor preset (2 off)
VR3	4k7 sub-min hor preset
VR4	100k lin

CAPACITORS

C1	100µ 16V radial elect
C2,C4,C14	1µ 63V radial elect (3 off)
C3,C13,C15,C16	10µ 25V radial elect (4 off)
C5	3n3 polyester layer
C6,C11	4n7 polyester layer
C7,C8	330p ceramic plate (2 off)
C9	1n polyester layer
C10	1n5 polyester layer
C12	220p ceramic plate

SEMICONDUCTORS

IC1	LF353
IC2,IC5,IC6	LF351 (3 off)
IC3	TDA1097
IC4	4001BE

MISCELLANEOUS

JK1,JK2,JK3,JK4 (see text); printed circuit board, PEXX; case about 205 x 140 x 40mm; power source (e.g. 8 x HP7 size cells in plastic holders); on/off switch; control knob; battery connectors; wire, etc.

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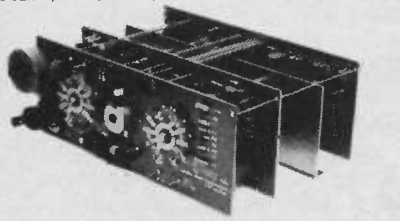

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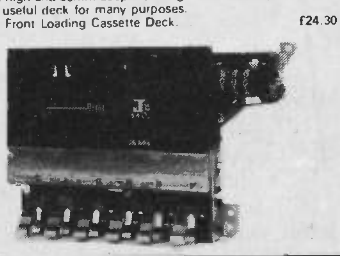

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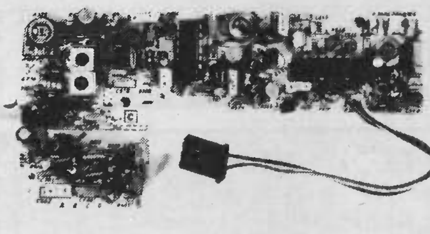

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CONSTRUCTIONAL PROJECT

ULTRASONIC TAPE MEASURE

BY R. A. PENFOLD

Keep your distance

An ultrasonic rangefinder with a longer reach than a tape measure – and you only have to hold one end of it!

THE subject of ultrasonic ranging was covered in a recent 'Experimental Electronics' article, and a digital distance measuring project based on ultrasonic echo techniques was promised therein. This article describes the resultant unit which has been developed from the circuits provided in the original article. The unit has a three digit l.e.d. display which shows the distance reading in centimetres. The maximum range attainable depends very much on the size of the target object, and on how well or otherwise it reflects ultrasonic soundwaves. With fairly small objects or things that are poor reflectors of sound a range of less than a metre might be the best that can be achieved, but with any fairly co-operative target object a range of more like 3 metres will be achievable. With something like a large flat wall that is free from any objects that would scatter the soundwaves a range of 4 or even 5 metres should be possible. Most tape measures are two or three metres long, and this unit is therefore generally usable as an alternative to one of these.

One point that has to be emphasized is that this device is not suitable for use where highly accurate results are needed. The resolution of 1 centimetre obviously limits the accuracy, and there are other factors which can adversely affect the accuracy of the unit. These are primarily factors which alter the speed at which sound travels, such as air pressure and humidity, although the effect of these is normally quite minor. I would consequently not recommend the unit for use in applications where it is important that measurements are accurate to within a few millimetres, but it is well suited to applications where quick and relatively low resolution measurements are needed. It is well suited to such purposes as measuring the sizes of rooms by (say) estate agents, or decorators when estimating the amount of paint required for the walls. I have found the unit to be extremely useful in photography for setting the correct flash to subject distance, and there must be many other measuring tasks which a unit like this could make very much easier and quicker than when using a conventional measure.

SYSTEM OPERATION

The block diagram of Fig. 1 shows the various stages used in the unit and the way in which they fit together. At the transmitter a 40kHz oscillator generates bursts of signal which are sent out at roughly half second intervals. The oscillator is controlled by a set/reset flip/flop, and this is 'set' by short pulses provided by a low frequency oscillator. The 40kHz oscillator then provides an output signal, but a divide by six circuit counts the number of output pulses and after the appropriate number has been sent it resets the flip/flop and gates the oscillator off again. The divider circuit also provides a 'set' pulse to a second flip/flop, and this one controls a simple gate circuit. When 'set', the flip/flop opens the gate and permits a clock signal to be fed through to the input of a three digit circuit.

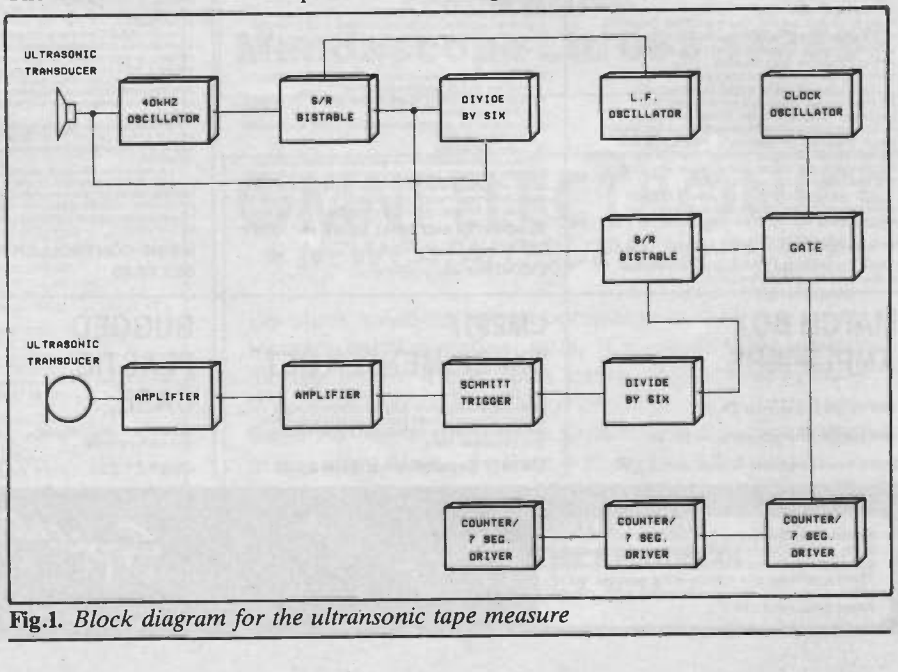


Fig.1. *Block diagram for the ultransonic tape measure*

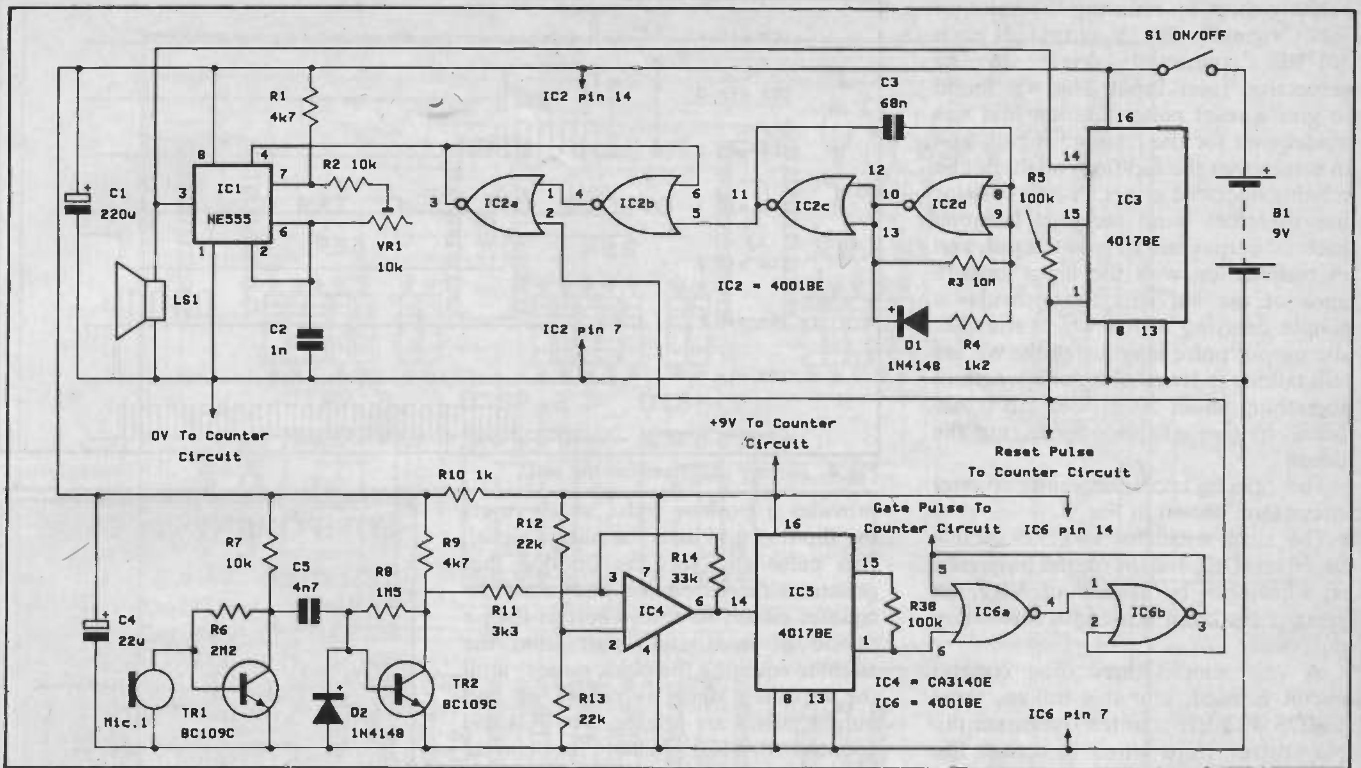


Fig.2. *The circuit diagram of the gate pulse generator*

At the receiver the reflected pulses are detected by a microphone and converted to small electrical pulses. These are considerably amplified by a two stage amplifier and then processed by a Schmitt trigger to remove noise and give a logic compatible output signal. The output pulses are fed to another divide by six circuit, and this resets the flip/flop when it has received a full set of pulses. The gate is then closed so that the clock signal is blocked, and the count on the display is then shown until the next measurement is taken when the whole cycle of events is repeated about half a second later. With sound travelling at roughly 33 centimetres per millisecond, on the face of it a clock frequency of 33kHz is needed in order to give readings in centimetres. In fact the clock frequency only needs to be about half this figure as the sound has to travel to the target object and then back to the unit again, giving a gate period of around 2 milliseconds at a range of 33 centimetres.

CIRCUIT OPERATION

The circuit diagram for the stages that generate the gate pulse signal appears in Fig. 2. This will not be described in detail as it is essentially the same as the circuit described in the 'Experimental Electronics' article. It does differ in a few respects, and one of these is a reduction in the operating frequency of the low frequency oscillator to about 2Hz by increasing the value of C3. The output pulse duration has been kept

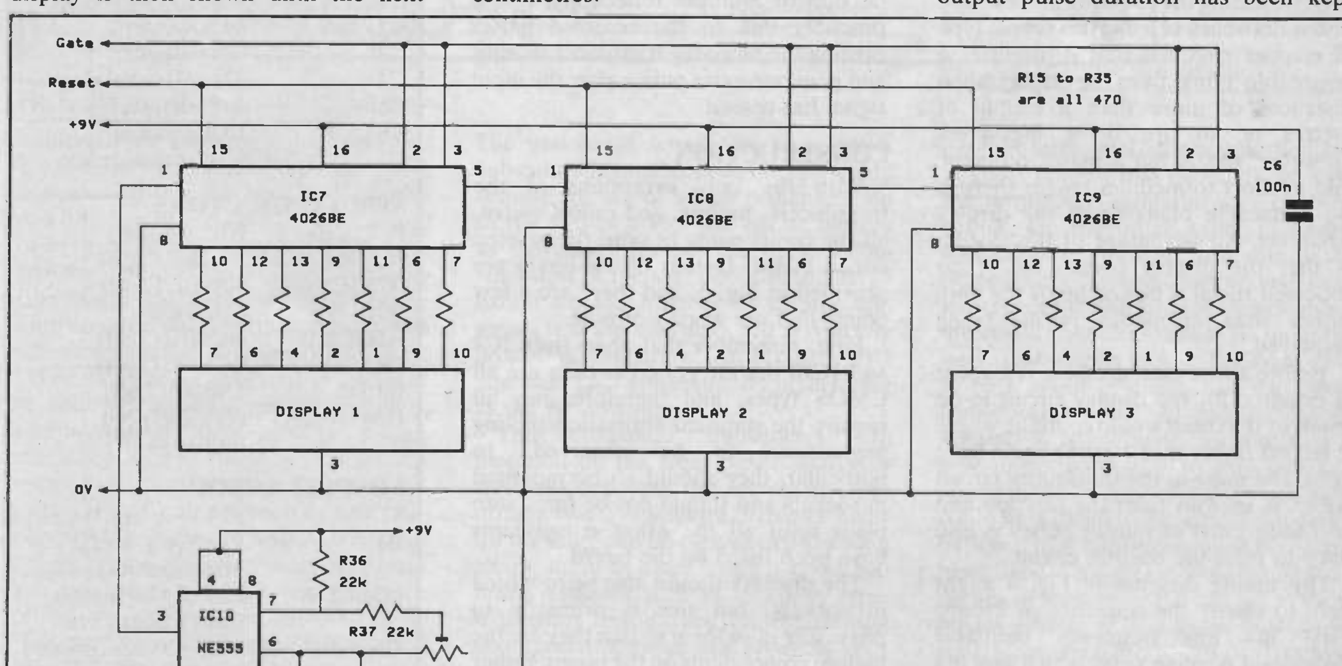


Fig.3. *The clock oscillator and counter circuits*

suitably short by reducing the value of R4. Originally the '5' output of each 4017BE connected direct to its respective 'reset' input. This was found to give a reset pulse duration that was inadequate for the counter circuit, and in some cases the flip/flops might not be reliably operated either. A 100k resistor has therefore been included between each '5' output and its 'reset' input, and in conjunction with the input capacitance of the 4017BEs this provides a simple delaying action which stretches the output pulse length slightly. We are still talking in terms of a pulse length of something under 500ns, but this is sufficient to give reliable operation of the circuit.

The clock oscillator and counter circuits are shown in Fig. 3.

The clock oscillator is a 555 astable based on IC10, and the output frequency is adjustable by means of VR2. In practice the latter is used for calibration purposes.

A very simple three digit counter circuit is used, and this utilizes three CMOS 4026BE counter/7 segment display driver chips wired in series. The displays are high efficiency common cathode l.e.d. types driven via current limiting resistors R15 to R35. The 4026BE has a built-in gate which can be used to control the clock signal by way of the 'clock inhibit' input at pin 2. The gate signal is therefore coupled to this, but note that it is not the Q output of the flip/flop that is used, as it is a low logic level that enables the clock signal to pass through to the counters. The 'display enable' input at pin 3 of each 4026BE is also driven by the gate pulse, and this has the effect of blanking the displays during the counting proces. One minor drawback of using this simple type of counter circuit is that it produces a noticeable 'blink' from the display when distances of more than a couple of metres or so are being measured. However, this is not a major problem, and at short to medium ranges there is no noticeable blanking of the display whatever. An advantage of this system is that the display blanks out if no reflected signal is picked up by the unit, rather than erroneous results being displayed.

Before a new measurement is made it is essential for the display circuit to be reset, or the count would continue where it left off rather than starting again from zero. The pulse in the transmitter circuit which is used to reset the flip/flop and end each burst of output pulses is also used to reset the counter circuit.

The timing diagram of Fig. 4 might help to clarify the sequence of events. First the low frequency oscillator provides a positive pulse which sets the output of the flip/flop high. This produces a series of output pulses from IC1, but only until IC3 has counted out the appropriate number, and it then

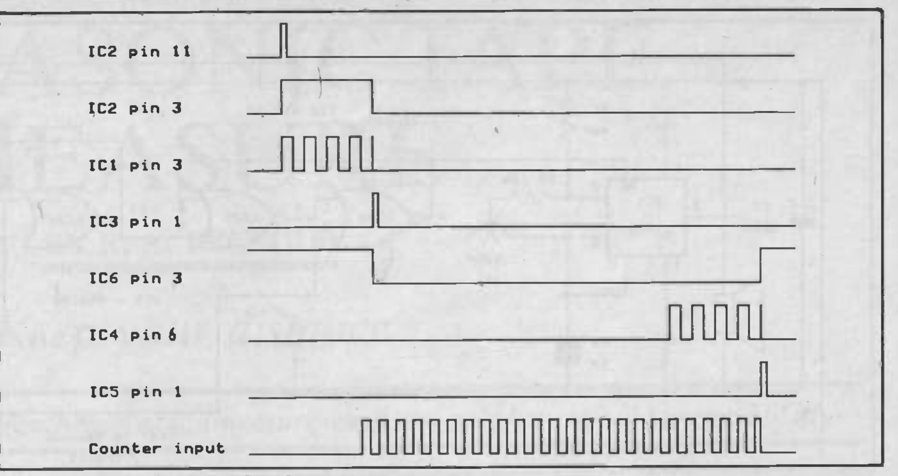


Fig.4. *Timing diagram for the unit*

provides a positive pulse which resets the flip/flop and halts the output signal. This pulse also sets the flip/flop that generates the gate pulse and resets the counter circuit to zero. There is then a period of inactivity (apart from the counter counting the clock pulses) until the reflected signal is picked up and output pulses are produced by IC4 and counted by IC5. When the correct number have been received IC5 generates a pulse which ends the gate period, the clock signal is cut off from the counter circuit, and the final count is displayed.

There is an apparent flaw in this system in that the pulse counter at the transmitter cuts off the last pulse at only a fraction of the normal pulse duration, and this gives one pulse too few to activate the pulse counter at the receiver. In practice there seems to be no problem here, and considerably more pulses are received than are transmitted. This could be due to multiple reflections, but is probably due to the received pulses causing the receiving transducer to 'ring' and generate extra pulses after the input signal has ceased.

CONSTRUCTION

With the only exceptions of the transducers, battery, and on/off switch, all the components fit onto the printed circuit board. Details of the board are provided in Fig. 5, and there are a few points that are worthy of note.

First, remember that apart from IC4 and IC10 the integrated circuits are all CMOS types, and therefore they all require the standard antistatic handling precautions to be observed. In particular, they should all be mounted in sockets and should not be fitted into place until all the other components have been fitted on the board.

The displays should also be mounted in sockets, but this is primarily to physically raise them so that they are the highest components on the board, rather than to protect them from damage. Suitable sockets would seem to be unavailable, but they can be improvised from ordinary 14 pin DIL integrated circuit

COMPONENTS . . .

RESISTORS

R1,R9	4k7 (2 off)
R2,R7	10k (2 off)
R3	10M
R4	1k2
R5,R38	100k (2 off)
R6	2M2
R8	1M5
R10	1k
R11	3k3
R12,R13,R36, R14	33k
R15–R35	470 (21 off)
R37	22k (4 off)

POTENTIOMETERS

VR1	10k sub-min hor preset
VR2	22k sub-min hor preset

CAPACITORS

C1	220u 10V radial elect
C2	1n polyester
C3	68n polyester
C4	22u 16V radial elect
C5	4n7 polyester
C6	100n ceramic
C7	470p ceramic plate

SEMICONDUCTORS

IC1,IC10	NE555 (2 off)
IC2,IC6	4001BE (2 off)
IC3,IC5	4017BE (2 off)
IC4	CA3140E
IC7,IC8,IC9	4026BE (3 off)
TR1,TR2	BC109C (2 off)
D1,D2	1N4148 (2 off)
Display 1,2,3	0.56" c.c. l.e.d. display (3 off)

MISCELLANEOUS

S1	SPST sub-min toggle
B1	9 volt (e.g. 6 x HP7 in plastic holder)
Mic.1/LS1	Pair of 40kHz ultrasonic transducers

Case about 170 x 145 x 35mm, printed circuit board, 8 pin DIL IC socket (3 off), 14 pin DIL IC socket (5 off), 16 pin DIL IC socket (5 off), battery connector, wire, solder, etc.

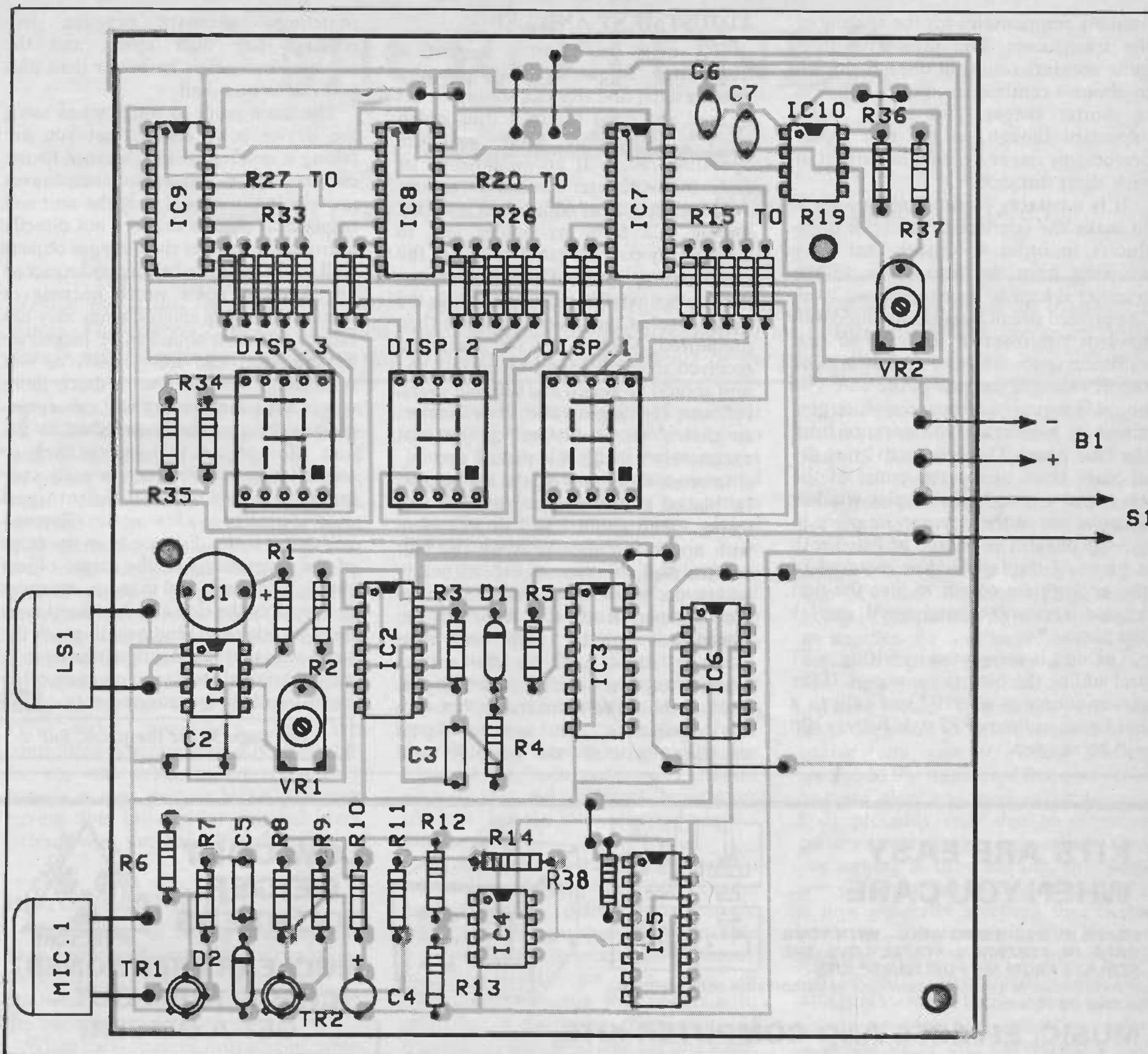


Fig.5. *Details of the printed circuit board*

holders. First cut each holder into two 7 way SIL holders, and then use pliers to remove the pins at both ends of each row. This leaves five pin SIL holders, and two of these can be soldered into position and used to hold each display (the board has been designed to take into account the fact that the holders will be somewhat over-length).

The displays are operated at a current of only a few milliamps per segment, and accordingly they must be a high efficiency type if they are to give a reasonably bright display. Standard 0.5 inch and 0.56 inch common cathode displays will fit the board layout, but some 0.5 inch types seem to offer relatively low efficiency, and 0.56 inch types are probably a safer option.

A case measuring about 170 x 145 x 35 millimetres acts as the housing for the prototype. This will comfortably accommodate the printed circuit board and a fairly high capacity 9 volt battery such as six HP7 size cells in a plastic holder. The unit could actually be built into a substantially smaller case, but this would require the use of a high power version of the PP3 or a PP3 size NiCad battery as the power source. The current consumption of the unit depends to a large extent on the number of display segments that are activated, but is typically around 80 milliamps. An ordinary PP3 size battery is consequently inadequate as the power source.

The ultrasonic transducers are mounted on the front panel, and with most modern types this merely involves drilling two 2 millimetre diameter holes for the terminals on each device and then gluing them in place using a good gap filling adhesive such as an epoxy type. With some transducers the transmitting and receiving types are identical, but with others there are specific transmitting and receiving transducers. The retailer's literature should make it clear whether or not the two units are the same, and if not, which is which.

In the interest of accuracy, particularly at short ranges, it is beneficial to have the transducers mounted very close together. On the other hand, to ensure that the direct pick up from one to the other is kept down to a low enough level to prevent the unit from malfunctioning, the two transducers should be mounted well apart. Direct pick up does not seem to be a major problem, and with most transducers about 40 millimetres of separation is adequate. However, it is probably a good idea to play safe and use somewhat greater separation as it could be difficult to increase the distance between the transducers once they have been fixed in place (I used about 70 millimetres of separation). Accuracy at short ranges suffers with a large amount of separation since the sound has to travel a few centimetres to get from one transducer to the other. However, the timing of the circuit is such that a few clock cycles are effectively lost at the beginning of each gate period, and this partially compensates for the spacing of the transducers. The prototype gives quite accurate results at distances down to about 4 centimetres, but is hopeless at shorter ranges. This is not really important though, as the unit would presumably never be used in earnest at such short distances.

It is advisable to use screened leads to make the connections to both transducers in order to ensure that stray coupling from the transmitter to the receiver is kept to an insignificant level. The printed circuit board is mounted well towards the front of the case so that sufficient space is left for the battery and on/off switch at the rear of the unit. The board is mounted on spacers which give about 20 millimetres of clearance from the base panel. This is done to bring the displays close to the top panel of the case, and a rectangular display window must be cut at the appropriate place in the top panel. This should be fitted with a piece of display window material of the appropriate colour to give the unit a neat appearance and good display contrast.

The unit is completed by wiring in S1 and adding the battery connector. If the power source is six HP7 size cells in a holder, an ordinary PP3 style battery clip will be needed.

ADJUSTMENT AND USE

VR1 must be adjusted to give a transmitter frequency that provides good results, and this can simply be set by trial and error to any setting which gives a reasonably good maximum operating range. If an oscilloscope or audio millivoltmeter is available, a more accurate method of adjustment is to first unplug IC2 from its holder and to temporarily connect pin 4 of IC1 to the positive supply rail. This turns on the transmitter continuously, and with the signal level at the collector of TR1 then monitored, VR1 is set for maximum received signal strength. Of course, the unit should be aimed at a suitable sound reflector at a range of about 1 or 2 metres so that a reasonably strong (but not excessively so) signal is picked up.

In order to set up VR2 the unit should be placed at the edge of a table and facing a wall about 1 to 2 metres away, with no obstructions between the unit and the wall, or even any objects nearly within the 'view' of the unit. Measure the distance from the front of the transducers to the wall, and then carefully adjust VR2 for the correct reading on the display. The display reading should be quite stable, but with any equipment that uses a digital counting process the display will sometimes alternate between two readings one digit apart, and the accuracy can never be better than plus and minus one digit.

The main point to watch when using the device is to ensure that you are taking a reading of the distance to the correct object. Ultrasonic soundwaves are highly directional, but the unit will respond to objects that are not directly in front of it, and at short ranges objects well out of the main beam may be picked up. Another point worth keeping in mind is that very small objects may not reflect sufficient sound to be picked up by the unit, and things such as soft furnishings tend to absorb much more sound than they reflect and can consequently be practically invisible to the unit. Most objects that you are likely to use as target objects, such as walls, cupboards, etc. will reflect sufficient signal even at a range of a few metres. Remember that it is the distance from the front of the transducers to the target object that is measured, and in many instances the depth of the case and the transducers must be added to readings, in much the same way that the depth of the case of a conventional steel tape measure often has to be added to measurements. PE

See page 32 for the p.c.b. foil

MICRO TUNER

BY JOHN M.H. BECKER

Computer controlled measurement for musical notes

Beside the usual frequency-measuring applications, a frequency counter can also be used as an instrument tuner. The Micro Tuner is designed with the accurate measurement of tones in the musical spectrum at the forefront, adapting its sampling rate to the precise requirements of the pitch to be measured.

THE Micro-Tuner has been designed as a very accurate computer controlled musical tuning aid and frequency counter. Monitoring is by a visual display that shows both the received and calculated ideal frequencies in relation to the nearest true note across nine octaves. As a general purpose frequency counter it caters for frequencies from 0.01Hz up to 5MHz, subject to tolerance factors discussed later. A 440Hz audio output reference is included. It is basically designed for use with C64, BBC and PET series computers, but the controlling program is readily adaptable for use with other computers if they possess a user port or IEEE 488 port having the usual 8-bit parallel data outputs with two handshake lines.

HISTORICAL NOTES

The subject of tuning accuracy has been a source of discussion for centuries, since it is related not only to mathematics, but also to the sounds that the ear regards as pleasing.

When early stringed instruments came into being, there was probably little understanding that attractive sounds were caused by the number of times that the strings vibrated. It would have been known that the length of the string was important, and that some changes would produce greater satisfaction than others when different notes were played consecutively.

In the 6th century BC, Pythagoras showed an interest in this phenomenon and concluded that the simplest relationship was between a note and its octave, with a string division ratio of two to one. He also found that another commonly experienced relationship was three to two. This was true irrespective of the overall string tension as long as it was constant for both portions. Different pitches required different lengths or tensions, but the ratio required was the same.

We consider now that string lengths in relation to satisfying frequencies can be mathematically defined as simple multiples of a logarithmic function. This is a comparatively recent development, and is largely for the sake of convenience. Purists will continue to hold that a particular relationship of frequencies may hold true for one scale, but that a slightly different set of relationships would apply to another scale. In terms of precise ratios relating to three to two this is true, as will be shown, but other factors are also involved, and the perceived ideal can vary from culture to culture. The reason for this arose even earlier than man's use of musical instruments. Music originated from the sounds of the human voice, and a set of sounds that sounded right to one group of people may have sounded alien to another. By and large, and despite common factors, personal opinion was the primary consideration.

These scale differences are still apparent today, for instance between the twelve tone scale of modern Western music and the traditional five note scales of many older and more ethnic sources. It is probably only due to increased cultural interchange, particularly since the coming of broadcasting, that some sort of standardisation has developed. It is now generally accepted that twelve notes to an octave is the Western standard, and that note 'A' in the treble clef, should have a frequency of precisely 440Hz (Concert A). This was adopted as recently as May 1939, but prior to that A in the treble clef has varied widely from as low as 373Hz to over 567Hz.

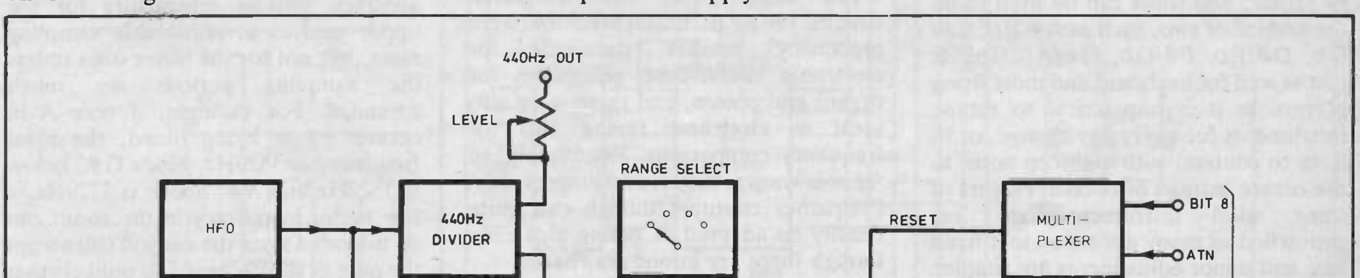


Fig.1. *Block diagram of Micro Tuner*

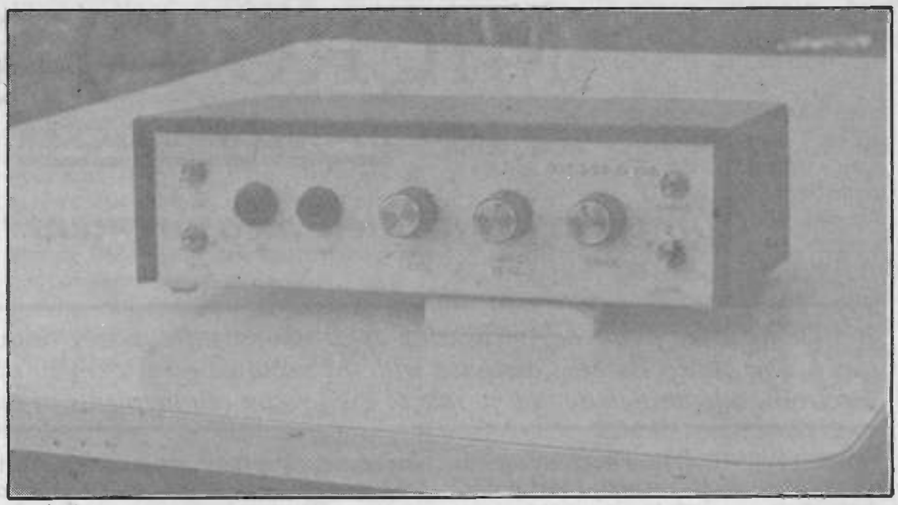
TUNING STANDARDS

Standardised tuning for twelve notes is not without its complications, for there are two distinct ways of doing it. The differences between the methods can be illustrated by the problem experienced in tuning a piano, since it can be quite readily tuned by ear starting from a known point.

Initially a tuning fork is used to set the first note, usually 440Hz. This is remarkably easy to do and it is not necessary to have perfect pitch, for the ear can readily discern the beat frequency produced when two notes are struck simultaneously. By adjusting one note until the beats are cancelled, precise tuning can be achieved. From the first note, the frequency ratios of two to one, and three to two are used. The ratio of three to two produces a 'fifth', so called since it results in the fifth note of an eight note scale, and is an interval covering three whole tones and one semitone. Using a series of descending fifths and ascending octaves it is possible to fully plot the piano tuning simply by listening for beat frequencies. If the notes are tuned so that the beats are cancelled all the notes will be harmonically related.

In practise though this only ensures that all subsequent notes are harmonically related to the first. If the starting point were to be a different note, and tuning carried out against that in the same way, the scale would still be harmonically correct, but the frequency of some notes from this scale would differ from the supposedly identical notes of the previous one! "Just" tuning, as this method is called, can result in at least eighteen different notes being required to cover all tuning points relating to different fixed starting notes. However since some of these points are so close to each other, a compromise can be struck, and some can be used to do the service of two, such as A#/B*b*, C#/D*b*, D#/E*b*, F#/G*b*, G#/A*b*. This is just as well for keyboard and most string players as it is impractical to retune instruments for every key change, or to have to contend with eighteen notes to the octave instead of twelve. Players of some wind instruments are less concerned as many are tuned to a fixed key, and minor adjustments are simpler. The scale derived from these twelve compromise notes is known as a **tempered scale**, and is related to logarithmic progressions.

If the log of one note is taken and subtracted from the log of a note one octave higher, the difference is a constant, irrespective of which notes or octaves are selected. This difference is in fact the log of two and each note in the tempered scale represents one twelth of log two. Consequently, given a known starting point, the frequency of each additional note up a scale can be calculated by adding this twelth part to the log of the preceding number. To convert the log back to a frequency, the answer can be produced from equivalent anti-log tables, or with a computer by taking the exponent of the number.



By comparing calculated tempered frequencies with the frequencies calculated for the Just scale, the differences can be used to establish beat frequency tables for any two notes in close proximity. Then when tuning the piano, octave differences would still be tuned for beat frequency cancellation. With the descending fifths though, adjustment would be made so that the beat quantity coincided with the table.

TUNING AIDS

Any musician should be capable of tuning an instrument by ear in conjunction with tuning forks or tuning pipes. However in many cases it may be considered preferable to tune against a series of preset electronically produced notes, or using a frequency meter of some sort, especially for solo instrumentalists.

For many years two integrated circuits, the AY10212 and MK50240 were practically market standards for electronic twelve-tone generators for organs and pianos, and these were also ideal as electronic tuning aids for frequency comparison. Regrettably, so far as is known, they are no longer made. Frequency counters though can quite readily be adapted as tuning aids even though there are minor drawbacks.

FREQUENCY COUNTERS

These normally count the number of cycles or pulses received during a fixed period of time, but the accuracy can vary with frequency. For example, if the sampling period is accurately fixed at precisely one second and one million cycles are received during that second, then obviously the frequency is 1MHz, accurate to within one cycle or one millionth of a second. At the lower end of the range, if 50 cycles are counted during one second the frequency is 50Hz. The accuracy is still to within one cycle, but the cycle width now represents 20000 microseconds so the timing accuracy is less precise. Normally accuracy to within microseconds is probably not too important, but this is not true for musical purposes where relative accuracy should be constant irrespective of the musical octave.

TUNING RANGES

The fundamental range of musical frequencies normally covers seven octaves C-C from 32Hz to 4187Hz, though exceptionally some instruments such as synthesisers, organs and harps may have a wider range. From here on, these octaves will be referred to by numbers between −2 and +4, with octave 1 being the treble clef, and containing the note Concert A at 440Hz.

Harmonics and subharmonics may also extend the seven octave range considerably to either side, but for tuning purposes it is the fundamental frequency that has the greatest importance. If a conventional frequency counter is used for note determination, accuracy will be satisfactory for the upper octaves at reasonable sampling rates, but not for the lower ones unless the sampling periods are much extended. For example, if note A in octave +4 is being tuned, the ideal frequency is 3520Hz. Since G#' below is 3322Hz and A#' above is 3729Hz, a few cycles inaccuracy in the count can be tolerated since the ear will still accept the note as satisfactory. It is unlikely that most ears will detect deviations less than one sixteenth of a semitone in octave +4. Below octave 1, pitch discrimination will probably be far less easy, until in octave −2, a difference of as much as one sixth of a tone may be difficult to detect. Even the tone generators mentioned above were not absolutely precise. They divided a master frequency into twelve parts by whole number divisors, and unless the original frequency is so high as to be impractical, whole number division simply cannot achieve total note frequency perfection.

SAMPLING RATES

One 16th of a semitone from A at 3520Hz is about 12Hz, but with A at 110Hz a 12Hz count error is roughly a full tone. To do better than that, a normal frequency counter would have to sample at a rate slower than once every ten seconds. This would require the musical instrument to sustain its vibrations at a reasonable level for at least this long. Synthesisers, organs and wind instruments can normally produce a note of this duration, but plucked or percussive instruments, including pianos, would probably find it hard to comply with such requirements. It therefore seems preferable that a different method of frequency counting be used, enabling sampling to take place at a much faster rate.

A fundamental fact about frequency is that there is a fixed period of time between one cycle and the next. The tuning aid presented here takes advantage of this fact, and in effect simply measures the length of each individual cycle. Consequently the sampling rate is related to the length of each cycle, rather than to another slower frequency. With this method the timing accuracy is better at lower frequencies where it is more essential, rather than at high ones where a greater tolerance can be accepted.

BLOCK DIAGRAM

From the block diagram it will be seen that in essence the unit consists of a counter that counts the number of pulses from a fixed oscillator during the period of one cycle of an unknown input frequency. The count is read by a computer which calculates the frequency from the number of pulses received, relates the answer to particular notes and octaves, and displays the deviation from the ideal. A few other peripherals are included in the circuit to enhance the versatility, enabling frequencies outside the normal musical range also to be sampled and displayed.

REFERENCE CLOCK

The reference clock used for determining the input frequency cycle width is derived from a 1MHz square-wave generator around IC1a–IC1c, and is precision controlled by the crystal. The output pulses from this clock will subsequently be counted during one input frequency cycle, either directly or after division in the range selector.

PRE-AMP

The input frequency to be analysed can come from acoustic instruments via a high output microphone placed close to the instrument, or direct from electronic musical instruments and other frequency generators. At the pre-amp there are three switched choices. With S3 the pre-amp can be bypassed so that signals from an electronic source producing 5V pulses or square waves (TTL mode) can go direct to the counter gate. For low level signals, such as from a microphone, they go via the first pre-amp stage IC10a and IC10b which

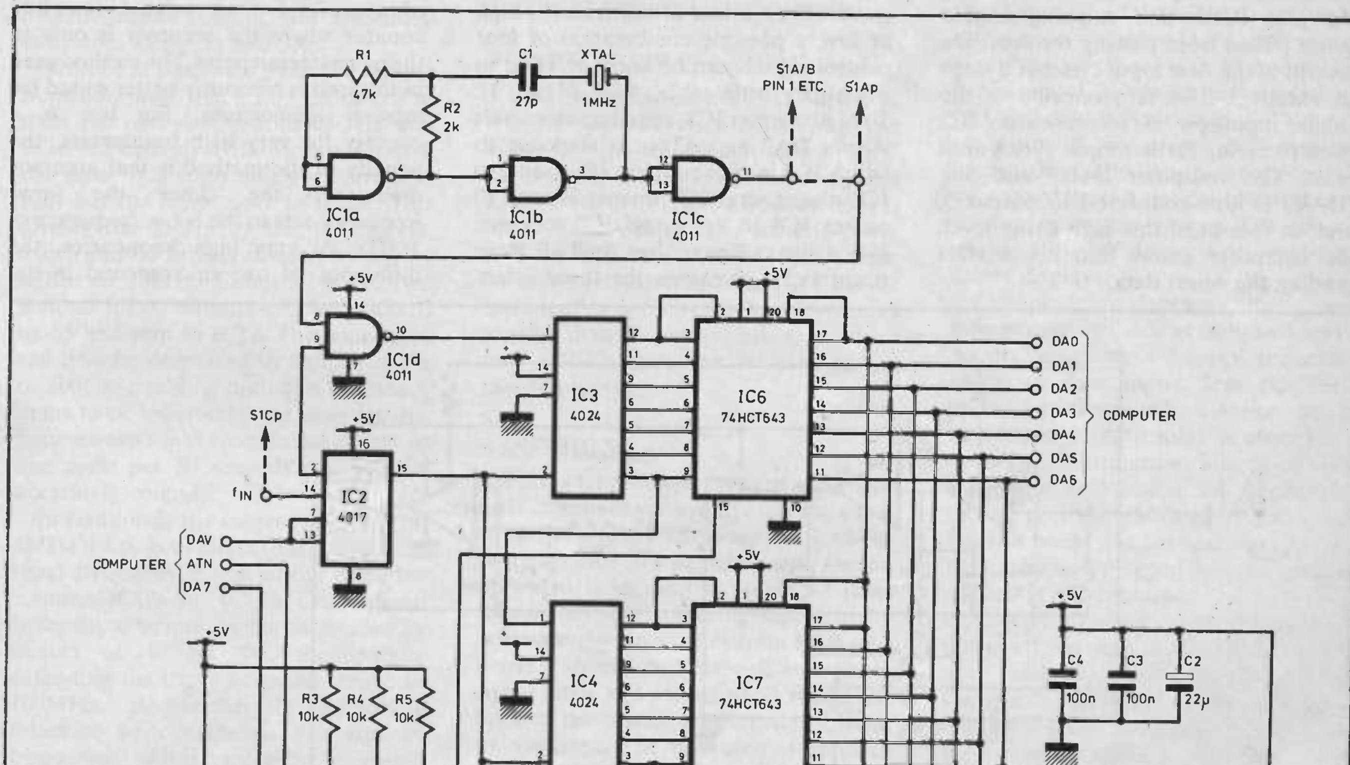


Fig.2. *Main circuit diagram*

provides a fixed gain of about 300, though C6 progressively reduces the gain above 5.5KHz. Pre-amp stage two, IC10c, has a gain of about 150 and will take signals from pre-amp stage 1, or signals from intermediate level sources switched in direct via S2. VR1 provides manual control over either level. IC10c then raises the signal to saturation levels, suitable for clocking the counter gate.

COUNTER GATE

Ignoring the Range Selector for the moment, the amplified source signal ends up at the decade counter IC2. This will have previously been reset by a control signal sent from the computer. On receipt of the leading edge of the input waveform, IC2 is clocked on by one place and output 1 (pin 2) goes high, opening the gate IC1d allowing a stream of pulses from the h.f.o. to pass through to the series of counters IC3 to IC5. IC2 ignores the falling edge of the input waveform, but on receipt of the next leading edge, it is stepped on by one place so that output 1 goes low, closing the gate IC1d, and stopping further count pulses from passing through. On receipt of the next input cycle, IC2 steps to output 3. This is connected to the Inhibit input, pin 13, so preventing IC2 from receiving further input cycles until reset. The computer Data Valid line (DAV) is also connected to output 3, and on receipt of this high going level, the computer knows that it can start reading the count data.

COUNTERS

IC3 to IC5 are three seven-stage binary counters connected in series. Each counts 128 pulses before triggering the next, so 2097152 (2^{21}) can theoretically be counted. Since the pulses only pass through the gate IC1d for the duration of one input cycle, the count will represent the number of microseconds of the input cycle period.

Most computers have only eight data lines, but the number of outputs from IC3 to IC5 is 21. As 21 divides readily by three, seven of the computer data lines are used to read the counters in succession via the gates IC6 to IC8. These are opened in turn allowing the data from the relevant counter through to the data lines DA0 to DA6.

MULTIPLEXER

So that the correct counter gate is opened at the correct time, the computer uses data line DA7 and its handshake line ATN, to control a multiplexer, that in response to the correct code, opens or closes any of IC6 to IC8. With two control lines, either of which can be high or low, a possible combination of four control signals can be used, relating to the binary truth table of 00, 01, 10, 11. To read counter IC3, the computer sends 00 via DA7 and ATN, in response to which IC6 is opened. Next 01 is sent, so IC6 closes, and IC7 opens. Binary 10 causes IC8 to open and IC7 to close. When the computer has read all three counters, it combines the three totals, and arrives at the length of the input cycle in microseconds, calculates the frequency, and from this the note and octave relationships. These are calculated using the logarithmic and exponential properties of music frequencies referred to earlier. Upon completion of the calculations and resulting displays, the computer sends '11' to IC9. This closes IC8 and resets the counters IC2 to IC5. IC2 can now accept the next input squarewave, and the whole process be repeated.

Since only four input pulses are needed to control the sampling rate, the number of times per second that the input can be sampled is in theory one quarter of its frequency. In practise the computer takes a brief moment to calculate and display the answers, and realistically the sampling rate is about twice a second. During this time the count accuracy is of course to the nearest microsecond pulse from the h.f.o. For frequencies below 100Hz, accuracy is displayed to decimal places. Note the difference between this method and that of a normal time related sampling counter where the accuracy is only to the nearest input pulse. The method used in this unit is obviously better suited for musical applications. For use as a counter for very high frequencies, the penalty of the method is that accuracy diminishes the closer the input frequency sets to the h.f.o. frequency of 1MHz. At very high frequencies, the difference of one microsecond in the

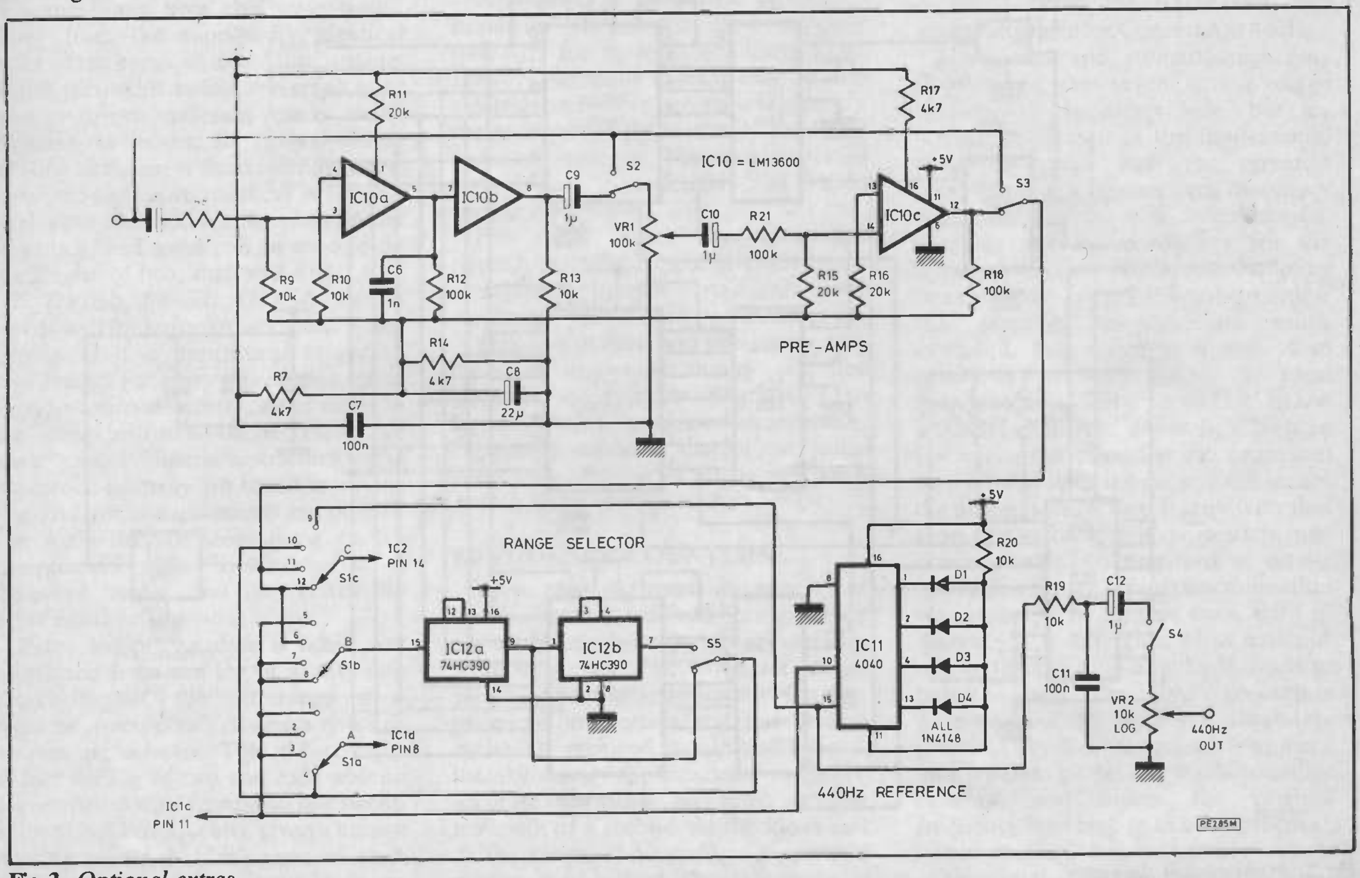


Fig.3. *Optional extras*

count can become significant. For example if two microsecond pulses are counted, the answer produced would be 500kHz. If only one one-microsecond pulse is counted the answer would be 1MHz. So the counter cannot differentiate anything between 500kHz and 1MHz. For musical frequencies though, with the maximum likely frequency of around 4kHz, the accuracy tolerance factor is excellent. At the lower end of the scale, there are limits imposed by the h.f.o. 1MHz rate. As previously said the three cascaded counters can accept a count quantity of 2^{21}, so if the input frequency is too slow the counter will fill up and start from zero again. Thus without additional circuitry, the minimum frequency that can be sampled is about 0.5Hz.

RANGE SELECTOR

Optional additional circuitry is included in the design so that the upper and lower ranges of accuracy can be extended. This is achieved by the use of a dual decade counter and associated switching, IC12, S1 and S5.

With S1 in position 3, both the sample frequency and the h.f.o. go direct to their relevant destinations of IC2 and IC1d respectively. With S1 in position 4, the input frequency still goes direct to IC2, but the h.f.o. goes to IC12c. This divides the IMHz by ten to 100kHz, which can be further divided by ten by IC12b to 10kHz. Either of these two divided h.f.o. outputs can be selected by S5 and sent to IC1d. The count rate can thus be decreased by factors of ten or 100, so enabling the input frequency limits to be lowered by the same factors. Squarewave input frequencies as low as one cycle per 50 seconds can thus be accurately counted.

In position 2, the reverse applies. The 1MHz h.f.o. goes direct to IC1d, but the input frequency is sent to the cascaded counters IC12a and IC12b. Consequently the input frequency can be divided by factors of 10 or 100, theoretically extending the input frequency range to 100MHz. Regrettably electronics is reluctant to operate at this sort of frequency unless specially designed devices are used. IC1 and IC2 will probably behave themselves with frequencies up to 5MHz, and IC12 up to 50MHz, so if the input frequency comes direct from a digital source, frequencies beyond IMHz can be appropriately handled. The upper limit imposed by IC10 through is 5.5kHz via IC10a, and approaching 2MHz via IC10c. IC10 also imposes a lower limit of about 15Hz due to the capacitive coupling of C5, C9 and C10. The lower frequencies of these ranges should therefore be digital so that adequate leading edges to the input signal are retained.

440Hz REFERENCE

Since the HFO is at a fixed frequency, it is simple to produce a 440Hz reference audio output. The 1MHz clock is additionally fed to the 12 stage counter IC11. In order to produce 440Hz from 1MHz, a dividing factor of 2272.72 is needed. This is close enough to 2272 for the counter to reset itself when the outputs reach the binary equivalent, as set by the AND gate diodes D1 to D4. The resultant output frequency from a 1MHz clock is actually 440.14Hz, but is sufficiently close to the ideal of 440Hz as makes little difference. With an historical range of treble A from 370 to 570Hz, not many ears will notice a difference of 0.14Hz. This reference frequency is a square wave, and as such is a little harsh for listening to, so for the audio output, the signal is slightly rounded by the inclusion of R19 and C11. VR2 varies the output level which can be fed to any normal amplifier. The 440Hz squarewave can also be switched by S1 in position 1 to act as a self check facility of the unit by the computer.

POWER SUPPLY

The unit requires a power supply of +5v at approximately 8mA. This can either be supplied direct from a 5V PSU, or in many cases, from the computer itself. Both the PET and C64 can deliver up to 100mA from their cassette ports, and the BBC can deliver 100mA from its user port. Alternatively IC13 can be included as a 5V regulator if voltages greater than 7V are available, in which case a 9V battery can be used as the power supply.

ASSEMBLY

This is very straight forward and needs little comment, except to offer the usual advice of using resistor cut off leads or single strands of connecting wire for the on-board links, and to check all joins thoroughly after soldering. Additionally note that the clock leads from PCB pins 8 and 9 should be kept well away from signal leads and routed to S1 round the back of the board, keeping signal leads to the front. The box used is approximately 22.7cm x 12.7cm x 4.5cm, and the front panel should be drilled with jack socket, pot and S1 centres 30mm above the base, about 35mm apart starting 45mm from the left. Toggle switches are 20mm from the sides at 17mm and 42mm above the base.

COMPUTER PROGRAM

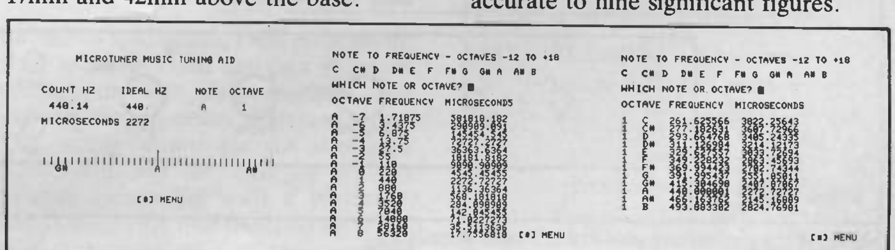
The program has been written as a very comprehensive software facility and offers four menu options. Option 1 is the one normally used to read the count and translate it into frequency, nearest note, ideal frequency aimed at, and also the microsecond count. In this mode it also gives a type of bar graph read out in which 32 divisions are seen on the screen together with a pointer. Sixteen of these divisions make a semitone, and so a span of two semitones is displayed, with the pointer indicating the nearest subdivision associated with the frequency. The pointer remains static, but the divisions slide across the screen in an apparently endless ribbon so catering for all notes of all octaves. The computer determines which relevant section to display. The full display is upgraded after each sample is analysed.

Note that an intercept at DAV detection is inserted so that if DAV is not received within a given period the computer displays a series of asterisks in place of count data. This is set for 100 attempts at acquiring DAV, representing about 2s on the PET. If frequencies below about 2s are to be sampled this factor should be increased.

Option 2 is practically identical, except that the computer takes the average of the last ten samples and bases its display on that answer. The effect is similar to using damped or undamped meter displays.

Option 3 displays the same information outlines as options 1 and 2, but in this mode a prompt requests a keyboard data input. This enables a particular frequency number to be entered and the display is then based upon this information. This is of value for static calculation of frequencies, timing periods and note relationships. For this mode it is not necessary to have the tuning unit plugged in as the program section is self contained.

Option 4 is also self contained and does not need the unit. Here any of the 12 note symbols can be entered from the keyboard. The display will then be a tabulated readout of the frequency and microsecond values of that note throughout all octaves between −7 and +8. Alternatively an octave number between −12 and +18 can be entered, and the frequencies and microsecond values of all notes in that octave will be displayed. All displayed numbers will be accurate to nine significant figures.



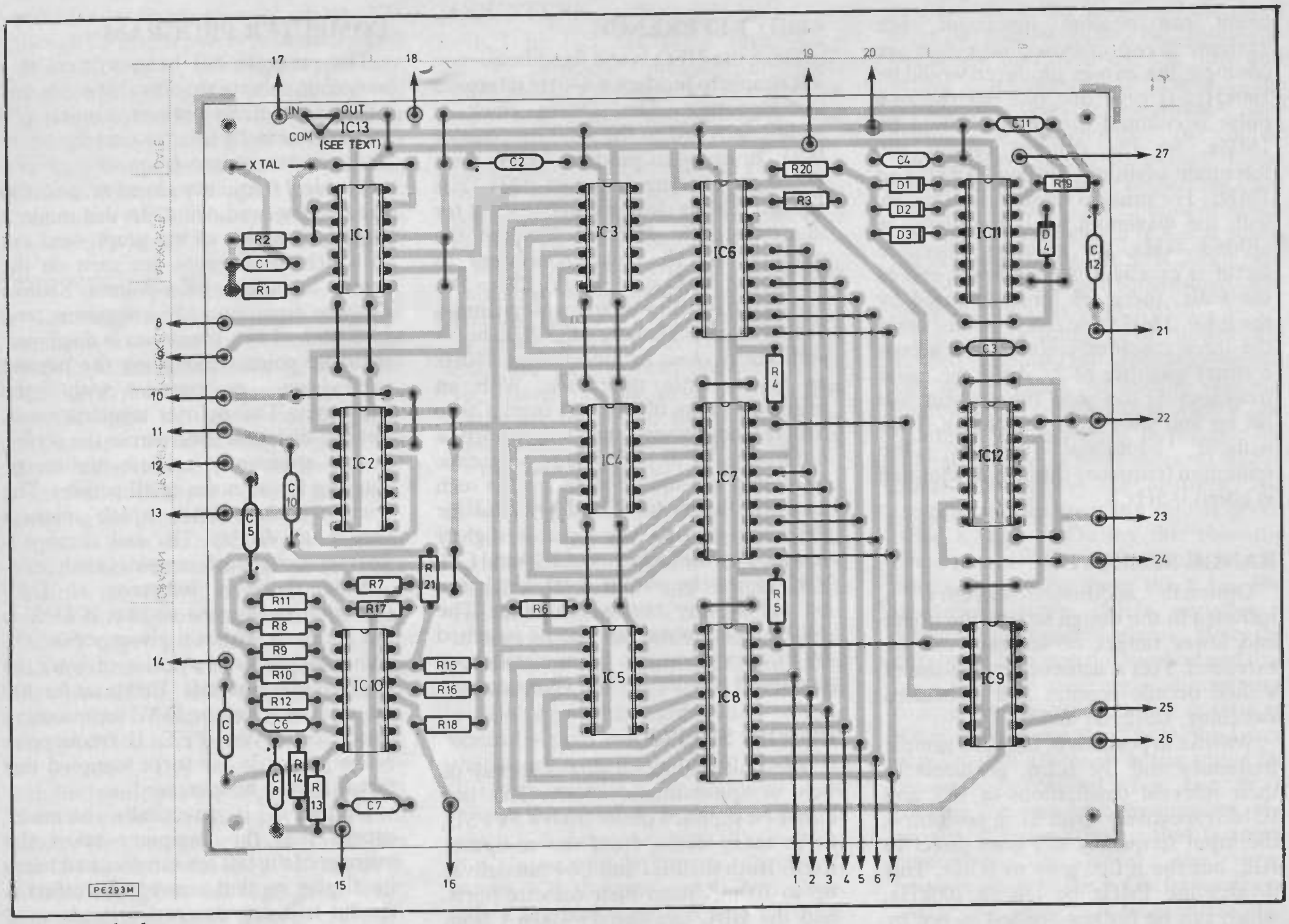
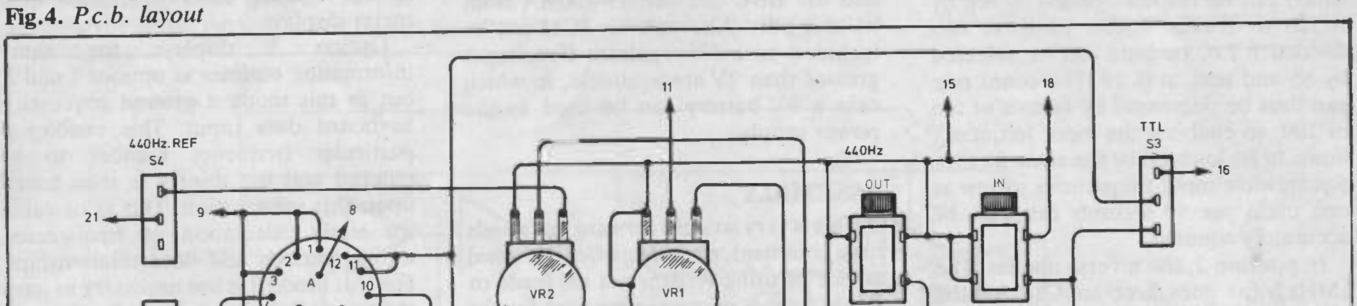


Fig.4. *P.c.b. layout*



P.c.b. and kit available from Becker-Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.

Fig.5. *Wiring diagram and front panel details*

```
100 REM MICRO-TUNER TUNING FORK T132 PROG257 16DEC86
110 REM *** SEE NOTES AT END BEFORE TYPING IN ***
120 DATA1-PET USER:REM SUBSTITUTE RIGHT NO & NAME IN THIS LINE = 2-C64, 3-BBC
130 V$="":R=0
140 READA$:ONVAL(A$)GOSUB830,830,850:ONVAL(A$)GOSUB870,900,930
150 GOSUB610:PRINT:PRINTTAB(13);"SETTING UP"
160 DIMN$(11):DATAC ,C#,D ,D#,E ,F ,F#,G ,G#,A ,A#,B ,*
170 S$=CHR$(CL)+"                    ":B$="||||||||:||||||||||||||||||||||||||||||"
180 FORB=0TO11:READN$(B):D$=D$+N$(B)+"                    ":H$=H$+CHR$(CL)
190 V$=V$+CHR$(CD)+CHR$(CD):NEXTB:GOSUB810
200 D$=RIGHT$(D$,18)+D$+LEFT$(D$,18)+"      ":DV=LOG(2)/12:GOTO550
210 IFZ=2THENPRINTCHR$(CU);CHR$(CU);"AVERAGED FROM LAST 10 SAMPLES":PRINT
220 PRINT"COUNT HZ";TAB(12)"IDEAL HZ";TAB(25)"NOTE";TAB(31)"OCTAVE"
230 PRINTLEFT$(V$,3);"MICROSECONDS"
240 PRINTLEFT$(V$,3);TAB(18);"|":PRINTB$:PRINTLEFT$(V$,4);TAB(15);"[*] MENU
250 PRINTCHR$(CH);LEFT$(V$,8):POKEDRT,128:IFZ=3THEN410
260 POKEOUT,128:POKEAT,UP:POKEAT,DN:POKEOUT,0
270 GETZ$:IFZ$<>""THEN550
280 IFPEEK(DAV)ANDSETTHENA=0:GOTO310
290 A=A+1:IFA>100THENA=0:GOSUB370:GOTO260:REM BBC - IFA>500 ...
300 GOTO270
310 B=127-(PEEK(IN)AND127):POKEOUT,128:C=127-(PEEK(IN)AND127):POKEOUT,0
320 POKEAT,UP:D=127-(PEEK(IN)AND127):POKEOUT,128
330 T=B+(C*128)+(D*16384):IFT=0THENGOSUB370:GOTO360
340 IFZ=2THENG=G+1:A(G)=T:FORM=2TO10:T=T+A(M):NEXTM:T=INT(T/10):IFG=10THENG=0
350 F=1000000/T:GOSUB450
360 POKEOUT,0:POKEAT,DN:GOTO270
370 PRINTCHR$(CH);LEFT$(V$,9)
380 PRINT"                                        ";CHR$(CU)
390 PRINTTAB(3)"*";TAB(14);"*";TAB(26);"*";TAB(33);"*":PRINT
400 PRINTTAB(13)" *              ":PRINTCHR$(CH);LEFT$(V$,8):RETURN
410 PRINTLEFT$(V$,5);"FREQUENCY                       ";H$;:INPUTF$:IFF$="*"THEN550
420 F=VAL(F$):IFF=<0THENGOSUB370:GOTO410
430 IFF>1000THENF=INT(F)
440 T=1000000/F:GOSUB450:GOTO410
450 L=LOG(F)/DV:K=INT(L/12)*12:W=(L-K)*16+14
460 N=INT(W-2)/16-1:IFN-INT(N)>=.5THENN=N+1
470 N=INT(N):V=(K+N)*DV+X:S=EXP(V):P=INT((K+N)/12)-7:IFN>11THENN=N-12
480 IFF>5000THENF=INT(F):S=INT(S):GOTO510
490 F=INT((F+.0051)*100)/100:S=INT((S+.0051)*100)/100
500 IFW-INT(W)>=.5THENW=W+1
510 PRINTCHR$(CH);LEFT$(V$,3):IFW<20THENW=192+W
520 IFF<>RTHENPRINT"                                        ";CHR$(CU):R=F
530 PRINTF;TAB(12);S;TAB(26);N$(N);TAB(32);P:PRINT:PRINTTAB(12);T;S$
540 PRINTLEFT$(V$,5);MID$(D$,W-19,40);CHR$(CH);LEFT$(V$,8):RETURN
550 GOSUB610:PRINT:PRINT"1  INPUT FREQUENCY DISPLAY - DIRECT
560 PRINT:PRINT"2  INPUT FREQUENCY DISPLAY - AVERAGED
570 PRINT:PRINT"3  FREQUENCY TO NOTE CALCULATE
580 PRINT:PRINT"4  NOTE TO FREQUENCY CALCULATE
590 PRINT:INPUT"WHICH";Z$:Z=VAL(Z$):IFZ<1ORZ>4THEN590
600 GOSUB610:ONZGOTO210,210,210,630
610 PRINTCHR$(CC);LEFT$(V$,4);TAB(5);"MICROTUNER MUSIC TUNING AID";LEFT$(V$,3)
620 RETURN
630 PRINTCHR$(CC)"NOTE TO FREQUENCY - OCTAVES -12 TO +18":PRINT:FORA=0TO11
640 PRINTN$(A);" ";:NEXTA:PRINT
650 PRINTCHR$(CH);LEFT$(V$,4);"WHICH NOTE OR OCTAVE      ";LEFT$(H$,5);
660 D=0:INPUTN$:IFLEFT$(N$,1)="*"THEN550
670 V=VAL(N$):IFV<-12ORV>18THEN650
680 IFN$="0"ORABS(V)>0THEND=1:E=DV*12*(V+7):GOTO710
690 IFRIGHT$(N$,1)<>"#"THENN$=N$+" "
700 FORA=0TO11:IFN$<>N$(A)THENNEXTA:GOTO650
710 PRINT:PRINT"OCTAVE";TAB(7);"FREQUENCY";TAB(18);"MICROSECONDS":PRINT
720 IFD=0THEN770
730 FORC=0TO15:B=EXP(E+X+(DV*C)):PRINT"                                        ";CHR$(CU)
740 IFC>11THENPRINT:GOTO760
750 T=1000000/B:PRINTN$;"  ";N$(C);TAB(6);B;TAB(19);T
760 NEXTC:GOTO790
770 B=EXP(DV*A+X):FORC=-7TO8:PRINT"                                        ";CHR$(CU)
780 T=1000000/B:PRINTN$;" ";C;TAB(5);B;TAB(18);T:B=B*2:NEXTC
790 PRINTCHR$(CU);TAB(31);"[*] MENU":GOTO650
800 REM ESTABLISH CORRECTION FACTOR
810 DV=LOG(2)/12:FORA=1TO20:IFEXP(DV*A)<1.71875THENNEXTA
820 X=LOG(1.71875)-(DV*(A-1)):RETURN
830 REM PET & C64 CURSOR CODES
840 CU=145:CD=17:CL=157:CC=147:CH=19:RETURN
850 REM BBC CURSOR CODES
860 CU=11:CD=10:CL=8:CC=12:CH=30:RETURN
870 REM PET CONTROLS
880 DN=205:SET=2:UP=237:DAV=59469:DRT=59459:IN=59457:OUT=59471:AT=59468
890 POKE59467,0:RETURN
900 REM C64 CONTROLS
910 DN=195:SET=16:UP=199:DAV=56589:DRT=56579:IN=56577:OUT=56577:AT=56576
920 RETURN
930 REM BBC CONTROLS
940 DN=14:SET=16:UP=206:DAV=&FE6D:DRT=&FE62:IN=&FE60:OUT=&FE60:AT=&FE6C:RETURN
950 REM PROGRAM GENERAL NOTES
960 REM EXPERIENCED PROGRAMMERS CAN OMIT STATEMENTS UNRELATED TO THEIR MACHINE
970 REM ALL 'REM' STATEMENTS CAN BE OMITTED WHEN TYPING IN
980 REM NON-BBC USERS DISREGARD THE FOLLOWING LINES
990 REM THE BBC USES '?' INSTEAD OF 'PEEK' AND 'POKE'
1000 REM THUS 'POKEOUT,128' WOULD BECOME '?OUT=128', ETC.
1010 REM FOR 'PEEK' THE '?' CAN BE SUBSTITUTED DIRECTLY
1020 REM THUS 'IFPEEK(DAV)' WOULD BECOME 'IF ?(DAV)'. LOG( ) BECOMES LN( ).
1040 REM DUAL TABS SHOULD BE USED IN SOME CASES E.G.LINE 370 - PRINTTAB(0,10);
1050 WHEN TYPING IN, NORMAL BBC REQUIREMENTS FOR A SPACE BETWEEN SOME
1060 STATEMENTS SHOULD BE OBSERVED. A SEPARATE BBC LISTING CAN BE SUPPLIED
1070 REM BY THE AUTHOR ON REQUEST WITH ORDERS FOR PCB OR KIT.
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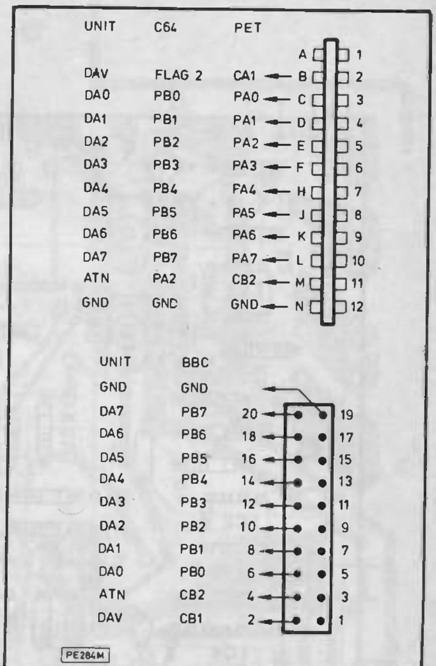


Fig.6. *Computer parts*

COMPONENTS . . .

RESISTORS

R1	47k
R2	2k
R3,R4,R5,R6, R8,R9,R10,R13, R19,R20	10k (10 off)
R7,R14,R17	4k7 (3 off)
R11,R15,R16	20k (3 off)
R12,R18,R21	100k (3 off)

All resistors 0.25W 5% carbon

POTENTIOMETERS

VR1	100k mono rotary
VR2	10k log mono rotary

CAPACITORS

C1	27p polystyrene
C2,C8	22µ 16V electrolytic (2 off)
C3,C4,C7,C11	100n polyester (4 off)
C5,C9,C10,C12	1µ 63V electrolytic (4 off)
C6	1n polystyrene

SEMICONDUCTORS

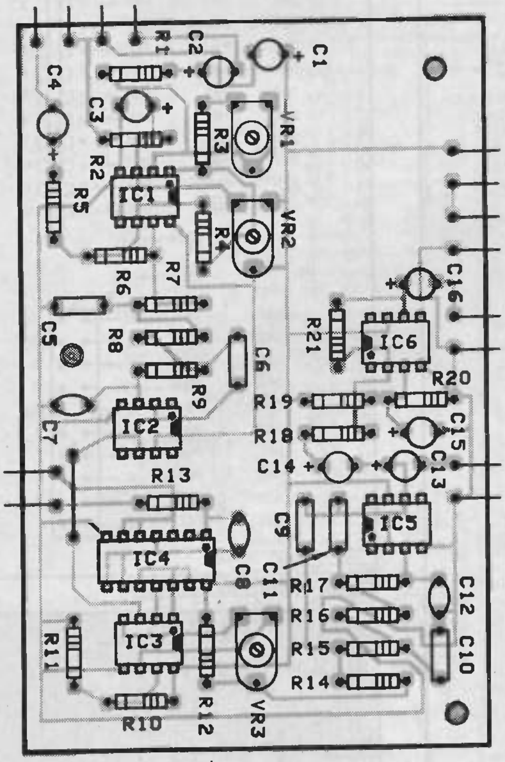
D1,D2,D3,D4	1N4148 (4 off)
IC1	4011
IC2	4017
IC3,IC4,IC5	4024 (3 off)
IC6,IC7,IC8	74HCT643 (3 off)
IC9	4052
IC10	LM13600
IC11	4040
IC12	74HC390

MISCELLANEOUS

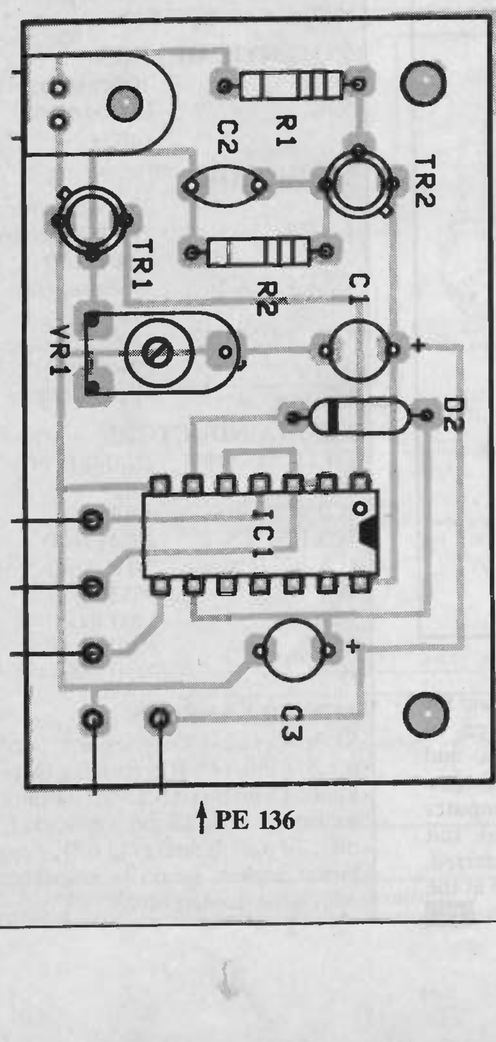
S1 3p-4w; S2–S5 min s.p.d.t. (4 off); p.c.b. clips (4 off); crystal (1MHz); knobs (3 off); p.c.b.257A; 14-pin i.c. socket (4 off); 16-pin i.c. socket (5 off); 20-pin i.c. socket (3 off); 3.5mm jacket socket; mono jack socket (2 off); wire, solder, etc.

COMPUTER DIALECTS

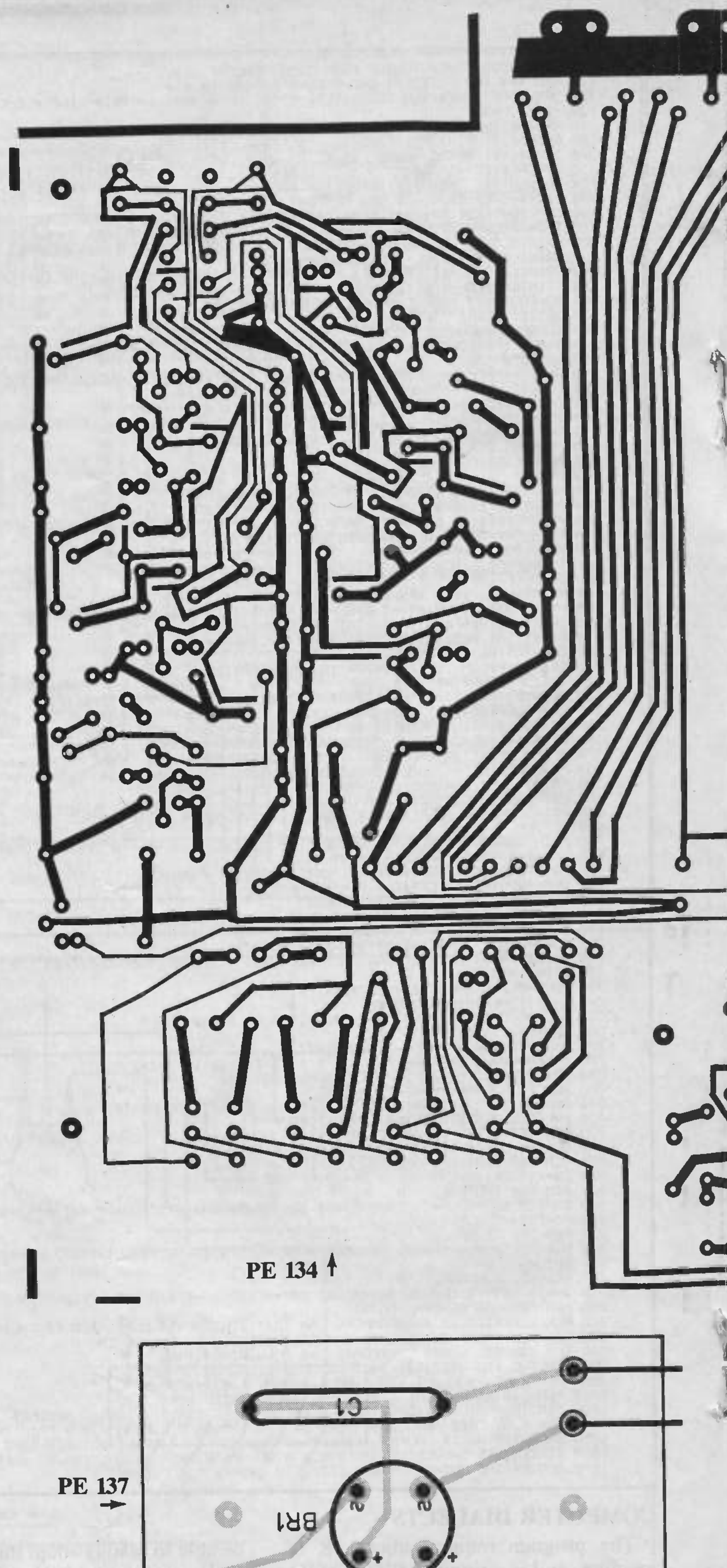
The program requires about 4K of memory, and is written in PET BASIC, but the differences between this, the C64 and the BBC are minimal. Notes relating to these three computers are included in the software listing and largely relate to memory and cursor control codes. Users of other computers that have normal parallel user or IEEE 488 ports should be able to readily adapt this program for their machine from the data given, in conjunction with their manuals, and making any necessary dialect changes. The wiring shown for the computer connection can be changed to suit existing connecting leads if preferred, just making sure that they end up at the correct destinations. PE



↑ PE 135

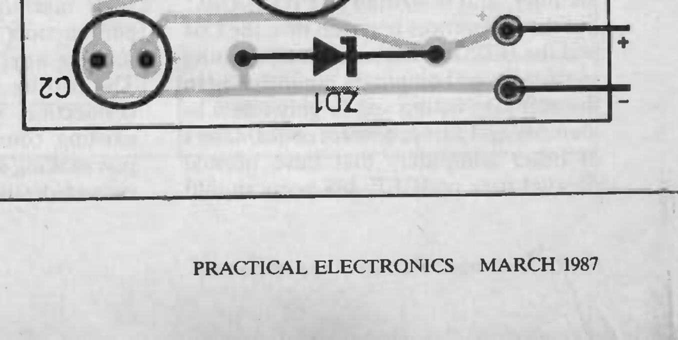


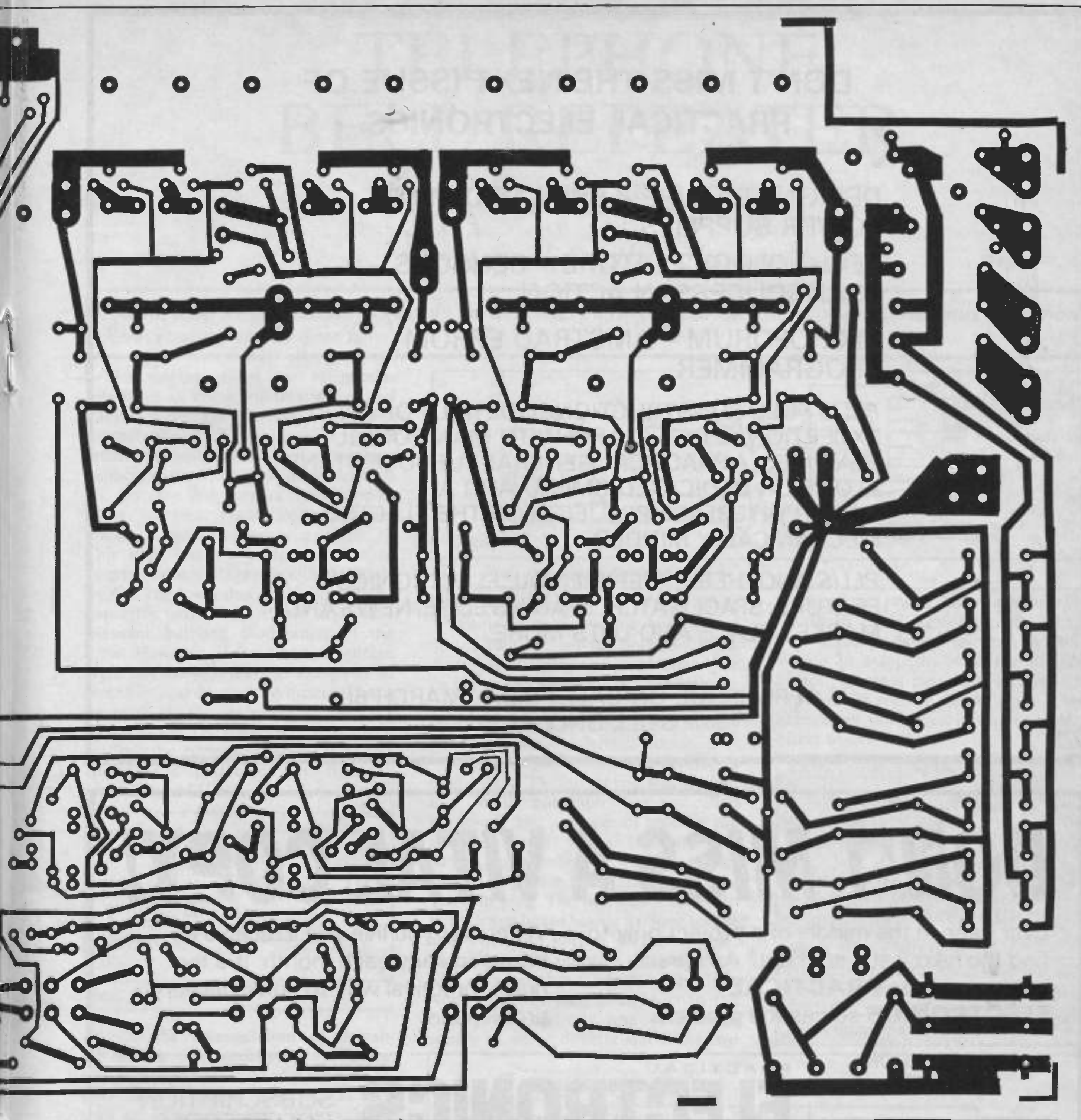
↑ PE 136



PE 134 ↑

PE 137 →





P.C. BOARDS

Printed circuit boards for certain PE constructional projects are now available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £2 per board for overseas airmail. Remittances should be sent to: **PE PCB Service, Practical Electronics, Practical Electronics Magazines, 16 Garway Road, London W2 4NH.** Cheques should be crossed and made payable to Practical Electronics.

Please note that when ordering it is important to give project title, order code and the quantity. Please print name and address in Block Capitals. Do not send any other correspondence with your order.

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CONSTRUCTIONAL PROJECT

TELEPHONE BELL REPEATER

BY GILES READ

Next-to-the-telly 'phone

Modem, light weight phones frequently fail to delivery a ringing punch. This repeater device puts a telephone wherever you want to hear it.

The ringing signal for telephones which we all know and love is a pulsed 25Hz a.c. voltage of about 50V, which drives the bell mechanism of a traditional telephone via a d.c. blocking capacitor of a couple of microfarads or so. Because less current is required to power the piezo buzzer in the repeater circuit, a smaller capacitor is used (C1). This then feeds a bridge rectifier to provide a d.c. voltage, smoothed slightly by C2. The low value of this smoothing capacitor permits the ripple to cause a pleasant burbling modulation of the tone. However, if the rectified voltage were not limited, it could easily rise to over 50V and destroy the buzzer. This is avoided by the inclusion of the 12V Zener diode, D1. No resistor is included to limit the current through D1 as this function is performed by the a.c. impedance of C1.

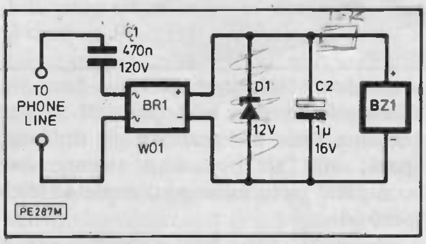


Fig.1. *The Circuit*

SINCE the de-regulation of British Telecom a few short years ago, there has been a proliferation of new types of phones and gadgets. One suspects that they are generally designed to make it as easy as possible to run up enormous telephone bills, though a few are genuinely useful. Not all the goodies on offer are approved for connection to the Telecom network, but the growing number of private internal exchanges (PABXs) can provide a market for such items.

One problem with the new, light-weight, 'all plastic' phones is the apparently low volume of the ringer device when compared to the traditional bells. This can mean that important calls are missed because of the lack of audio penetration. All is not lost however. A suitably installed telephone extension ringer can provide a penetrating sound in just the right place.

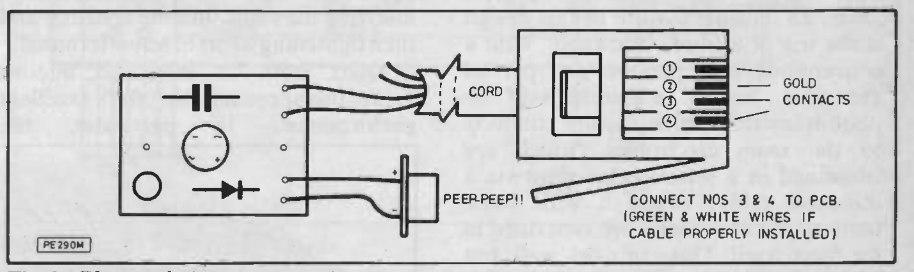


Fig.2. *Plug and ringer connections*

CONSTRUCTION

Not a lot to go wrong here – just ensure that you get the polarities right. Avoid overheating the piezo buzzer, as its pins are moulded into a thermoplastic casing which melts at the slightest opportunity, resulting in at best a wobbly pin and at worst a defunct buzzer.

The bell repeater can be connected in many ways. The prototype was housed in a small 'mountable' box (so called because it had a couple of holes in the back to hold fixing screws), and connected to the outside world by a short length of phone lead terminated in a Telecom plug. The box was screwed to the skirting board beside a phone socket and when the normal phone was not plugged in, the repeater took its place. The diagram shows which of the four wires from the plug to connect to the circuit. Alternatively, the circuit can simply be wired directly across the two wires of the phone line via a suitable length of cable. Unfortunately, whenever a call is dialled the repeater will burble in sympathy with the dialling pulses. It is not easy to overcome this problem in such a simple circuit, but experience shows that it is an easy side-effect to live with. **PE**

COMPONENTS . . .

CAPACITORS
C1 470n 125V
C2 1μ 16V

SEMICONDUCTORS
BR1 W01 or any 100VPIV bridge
D1 BZY88C12V 300mW 12V Zener

MISCELLANEOUS
BZ1 Roxborough type SM2 sounder (available from Verospeed, code 41-22514C), or any other low-current piezo buzzer; wire, solder, etc.

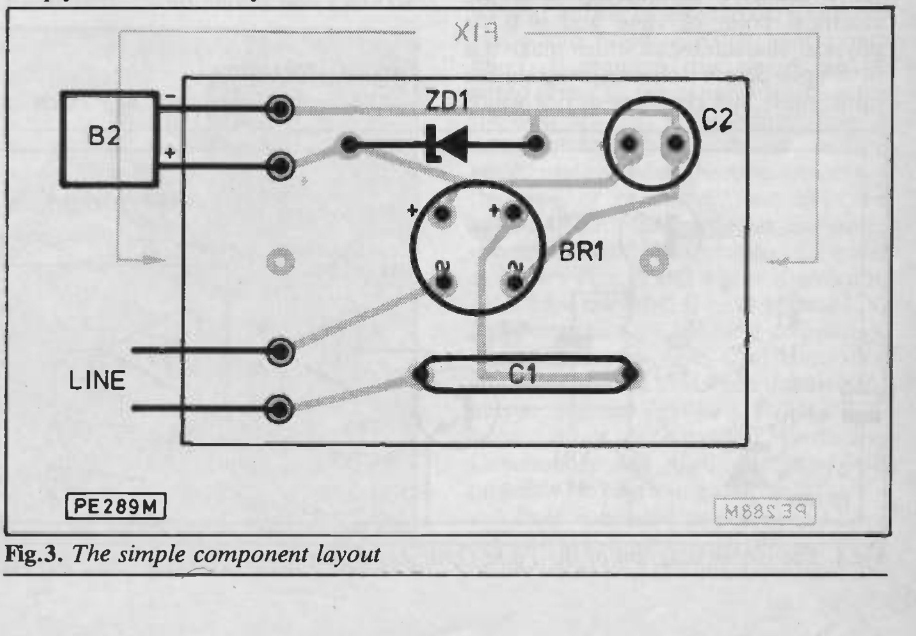


Fig.3. *The simple component layout*

FIBRE OPTIC LIGHT PEN

BY R. A. PENFOLD

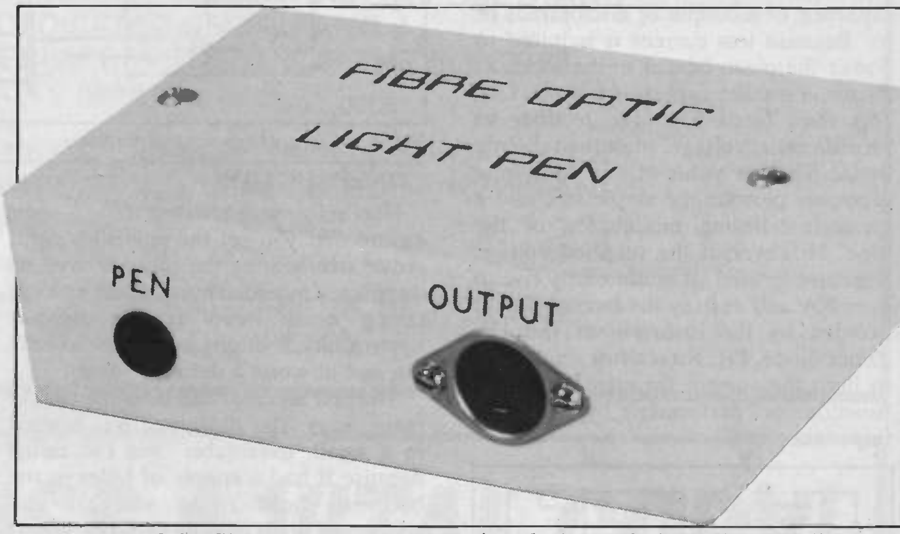
Get to the point

Most light pens have a wide angle of view which restricts their speed and accuracy. This design uses fibre optic cable, which coentrates on the target area with greater precision.

ALTHOUGH a light pen is far from being the most original of project ideas, an unusual feature of this design is the use of a fibre optic cable. With a conventional light pen the 'pen' part of the unit houses a photodiode or phototransistor which usually connects to the main electronics (which are contained in a separate housing) via a screened cable, although with some units all the electronics are contained in the 'pen' itself. This can work well, but with most types of photodiode and phototransistor the angle of view is fairly wide. This is true even with most devices that have a built-in lens, and the practical result is often a lack of consistency with the light pen tending to point to an area of the screen rather than a point. This is not actually of great importance in some applications such as menu selection, but in more critical functions it can render a light pen unusable.

With a fibre optic light pen the 'pen' part of the unit has no electronics at all, and is merely the end of a fibre optic cable. A pen casing or something of this nature can be used here in order to make the device easier to hold and use, but it has no other purpose (not so much a light pen as a very light pen). The photocell is housed on the printed circuit board with the rest of the electronics, and in this case a special fibre optic photodiode is used. This is actually a fairly ordinary photodiode from the electrical point of view, and it is its physical characteristics which make it a fibre optic device. It has an integral fibre optic guide and clamping device which enable it to be easily coupled to the fibre optic cable. In fact it is just a matter of inserting the cable into the aperture and then tightening a sort of screw terminal.

Apart from its increased interest value, this approach also offers excellent performance. In particular, the narrowness of the filament in the cable (usually 1 millimetre in diameter) combined with the fact that only light hitting the filament almost parallel to the direction of the cable will be effectively coupled into it, results in the light pen responding to only a very small area of the screen. This helps to give consistent results as well as good accuracy and resolution.



Circuit Operation

Although the speed at which a television picture is constructed renders the process imperceptible to the human eye, it is actually produced by a spot of light scanning across and down the screen in a series of horizontal lines. Fifty scans of the screen are completed each second, and with the usual interlacing technique alternate lines are scanned on the first pass, then the missing lines are scanned on the next pass, and so on, with twenty five complete pictures being completed each second.

A computer has circuits which generate the timing signals for the production of the display, and if it has a light pen input this normally operates in conjunction with two counters which are part of the display generator circuit. The most common arrangement has one counter reset at the beginning of each

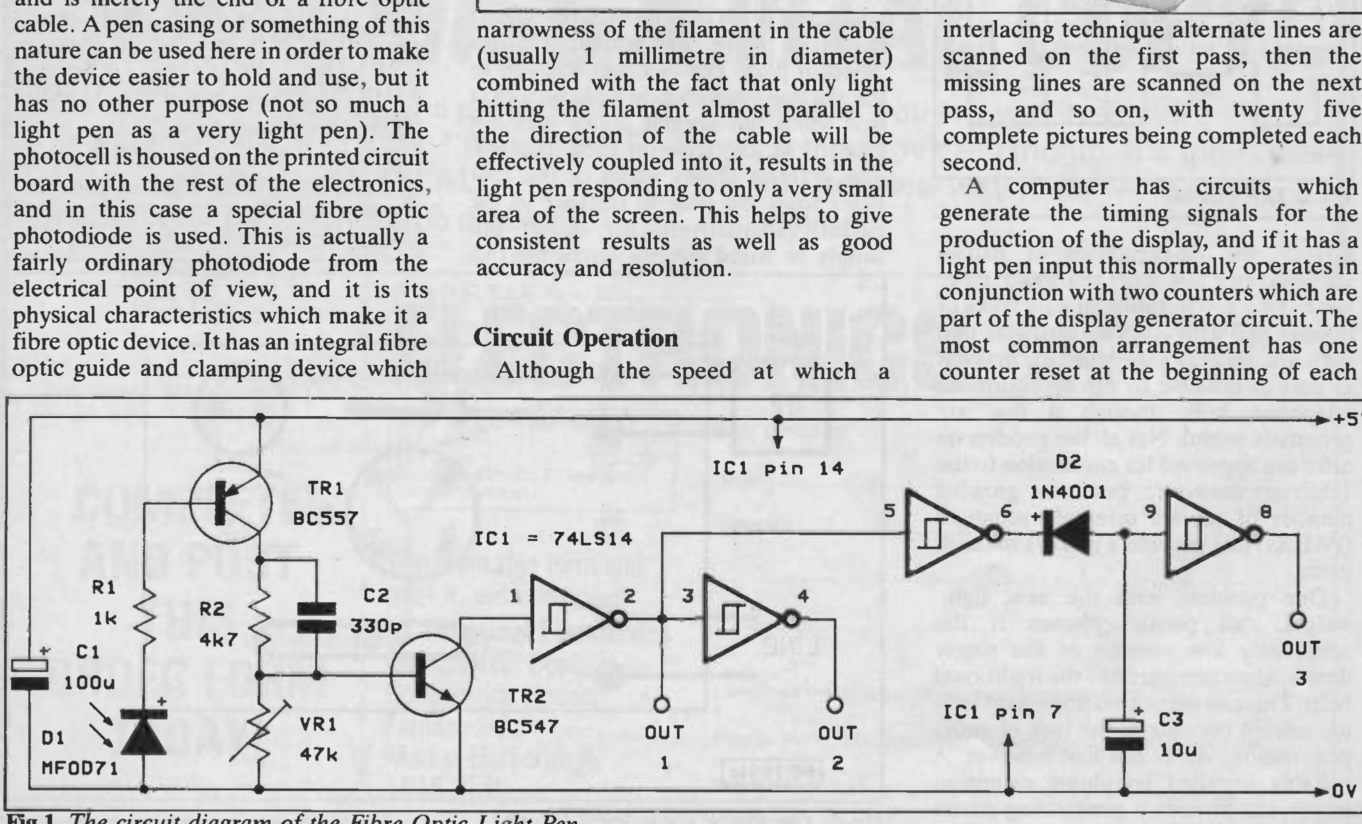


Fig.1. *The circuit diagram of the Fibre Optic Light Pen*

frame and incremented as each new line of the display is commenced. The second counter is reset at the start of each line scan, and is incremented from (say) 0 to 255 during the course of each line scan. With some computers (notably those that use a 6845 CRT controller) the two counters operate together to provide a single large number which increases during the course of each frame scan.

In either event, the purpose of the light pen is to detect the spot of light as it passes through the pen's field of view, and to send a strobe pulse to the counter circuit which 'freezes' the count. From the values read from the counter circuit it is possible for software routines to determine the position of the light pen on the screen.

The photocell used in a light pen must be a reasonably fast type, and although most phototransistors are adequate, the higher speed of a photodiode is preferable. The disadvantage of a photodiode is that it is relatively insensitive, and in this case the relatively small amount of light taken from the screen and transmitted down the cable to the device exacerbates the problem. A large amount of amplification is therefore needed in order to give a logic compatible output from the minute current pulse generated by the photodiode.

D1 is the photocell and it is used in the reverse biased mode. In this mode the diode has the very low reverse leakage current associated with a diode, but only when it is in darkness. The pulses of light from the screen cause a much higher leakage level, although still one which is quite small in absolute terms. This provides a base bias current to TR1 which supplies an amplified current into the base of TR2. This biases TR2 hard into conduction. VR1 is a sensitivity control, it is is adjusted for a setting that gives a good compromise between sensitivity and consistency of readings.

TR2 might be able to directly drive some light pen inputs correctly, but in most cases some buffering to give a standard logic output signal will be needed, and a phase inversion may also be required. IC1 provides two inverting Schmitt Triggers that give antiphase output signals, and one or other of these should be suitable for any lightpen input.

Two stages of IC1 are left unused, but the remaining two are used in a simple circuit which smoothes the output pulses to provide a high output level when the pulses are present. This signal can be used to automatically indicate to the software when the pen is in position on the screen and new readings are available from the light pen registers. Of course, this is only possible if the computer has a spare digital or analogue input available which can be used to monitor this output. Where no suitable input is available the alternative of manual indication via the keyboard has to be used.

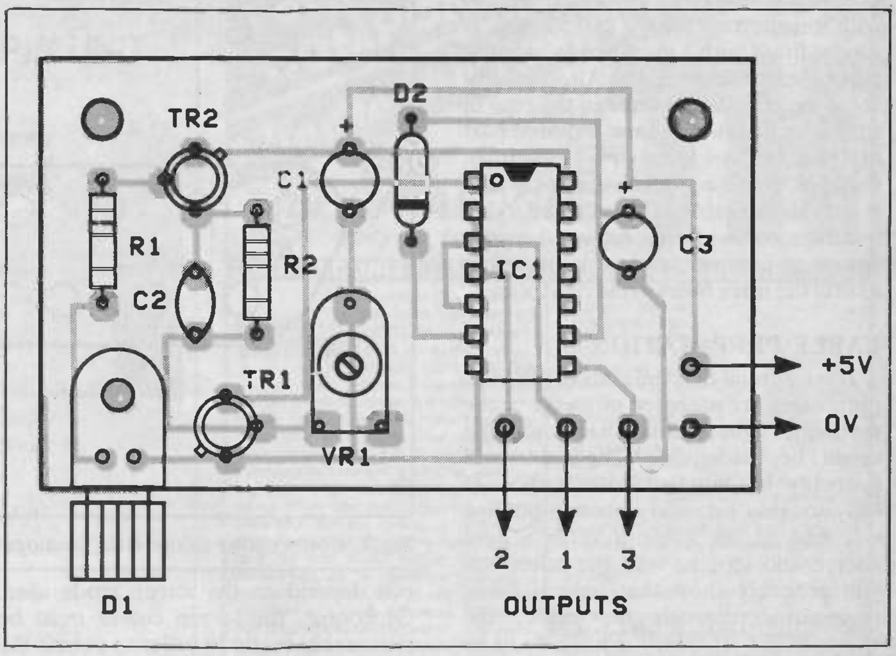
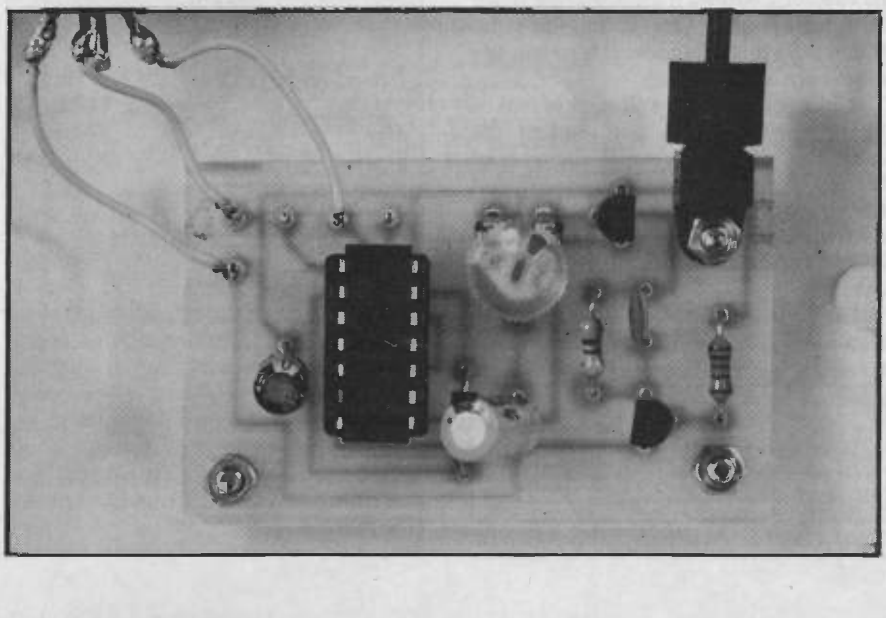


Fig.2. *P.c.b. and wiring details*



The circuit requires only a +5 volt supply, and as the current consumption is only a few milliamps the computer should be able to provide this without any difficulty.

CONSTRUCTION

The printed circuit layout for the unit is provided in Fig. 2, and the only unusual aspect of construction is the mounting of D1. This is bolted to the board using a 6BA screw about 6 millimetres long plus a matching fixing nut. There are two plastic pins on the underside of D1 and well towards the front of the device, and matching holes for these could be drilled in the board. However, there seems to be no problem if these are simply trimmed off using wire cutters.

The unit can be fitted into practically any small plastic case. On the prototype the output leads are taken to a DIN socket, and are coupled to the computer via a lead fitted with the appropriate plugs. If preferred the board can be wired direct to the connector which fits the light pen port of the computer, with an exit hole being drilled at the appropriate point on the case. Obviously the type of connector used must be varied to suit the particular computer concerned, and as a couple of typical examples Figs. 3 and 4 give connection details for the BBC B (and Master 128) and Amstrad CPC464/6128 computers. These all have a 6845 CRT controller, and seem to work best when driven from output 1 of the light pen. Results with most other computers (including Commodore and Atari machines) will probably be best using output 2.

A hole is needed to permit the fibre optic cable to pass through to the interior of the case, and this must be carefully positioned so that it is accurately aligned with the aperture for the cable in D1. It can be fitted with a grommet to give the unit a neater appearance. Alternatively, the board can be mounted in the case in such a way that the screw terminal part of D1 protrudes through a hole cut in the case. This is more convenient in that it enables the cable to be attached to D1 and removed without opening the case, but great care would have to be taken to drill the three holes in the right places.

CABLE PREPARATION

It is essential that the ends of the fibre optic cable are prepared properly, or the amount of light reaching the photodiode might be inadequate. The cable will probably be supplied with both ends only roughly cut, and although holding one end of the cable towards a light source and looking into the other end will probably show that light is being transmitted through the cable, the transmission efficiency is unlikely to be adequate. The easiest way of preparing the end of the cable seems to be to just cut it through using a sharp modelling knife. It should be cut with a single press on the knife, being careful to make the cut at right angles to the cable and to cut through nothing other than the cable. The cable should then work efficiently without the need for any polishing or filing of the filament.

IN USE

Obviously the software routines for the light pen must be designed to suit the particular computer with which the unit will be utilized, and the manual (or an advanced manual) should give details of the light pen registers and how they can be used. In the case of the BBC computers the high order byte of the light pen counter is read by first writing a value of 16 to address &FE00, and then reading from address &FE01. The low byte is read by writing 17 to address &FE00 and then reading from &FE01. Multiplying the high order byte by 256 and adding it to the low order byte gives the total value in the counter. Note that the light pen registers of the 6845 are not accurate if the screen scrolls. This simple routine will read the light pen registers and display the total count on the screen.

```
10 MODE 5
20 COLOUR 1
30 COLOUR 131
40 ?&FE00 = 16
50 A = ?&FE01 * 256
60 ?&FE00 = 17
70 B = ?&FE01
80 PRINT A + B
90 FOR D = 1 TO 300:NEXT
100 CLS
110 GOTO 40
```

There will be a large offset to remove from the counter value before it can be manipulated to indicate a screen position, and the mathematics needed will depend on the screen mode used. Of course, the screen colour must be reasonably bright in order to permit the light pen to operate. VR1 is adjusted for the lowest sensitivity that gives good results at any point on the screen (the screen brightness tends to be lower in the corners). If automatic operation is required one of the 'firebutton' inputs on the analogue port can be used to read output 3 of the light pen.

Incidentally, the MFOD71 diode is intended for use with a standard 2.2 millimetre fibre optic cable with a 1 millimetre diameter core, and it will not properly clamp in place any other type. About 0.7 to 1 metre of cable should be sufficient. An important point to keep in mind is that fibre optic cables can be damaged if they are taken through tight curves. With most types a minimum radius of 20 to 30 millimetres is recommended.

About 5 millimetres of the outer cladding must be removed from the end of the cable which fits into D1. I did not find ordinary wire strippers to be very good for this task, but the sleeving can be removed without too much difficulty by carefully cutting it away using a sharp knife. Be careful not to cut into the filament as this could severely impair the efficiency of the cable.

It is not essential to fit some form of finger grip onto the 'pen' end of the cable, but due to the small diameter of the cable it will be much easier to use the unit if this is done, and it is not difficult to fit something like an old ballpoint pen casing onto the end of the cable.

The Amstrad CPC464/6128 computers also have a 6845 CRT controller, and it is read at IN/OUT address &8F00. Values of 16 and 17 are first written to IN/OUT address &8C00 in order to read the high order and low order bytes respectively.

Results with the unit seem to be very good, and the readings seem to be more stable than with the other light pen designs that I have tried. However, with any light pen it is essential to hold the pen still in order to obtain good results, and the light pen circuits of some computers have a tendency to 'glitch' occasionally. This can usually be overcome by taking several readings and discarding any that are well away from the average reading. The remaining readings can then be used to calculate a final average value. PE

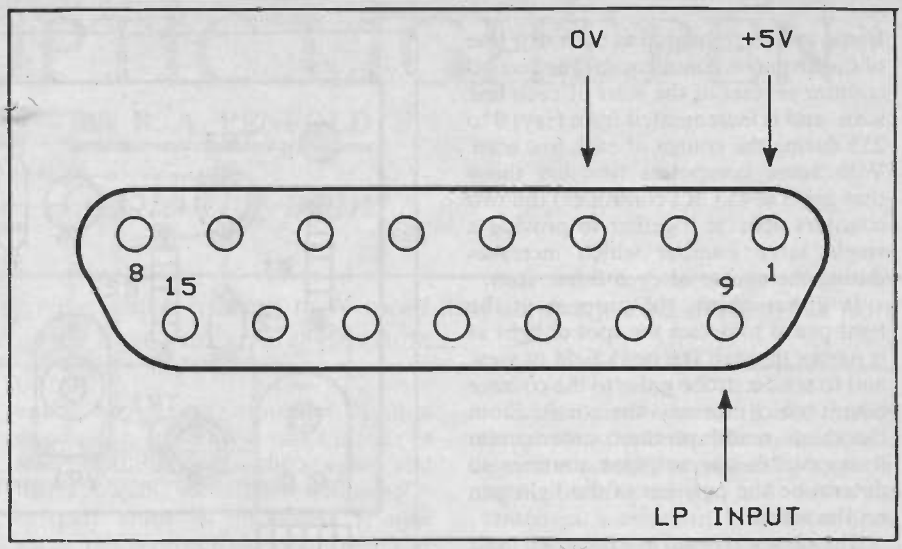


Fig.3. *Connections to the BBC analogue part*

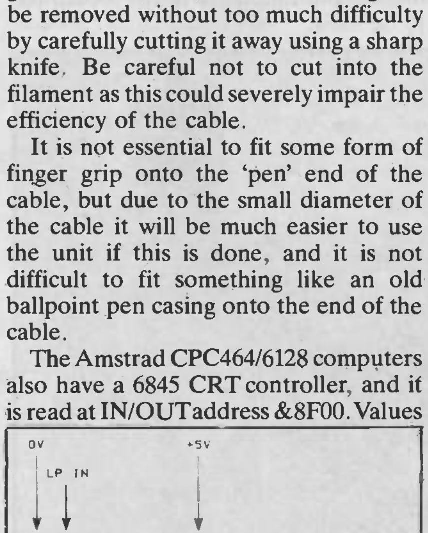


Fig.4. *Connection details for the Amstrad*

COMPONENTS . . .

RESISTORS

R1	1k
R2	4k7

All 0.25W 5% carbon

POTENTIOMETER

VR1	47k sub-min hor preset

CAPACITORS

C1	100u 10V radial elect
C2	330p ceramic plate
C3	10u 25V radial elect

SEMICONDUCTORS

IC1	74LS14
TR1	BC557
TR2	BC547
D1	MFOD71
D2	1N4001

MISCELLANEOUS

Small plastic case, about 1 metre of 2.2mm diameter fibre optic cable, printed circuit board, connecting cable and connectors, 14 pin DIL IC holder, pins, wire, etc.
(The MFOD71 and fibre optic cable are available from Maplin Electronic Supplies Ltd.)

SURFACE ACOUSTIC WAVE DEVICES

BY ANDREW ARMSTRONG

Applications of acoustic signal processing

Surface acoustic waves can be used to provide precisely controlled filter characteristics, and neatly outperform discrete component filters. In addition, they can provide functions not otherwise practical, such as fast realtime convolution and chirp radar signal generation/processing.

SEVERAL TYPES types of piezoelectric crystals have the property that waves can be set up on their surface, like ripples on a pond, by electrical excitation. The effect is reciprocal, so that an electrical signal can easily be generated from the wave. This immediately suggests one application: a delay line. In fact, devices using this property can do far more than provide a delay, but in order to understand them it is first necessary to investigate the waves more closely.

WAVE PROPAGATION

First of all let us consider a wave set up in a simple crystal with a cubic lattice. The majority of such waves would be bulk waves of various sorts. It is helpful if you visualise the crystal as consisting of little round weights each with six springs connecting to adjacent weights. A bulk wave would simply be a wave of spring compression travelling through the body of the crystal, for example along the line of one set of springs. As each weight deflects, one spring is stretched, one is compressed, and the other four are bent. In this simple wave, the weight undergoes linear motion only, in the direction of propagation of the wave.

The performance of an atom in a crystal lattice is very much like that of the weights in our model. The six bonds constitute a stiff suspension, so the coupling between one atom and the next is tight and the wave propagates rapidly. The effect is different for a wave launched on the surface of the crystal, though. The atoms here are suspended on five bonds rather than six, and the propagation of a wave on this relatively floppy suspension is slower than a bulk wave. The movement of an atom on the surface of the crystal is in an arc as against the linear motion experienced by atoms in the body of the material.

All this means that if a wave can be launched on the surface, it will tend not to excit bulk modes but will remain on the surface. Fig.1 shows the form of a transducer which can launch a surface wave. The piezoelectric effect of the crystal causes expansion and contraction of the areas of crystal between the fingers of the transducer, and thus launches a wave in two directions.

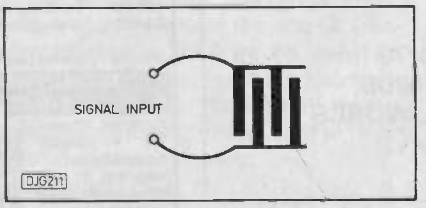


Fig.1. *A simple broadband transducer. The transducers consist of metalised strips laid down on the surface of the crystal.*

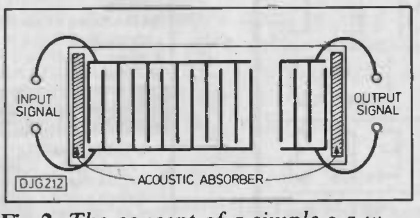


Fig.2. *The concept of a simple s.a.w. filter.*

In a real device, such as the simple filter shown in Fig.2, the wave travelling in one direction is absorbed by an acoustic absorber, and only the wave travelling towards the receiving transducer is used. This means that 6dB is lost on transmission, and a further 6dB on reception. The long transducer used for transmission has the effect that if the wavelength of the wave launched does not fit the spacing of the transducer fingers accurately it will not be launched with full efficiency. This gives a frequency selectivity, but in this simple case the shape of the response is not one which is normally considered useful. One can visualise a series of beats between the wavelength of the wave and the spacing of the transducer as the frequency is varied, so that there are peaks and troughs in the frequency response.

UNWANTED EFFECTS

The intention of the transducer is to launch a surface wave, but we can deduce from the law of the conservation of misery that it will do other things as well. Fig.3 shows how a bulk wave can be launched at a frequency outside the passband of the surface waves launched by the transducer. As the diagram shows, this bulk wave can couple signals from input to output and thus degrade the out-of-band response. This effect is minimised by mounting the crystal on an acoustically absorbent base.

Another effect which can cause problems is called triple transit. What happens is that a wave launched from the sending transducer is reflected from the receiving end and then reflected back from the transmitting end again, so that it is finally received by the receiving transducer after three times the normal time delay. By this time the dignal is much attenuated, and of course we are only dealing with in-band signals anyway, but it can cause ripples in the passband and can smear signals in the time domain. This would clearly be

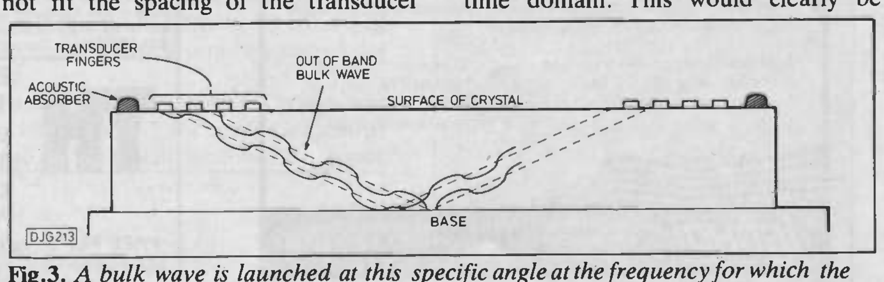


Fig.3. *A bulk wave is launched at this specific angle at the frequency for which the contributions from each part of the transducer are in phase. Despite loss on reflection, some signal reaches the other transducer.*

important if the filter were to be used in an application where accurate pulse response is important, such as television or radar receivers.

At first sight it might seem that triple transit could be reduced almost to nothing by using a well matched acoustic absorber at the receiving end, but this is not the whole story. Even if we assume that the absorber is so well matched that it appears to the signal just like an infinitely long piece of crystal, the mere presence of a transducer will disturb things. If the transducer is actually loaded with a matched electrical load the disturbance is far worse. The effect can be likened to teeing a 50Ω load in the middle of a long 50Ω cable. Reflections will inevitably occur from the tee point.

If the send and receive transducers are not electrically matched, the attenuation of the filter can be very high. To quote an example, the Signal Technology BP1102 70MHz bandpass filter (2MHz bandwidth) is quoted as having input and output impediances in series with 10pF. At 70MHz, 10pF has an impedance of 227R, so any input signal will be significantly attenuated before it reaches the crystal unless the capacitance is tuned out by means of a series inductor.

The attenuation of this device is quoted in the data sheet as 24dB, but this is with the use of matching inductors. Without them, an attenuation of 44dB is measured. Unfortunately, even with this narrow bandwidth the response is degraded due to triple transit if matching is used, and the effect is worse with higher bandwidths.

If the loading on the transducers is minimised, there is still a certain amount of reflection from the transducer fingers simply due to their presence. A simple transducer layout would involve metalisation covering about half the total area of the transducer. The middle part of each finger does not contribute much to the perfomance so it can be omitted, thus reducing the mechanical loading on the acoustic wave and hence cutting down the reflection. This type of pattern is illustrated in Fig.4.

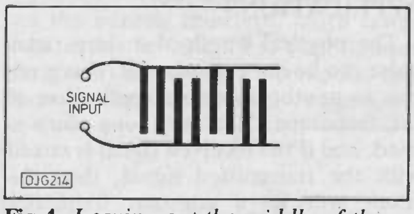


Fig.4. *Leaving out the middle of the transducer finger in this manner considerably reduces the mechanical loading on the crystal.*

MATERIALS

There is one saving grace for some wider bandwidth filters. A more efficient material is often used. For narrow bandwidth filters quartz is the usual material, but for wider bandwidth devices lithium niobate or lithium tantalate is used. These materials have a piezoelectric response which couples more effectively to the transducers, so that matching is not normally necessary.

There is another disadvantage to the use of lithium niobate and lithium tantalate, though. The quartz ST cut substrates (similar to the AT cut used for oscillator crystals) has almost zero temperature coefficient. Lithium niobate, on the other hand, has a temperature coefficient of about –90 PPM/°C, so the centre frequency of the filter depends on the temperature. This causes problems for some military and telecomms applications.

APPLICATIONS

One of the major applications of s.a.w. devices is filtering, so it is worth considering a couple of types of design in use. It is worth noting that probably the largest volume for s.a.w. devices of any sort is as i.f. filters in domestic television sets. In this applicatioon they can keep costs down and performance up, as the performance of filters available at a very low cost in quantity is very good. Misadjustment in production and degradation in use no longer represent problems, which has also helped.

First of all consider the bandpass characteristics. A rectangular transducer like the one shown in Fig.2 will give an approximately sin(x)/x frequency response. The approximation is due to the finite number of elements in the transducer. In general the frequency response of a s.a.w. device approximates to the fourier transform of the apodisation (phase and weighting) function of the transducer. This last is intuitively obvious because if you hit the transducer with an impulse you will generate a time response corresponding with the transducer pattern.

To generate a bandpass filter function, a sin(x)/x transducer pattern is used, as illustrated in Fig.5. Of course, there would be many more fingers to the transducer in a real design. In this design, the amount of overlap of the fingers determines the relative amplitude of the wave launched from each part of the transducer, and the relative placement controls the phase. Thus we have a filter design in which the amplitude and phase characteristics are almost independent. This is specially important in radar, television, and digital data applications, where an

Fig.5. *This pattern, used in conjunction with a broadband transducer, will give a bandpass response.*

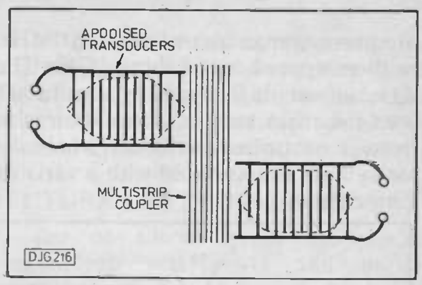


Fig.6. *The multistrip coupler prevents the two apodised transducers from interacting.*

uneven phase response can cause serious degradation of the pulse response.

In general, to provide any particular frequency and phase response, a numerical inverse Fourier transform is carried out on data representing the desired frequency and phase response and, with the application of fudge factors to compensate for the fact that a theoretically infinite function has to be represented by a finite number of elements, the resulting data specifies the transducer pattern. For anyone keen on the maths of filter design, s.a.w. filters can be designed with a vast number of zeros, but no poles.

So far, the filter designs we have looked at consist of one apodised transducer which determines the frequency response, and one broadband transducer. The reason for this is that if two apodised transducers were used, the resulting filter response would be that of each of the transducers multiplied together. This would multiply the problems of design, and of manufacturing tolerances. To avoid this problem, and to gain the advantage of cascaded filters, a multistrip coupler is used. This serves as a broadband transducer which receives and relaunches the wave to a second apodised transducer which is offset from the first one. This technique is shown in Fig.6.

Another interesting transducer arrangement is possible. Because amplitude and phase response can be determined separately, it is possible to design a filter with a specified amplitude response but employing carefully phased transducers which only launch a wave in one direction (in band) and cancel the reverse wave. In this way, the otherwise minimum loss of 12dB can be cut almost to nothing, so that the overall efficiency depends on the piezoelectric coupling efficiency and the accuracy of the electrical matching. Of course, this type of design has the problems of response ripple and non-linear phase response as might be expected.

OSCILLATORS

Two types of s.a.w. device are used as frequency determining elements in oscillators. The one most like unto a filter is the delay line. Delay lines are used top make oscillators in the frequency range above about 500MHz, with an upper limit of about 3GHz. The Q is not very high, typically about 1000, and the main area of application is in voltage controlled oscillators, where the delay lines is associated with a variable phase shifter.

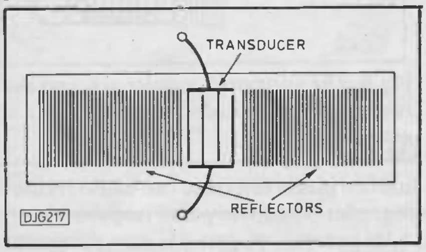


Fig.7. *A single resonator*

It is also possible to make a resonator, which works much like a microwave cavity resonator. This technique is shown in Fig.7. The Q can be as high as 6,000,000, which is higher than that available from an ordinary bulk mode resonator, in other words the familiar quartz crystal. The frequency range is from about 50MHz to about 1GHz, and the main application is in oscillators requiring excellent spectral purity and very low phase noise. This can be important in some microwave applications.

As with tuned circuits, resonators can be applied to filters as well as to oscillators. The coupled resonator pattern shown in Fig.8 provides a narrow bandpass response with a low loss.

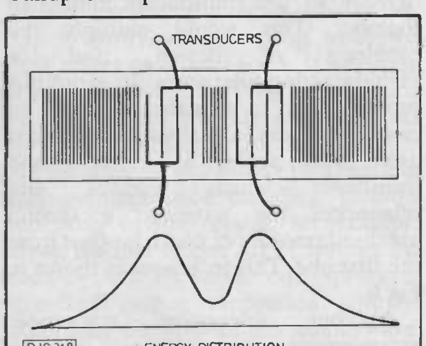


Fig.8. *A pair of coupled resonators*

CHIRP RADAR

Chirp radar uses the same principle that bats use to lower the peak pulse power while keeping the energy content high enough to be useful. The frequency of the transmitted pulse is swept in a controlled manner during transmission. Though the pulse may have a long duration, and therefore occupy a large spatial length at any particular frequency bandwidth is short. If the inverse of the function used to sweep the frequency is employed at the receiver, the pulse is effectively compressed as accurately as the match between the transform used on transmit and its inverse used on receive.

This technique enables the bat to generate acoustic radar pulses which have enough energy to give useful range, without demanding more peak power than it can supply. The same argument applies to semiconductor radar transmitters, which cannot provide, for example, a 100ns long pulse with a peak power of 1kW, but which may be able to provide 10W for 10μs.

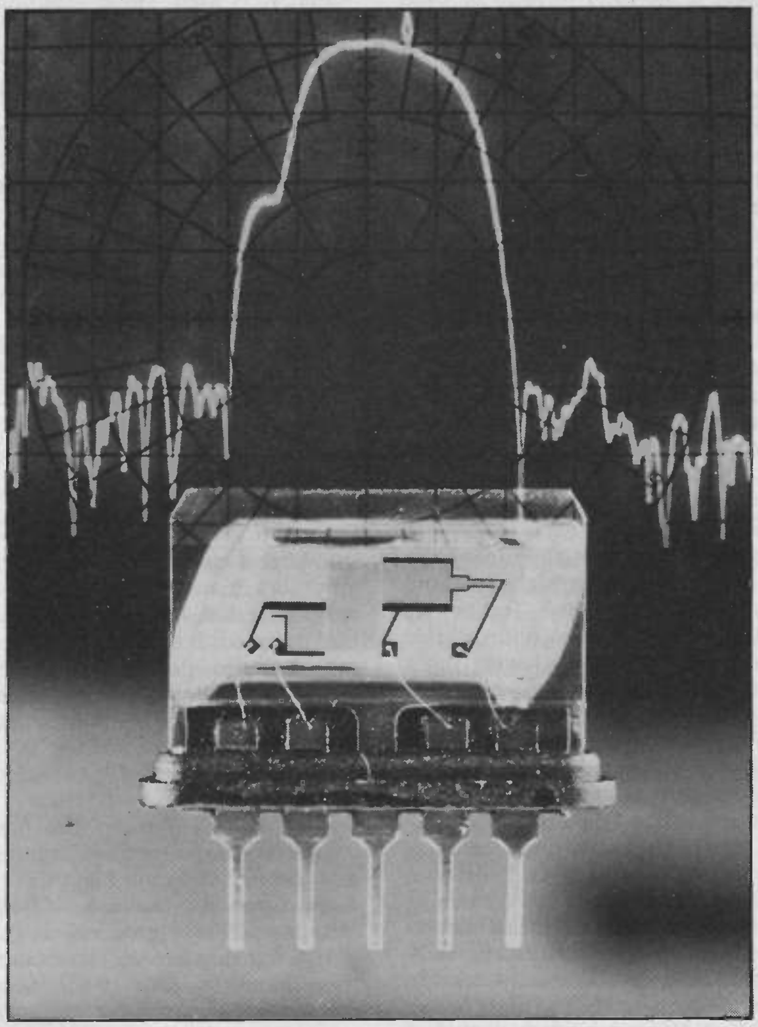


Photo.1. *A Siemens of W361 S. A. W. filter pictured against its frequency response curve*

The chirp may be generated by feeding a pulse into a dispersive surface acoustic wave (d.s.a.w.) delay line. A dispersive line is one which has a different time delay for different frequencies. An impulse contains a wide spread of frequencies, and a dispersive delay line disperses these frequencies. This type of effect can sometimes be observed when passing through a tunnel supported on one side by pillars. Interference effects mean that the angle subtended to the pillars along the tunnel affects the frequency preferentially reflected, so that superimposed on the echoes of say a handclap is a kind of wheep noise, as different frequencies are reflected from pillars a different distance away.

Approximately this principle is used in a s.a.w. dispersive delay line. Fig.9 shows four different dispersive delay line techniques – all of these use a different path length for different frequencies. To reconstitute a pulse from the chirp a delay line with the inverse spacing of the dispersive elements is used.

Normally a linear frequency sweep would be used for the chirp, because with this type of chirp a doppler shift simply manifests itself as a slight tuning offset. Other chirp laws are poaaible, however, and can give better signal to noise ratios for any given sidelobe levels and main lobe spreading.

OTHER DISPERSIVE APPLICATIONS

The physical length of a chirp radar pulse can be quite substantial. This gives rise to another possible application of the technique. If a very long chirp is used, and if the received signal is mixed with the transmitted signal, then the result will be a constant frequency dependent on the range. Clearly this is only suitable when there is only one substantial target, but it is ideal to produce an altimeter. The ground is certainly a substantial target.

This type of radar altimeter is even suitable for use in satellites, though I don't know whether it is used in this application at present.

Another fairly obvious application of a dispersive delay line is as a spectrum

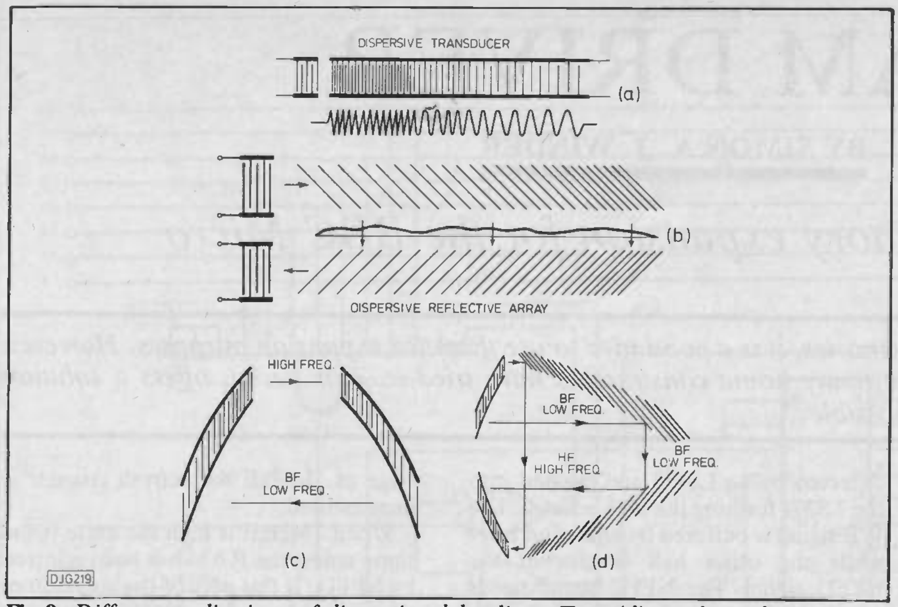


Fig.9. *Different realisations of dispersive delay lines. Type (d) can have dispersive transducers and dispersive reflectors, thus allowing a greater range of responses to be achieved*

analyser. If a burst of signal is fed into the input of a line, the output will be a time representation of the frequency spectrum of the input. To put it another way, if the output envelope were displayed on an oscilloscope synchronised with the input signal burst, you would see the familiar spectrum analyser display.

The spectrum analysis is not completely accurate because the act of gating the signal input to the line introduces sin(x)/x sidelobes to the signals. The longer the burst of input signal, the less effect the sin(x)/x sidelobes have but the longer the minimum time output per unit frequency, hence the less the resolution. In addition to this, the finite number of elements in the line imposes a limitation, but despite all these factors this type of device is very useful. It does, in fact, provide an accurate Fourier transform of the input signal.

CONVOLUTION

The s.a.w. Fourier transformer carries out the Fourier transform much faster than even the best f.f.t. (fast fourier transform) algorithms on computer can manage. The s.a.w. convolver (no weed this) is similarly ahead of the competition in its field.

Mathematically, convolution is the integral of two functions multiplied together. In electronics this process may be used for signal processing in spread spectrum telecommunication systems, or as a correlator to recognise a specific code, which must be applied repetitively to one of the inputs of the device. A possible layout for a convolver is shown in Fig.10.

In a convolver, two signals are concentrated so that when they interact under the convolution electrode, they mix non-linearly giving rise to the product of the two signals. The electrode integrates this product, and the output is the convolution product of the two input signals with a time compression of 2.

If a signal r(t) is repetitively applied to one input, with a repetition rate equal to twice the time delay in the device, it will perform, with respect to the other input, as a filter with impulse response r(t). The time compression means that gating must be applied to the output, but if this is carried out correctly an adaptive filter is possible because the input r(t) can be changed to fit current requirements.

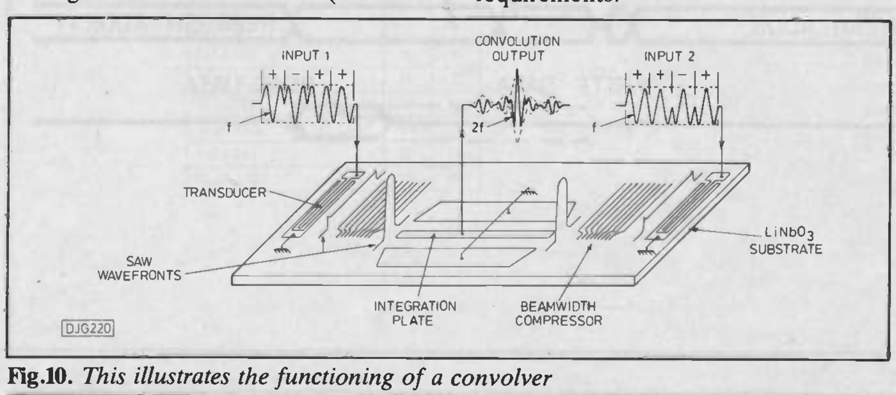


Fig.10. *This illustrates the functioning of a convolver*

In this type of device, the maximum duration of the signal to be convolved is set by the length of the convolution electrode, and the useful bandwidth is limited by the transducers.

FUTURE DEVELOPMENTS

Ten or fifteen years ago s.a.w. technology was novel and under development. Now it is a standard part of the engineer's armoury, and a vast range of off-the-shelf devices is available. Development is still taking place, however, to improve various device parameters and so open up new market areas. This is carefully necessary for the producers of s.a.w. devices, because as the speed of available digital processors increases they take over applications previously reserved for s.a.w. For example, there is no reason in principle why the chirp transmitted in a chirp radar should not be generated digitally, even if a sa.a.w. device is needed for the receive processing.

A whole new application area awaits when the loss in s.a.w. filters can be reduced to about 2dB, when roofing filters for television tuners will be practical. In this application, the signal from the aerial is fed into a s.a.w. filter having a frequency range of say 400 to 800 MHz. This will allow television signals through with minimal attenuation, while cutting out unwanted signals such as the police radios, CBs, radio amateurs to name but a few. Narrower bandwidth low loss filters could serve in portable telephones, pagers and the like as input filters connected to the aerial.

Such market expansion should ensure that s.a.w. devices are with us for the forseeable future.

RAM DRIVER

BY SIMON A. J. WINDER

Low/cost memory expansion for the BBC Micro

With the falling price of dynamic memories, it is a good idea to use them for expansion purposes. However, interfacing them is difficult and not many home constructors have tried it. This design offers a solution using as few extra components as possible.

READERS may be aware of the advantages of dynamic RAMs in terms of cost and size but, due to the complexity of control required, together with the necessity for refresh, may find difficulty in interfacing these DRAMs to their home micros. This circuit was designed to drive a bank of eight 4164-15 RAM i.c.s from the BBC's 1MHz bus resulting in an extra 64K RAM paged in the usual way.

The eight RAM i.c.s have all their address and control lines connected in parallel to the corresponding outputs from this circuit. The D and Q pins are connected together on each i.c. and taken to a data line from the bus, so that eight i.c.s make up a byte.

Paging is performed by writing the page number to &FCFF which is detected by an LS133 and latched into the LS374 forming the high address. The $\overline{WE}$ signal is buffered by half of an LS74 while the other half de-glitches the NPFD signal. The NPFC signal needs no de-glitching in this application.

The circuit produces the signals for $\overline{RAS}$ only refresh cycles while 1MHzE is low, and read/early write cycles when 1MHzE is high.

When 1MHzE is low the refresh address, from an LS393 counter, is presented to the RAM address bus. A pulse of about 50ns duration is produced on both edges of 1MHzE by an LS86 to trigger half of an LS123 to produce the $\overline{RAS}$ cycle. When this monostable times out (160ns later) the $\overline{RAS}$ line goes low latching the low address or refresh address into the RAMs. On the leading edge of 1MHzE the refresh counter is incremented.

When 1MHzE is high the cycle is the same unless the RAM has been selected by NPFD. If this occurs, the signal from the second half of the LS123 is gated to the $\overline{CAS}$ line latching in the high address which comes from the enabled LS374. $\overline{CAS}$ is brought high again when 1MHzE returns low, causing the RAM outputs to be tri-stated off after a read. The 100R resistors help prevent ringing on the strobe lines.

The circuit should need no buffering if used on its own and should be well decoupled with 47nF capacitors.

This description is simplified because in actual fact the individual gate propagation delays are crucial to the circuit's operation. PE

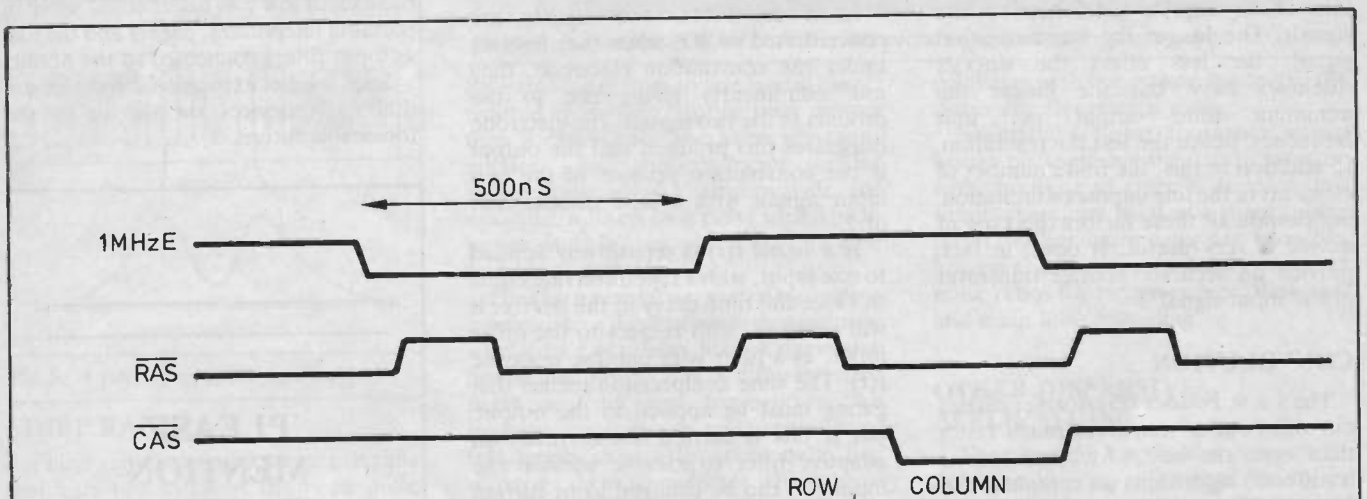
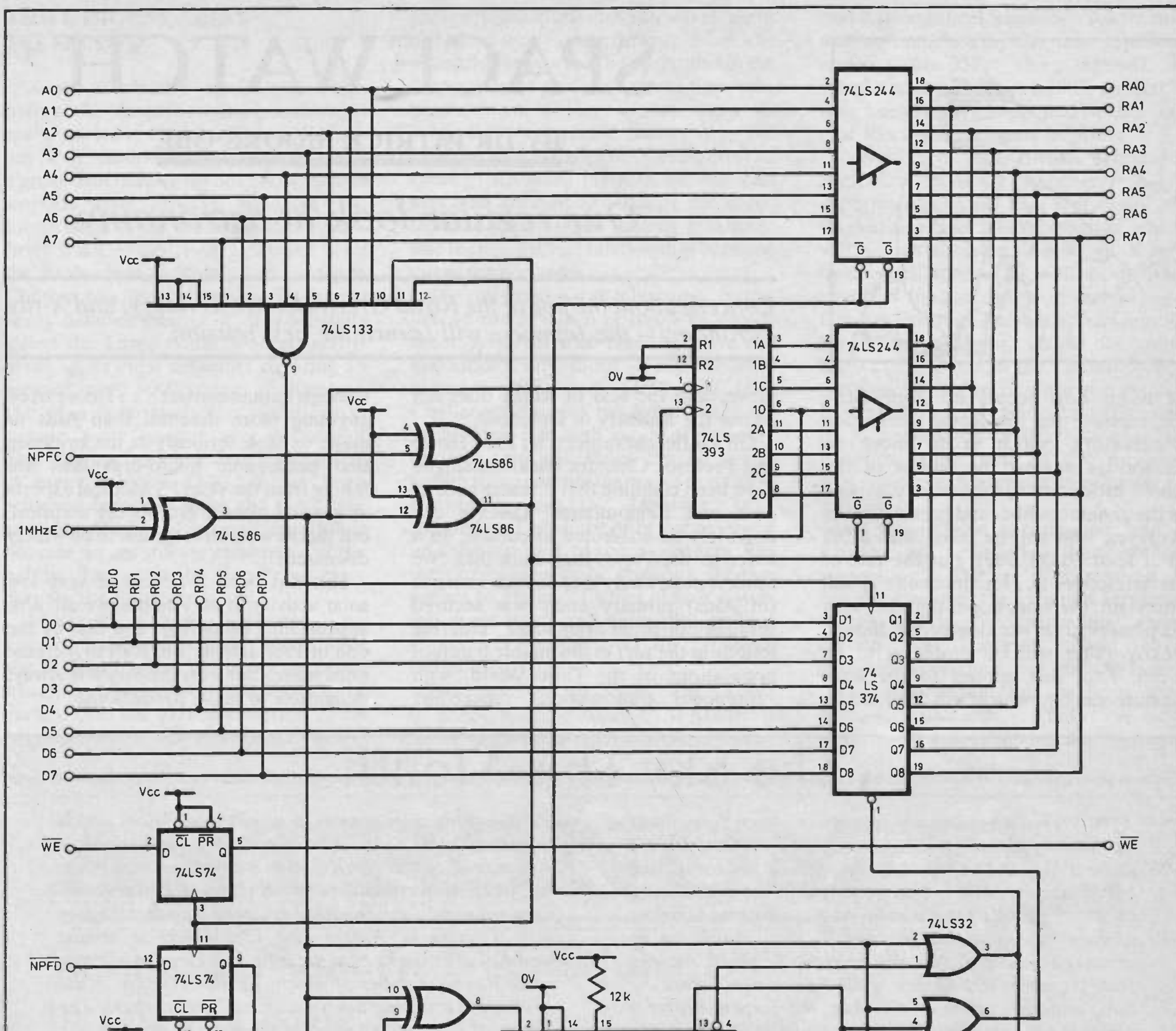


Fig.1. *The timing diagram for the RAM interface*



POWER SUPPLY CONNECTIONS

IC TYPE	Vcc	0V
4164	8	16
74LS86	14	7
74LS32	14	7
74LS133	16	8
74LS74	14	7
74LS123	16	8
74LS393	14	7
74LS244	20	10
74LS374	20	10

Fig.2. *Circuit diagram and connections*

SPACEWATCH

BY DR PATRICK MOORE OBE

Our regular look at astronomy

Concern about the fate of the Royal Greenwich Observatory; and X-ray astronomy – the Japanese will launch the next mission.

THERE now seems no hope of a reprieve for the Royal Greenwich Observatory, which is to move to Cambridge against the wishes of the whole astronomical community as well as the general public (and presumbly the taxpayer, who will be faced with a bill of at least £6,000,000), but the fate of the telescopes at Herstmonceux is still uncertain; there are hopes that they may be preserved in working order, though clearly there will be problems to be faced. This also applies to the laser satellite ranger, which will be hard to move, and the loss of which does not please the Ministry of Defence.

On a different subject, Sir Fred Hoyle and Profesor Chandra Wickramasinghe have been claiming that diseases such as Aids and Legionnaires' Disease can definitely be attributed to comets. In a letter to the Press, they state that "we think it most likely that in each instance (of Aids) primary entry was secured through infected rainwater entering lesions in the feet in the mainly barefoot populations of the Third World, with subsequent transmissions proceeding through human contact . . . Do we need anything more dreadful than Aids to make us look seriously at the evidence that pathogenic micro-organisms are falling from the skies?". Medical experts in general remain profoundly sceptical, but this new claim is certain to be widely discussed.

This has been a period of very low solar activity. It may be that we are now approaching minimum, and that by the end of 1987 activity will start to increase once more, but with the Sun it is always dangerous to make predictions!

The Sky This Month

THIS is not a particularly good month from the point of view of planetary observers, though Venus continues to be a brilliant object in the south-east for some time before sunrise. Mars remains visible in the west during the evening, but its magnitude has now dropped to below 1; large telescopes are needed to show much on its shrunken disk. Jupiter is also on view after dark, moving from Aquarius into Pisces, while Saturn rises before the Sun, and remains in Ophiuchus, the Serpent-bearer – which is not officially a Zodiacal constellation, but which does intrude into the Zodiac between Scorpius and Sagittarius.

This leaves Mercury, which is an evening object for much of February, and reaches its greatest eastern elongation from the Sun (18 degrees) on the 12th. It is surprisingly bright; the magnitude on February 4 is 0.9, brighter than any star in the sky apart from Sirius, though of course Mercury can never be seen against a dark background, and one has to bear in mind how brilliant it really is. The planet reaches inferior conjunction on the 27th, so that before then it will of course be lost to view.

Last month I wrote about the "Schröter effect", or discrepancy between the theoretical and observed phase of Venus. Whether there is also a Schröter effect for Mercury is not so certain, but adequately-equipped observers may care to investigate.

The theoretical phase is 80 on February 5, 65 per cent on the 9th, dichotomy (50 per cent) on the 12th, and only 20 per cent on the 19th. The apparent diameter ranges from just over 5 to just over 8 seconds of arc – much the same as that of Mars at the moment.

Halley's Comet, still in the Crater area, is now too faint to be seen with instruments of the size used by most amateurs. Of the non-periodical comets on view, Wilson's has dropped into the far south, but Sorrells' comet reaches perihelion on March 9, and should be observable even though its magnitude during February is below 11.

The evening skies are now dominated by Orion, which is unmistakable; Sirius is also at its best, and seems to flash various colours even though it is in fact a pure white star. (Ancient astronomers called it red, but it certainly is not red today, and frankly I am quite sure that it never was!) Capella in Auriga (the Charioteer) is almost overhead after dark; note the little triangle of stars close beside it, one member of which, Epsilon Aurigæ, is the remarkable eclipsing binary with a 27-year period. The Square of Pegasus is setting in the west; in the east, the main constellation of spring, Leo, is coming into view.

The most famous of all eclipsing binaries, Algol, is high up after dark. Every 2½ days it fades from its normal magnitude (2) down to 3.4, remaining at minimum for a mere twenty minutes and then taking four hours to regain its lost light.

This month, minima at convenient observing times are due on the 2nd, at 02h.4; the 4th, 23h.2; the 7th, 20h.0; the 25th, 00h.9; and the 27th, at 21h.8. It is always interesting to see how Algol changes in brightness over periods of only a few minutes during the course of an eclipse.

Another variable star in the news is SU Tauri, in the Bull. This is an R Coronæ star, usually about magnitude 9.7, but which at unpredictable intervals falls by several magnitudes. The latest fade began last November. Whether SU Tauri will have returned to maximum by February cannot be forecast much in advance; but of course, telescopes of reasonable size are needed to show it at any time. Evidently the fadings of R Coronæ stars are due to the accumulation of 'soot' in their atmospheres. From Britain, R Coronæ itself, in the 'bowl' of the Crown, is the only star of the class which is on the fringe of naked-eye visibility when at maximum.

PE

THE LARGEST X-RAY TELESCOPE

X-ray astronomy could not begin before the development of rockets; it really started in 1963, but although much has been learned since then there is still a great deal that we do not know. British workers have always been in the forefront of X-ray research, and a team from the University of Leicester, with the Rutherford Appleton Laboratory at Chilton, has now completed the largest X-ray detector ever built. It is officially called the Large Area Counter, and is made up of eight detectors covering an area of some 5000 square centimetres. The plan is to study the variations in cosmic X-ray sources over periods of time ranging from less than a second up to many months. This has not been achieved before in quite the same way, and is clearly of great importance because we are still very uncertain of the nature of some of the X-ray emitters – notably the 'bursters'.

Moreover, it seems that some X-ray sources are associated with black holes, the famous Cygnus X-1 being the prime example. Material which is about to be sucked over the eventual horizon of the black hole is so intensely heated that it gives off radiations at X-ray wavelengths before disappearing forever from the accessible universe. The variations in the X-ray sources give a clue as to their size, because an object cannot vary its luminosity in a period shorter than the time taken for light (or X-radiation) to cross it. Knowing the size, we can also make an attempt to estimate the mass, because with a black hole or a neutron star there is a direct relationship between diameter and mass.

We can build X-ray telescopes, but as yet we are not in a position to launch them ourselves. The Russians have not announced any more X-ray missions before 1990 and, following the Challenger disaster, the American space programme is in such a state of dis-array that no time schedules can be given. Under these circumstances we must look elsewhere, and the Japanese have stepped in. They have only just emerged into the top rank of space pioneers, but their first 'deep-space' missions, the two probes to Halley's Comet almost a year ago, were completely successful, and we all have a great respect for Japanese technology.

The satellite to carry the X-ray telescope is called Astro-C. It has been tested at the Japanese Institute of Space and Astronautical Science in Tokyo, and will be launched by the new Japanese rocket, Mu-352. The take-off is scheduled for February 1987, so that it may already have happened by the time that this article appears in print.

Apart from the British telescope, Astro-C carries another X-ray experiment, from the University of Osaka; this is an all-sky monitor, which will search for short bursts of X-rays from weak sources as well as obvious changes in the more powerful and familiar emitters. There is also a Gamma Ray Burst detector, which has come from Los Alamos in the United States; the plan here is to monitor the sky for isolated flashes of gamma-rays. This will be of tremendous interest, because we have to admit that at the moment gamma-ray astronomy is very much in its infancy.

All this is most encouraging, and it stresses, yet again, that there are no international barriers in astronomy. A few decades ago, the idea of a Japanese rocket carrying experiments from Britain and America would have sounded far-fetched, but nothing is less remarkable today. Let us hope that Astro-C succeeds. There is no conceivable reason why it should not.

THE PE 30 PLUS 30

PART TWO BY GRAHAM NALTY

An amp of excellence!

The PE 30 + 30 is a very high quality amplifier with engineering features and sound quality well in advance of any comparable manufactured amplifier. With its high quality case, it will look as well as sound attractive in any hi-fi environment. See February issue for part one.

Try to make each solder joint the best you have done as poor solder joints can cause inferior sound, or even cause failure. When you have completed the soldering, check the board for bits of solder bridging tracks by holding up to the light.

You can now fit the transformer, mains circuitry and reservoir capacitors into the case. It may be a good idea to leave off the front panel and heat sink until after you have tested the working of the board in case you need to take the board out. The front panel is attached to the case by the fixing nuts for the mains switch and headphone sockets on the left and by double sided sticky tape on the right.

When the amplifier is completely wired (it may be helpful at this stage to leave off the wires from the CD and radio inputs) you can now test it. Examine every component visually one last time to spot any errors you may have failed to detect. Take out the fuses on the p.c.b. and solder a high wattage resistor of 50 ohms to either end of each fuseholder. Next turn VR5 fully anticlockwise for minimum bias voltage to the output transistors. Switch the mains on and check all the voltages at the test points with a digital (ideally) or analogue multimeter. To allow for voltage drop across the resistors, the voltage should read about 80% of the working voltage for that point except voltages across diodes or at the outputs of IC1 and IC2 and in the disc circuitry. With a stereo amplifier, an error in one channel may not be repeated in the other so this makes finding possible faults easier.

When all the test voltages are OK, you can now set the quiescent current in the output transistors. I would suggest that you set the quiescent current at around 40 mA. A higher quiescent current will give you more 'depth' to the sound, if you know what I mean, but will make greater demands on the heat sink. There are a number of ways to do this:

1. With an oscilloscope set to DC, observe the voltage drop across R49 and R50 in each channel. For a 40 mA quiescent current the DC volts drop across R49 and R50 combined should read 12mV.
2. Use a digital multimeter to measure the voltage drop.
3. Using an analogue multimeter, observing the increase in volts drop across either of the resistors (R66,67) which bypass the fuseholder.
4. To increase the current, turn VR5 (VR105) slowly until the required reading is achieved. If you are using the analogue multimeter across the resistors bypassing the fuseholder, adjust until the voltage reading has increased by 2v for each channel.

The final check is to set the output offset voltage. With the value of R35 selected (220K), the offset should be within 200mV either way, which I regard as a maximum limit. Above this there is an unwelcome noise when you connect the speakers to the amplifier. If the output offset is positive, you can reduce it by increasing the value of R35; if negative you can reduce the offset by decreasing R35. Some readers may prefer to use a 470K preset pot in place of R35, but my own preference is for a little bit extra DC offset rather than an extra wiper contact in the circuit.

The amplifier as described is capable of excellent sound quality. However, you can only achieve the sound quality of the prototype if you follow the instructions faithfully and, very important, use components of the quality specified. If, for example, you use ordinary 1% metal film resistors in place of the Holcos, you may save about £3, but you may well have an amplifier that sounds quite a bit inferior to the prototype. If you wish to use better components than specified you can be sure of even better sound than the prototype. In this amplifer, resistors can be more easily upgraded than capacitors, because of space considerations. Even though Holco resistors sound noticeably better than low cost 1% metal films, the improvements in using bulk metal foil resistors with temperature coefficients down to 5 parts per million per degree centigrade and better in critical parts is remarkable. Other possible improvements are the use of gold plated photo and loudspeaker sockets, silver plated switches and Kimber cable for internal wiring. Although Kimber cable is quite expensive, it is the only cable I have found so far which sounds extremely good and is an acceptable size for internal wiring. Also you may change TR9 and TR10 to a dual matched pair such as MATO1GH. This may well give audibly better sound as a result of close matching and closer temperature tracking. The same may well apply to TR11 and TR12.

PE

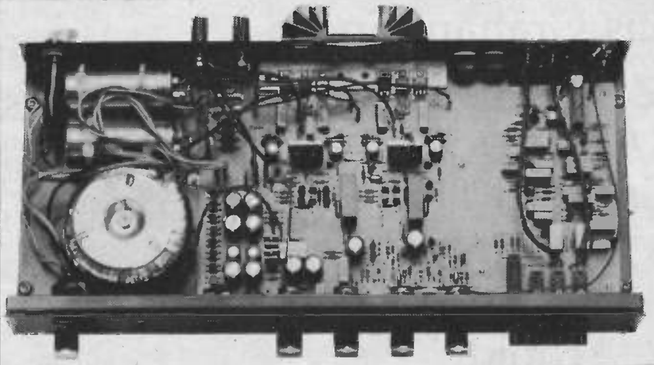


Photo.1. *Internal view of the PE30+30*

Photo.2. *External view of the PE30+30*

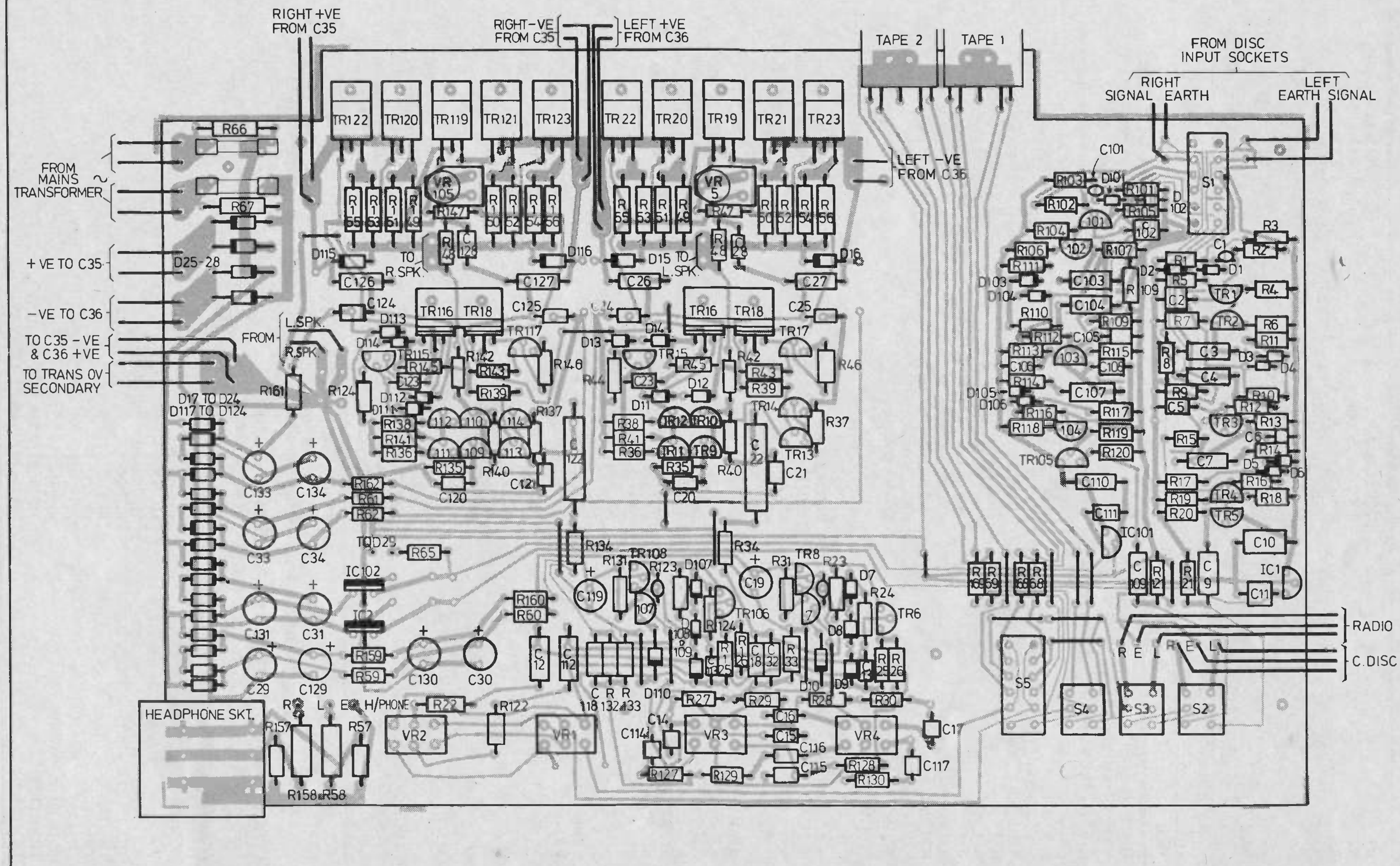


Fig.1. *Printed circuit board design and component layout of the PE 30 + 30.*

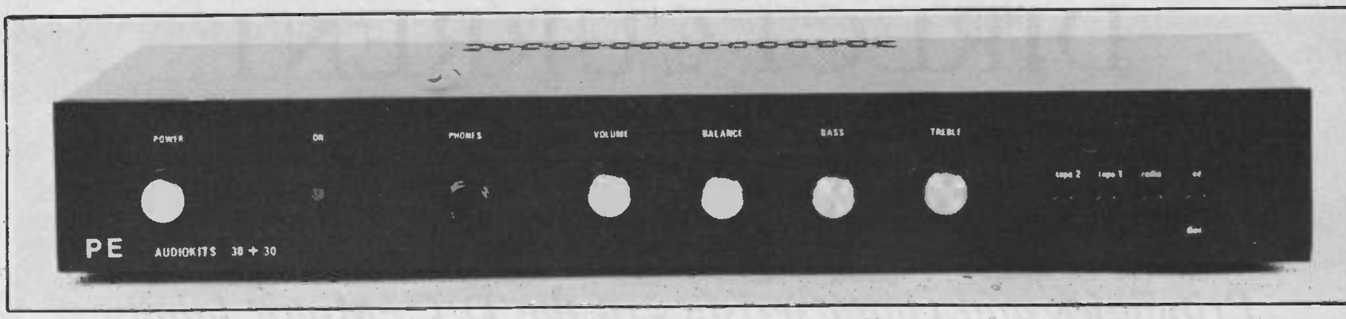
PARTS LIST FOR MOVING COIL STAGE

	Standard kit	Improved performance
R1	100R Holco H8	100R Bulk metal foil
R2	10K 2% metal film	10K Holco H8
R3	47K 2% metal film	47K5 Holco H8
R4,R6	100R 1% metal film	100R Holco H8
R5	22R 1% metal film	22R1 Holco H8
R7	470R 1% metal film	475R Holco H8
R8	220K 2% metal film	221K Holco H8
C1	10μF 6.3v tantalum	
C2	10nF Polycarbonate	10nF Polystyrene
C3	470nF Polyester	470nF Polycarbonate
D1,D2	1N4148	
TR1	2SD786,2SC2385	
TR2	2SB737,2SA978	
S1 + button	4P C/O	4P C/O ITT FOX-N silver plated

Holco H8 resistors are specified as 0.5% tolerance 50 ppm/°C temperature coefficient.

PARTS LIST FOR MAIN AMPLIFIER

	Standard Kit	Improved performance
R9	68K1 Holco H8	68K Bulk metal foil
R10,R16,R35	220K 2% metal film	221K Holco H8
R11,R17,R23,R24,R31,R39,R41	47K 2% metal film	27K5 Holco H8
R12,R18,R22,R26,R29,R30,R33,R36,R38	1K 1% metal film	1K Holco H8
R13	27K 1% metal film	27K4 Holco H8
R14,R59	3K3 1% metal film	3K32 Holco H8
R15	1K5 1% metal film	1K5 Holco H8
R19,R65,R43,R45	22K 1% metal film	22K1 Holco H8
R20,R65	4K7 2% metal film	4K75 Holco H8
R21	470K 2% metal film	442K Holco H8
R25,R32	6K8 1% metal film	6K81 Holco H8
R27,R28,R63,R64	10K 1% metal film	10K Holco H8
R34	4K75 Holco H8	4K7 Bulk metal foil
R37,R58	330R 1% metal film	332R Holco H8
R40	2k21 Holco H8	2K2 Bulk metal foil
R42	221K Holco H8	221K Bulk metal foil
R44	15R 2% metal film	15R Holco H8
R46	47R 2% metal film	47R5 Holco H8
R47	470R 2% metal film	475 Holco H8
R49,R50,R53,R54	OR15 2½w w/w	–
R49–R56	–	Holco H2 1% 1RO
R57	680R 1W	Holco H2 1% 681R
R60	2K2 2% metal film	2K21 Holco H8
R61,R62	100R 2% meal film	100R Holco H8
R66,R67	47R 2½-5w w/w	
VR1	100K MN balance	–
VR2	50K Log stereo	–
VR3	100K Lin stereo	–
VR4	10K Lin stereo	–
VR5	2K2 Horizontal preset carbon	– cermet
C4,C19mC12mC32	470nF Polyester	470nF polycarbonate
C5,C13	100pF Polystyrene	–
C6	33nF 5% Polyester	–
C7	100nF 5% Polyester	–
C8,C11,C28	220nF Polyester	220nF Polycarbonate
C9	1uF Polyester	1uF Polycarbonate
C14,C15	47nF 5% Polyester	–
C16,C17	10nF 5% Polyester	10nF 2½% Polystyrene
C19	220uF 25v radial	220uF 25v Mullard 108
C21	470pF Polystyrene	–
C22	4.7uF Polycarbonate	–
C23	47pF Polystyrene	
C24,C25,C31	100uF 40v radial	100uF 40v Mullard 108
C26,C27	10uF 40v axial	22uF 40v Mullard 108
C29,C30,C33,C34	220uF 40v radial	220uF 40v Mullard 108
C35,C36	6800uF 35v can	10,000uF 40v BHC ALS20A
D3–D14	1N4148	–
D15–D24	1N4002	–
D25–D28	1N5401	–
D29–D31	green l.e.d.	–
IC1	MC7L815	–
IC2	MC7818CT	–
TR3,TR5,TR6–10,TR14,TR17	BC184C	–
TR4,TR15	BC214C	–
TR11–TR13	BC547C	–
TR16	BD244C	–
TR18,TR19	BD243C	–
TR20 (TR22)	TIP131,BDW73B,BDT63A,BDW93B	–
TR21 (TR23)	TIP136,BDW74B,BDT62A,BDW94B	–



PARTS LIST

All the above parts are duplicated for the other channel except;
R64,R65.
VR1–VR4
C35,C36
D25–D29

	Standard Kit	Improved performance
S2–S4	2P C/O	2P C/O ITTFOX-N
S5	4P C/O	4P C/O ITTFOX-N
S6	2P mains switch	–
Buttons for push button switches	–	–
2 5 pin DIN 180° sockets	–	–
6 Phono chassis sockets	–	Phone socket – gold
5 Knobs	–	–
4 PCB fuse mounts	–	–
1 fuseholder 5 x 20mm	–	–
2 3.15A fuses	–	–
1 2.5A fuse	–	–
1 fuseholder cover	–	–
1 rectangular cover	–	–
2 4mm terminal sockets black	)	Mitchell amplifier
2 4mm terminal sockets red	)	terminals
2 Brackets for driver transistors	–	–
1 VDR 26j	–	–
1½m 3 core mains cable	–	–
1 ⅜" dia grommet	–	–
4BA and 6BA nuts, bolts, washers and solder tags	–	–
6 6BA × ⅜" threaded spacers	–	–
1 Mains transformer 120VA 0–240V primary	22-0-22 secondary	25-0-25 secondary
5m assorted cable for internal wiring	–	5m Kimber cable

VOLTAGE TEST POINTS

From	To	Voltage
Junction D1,R3	0v	1.2
Collector TR2	0v	0.7–3
Collector TR3	0v	5–10
Emitter TR5	0v	4–9
Junction D7 R23	0v	1.8
Collector TR8	0v	16–26
Emitter TR8	0v	7–12
Base TR11	0v	1.2
Anode D13	Cathode D14	1.2
Base TR13	Emitter TR14	1.2
Base TR18	Emitter TR19	1.2

NEXT MONTH:
INFORMATION ON THE POWER SUPPLY, PLUS A FEW POINTS ARISING.

PCB IS AVAILABLE THROUGH THE PCB SERVICE
(see page 60).
A FULL KIT OF PARTS IS AVILIABLE FROM

Audiokits, 6 Mill Close,
Borrowash, Derby DE7 3GU.
Also see advert.

DIRECT CURRENT MOTORS

PART ONE BY BRIAN BROOKS

Principles and characteristics of the D.C. Motor family

D.c. motors are found almost everywhere. Typical domestic uses of d.c. motors are in cassette recorders, hair dryers, cameras, toys, battery powered shavers, and "cordless" kitchen appliances. In cars they drive the wipers, washers, ventilation fans and start the engine. In industry d.c. motors are used extensively, ranging in size from tiny micromotors in instruments right up to thousands of horsepower in steel mills and mines.

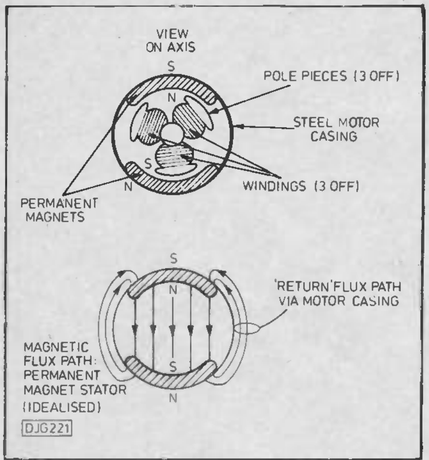


Fig.1.

PRINCIPLES

Despite the wide range of application, all d.c. motors operate on the same principle, that a wire carrying an electric current in a magnetic field experiences a force proportional to the current and the strength of the magnetic field. The force acts at right angles both to the current and the magnetic field, and its direction is reversed if *either* the current of the magnetic field is reversed. Reversing *both* the magnetic field and the current will leave the direction of the force unchanged — a property which enables some motors to run from both a.c. and d.c.

In permanent magnet (PM) Motors the magnetic field is provided by one or more permanent magnets guided by iron or steel pole pieces and sometimes the outer casing of the motor itself. Usually this is the stationary part of the motor. The wire which carries the current is wound on the rotating part of the motor and can be done in a variety of ways. The simplest way is that used in cheap model motors where a three pole laminated structure is used. Fig 1 shows the construction of a typical small model motor and the magnetic flux paths. The magnetic field is produced by two ferrite magnets, curved to fit inside the steel motor casing and magnetised through their thickness. This produces a strong magnetic field through the centre of the motor. Magnetic flux has to travel by closed paths and does so via the steel motor casing. Current flowing in one winding produces a force which turns the rotor to align with the magnetic field. At this point the rotor would remain stationary with no further tendency to rotate. However, if current was now connected to one of the other windings the rotor would again move and align in a new position.

Current is carried to the rotor by means of two "brushes" which make contact with a conducting ring on the rotor. This ring (or commutator) is divided into three segments arranged to work in conjunction with the brushes to switch the current from winding to winding as the motor rotates. Fig 2 shows the operation of the motor. In the position shown, current flows in one direction through the winding on pole B and in the opposite direction through the two other windings which are effectively connected in series. Pole B is attracted to the south magnetic stator pole and poles A and C are attracted to the north magnetic stator pole. These forces cause the rotor to move clockwise. A small clockwise movement brush contacting segment Z of the commutator. This has the effect of reversing the current in winding A (which is now in series with winding B). The direction of current flow in the other windings is left unchanged. Pole A now repels the north magnetic stator pole and motor rotation continues. The next action of the commutator is when pole B aligns with the south magnetic stator pole and the negative brush changes from armature segment Y to segment X. The current in the winding on pole B is thus reversed and pole B now repels the south

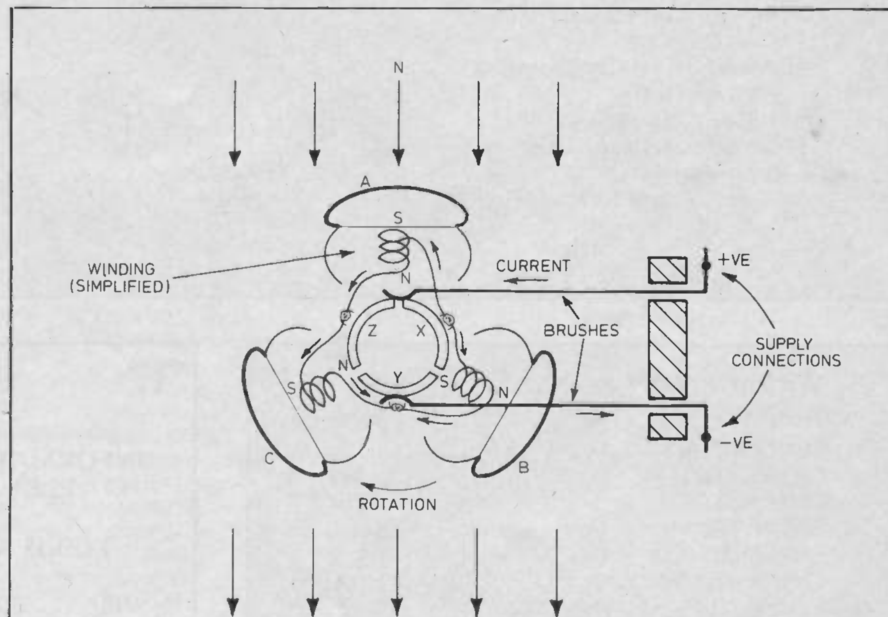


Fig.2.

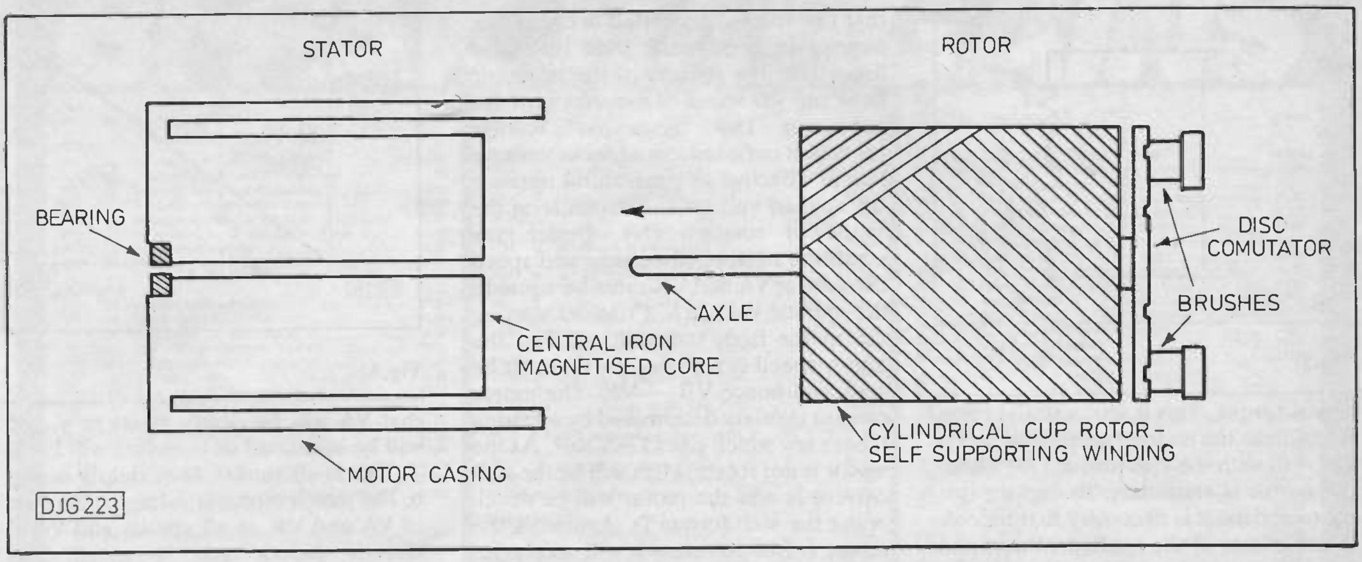


Fig.3.

magnetic stator pole. The whole cycle of rotation continues in this way with the current switched from winding to winding and reversed by the combined action of the commutator and brushes.

VARIATIONS

The three pole type of motor shown is about the simplest arrangement that will work satisfactorily. It suffers from several shortcomings but because of its simplicity it is compact and can be made cheaply. One such shortcoming is that the torque varies in the motor turns. At high speeds this is not a problem because the inertia of the motor and its load have a smoothing "flywheel" effect. Reliable low speed running is a problem however, with the motor tending to jump from one preferred position to another as it rotates.

These problems are solved in large motors by the use of rotors with larger numbers of poles, and corresponding numbers of commutator segments, along with carefully designed stators to give better distribution of the magnetic field. Some larger motors such as the ones used in better model railway engines have seven pole rotors and a circular ring magnet for the stator. This gives smooth slow running characteristics with low vibration and noise.

Larger motors have even greater numbers of poles (thirty or more in some cases) so that the rotor begins to look cylindrical, and the winding methods are more complicated. As well as these standard 'iron rotor' motors there is a variety of other types of construction to provide desirable characteristics for particular jobs. Servo control systems, for example, require low inerta motors for quick response. Motors for applications such as these are frequently of the "ironless rotor" type where the windings are in the form of a self supporting cylinder, open at one end with a disc shaped commutator at the other. A radial magnetic field in which the windings rotate, is formed between a central iron core and an outer cylinderical shell. Fig 3 shows this type of construction.

In another type of motor the rotor is in the form of a disc rotating between two circular magnets. Brushes on either side of the disc carry the current to the windings and the whole rotor assembly resembles a double-sided circular printed circuit board with the windings and commutator etched onto it. The list of variations is almost endless.

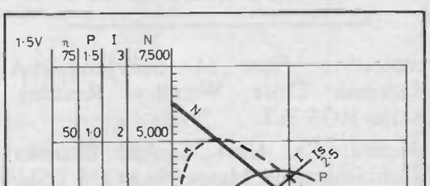


Fig.4.

The motors considered so far have magnetic fields provided by permanent magnets. In another group of motors the magnetic field is provided by electromagnets. These are usually in the form of windings around stationary pole pieces which are energised either in series or parallel with the rotor, or possibly a combination of both. The ability to alter the magnetic field strength as well as the current in the rotor makes such motors an extremely useful source of industrial motive power because they are easy to control. Such motors are worthy of mention here because of their widespread use in everything from vacuum cleaners upwards. Their control possibilities are beyond the scope of this article, which will concentrate on permanent magnet motors.

CHARACTERISTICS

In the section headed "Principles" it was stated that the force on a current carrying conductor in a magnetic field is proportional to the current and the field. From this it follows that within limits the output torque of a motor with a constant magnetic field is directly proportional to the current. Fig 4 shows manufacturers curves for a typical small motor rated at about 1W and another much larger motor rated at 80W. These are based on an axis of torque (T) at a constant voltage and give curves of speed (N), efficiency (n), power (P) and current (I).

As predicted, the relationship between current and torque is a straight line. Regardless of the voltage applied or the speed of rotation the T/I ratio is a constant for any one motor. It is a function of the number of turns on the rotor, the strength of the magnets, the type and amount of iron in the rotor and stator, and the air gap between the two (among other less important things).

The second relationship that can be derived from the curves is that of speed

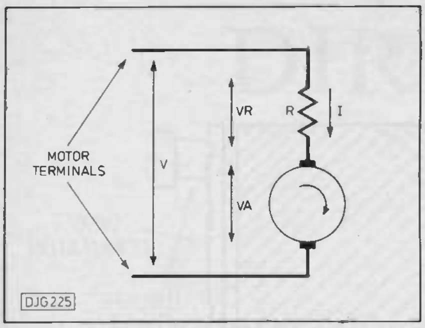


Fig.5.

versus torque. This is also a straight line which links the no load speed (the speed at T = 0) with the stall torque (Ts) where the motor is stationary. To explain this characteristic it is necessary first to look at the effects of the applied voltage and the rotor resistance. The motor can be represented as in fig 5 by an ideal wound rotor with no resistance, in series with a separate resistor which represents the true effective winding resistance as seen at the terminals. The terminal voltage applied to the motor is the sum of the ideal rotor voltage VA and the voltage drop across the winding resistance VR.

Voltage VA is the so-called "back EMF" which is generated in the rotor windings as they rotate. The generated voltage behaves according to the laws of electromagnetic induction which state that the voltage generated in conductor moving in a magnetic field is related linearly to the strengh of the magnetic field and the speed of movement of the conductor. This "generated" voltage (note that permanent magnet motors are just as effective as generators) opposes the applied voltage and depends on the speed of rotation (N). Under any condition of applied voltage and speed the sum of VA and VR must be equal to the applied voltage V. Consider starting the motor from standstill. At first the motor speed is zero and so VA must be zero and hence VR – VX. The motor current is solely determined by applying Ohm's law which gives I – VR/R. As the motor is not rotating this will be the stall current Is and the motor will be developing the stall torque Ts. Assuming the motor is free to rotate it will accelerate and VA will begin to increase linearly with speed. As this happens VR which is the difference between VA and applied voltage V will begin to decrease. The current I which is given by Vr/R will also begin to decrease, and hence the torque Twhich is proportional to I will decrease. This process continues as the motor accelerates: the speed increases and the torque decreases until a stable point is reached where the motor torque matches the requirement of the load. For a free running motor the only load will be bearing friction and air resistance so

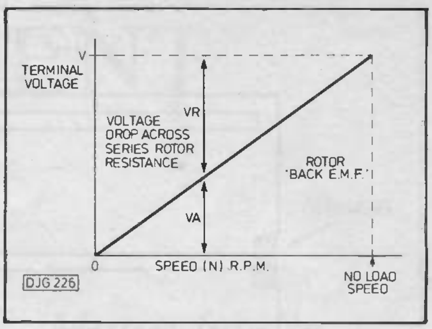


Fig.6.

that VA will be nearly equal to V, VR will be small and so therefore will I and T. This is all shown more clearly in Fig 6. The motor terminal voltage is the sum of VA and VR at all speeds and VA is directly proportional to speed. The motor current I and hence the torque are directly proportional to VR. The relationship between torque and speed at constant applied voltage is therefore linear and can be summarised as SPEED = 1 – TORQUE (ignoring the units of measurement).

The two linear relationships developed here can be exploited in various ways to control the speed and torque of small motors. A variety of circuits, some simple, others more complicated will be described in the next part of this article. PE

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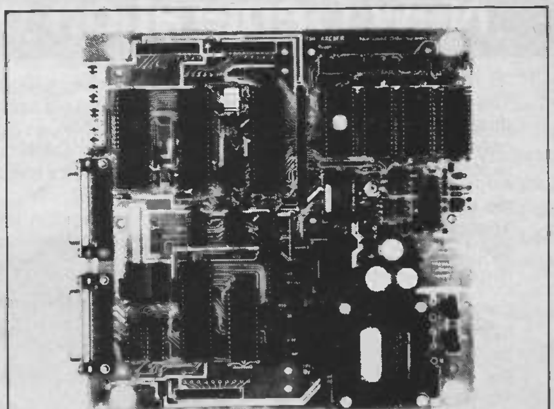

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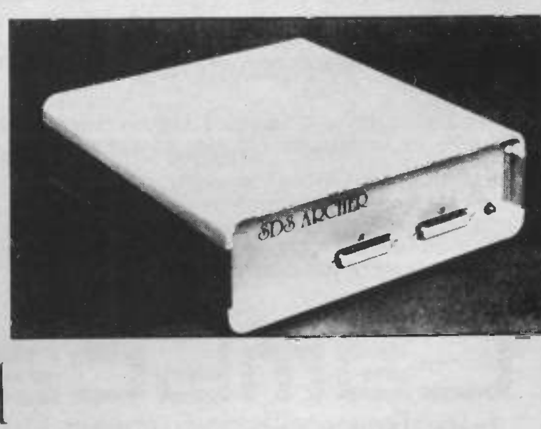

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INDUSTRY NOTEBOOK

REPORT BY TOM IVALL – PE's NEXUS

Where is education leading us

Kenneth Baker's proposed City Technology Colleges are a response to industry's need for more skilled technicians and engineers. But is it true that specialisation at an earlier age will raise the standard of industry engineering?

So far there has been no great rush of electronics companies to sponsor Kenneth Baker's proposed new City Technology Colleges. You may remember that the Secretary of State for Education and Science put forward this idea late last year. The CTCs are intended to provide a broad secondary education for 11 to 18-year-olds but with a strong bias towards science and technology.

They are to be independent of local authorities but will not charge fees. Indeed the free education is intended to help out mainly in the big cities where the existing public education system is under the greatest strain. CTCs will be owned and run by companies, trusts or other organizations and will receive financial grants from the government.

In a speech to employers and teachers Mr Baker said he would like these new technical schools to give pupils a familiarity with information technology and an understanding of its applications. And Mr Baker was himself an enthusiastic minister for information technology at one point. So you would expect electronics companies to show a certain amount of interest, especially as these firms are always complaining that the country's education system fails to supply them with enough skilled people at the technician and technician engineer level.

But paying out money is a different matter. The hard-nosed businessmen who run these companies – some of them struggling with recession and declining profits (see December 1986 Notebook) – may not see any obvious return from such an investment in people. The CTCs' catchment areas may not be in the right places to help the firms with a local supply of skilled workers, and in any case a General Election is coming up and a change of government could scotch the whole plan.

Furthermore some UK industrialists, like more European educationists, think that our children already specialise too early in school – the familiar Arts-Science divide – and this process is being continued in the CTCs. They would rather have their workforce well and broadly educated up to the age of 18 or the early twenties, and sufficiently literate and numerate to be able to take in their own specialized industrial training. For example, the BBC recently advertised for arts and other graduates not necessarily connected with science or technology to train as broadcast engineers. It was a shot in the dark and they didn't expect much of a response. But it proved embarrassingly successful. They received about 8000 enquiries.

The CTC idea is just one more shift in the constantly changing pattern of educational organization. Much more fundamental is Mr Baker's recent proposal for a nationally defined curriculum for all schools, as in France and some other countries. We have also seen much turmoil involving teachers, parents and pupils. All this agitation may well arise from our fundamentally subjective and value-laden views of what education is supposed to be for. Is it to develop the potentialities of the individual, or to produce model citizens conforming to the ideals of the state, or simply to churn out meal tickets and factory fodder?

The question is too broad for this particular column. More to the point, perhaps, is to enquire "what is industry for?". That includes the electronics industry of course and may shed some light back on technical education. So far in these monthly notebooks I have been discussing the electronics industry on a rather parochial basis, as if it were a social entity, as if the successes, failures, problems, etc. of its member firms really mattered in themselves.

But for many ordinary people, and perhaps some PE readers, these domestic concerns will hold very little interest. So let's look at this industry in a larger context: its effect, if any, on the world we live in, on the society we belong to, and therefore on us as individuals. I say "if any" because the most significant influence could be working in the opposite direction. We as individuals could be, though very indirectly, shaping what the industry is and does. If this is a valid point, you could use the analogy of a closed-loop control system or an amplifier with negative feedback: there are two signal paths, working in opposite directions.

The electronics industry is, of course, based on a branch of physics. From the science we have derived a technology. This exploits the natural behaviour of the electron to make it do things that are useful to mankind. The industry manufactures objects which embody this technology, designs them so that they can be applied successfully to particular tasks, and trades these objects on the market. But at this point the process 'takes off' and can fly in various directions, because all kinds of human motives and interests are at work. The motives are principally those of the sellers and buyers, but others, for example from government and politics, have an effect as well.

So it is unrealistic to consider the technology/industry in isolation from the society which produces it. Technological determinism doesn't hold water. You can certainly say that technologists and industrialists create things which change our lives. These individuals, however, are part of society and subject to its pressures. Furthermore the technology and products we have are a symptom of the kind of society we are: they develop in particular directions in response to our material, emotional and spiritual needs. Television and other domestic electronic systems, for example, are technological responses to the needs of the 'nuclear family' for entertainment and even 'company' in homes that are becoming socially isolated from communities.

Before continuing this theme next month, let me leave you with a quotation from the historian R.H. Tawney: "The purpose of industry is obvious. It is to supply man with things which are necessary, useful or beautiful, and thus to bring life to body or spirit." This is a somewhat oracular statement, but worth bearing in mind as a reference point when we come to consider how the purpose as seen by Tawney often gets deflected or forgotten altogether. PE

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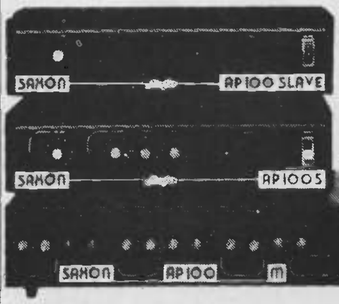

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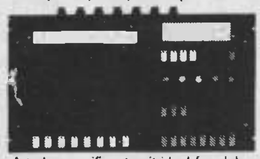

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4089 80p, 4093 18p, 4094 48p, 4095 58p, 4098 50p, 4099 45p, 4501 30p, 4502 38p, 4503 32p, 4504 55p, 4505 200p, 4506 60p, 4507 33p, 4508 70p, 4510 37p, 4511 40p, 4512 42p, 4513 80p, 4514 75p, 4515 75p, 4516 40p, 4517 120p, 4518 38p, 4519 30p, 4520 38p, 4521 90p, 4522 50p, 4526 40p, 4527 44p, 4528 40p, 4529 75p, 4532 52p, 4551 80p, 4553 190p, 4555 29p, 4556 38p, 4557 190p, 4583 60p, 4584 30p, 4585 42p

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60	11.51	2.31
100	13.43	2.59
200	19.03	3.10
250	23.01	3.24
350	28.46	3.40
500	35.45	3.66
1000	64.28	4.62
1500	82.92	5.95
2000	99.76	6.36
3000	139.39	O/A
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2	1	6.09	1.90
4	2	10.84	2.20
6	3	12.54	2.25
8	4	17.16	2.58
12	6	21.84	2.79
16	8	30.89	3.15
20	10	36.66	3.60
24	12	43.87	3.80

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4	2	8.47	1.92
6	3	9.82	2.10
8	4	11.72	2.20
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250	23.01	3.24
350	28.46	3.40
500	35.45	3.66
1000	64.28	4.02
2000	99.76	6.36
3000	139.39	O/A
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2	1	8.67	1.91
4	2	11.15	2.20
6	3	16.12	2.34
8	4	18.38	2.55
10	5	23.23	2.78
12	6	26.50	3.02
16	8	37.25	3.65
20	10	43.37	3.99
24	12	49.98	4.65

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250	10.34	1.98
350	12.43	2.31
500	16.12	2.68
1000	28.79	3.25
1500	34.17	3.68
2000	51.09	4.62
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8	4	10.39	2.10
10	5	11.91	2.10
12	6	13.20	2.25
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VA	Pri	P&P
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9	2.79	1.50
12	3.06	1.60
25	3.56	2.00
50	5.89	2.50
100*	9.17	2.80

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