PRACTICAL ELECTRONICS

JUNE 1989 • £1.25

SCIENCE & TECHNOLOGY

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Ruling the micro waves

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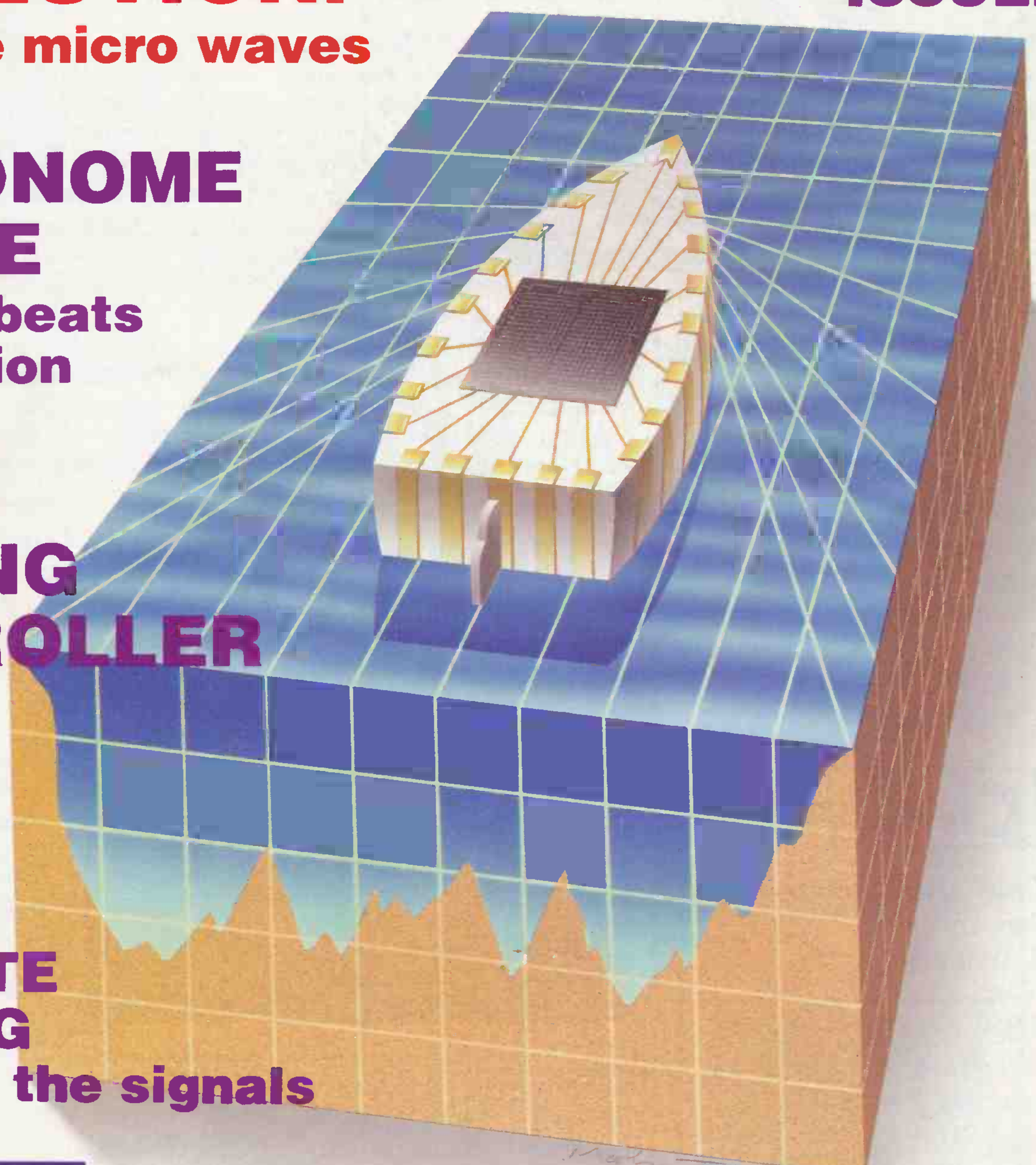
METRONOME DELUXE
Build the beats for precision

SOLAR HEATING CONTROLLER
Let the sun get you into hot water

SATELLITE SIGHTING
Dishing in the signals



PLUS ANOTHER EASI-BUILD PROJECT!

TRUE RMS METER
Rooting out meaness in metering

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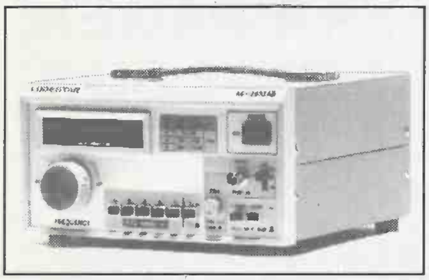
Cirkit NEWS

YOUR CHANCE TO WIN...



Once again, you'll need all your wits about you to identify the six items we've picked from the catalogue, and a Lodestar audio signal generator worth more than £180.00 is waiting for the sender of the first all-correct entry drawn in this season's competition.

Second and third prizes are top-of-the range multimeters from Cirkit's outstanding new range, offering frequency and capacitance measurement and transistor test, and valued at £55.00 each.

Fourth and fifth prize-winners will receive recently published books to the value of £30.00.

Cirkit

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Fax (0992) 669021

Also at

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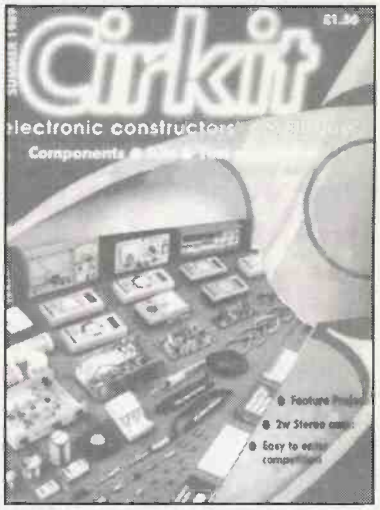
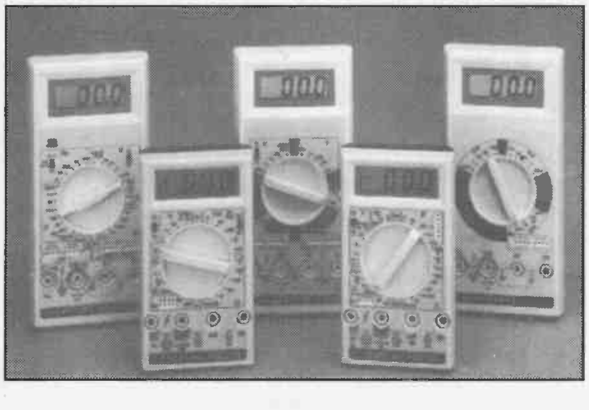
NEW CATALOGUE OUT 25th MAY



Over 3,000 product lines feature in the Summer 1989 edition of the Cirkit Constructors' Catalogue, available from most larger newsagents or direct from the company priced at £1.50. The latest books, an RF frequency meter, two new PSU designs and a 3.5MHz converter are among the innovative new kits this issue, while our construction project - a 2 Watt stereo amplifier - is bound to prove an absorbing activity for dedicated constructors. In the test equipment section there's a whole new range of multimeters, a bench DVM and a triple output PSU.

For eagle-eyed readers who enjoy a challenge of a different sort, there is the opportunity of winning an audio signal generator worth more than £180.00 In the latest fiendish competition. All prices now include VAT for quicker, easier ordering; and Cirkit's same-day despatch of all orders, combined with value-for-money discount vouchers, makes the line-up even more attractive.

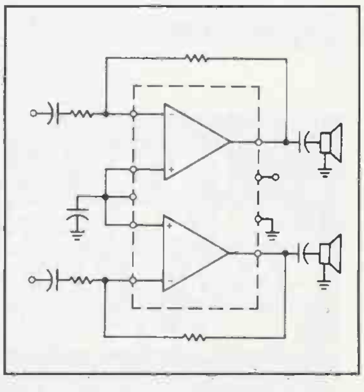
D-MM GOOD VALUE!

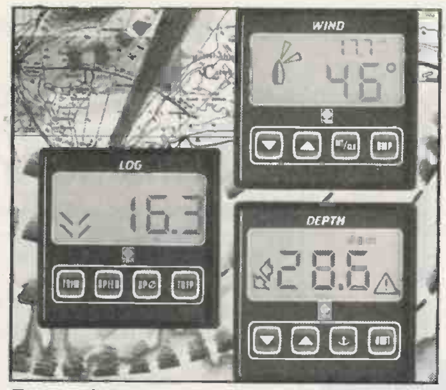


Cirkit's six new digital multimeters are packed with sophisticated extra facilities: capacitance measurement, frequency measurement up to 20MHz, temperature reading, transistor test and logic test in addition to the usual volts, current (DC and AC) and resistance measurement - and all unbeatable value with prices ranging from **£20.00** to **£55.00!**

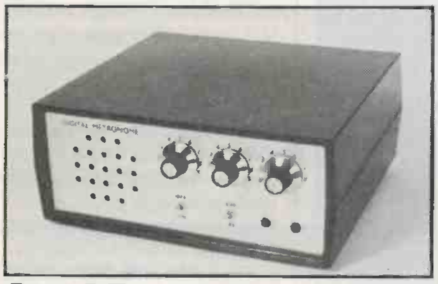
FEATURE PROJECT: 2W STEREO AMP

Our construction project this issue is for a straightforward but very effective 2 Watt stereo amplifier. Based on the LM1877, it is the perfect amplifier for a 'Walkman' cassette deck and equally suitable for AM/FM radios or mixer desks. Featuring 2W per channel and 75dB channel separation, it operates from a 10-26 volt supply, making it ideal for in-car applications. The catalogue includes full details of this economical kit.





Page 19 ▲ ▼ Page 12



Page 5 ▼

NEXT MONTH

Codes are the tools of trade for spy catchers, city slickers and hi-tech hackers - we reveal the cryptic low down on Encryption. That sinking feeling when timing slides to tape will sync without trace when you've built our Projector-Recorder Synchroniser. And you needn't get your fingers burnt if you use our Electronic Thumb heat monitor. That's just for starters, there's even more great interest lined up for the July 1989 issue.

★ **PLUS ANOTHER GREAT COMPETITION TO ENTER!**
★ **DON'T MISS OUR JULY 1989 ISSUE**
★ **ON SALE FROM FRIDAY JUNE 2ND**
★ **AND STILL AT ONLY £1.25**
★ **YOU CAN'T BEAT OUR VALUE**
★ **OR OUR NEW GOOD LOOKS!**

PRACTICAL ELECTRONICS

VOL 25 NO 6 JUNE 1989

CONTENTS

COMPETITION

CONSTRUCTIONAL PROJECTS

SPECIAL FEATURES

REGULAR FEATURES

PRODUCT FEATURES

PE TAKES TECHNOLOGY FURTHER - BE PART OF IT!

NEWS

MONITORING REVOLUTION

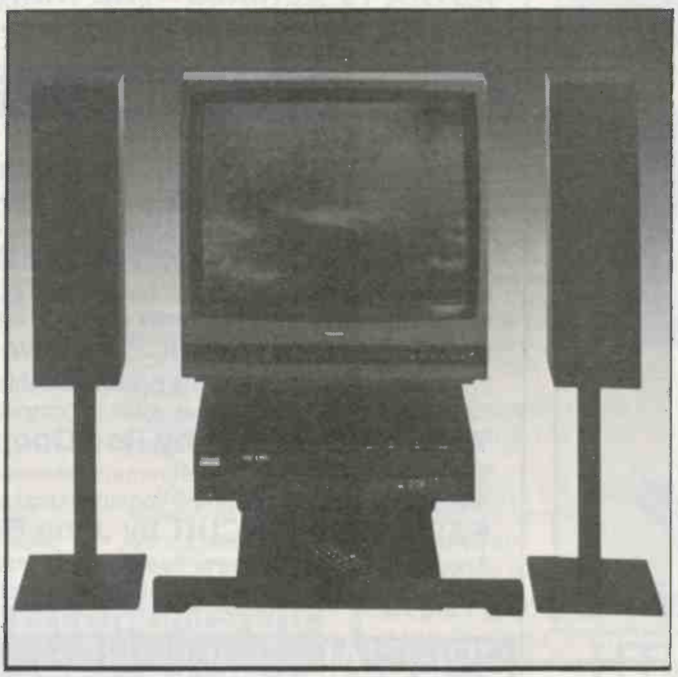
Ferguson has launched a revolutionary new range of monitor-style sets, where design and advanced technology are the watchwords.

There are four new "K-Series' sets in 51 cm and 59 cm presentations: the 51K7, with Fastext (fast access teletext); and the 51K5 and 59K5, additionally featuring on board NICAM digital stereo decoders.

The new Super Planar Black Matrix Tubes with anti-reflective screen – (featured on 59 cm models) – provide significant improvements in picture quality. Stereo twin speakers give superior sound, and on the 51K5 and 59K5 models, the on board NICAM digital stereo decoders will provide the benefit of digital stereo sound when broadcasting commences in 1989.

Super Planar picture tubes are simply the flattest TV tubes available, offering a perceptibly wider viewing angle and larger screen area to FST models.

All models include tv/video remote control handsets that access on screen graphics, the display giving instant information on volume, colour, brightness, contrast and channel status. Another feature of On Screen Graphics is "Child Lock'. Other standard features include: 40 programme frequency synthesis tuning; led displays; a headphone socket; and a Peritel socket.



The 51K7 and 59K7 will retail at around £429.99 and £499.99 respectively. The NICAM digital stereo models, the 51K5 and 59K5, will retail at around £529.99 and £599.99 respectively.

CONTACT: Anne Waterman, Ferguson Limited, Great Cambridge Road, Enfield, Middx, EN1 1UL. Tel: 01-363 5353.

Micro Thermometer

Temperature trend indication on the Keithley 820 thermometer automatically registers increasing, decreasing or stable temperature readings. Never again need there be a doubt about when to take a reading.

Features like microprocessor control, 0.1 accuracy and 0.1 degree (°F and °C) resolution throughout its full measurement range, coupled with high repeatability, render precision measurements for any application. Dual point measurements via the two thermocouple inputs permit easy two point comparison. With six data logging registers, the 820 stores the maximum and minimum temperature readings for both inputs, and simultaneously retains maximum and minimum differential readings.

The 820 is protected with a drop proof, splash proof, dust free case that features a built-in tilt stand/hanger for bench use or hands free, plus an AC adapter socket.

CONTACT; Keithley Instruments, 1/3 Boulton Road, Reading, RG2 0NH. Tel: 0734 861287

CATALOGUE DATABASE

We have recently received the following literature:

Wotan are a company who specialise in electronic lamps. Their products include a range of **miniature fluorescent lamps** that will be of interest to anyone who wishes to **contribute to the green welfare** of society by consuming less power. Although the lamps are not yet too readily available in retail shops, I acquired information from Wotan when they were exhibiting at the Ideal Home Exhibition in March. If you are interested in obtaining information on the availability of these lamps contact **Wotan Lamps Ltd,** Wotan House, 1 Gresham Way, Durnsford Road, London SW19 8HU. Tel : 01-947 1261.

Greenweld's new Spring supplement is now available and will be of great interest to all electronics constructors. It's got 32 well filled pages covering many great lines, including **a whole new range of exciting products,** such as sophisticated calculators, disco and music gear, Metex meters, leads and high power speakers. There's an **enticing list of surplus lines at bargain prices** as well - Greenweld are famous for such offers! Not only that, but there's a great competition to enter with a top of the range Metex multimeter as first prize. Another fantastic offer is that with every order over £10 a **free set of headphones and speakers** are yours for the asking. **Don't miss out on these great offers** - send a large sae for a copy of this supplement to **Greenweld Electronics Ltd,** 443c Millbrook Road, Southampton, SO1 0HX. Tel : 0703 772501.

Maplin have a catalogue that will be of **interest to professional electronics buyers.** Their latest electronic component buyer's encyclopaedia is a forty page colourful source of **essential products at reasonable prices** which fall even further the more you buy of each product. This latest edition has **over 800 new products** including a wide range of transistors, digital and analogue ics, diodes, crystals, and a superb range of top quality Antex soldering irons. There is also a good range of aerosol and service aids from Electrolube. It is good to know that these aerosols are free of CFCs and will not affect the ozone layer. If you are a professional electronics buyer you owe it to yourself to immediately ask for a copy of this catalogue from **Maplin Professional Supplies,** PO Box 777, Rayleigh, Essex, SS6 8LU. Tel : 0702 552961.

It's always a pleasure to receive the **latest news letter from BAEC,** the British Amateur Electronics Club. Their latest edition has just come in (I assume it's the latest even though it's dated "Fourth Quarter 1988") and as **usual has plenty of good advice and tips,** this time mainly relating to microprocessors. If you don't already belong, you really ought to join this nationwide club, I am sure that you will **benefit from the experience of sharing electronics** with others of similar interests. For further information write to the Chairman, B.A.E.C., C.Bogod, 26 Forrest Road, Penarth, South Glamorgan. And do please enclose an sae to cover the postage of his reply.

NEWS

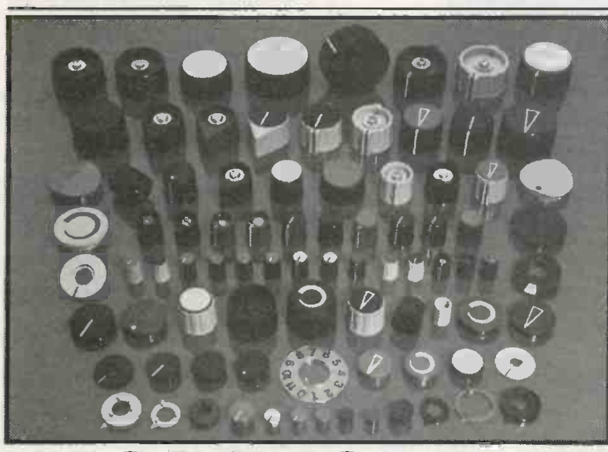
Solar Powered DMM

Universal Instruments have announced the availability of a pocket-size digital multimeter with an internal power cell that is automatically recharged by solar powered to give continuous use without the need for regular battery replacement.

The Hioki model 3242 is an easy to operate autoranging instrument with a single rotary switch and a $3^1/_2$ digit liquid crystal display showing units and symbols of measurement and polarity. DC voltage is measure from 0.1mV to 500V in 5 ranges with a basic accuracy of better than 1%, whilst ac voltage is from 1mV to 500V and input impedances are greater than 10M ohms. Resistance is from 0.1 to 20M ohms in six ranges plus audible and visual continuity and all are protected to 250V.

This compact hand held instrument measures just 120 x 65 x 18mm, which includes a fully enclosed test lead storage compartment, and weighs approximately 100 gms. Fully guaranteed for 12 months the latest Hioki innovation is supplied ready for use with a transparent vinyl storage case that allows the battery to be recharged even when the unit is not in use.

CONTACT: Universal Instrument Services Ltd. Unit 62. GEC Site. Cambridge Road, Whetstone, Leicester. LE8 3LH. Tel: 0533 750123.



KNOBS FOR MORE JOBS

Comprising a variety of diameters ranging from 8mm to 45mm, in four basic colours, Bulgin's expanded Multi range has a choice of collet (four colours) or push-fit (two colours) versions, making it one of the most versatile selections of control knobs available on the market.

Among the many advantages offered are pre-loaded collets which obviate the need to loosen screws before fitting - the control knobs are simply pushed on and the screw tightened. They are supplied with slotted head fixing screws as standard.

Wing- and arrow-shaped formats are available in addition to traditional round models and a low profile version with its height reduced by approximately 20 per cent is available, making it particularly suitable for all instrument construction.

The range may be further individualised with a comprehensive selection of caps in various shapes and colours and a variety of markings. These can be snapped into position and are supplied in three basic models - flat, prismatic or curved - in blue, yellow, green, metallic (flat only), light grey, dark grey, black and red. The flat caps may be marked with an indicator line, arrow, curved arrow or an aluminium disc; prismatic caps with a distinctive point; and curved caps with an indicator line; or left unmarked as required.

Contact: A.F. Bulgin and Co PLC, Bypass Road, Barking, Essex IG11 0AZ. Tel: 01-594 5588.

EVENTS DIARY

If you are organising any event to do with electronics, big or small, drop us a line – we shall be glad to include it here.

Please note: Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

May 8-10. Eurobus 89 – German Conference. Munich Sheraton Hotel, Munich. 01-940 4625.

May 9-12. Automan. Robotics and automation exhibition. NEC, Birmingham. 01-891 5051.

May 31-Jun 2. Computer Training Show. Olympia 2, London. 01-486 1951.

Jun. 5-9. Lasers, Optoelectronics, Microwaves. 9th International Trade Fair and Congress. Munich Fair Centre. 01-948 5166.

Jun. 6-8. Computer North. G-Mex, Manchester. 061 832 4242.

Jun. 13-15. Software Tools 89. Wembley Conference Centre. 01-868 4466.

Jun. 14-15. Instrumentation Scotland. The Forum, Livingstone. 0822 614671.

Jul. 10-13. EWEC '89. European wind energy conference and exhibition. Scottish Conference and Exhibition Centre, Glasgow. No reference tel. known.

Jul. 24-26. Vacuum Microelectronics – 2nd International Conference. Bath. Contact Dr R.A. Lee, GEC Hirst Research Centre, Wembley, Middx, HA9 7PP. 01-908 9000.

Aug. 25-Sep 3. International Audio and Video Fair. Berlin. 01-408 0111.

Sep. 4-6. Eurobus 89 – UK Conference. Novotel Hotel, London. 01-940 4625.

Sep. 12-15. EPOS 89. The World's largest exhibition of retail information systems. Alexandra Palace, London. RMDP. 0273 722687.

Oct. 16-20. Systems, Computers and Communications. 11th International Trade Fair and Congress. Munich Trade Fair Centre. 01-948 5166.

Oct. 24-26. Sensors and Systems – International Transducer Exhibition and Conference. Wembley Conference Centre. 0822 614671.

CAM-ZOOM DEBUT

Announced as the world's first VHS-C camcorder with a built in 12x variable speed power zoom f1.6 lens, Sharp's high-performance VL-C750H has made its UK debut.

The newcomer shares a range of features with Sharp's previous camcorder introductions, the well-received 8x power zoom VL-C650H - including a one-touch full auto system with full information lcd display, a 1/1000th sec high speed electronic shutter, a 0.5-inch solid state ccd image sensor and high quality picture system, fade control, self timer and palm fit grip design.

The 12x variable speed power zoom is the big feature of the new camcorder, offering the possibility of a "swoop" close-up from 1x to 12x in just six seconds or a more controlled zoom in 25 seconds. It has a macro capability, too.

The lcd display offers easy at-a-glance information covering not only the "full auto on" symbol but also warnings of low battery charge, excess dew or a cassette with no tab or no tape time remaining. Recording mode (sp/lp), lap time/tape counter, tape speed, focus mode, white balance and shutter speed mode symbols are displayed as well.

Editing functions catered for include flying erase head, audio-video fade in/fade out and audio dubbing, the latter permitting creative background sound effects and/or voice over.

Other key features are the camcorder's VHS index search system - which enables the user to set index points on the tape for rapid location of specific sequences for playback or editing - and the ability to tilt the electronic viewfinder for low angle shooting.

Incorporating a directional electret condenser microphone, the VL-C750H measures 131mm wide, 157mm high, 301mm deep and weighs 1.5 kg (without battery).

For further information contact: Sharp Electronics (UK) Ltd., Sharp House, Thorp Road, Newton Heath, Manchester M10 9BE. Tel: 061-205 2333.

DUETTO FOR UNO

A new concept in speaker design is an event. To produce a stereo sound-stage from a single cabinet has been a goal for speaker designers for many years.

After 15 years painstaking research and testing Walter Schupbach has achieved that goal, resulting in the Stereolith "Duetto" system.

The Duetto drive units are arranged on either side of a prism shaped cabinet, and can be placed in front of the listener, either at floor level or suspended from the ceiling. The resulting sound stage places the musical instruments both in the horizontal and vertical planes, over the full width of the listening room, without the need for being in a "sweet spot" for maximum effect.

Not only is the system suitable for hifi listening it will also enhance the stereo capabilities of pre-recorded software with television sets, video recorders and video disc players, as well as facilitate the use of surround sound, and can be used in any location where a pair of conventional speakers is aesthetically unacceptable.

The Duetto is available in either black or white, with a choice of either matt or piano lacquer finish, at prices from around £400.

For more information please contact: F.W.O. Bauch Ltd., 49 Theobald Street, Boreham Wood, Hertfordshire WD6 4RZ. Tel: 01-953 0091.

NATTY IDEAS WANTED

Nat West Bank and British Petroleum are launching a joint award scheme to help people put their innovative technological (and, of course, electronic!) ideas into practice.

The aim of the awards is to help with the cost of development in order to tum an idea into a commercially viable proposition. The judges will make bi-monthly awards up to a maxi-mum of £2,000 per successful entry.

For details and application forms **phone NatWest** on 01-374 3643.

DIAL-A-CHIP

Electronic designers can now, at the touch of a button, not only select the components they need, but order them direct from stockists, in a new development of Dialcom's Password electronics database service.

This expansion of the service allows buyers to access information on stock levels and prices for components in the UK, and then use Telecom Gold, British Telecom's electronic mail service, to order them from the distributor.

The development follows the decision of Macro Marketing, one of the UK's largest semiconductor trade distributors, to provide Password with data on its entire stock of more than 30,000 components. Information on price and availability is up-dated daily from Macro's Tandem computers to Password's cluster of Pyramid super-mini machines in London.

New features of the service include the ability to search by manufacturer or part number, view up to six price breaks for quantity discount and list alternate parts that meet the specification criteria if stocks are low or out.

Mr. Bill Noseworthy, Dialcom's Head of Design and Engineering Services, is delighted with the new development. He commented: "It provides the basis for a sophisticated 'trading floor' that brings suppliers and buyers into electronic communication with one another. I am confident that other distributors will follow Macro's lead, and use Password as the mechanism for trading with their customers in the future."

Companies interested in accessing the Password range of services can call Dialcom free on 0800 200700, or Macro Marketing on 06286 4383.

Klipping Coax

The exact stripping of various coaxial cable types using standard tools is a time-consuming procedure involving the adaption of the tool to suit different requirements.

Following intensive research, Klippon has in0troduced the CST Insulation Stripping Tool for cables measuring 2.5 to 8.00mm diameter. It allows 2 or 3 stage insulation and braid stripping in a single cycle – reducing the stripping and setting times considerably. It also enables the user to record the individual setting once it has been established.

Important features include an exchangeable screw holder which acts as a 'memory' various sized cassettes with standard cutter spacings and colour coding for easy identification. Weighing just 65g, the CST measure just 100mm x 42mm x 25mm.

CONTACT: John Bauckham, Klippon Electronics Ltd., Power Station Road, Sheerness, Kent, ME12 3AB. Tel: 0795 580999

Digitape

Solex have introduced a couple of feature-packed ultrasonic tapeless measure, the UR2000 and UR3000.

These two compact units incorporate a host of features which seem set to make the humble tape measure completely redundant! A three mode display function enables readings to be obtained in either metric (to the nearest cm), imperial/metric (feet to two decimal places) or imperial (feet and inches) all clearly displayed on the large lcd A memory recall facility will store the last reading entered even after the unit is switched off.

The UR3000 has a few extra surprises in store – just enter the length, width, and height of a room using the unit's independent auto memories and, at the touch of a button, the cubic capacity or floor area of the room will be displayed. Both models have a range from 60cm to a full 10 metres with accuracy better than 1% of the reading.

Available on 14 days approval, the units are priced at just £29 + vat for the UR2000 and £49 + vat for the UR3000.

CONTACT: Steve Fensom, Sales and Marketing, Solex International, 95Main Street, Broughton Astley, Leics, LE9 6RE. Tel: 0455 283486.

CHIP COUNT!

Highlighting some new semiconductor products.

INDEPENDENT AUDIO AMPS

Two new audio amplifier chips have been released that require no extra external components, apart from decoupling capacitors. The Philips TDA7052 and TDA7053 can deliver 1W mono or 2 x 1W stereo class-B audio output. These new chips feature a wide operating range, from 3V to 15V, and are the first low power consumer ics to incorporate bridge-tied load (BTL) configuration. Their typical quiescent currents are only 4mA and 9mA respectively, and neither chip requires a heat sink. With a fixed closed-loop voltage gain of 40dB, the TDA7052 connects to a mono speaker, while the TDA7053 is in fact two TDA7052s on a single crystal with compatible pinning, thus the same pcb design can be used for both stereo and mono amplifiers.

FASTEST 24-PIN PLD

Philips new programmable logic array PLUS173D features a worst case propagation delay of 12ns, and so exceeds the performance level of 24-pin PAL devices. The new device is made with two programmable arrays (AND and OR), thus providing a more flexible solution for complex combinatorial applications than PAL devices, which support programming only in theAND array. As a result, the PLUS173D can support an OR function of up to 32 inputs wide, compared to 7-input wide decoding functions on earlier devices. Another feature is its programmable output polarity, allowing each of its ten bi-directional in-out lines to be programmed active high or low.

SMALLEST 1M DRAM

With a chip area of only 40.5sq.mm, the Hitachi HM511000A and HM514256A are the world's smallest die for DRAMs. The smaller size of these die means that, compared with the currently available devices, some 55% more die can be obtained from a 6-inch wafer. This should result in increased production volumes of 1M DRAMs during 1989. Let's hope that increased yield on ranges like this will enable manufacturers to get back to producing more SRAMS – the international shortage still seems acute (have you tried to buy any lately?)

HIGH-PERFORMING MFLOPS

TI has disclosed a processor capable of 3million floating point operations per second (Mflops) in both single and double precision. With its exceptional performance, the SN74ACT8847 will allow supermini manufacturers to provide supercomputer performance in desktop systems, says Wally Rhines, executive vice president of TI's Semiconductor Group. The '8847 is the highest performance single chip floating point processor in the industry. When its multiplier and ALU operate in parallel, the chip can attain speeds of over 50Mflops. Such performance levels are critical to designs of future high-end systems such as minicomputers and 32-bit personal computers.

Manufacturer's details for further information

Hitachi Europe Ltd., 21 Upton Road, Watford, Herts, WD1 7TB, Tel: 0923 246488. **Philips Components Ltd,** Mullard House, Torrington Place, London WC1E 7HD, Tel: 01-580 6633. **Texas Instruments Ltd.,** Manton Lane, Bedford,MK41 7PA, Tel: 0234 270111.

LEADING EDGE

STEREO CONFUSION

BY BARRY FOX
Winner of the UK Technology Press Award

While satellite TV hogs the headlines, another television revolution has happened quietly – Nicam stereo is here to stay.

There is currently a great deal of confusion over stereo sound for video and tv.

The first VHS video recorder machines used a low fi linear track, and were mono.

Then the use of Dolby B improved sound quality a little.

Then some machines split the linear track into two halves to give stereo. This was an unsatisfactory system, because the half tracks are very narrow. So signal level is low, which aggravates this, and any tape weave causes one channel to disappear intermittently.

Then came hifi stereo, with the sound recorded as an fm signal by two extra heads on the rotating video head drum. This is called depth multiplex stereo because the sound and picture signals are interleaved in frequency and recorded at different depths in the tape coating.

To preserve compatibility, all hifi recorders also have linear sound heads; and all hifi tape recordings have both hifi and linear sound tracks. But to save on cost and complexity the linear sound heads on most (if not all) hifi machines are now mono, without Dolby. There is no need to provide stereo linear capability because virtually all the major duplicators now record stereo tapes in hifi.

Of course the duplicators also record a linear track, for compatibility with non-hifi machines. Some may record the linear track in stereo, for good measure, even though most non-hifi machines will play the linear track in mono only.

The trend to stereo has meant that many stereo tv sets have been sold over the last five years, with two sets of speakers and two amplifiers.

These sets are intended to reproduce the stereo sound available from pre-recorded video cassettes and video discs. With some clever connections, they can also reproduce simulcasts, where a radio station simultaneously broadcasts the stereo sound for a tv programme.

But these sets are *not* able to receive broadcast stereo in the new Nicam, all-digital system.

The Nicam broadcast stereo system was developed by the BBC, and there have been test transmissions on BBC1 and BBC2 from the Crystal Palace transmitters for the last two years. But, owing to cutbacks, the BBC has relinquished its lead and ITV will start the first Nicam service, from London and Yorkshire, this autumn. The BBC accountants (notably Director General Michael Checkland) will then have to face commercial reality and follow ITV.

Although Nicam receiver chips have become available over the last year (from Toshiba first, then Texas Instruments and Mullard/Philips) they have so far been used only in VHS video recorders – mainly from JVC.

Now Nicam chips are being incorporated into the latest stereo tv sets. The extra cost of providing Nicam is around £100 or £150, but it will come down as stereo becomes a familiar option.

No-one who has heard music programmes, films or sports broadcasts in Nicam can be in any doubt that the system works beautifully and adds considerably to the programme's impact.

In short, it would be crazy for anyone buying a new stereo tv or stereo vcr not to choose one which is either Nicam-ready, or can be easily retrofitted with Nicam chips.

DISHTRAUT

I have just heard something from a firm making satellite dishes that neatly sums up the appalling ignorance which currently abounds in the trade.

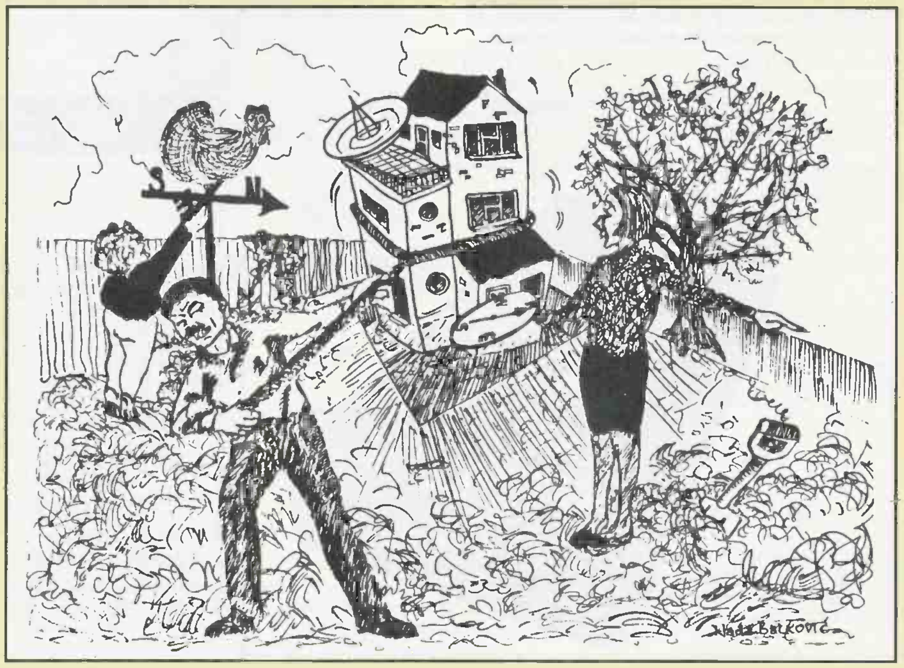
A dealer was taking orders for satellite systems ahead of the Astra launch, warning customers that if they did not pay a deposit in advance they would not get a dish "before June".

Sensibly, the sales staff were asking customers where they intended to put their dish and advising them on whether they would be able to get a line of sight on the Astra satellite.

But, until the mistake was discovered, one salesman had for weeks been telling customers that as long as they had a North-facing wall they would be able to receive Astra.

Exactly the opposite is true. PE

Which leads us to speculate on what problems may arise from this mistake . . .



PRACTICAL
ELECTRONICS

EDITORIAL

As yet there do not appear to be many ways in which PE can appropriately comment on ecological matters. Most aspects of electronics seem to be for the general good of society, though as 'green' issues become more thoroughly discussed, I expect that some areas of electronic production may come under scrutiny regarding environmental safety.

Take solder, for example. We are nationally becoming more conscious of the effect of lead upon the environment. Quite rightly we are in the process of encouraging the use of lead-free petrol, and I for one use it whenever possible. What about solder, though? It's an alloy consisting mainly of lead and tin. Although more usually the lead content is between 40% and 60%, it can be over 90% in some types. I get through about 2.5kg a year. Some of it probably ends up in the atmosphere simply from the fumes produced when soldering. Eventually, in years to come, the rest of this solder will end up discarded on a refuse tip. Surely this is a further source of lead pollution? And if I'm polluting the environment, what about manufacturers of electronic equipment? Think of the solder quantities they must use, all of which will sometime end up discarded. But what choice is there? Or am I misinterpreting the polluting effect of lead?

How about ferric chloride as used for etching the copper from pcbs? Where does that end up when discarded? I'll bet you don't take yours down to an approved disposal site. You'll no doubt tip it down the drain, in common with many other people. Have you ever given thought to what that could ultimately do to the water supply? Remember that we are currently being informed that our water is not as pure as it should be. And even when etchant is disposed of "safely", as industrial pcb manufacturers will ensure, is it really safe? Perhaps it may be necessary to look for an environmentally safe pcb etchant.

I was pleased to report recently that one manufacturer, Philips, has started to make batteries whose electrolyte is relatively harmless when discarded. Other manufacturers will undoubtedly follow suit, hopefully with a totally harmless product. Wotan is another company concerned for the environment. They are conscious of how much power is wasted in lighting applications and have produced electronically controlled lamps which consume less power for a given light output. The lamps can be plugged into any normal light socket and are not much bigger than a standard light bulb. You will find a further reference to them in the catalogues section on page four.

On the consumer electronics front, we shall all increasingly become more aware of power consumption factors. One of the themes repeatedly referred to at the Home Automation conference, on which I reported in April and May, was that of microprocessor control of heating. It is also likely that manufacturers will soon be stating on their products how much power they consume. Hopefully, consumers will then buy equipment that maximises power efficiency as much as it does functionality.

I am maintaining a watchful look out for other electronically related environmental matters, and shall keep you informed.

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DELUXE METRONOME

BY ROBERT PENFOLD

Turning a phase locked loop into a frequency synthesiser gives you the ultimate in modern electronics – a choice of click or thud!

Those readers who can remember back to electronics construction in the late '60s and early '70s will no doubt recall the very simple metronome designs of that era. These early metronome circuits were mainly based on unijunction transistors operating as relaxation oscillators, or a little later on the 555 astable was the more popular choice. These circuits were designed for simplicity, and often used only about half a dozen or so components! This metronome circuit is quite definitely a totally different concept, and it was designed to overcome the weaknesses of simple metronome projects. I believe it succeeds in doing so, but it inevitably costs substantially more to construct than a very basic design.

A common complaint about simple electronic metronomes is that they do not permit the beat rate to be set very accurately, and have poor repeat setting accuracy. This is due to the use of simple C – R oscillators that cover a fairly wide frequency range. Even using a large control knob and scale this inevitably gives quite cramped scaling, and compromises results. A lot of careful and very time consuming calibration is needed in order to obtain what is often still quite mediocre accuracy. The method of frequency generation utilised in this unit is based on frequency synthesis techniques, as used in a lot of modern radio frequency equipment. The frequencies involved in this application are very much lower, but the principle of operation is exactly the same.

The beat rate is selected using three switches rather than a potentiometer. Two of the switches are ten way types which enable a beat rate from 1 to 99 per minute to be selected, with a resolution of one beat per minute. The third switch is a range type, and by selecting the second range a beat rate span of 10 to 990 is obtained, with a resolution of 10 beats per minute. This permits the beat rate to be easily set at any desired figure, or something very close to it. The use of a crystal controlled timebase ensures excellent accuracy, and the frequency synthesiser technique removes the need for any calibration of the finished unit.

An accented beat facility can be switched in, with anything from every second to every eighth beat being emphasised. This emphasis is in the form of the usual "click" sound being replaced with a deeper and slightly louder "thud" type sound. Visual beat indicators are provided in the form of separate leds which flash in sympathy with normal and emphasised beats. Although the circuit is based on sixteen integrated circuits, these are all low power cmos types, and a small 9 volt battery is adequate as the power source.

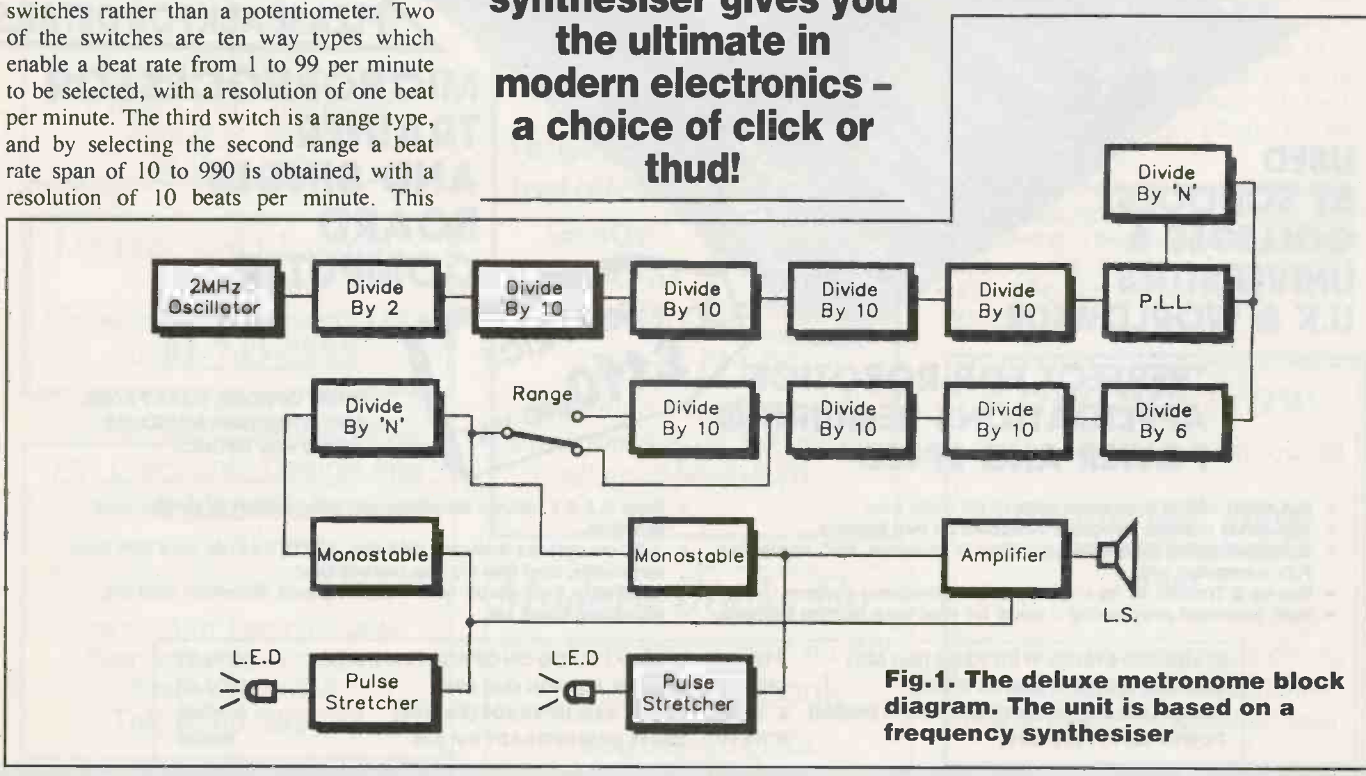


Fig.1. The deluxe metronome block diagram. The unit is based on a frequency synthesiser

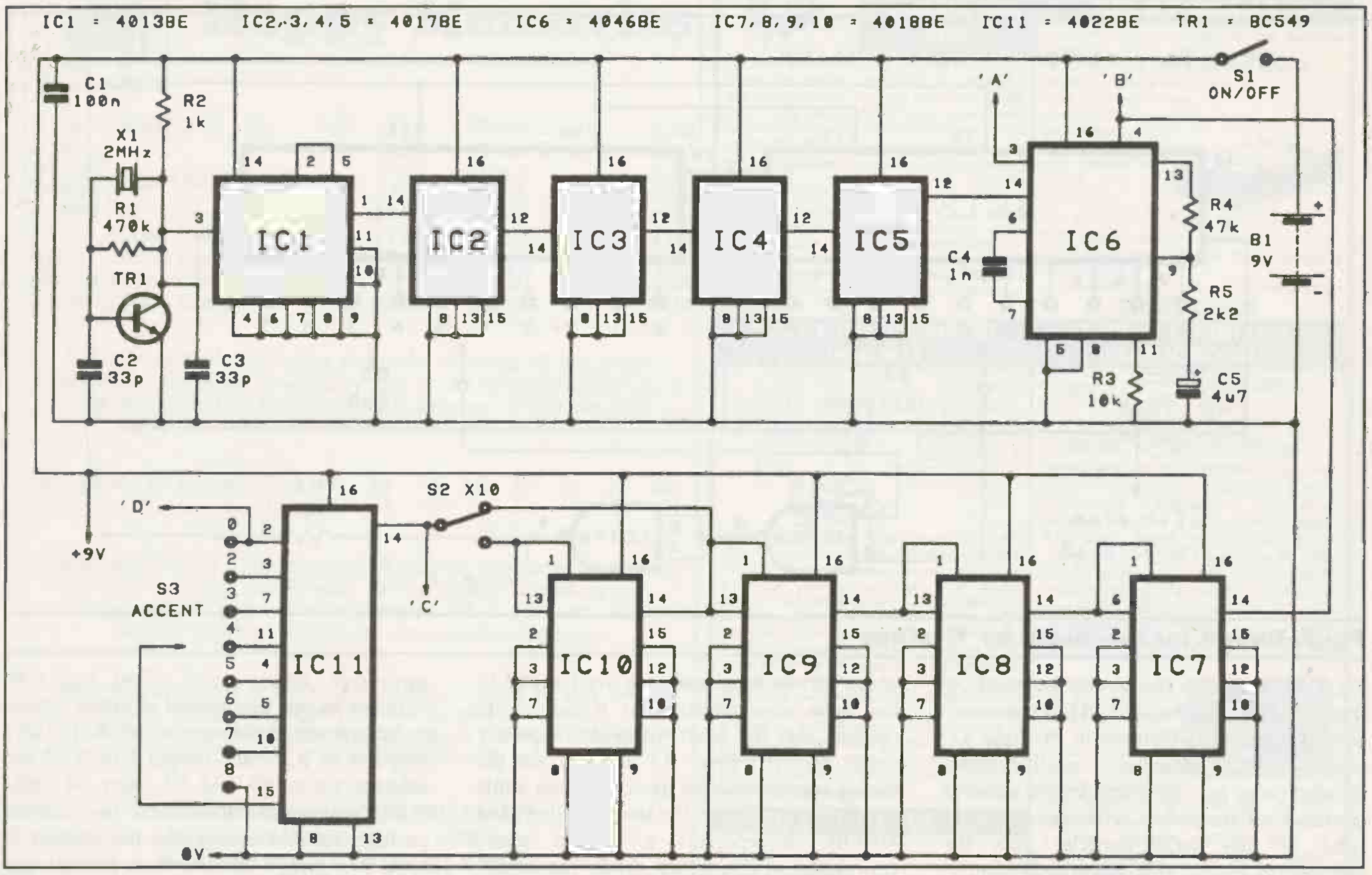


Fig.2. The main circuit diagram

FREQUENCY SYNTHESIS

The block diagram of Fig.1 shows the general make up of the unit, and should help to clarify the overall method of operation. The phase locked loop (pll) stage is at the heart of the unit, and is the main stage of the frequency synthesiser section. Although it is shown here as a single stage, the pll actually consists of a vco, a phase comparator, and a lowpass filter. The basic action of a phase locked loop is to maintain its vco at the same frequency as and in-phase with an input signal. In this case the input signal is a 100Hz squarewave derived from a 2MHz crystal oscillator and a series of frequency divider stages.

In order to make a phase locked loop function as a frequency synthesiser it is merely necessary to add a divide by 'N' circuit between its vco output and the input of its phase comparator. As a couple of simple examples, consider the action of the circuit with divisions of 2 and 5. With a 100Hz input, in order to obtain a matching 100Hz signal from the vco and divider the vco must function at 200Hz. After division by two this gives the correct 100Hz input signal to the phase comparator. Similarly, in order to give a 100Hz input to the phase comparator with a division by 5, the vco must operate at 500Hz. In fact the vco frequency will always be equal to the 100Hz input frequency multiplied by the division rate through the divide by 'N' stage. It is the signal from the vco that constitutes the output of the frequency synthesiser. In theory any output frequency that is a multiple of 100Hz can be obtained, although in practice the lock-on range of the phase locked loop will place a rigid constraint on the maximum available output frequency. Some phase locked loops have quite narrow lock-on ranges, but this application usually requires a type that has a very wide lock range.

In this case the divide by 'N' circuit provides divisions of 1 to 99 inclusive, and the cmos phase locked loop used in the design is well able to handle this wide frequency range. Of course, this gives a basic 100Hz to 9.9kHz frequency range, which is well above the required frequency span of about 0.5Hz to 6Hz. However, some frequency division is all that is needed in order to give an appropriate output frequency range. A divide by six stage followed by a series of three divide by ten circuits give an overall division rate of 6000. This provides an output frequency that is in multiples of 0.0166Hz. At a first glance this may seem an odd figure to use, and it is perhaps more conveniently thought of as 1 cycle per minute. This gives the unit its basic 1 to 99 beats per minute range, and by switching out the final divide by ten stage the beat range can be altered to 10 to 990 beats per minute.

The output from the frequency synthesiser is a squarewave signal, but what we require in order to provide the standard metronome "click" sound is a very brief pulse of around 0.5 milliseconds in duration. This is obtained by triggering a monostable from the squarewave signal, and the resultant pulses are used to drive the loudspeaker by way of a simple amplifier stage. Accented beats are obtained by feeding the squarewave output signal to a divide by 'N' stage. This can be switched out if no accentuation is required, or set for a division rate of 2 to 8 when the accentuation is required. This divider drives a second monostable which has a longer output pulse of around 5 milliseconds in duration. The output of this monostable is mixed with the output of the first monostable, and it is has the effect of lengthening the output pulses on accentuated beats so as to give the required deeper "thud" sound.

Visual indication of the normal and accentuated beats are provided by driving leds from the two monostables. Simply driving the leds direct from the monostables does not give very good results as the output pulses are too brief. The leds visibly flash, but their apparent brightness is quite low. Two pulse stretcher circuits are used to give longer and more noticeable flashes from the leds.

THE CIRCUIT

The main circuit diagram appears in Fig.2, but the divide by 'N' and output stages are shown separately in Fig.3 and

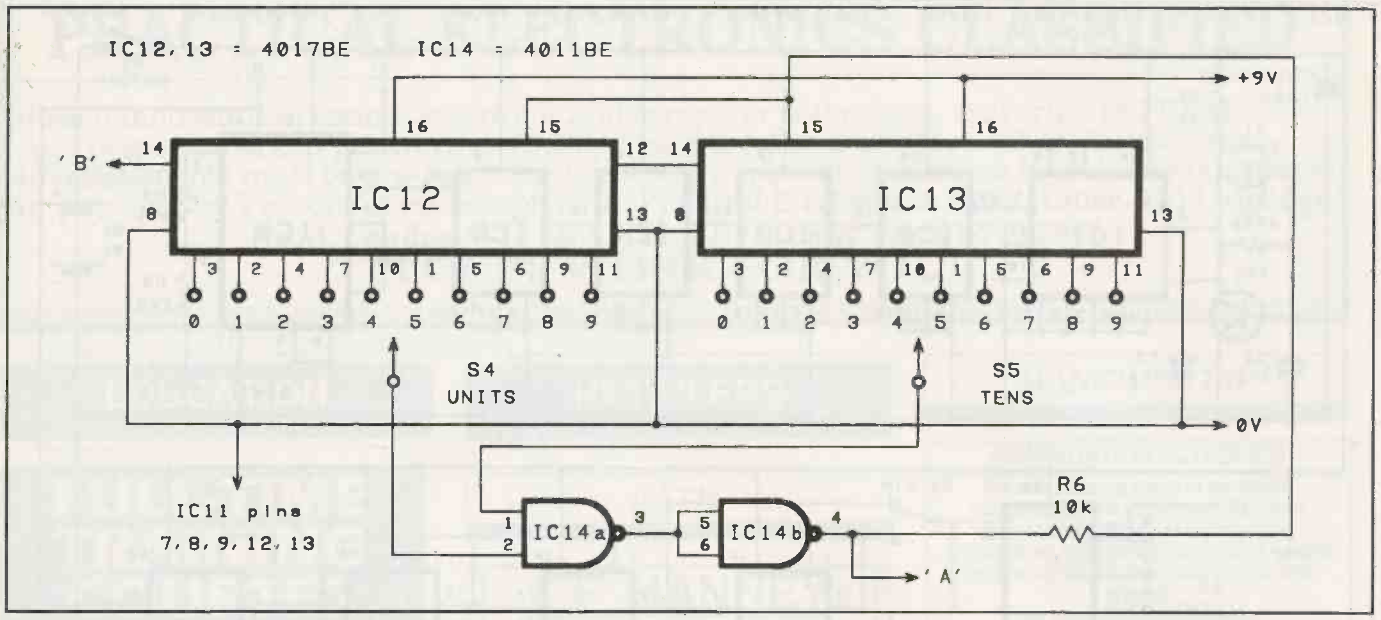


Fig.3. Circuit for the divide by 'N' stage

Fig.4 respectively. The circuit is based on that of the "Synthesised AF Generator" project which was featured in PE June 87, albeit with extensive modifications. Readers who are interested in the detailed operation of frequency synthesisers should refer to this earlier article, plus the companion feature ("Frequency Synthesisers") in the same issue.

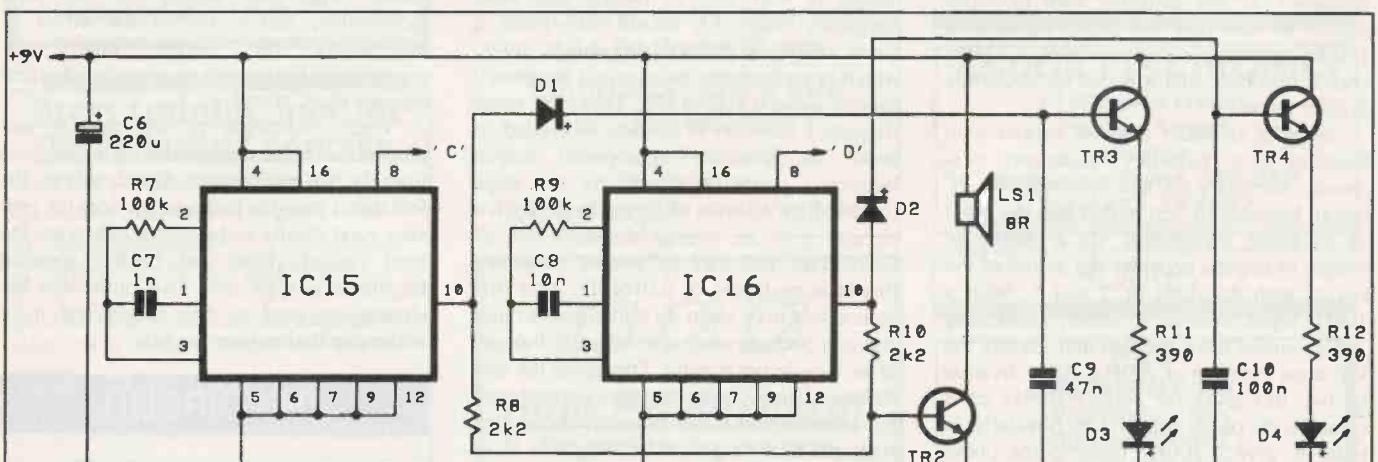
TR1 acts as the basis of the 2MHz crystal oscillator, and this uses a standard configuration. There is no need to include a trimmer to permit fine adjustment of the output frequency as any error here will be totally insignificant. ICI is a dual 'D' type flip/flop, but in this circuit only one section is utilised, and it operates as a simple divide by two stage. This is followed by a series of four 4017BE one of ten decoders. In this case these devices operate as simple divide by ten circuits using the "carry" outputs and ignoring the other ten outputs of each device.

IC6 is a cmos 4046BE "micropower" phase locked loop, and it is well suited to this type of application as it can easily operate over the relatively wide frequency range involved here. R3 and C4 are the timing components for its vco section while R4, R5, and C5 form the lowpass filter. The 4046BE incorporates a second phase comparator and a zenor diode for supply stabilisation purposes, but in this circuit neither of these extras are used.

The divide by 'N' circuit is based on IC12 and IC13, which are both 4017BE one of ten decoders. They are connected in series so that the basic action of the circuit is to provide a division by one hundred. However, the division rate is always less than this due to the inclusion of IC14 which resets both devices prematurely. It has one input driven from IC12 and the other driven from IC13, and the resetting of the dividers occurs when the two outputs that drive IC14 are both high. The action of a one of ten decoder is for its outputs (numbered from "0" to "9") to go high in sequence on successive input pulses. Two ten way switches enable any output of either device to be connected through to IC14. If (say) output 4 of IC13 and output 7 of IC12 are selected using S5 and S4, then 74 input cycles will occur before these two outputs go high simultaneously and the counter is reset. The circuit can therefore provide any division rate from 1 to 99 merely by dialing up the required division rate on S4 (the units) and S5 (the tens). Note that "00" is not a valid setting for these switches, and will probably produce quite a high output frequency.

The output from the vco feeds a divide by six stage which is a 4018BE with the appropriate method of connection. S2 is the range switch, and it selects the output from either IC9 or IC10. IC11 is the divide by 'N' circuit that provides the accentuated beats. This is a 4022BE one of eight decoder, and it is used in what is essentially the same way as the 4017BEs in the main divide by 'N' circuit. No gating is needed in this case

Fig.4. Circuit for the output section of the unit



as only a single device is involved, and it can directly reset itself. With output "0" (pin 2) connected through to the reset input IC11 is held permanently in the reset stage, and this disables the accented beat function. It is from this output that the divided output signal is taken.

Both the monostables are based on 4047BE cmos monostable/astables integrated circuits (IC15 and IC16) which are connected here to operate in the positive edge triggered monostable mode. C7 and R7 give an output pulse duration of approximately 0.45 milliseconds from IC15, while the values of R9 and C8 given an output pulse duration of about ten times this figure from IC16. The monostables drive the loudspeaker via a simple common emitter amplifier (TR2) which really operates as a switch rather than a linear amplifier. This is acceptable since the output signal is just simple pulses.

The led indicators are D3 and D4, and they are driven from the monostables via emitter follower buffer amplifiers. The diodes and capacitors at the inputs of these stages provide the pulse stretching, but the pulses to the leds still need to be quite short. Otherwise at high beat rates the leds would be permanently switched on, or would seem to blink off rather than flash on. The led which indicates the emphasised beats (D4) is flashed on for approximately twice as long as the other led. This factor, plus the use of a separate led for the emphasised beats, helps to make the emphasised beats stand out very clearly even when the volume of the music is so loud as to largely mask the sound of the unit.

As the circuit is based on low power cmos integrated circuits, and the loudspeaker is only fed intermittently with very brief pulses, the current consumption of the unit is very modest at only about 5 milliamps (a little more than this at high beat rates). A small (PP3 size) 9 volt battery is therefore perfectly satisfactory as the power source even if the unit is likely to receive a great deal of use.

CONSTRUCTION

Details of the printed circuit board are provided in Fig.5. The first point to note is that all sixteen integrated circuits are cmos types, and that they consequently require the standard anti-static handling precautions to be observed. I would strongly urge the use of sockets for all these components, and they should not be plugged into place until the project is finished in all other respects. The crystal is mounted direct on the board, and it must be a miniature wire-ended type (HC-49/U or similar) if it is to fit into place easily. Crystals can easily be damaged by excess heat when they are being soldered in place, so try to complete these soldered joints reasonably rapidly. The capacitors must be miniature types if they are to fit easily into the available space. In the case of the polyester types they should have 7.5 millimetre pin spacing. There are a fair number of link wires to fit onto the board, and the trimmings from resistor leadout wires should suffice for these. At this stage only fit single-sided printed circuit pins at the points where connections to the controls, leds, and loudspeaker will eventually be added.

I used a case for the prototype that is considerably larger than is really necessary. You may have to opt for a case of similar dimensions in order to obtain one with suitably generous front panel dimensions, or with a little ingenuity a much smaller case could probably be used. For example, by using one of the large sides of a case as the front panel it would be much easier to accommodate the front panel mounted

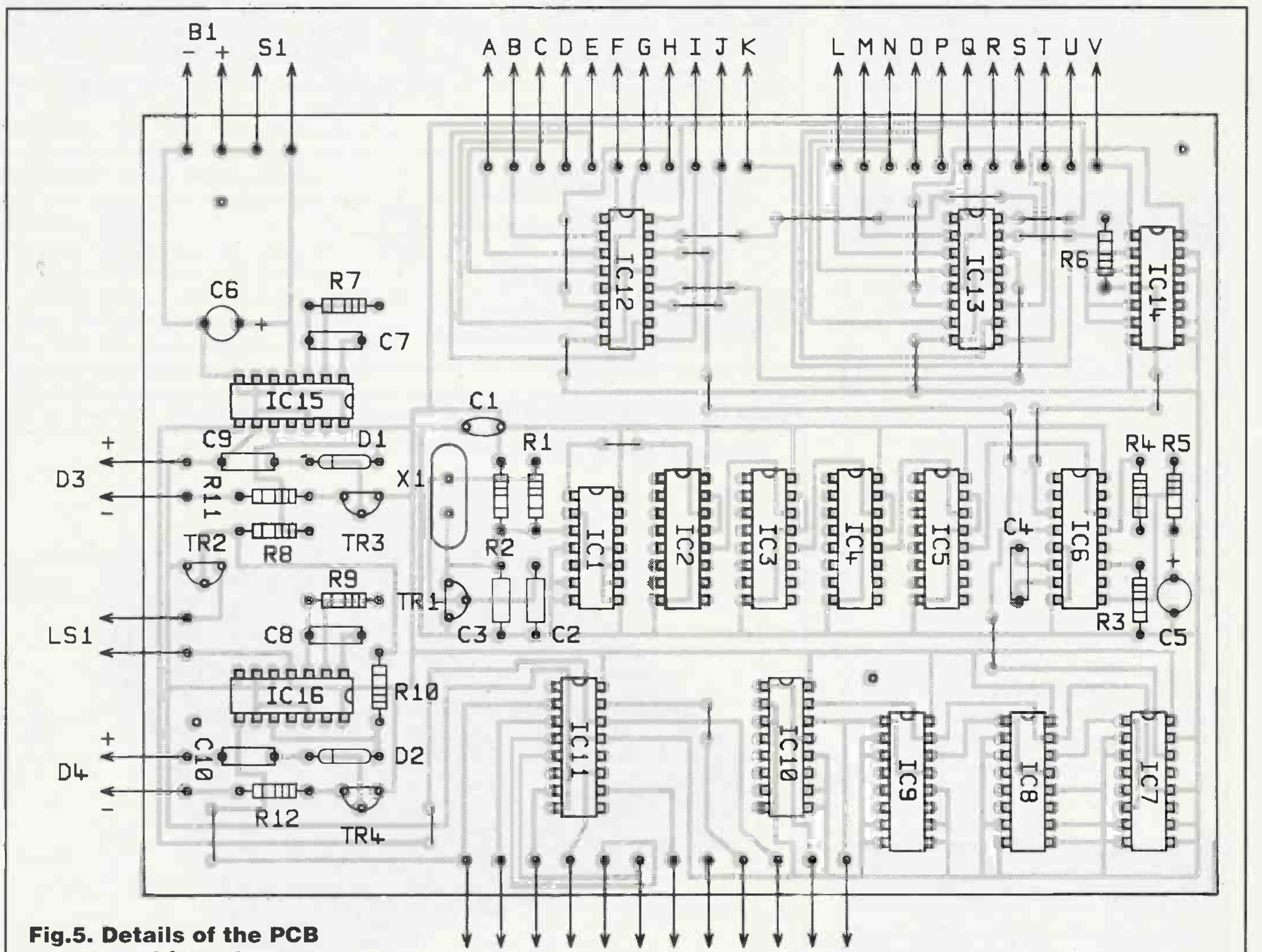


Fig.5. Details of the PCB component layout

components, or the loudspeaker could be fitted on the top panel of the case in order to reduce the amount of front panel space that is required. I would not recommend the use of a very small loudspeaker in order to save space. Small loudspeakers give relatively low volume, especially when fed with a simple pulse signal of the type involved in this application. I would recommend the use of a loudspeaker of at least 75 millimetres in diameter.

The exact front panel layout used is not critical, but S4 and S5 should be mounted side-by-side with S5 to the left of S4, so

COMPONENTS

Resistors

R1	470k
R2	1k
R3, R6	10k (2 off)
R4	47k
R5,R8,R10	2k2 (3 off)
R7,R9	100k (2 off)
R11,R12	390 (2 off)

All resistors 1/4W 5% carbon film

Capacitors

C1	100n ceramic
C2,C3	33p polystyrene (2 off)
C4, C7	1n polyester (2 off)
C5	4u7 63V radial elect
C6	220u 10V radial elect
C8	10n polyester
C9	47n polyester
C10	100n polyester

Semiconductors

IC1	4013BE
IC2,IC3,IC4, IC5,IC12,IC13	4017BE (6 off)
IC6	4046BE
IC7,IC8,IC9,IC10	4018BE (4 off)
IC11	4022BE
IC14	4011BE
IC15,IC16	4047BE (2 off)
D1,D2	1N4148 (2 off)
D3,D4	Red panel leds (2 off)
TR1,TR3,TR4	BC549 (3 off)
TR3	BC337

Miscellaneous

X1	4MHz miniature wire-ended
S1	spst miniature toggle
S2	spdt miniature toggle
S3,S4,S5	12 way 1 pole rotary with end stop, break before make (3 off)
LS1	8R impedance, 75mm dia. or more
B1	9 volt (PP3 size)

Case about 240 x 220 x 100mm (see text), printed circuit board, control knob (3 off), 14 pin dil ic holder (4 off), 16 pin dil ic holder (12 off), battery connector, pins, ribbon cable, stand-offs, etc.

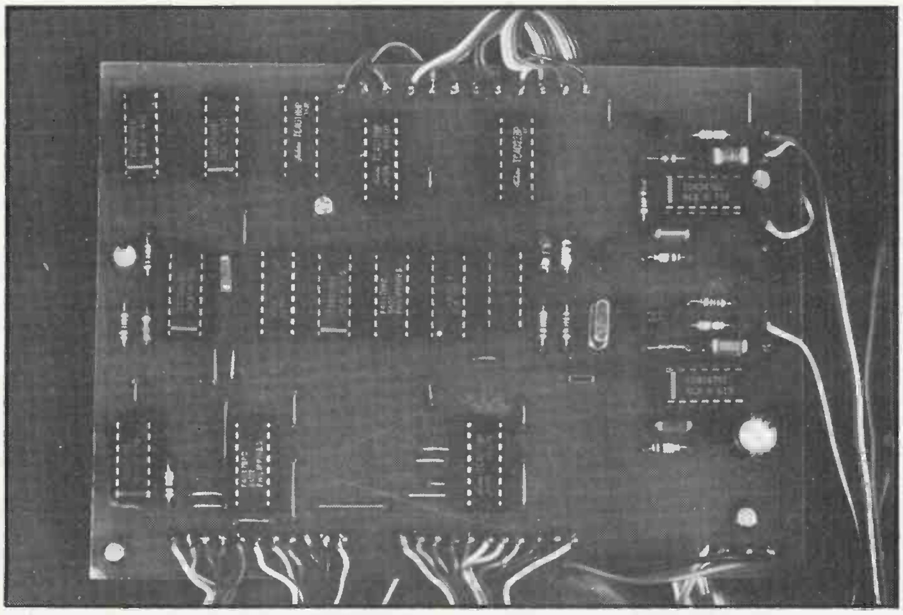


Photo of the completed PCB

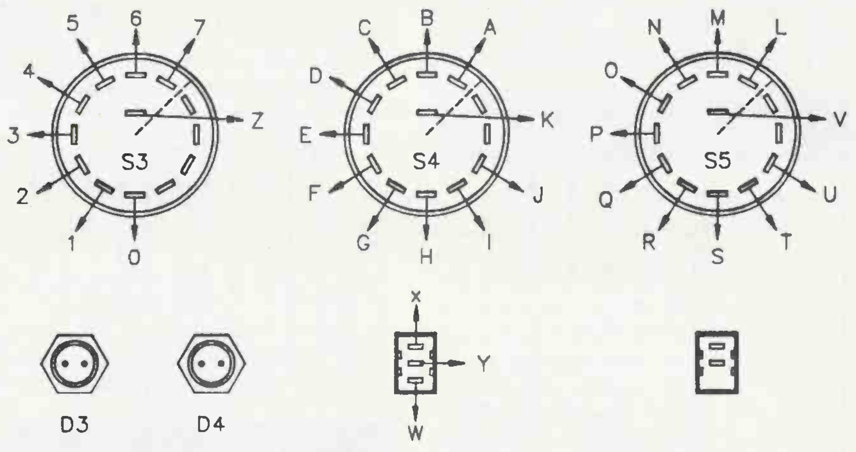
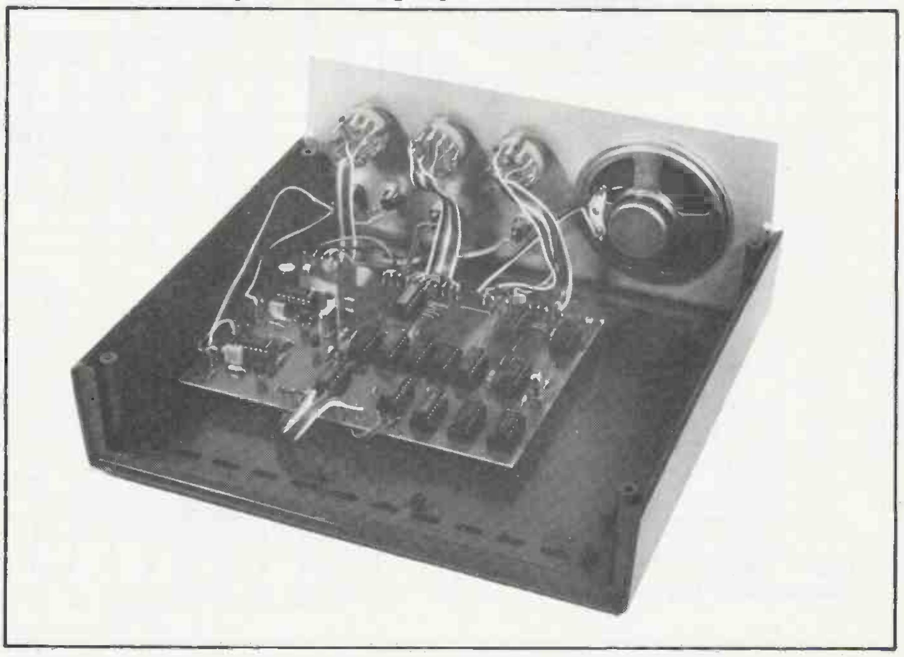
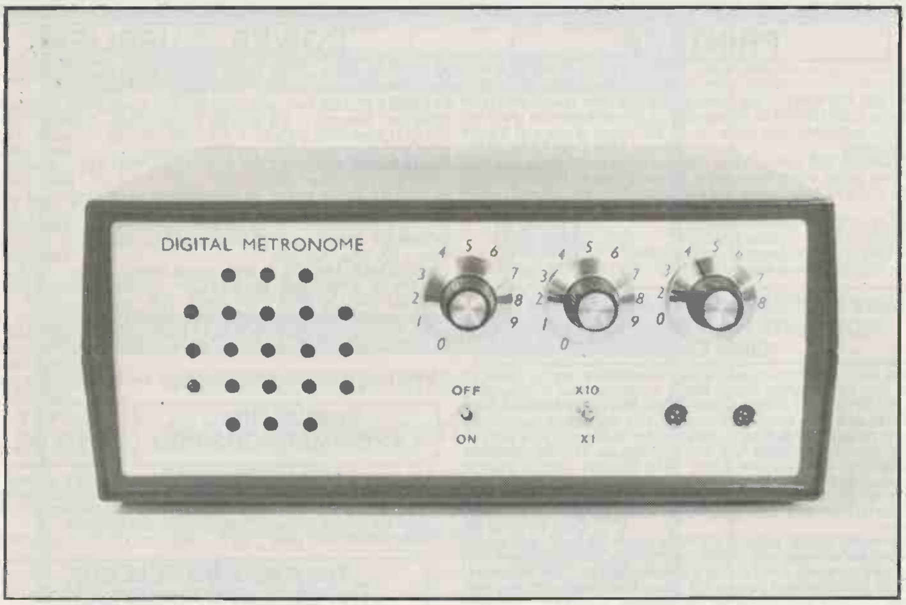


Fig.6. Switch wiring details

Photo of the completed wiring layout within the case





that it is easy to dial up the required number of beats per minute. The three rotary switches are all 12-way single pole types having adjustable end-stops (set to 8-way operation for S3, and 10-way operation for S4 and S5). With most of these switches the end-stop can be omitted if desired, so that the quick route from position 9 to position 0 (or whatever) can be taken. If you do this, connect the unused tags of each switch to one of the tags that is used, so that inputs of the counter chips can not be left floating. These switches must all be of the break before make variety. Otherwise two outputs will be short circuited together each time one of these switches is moved from one setting to the next!

A grille is needed for the loudspeaker, and the quickest way of producing this is to drill a matrix of holes about 5 millimetres in diameter. It is not as easy as you might think to make a really good job of this. It is best to start by drilling small holes (about 2 millimetres in diameter) as accurately as possible, and then enlarge these to the required size. If you use a loudspeaker of about 100 millimetres or more in diameter it may have provision for screw fixing, but smaller types usually have no built-in mounting bracket of any type. Often the only practical method of mounting them is to use a good quality adhesive such as an epoxy type. Try to avoid smearing any adhesive onto the diaphragm as this could seriously impair the efficiency of the loudspeaker. The printed circuit board is mounted on the base panel of the case using stand-offs or 6BA bolts plus short spacers.

To complete the unit the point-to-point wiring must be added. This wiring is shown in Fig.6, which must be used in conjunction with Fig.5 (eg point 'A' in Fig.5 connects to point 'A' in Fig.6). This wiring can be added using ordinary multi-strand hook-up wire tied into neat cable-forms, but ribbon cable offers a much quicker and easier solution. The cathode (+) terminals of the leds are usually indicated by shorter leadout wires.

IN USE

Even if you do not normally bother to mark panel legends on your projects, it is advisable to at least mark S4 and S5 with "0" to "9" scales so that it is easy to set them up for the required beat rate. Even fairly rough-and-ready scales will make the unit very much easier to use. The use of a crystal controlled frequency synthesiser means that this is the only form of calibration that is required. Before switching on the unit set S2, S4, and S5 for a sensible beat rate of around 50 to 100 beats per minute. When the unit is switched on it should produce the metronome "clicks" at a suitable rate – switch off at once and recheck all the wiring if there is any sign of a malfunction. To test that the unit is functioning accurately, set the controls for 60 beats per minute, and check against a clock or watch with seconds indication that the correct one "click" per second is being produced. With the accentuation switched on the accented beats should stand out quite clearly from the normal ones. However, the accented beats can be emphasised still fur her if desired by making C8 higher in valu›. Do not use a value many times larger than the specified value though, as this could produce a double "click" instead of the "thud" sound, and this would give confusing results.

PE

ED LINES

OPTICAL ILLUSION

Rumours that home automation might be aided by the use of a single fibreoptic cable coupled into the national grid seem to have been quashed. There have been suggestions that such a cable might carry many diverse data channels, ranging from tv programmes to telecommunications. In view of the current high-level attention being given to methods by which society can best be linked through microprocessed technology, speculation on how to make further use of the national grid is understandable.

However, according to a DTI report, the government has said that it is not prepared to underwrite the technology of nat grid comms, nor to allow BT to do so either. I wonder if anyone has considered putting fibreoptic links through gas pipelines? (Have you ever stopped to marvel that, if it weren't for the kinks in the pipe, you could look right down your gas cooker to the bottom of a North Sea gas well?)

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BOATING REVOLUTION

BY JOHN BECKER

A LIFE ON THE OCEAN WAVE-GUIDE

Modern craft do not so much make use of the sea as exploit a hi-tech highway. (With apologies to Joseph Conrad - *The Mirror of the Sea*, 1906.)

Of all the active leisure pursuits, sailing and cruising probably represent the largest single market to benefit from the dramatic advances in electronic technology. In the last five years microprocessors and miniaturised components have led to a booming proliferation of sophisticated control and monitoring products relating to practically every conceivable aspect of leisure marine. The rapid expansion in the ranges available vividly demonstrates how high-technology is being increasingly applied to satisfy a vast consumer market. This market spent around £570,000,000 during 1987!

With nearly 250,000 visitors to the Boat Show at Earls Court in January, there can be no doubt that many PE readers are amongst those who love messing about in boats. If you are one of that crew, I am sure you will find this review to be of great interest through finding out more about equipment (and some of its scientific background) that can add to your boating pleasure, and to your safety at sea. If you are a devout landlubber, have your eyes opened by reading on and seeing how technology, once having found a foothold, takes giant steps forward. You all could undergo a sea-change.

The Earls Court Marina

The report has been compiled from information obtained at the Boat Show, from subsequent discussions with manufacturers, and from data offered by other related organisations. It is not a catalogue of all products on the market, but rather, is a look at the different facilities being catered for by an emerging technology, both simple and complex. Though individual products are quoted, it is not implied that they are the only versions available; many manufacturers have similar products and I have no bias towards any particular company.

If anyone would like a list of relevant manufacturers and suppliers who were at the Boat Show please send a small stamped addressed envelope to me at the Editorial address.

Since compasses show us which way to go, let's head off in that direction first ...

MAGNETIC SENSORS

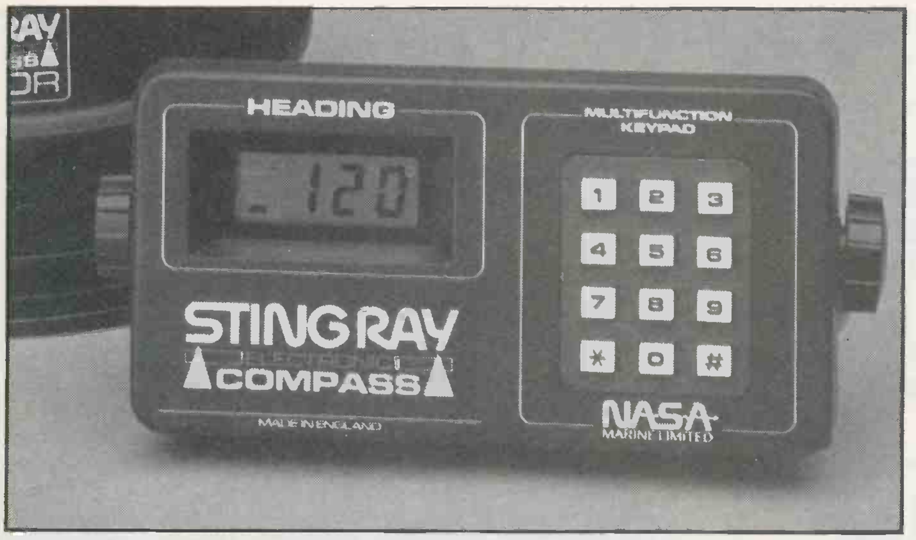
In its conventional form the rotating compass card, dancing around in its containing bowl, is only capable of providing a real-time analogue readout of the magnetic bearing. A variety of electronic methods have become available which allow the bearing to be displayed in a digital format and to be further processed. The techniques are of benefit to any seafarer, whether on a small craft, or piloting the largest oil tanker. Some are equally usable by motorists and even hikers. With the digital conversion comes the additional benefit of being able to interconnect the sensor to more sophisticated equipment, such as computers, automatic navigators and chart plotters.

Technology has provided us with several ways by which the compass bearing can be sensed and digitised. It can be assessed indirectly by monitoring the position of a compass pointer, or directly by sensing the direction and strength of a magnetic field. Judging by data quoted by some manufacturers, the likely variations in the strength of the earth's magnetic field (which varies around the globe) is around 5 to 40 micro Teslas.

Numerous options are available for sensing the pointer position, including pulse counting or proximity detection by means of optical, magnetic or mechanical detectors. For directly sensing magnetic fields, I am aware of three techniques: using fluxgates, Hall effect devices or magneto-resistive products. Only the first two appear to be in common use.

Fluxgate techniques involve the complex frequency relationship between the fields

Autohelm personal compass



NASA Marine Stingray compass set

induced in one or more coils; Hall effect devices produce an output current or voltage proportional to the strength and direction of a magnetic field; magneto-resistive products change their resistance in response to magnetic field variations.

Some commercial digital compasses make use of Hall effect devices, though the vast majority use the fluxgate technique, employing microprocessors to establish the correct bearing and its digital reading.

PRACTICAL COMPASSES

It is practical, and cost effective, for even the smallest craft to use a digital compass of some type. These range from simple all-in-one units containing the sensor, decoding circuitry and display, to those comprising a remote sensor well away from interference, a display in a position convenient to the helmsman or pilot, and a range of interfaces to other navigation equipment. It seems that no manufacturer bothers to produce a digital compass that does nothing else - they take advantage of miniaturisation and micro-processor control to incorporate other features, such as deviation from desired heading, variable damping, correction inputs and even additional analogue readouts.

The nearest exception to the last statement is Autohelm, who have a small handheld digital compass using the latest in fluxgate and microprocessor techniques. Even this, though, also has memory storage and timing functions. This instrument is ideal for land-based use as well as marine.

Otherwise, the simple units are represented by those such as lcd steering compasses. Displaying, for example, the boat's heading as a digital readout in degrees from 0 to 360°, the steering angle using an analogue pointer, the course made good, and with tactical self-checking for errors of magnetic disturbance or low battery voltage.

Most compass units allow selection of variable damping to electronically stabilise readings to suit sea conditions, fast in response to calm weather, progressively slower for rougher weather. Across the spectrum of different compasses, typical accuracies seem to be within about 1°. Widespread use is made of keyboard data entry pads for entire ranges of functions, companies vying with each other to stress how waterproof they are even in atrocious sea conditions.

Incidentally, in my report on Electronica 88 in PE Feb 89, I had meant to comment (but forgot!) on how many items of electronic apparatus are now designed for resistance to harsh environments. There were examples of multimeters and even computer keyboards shown immersed in water as well as covered by sand.

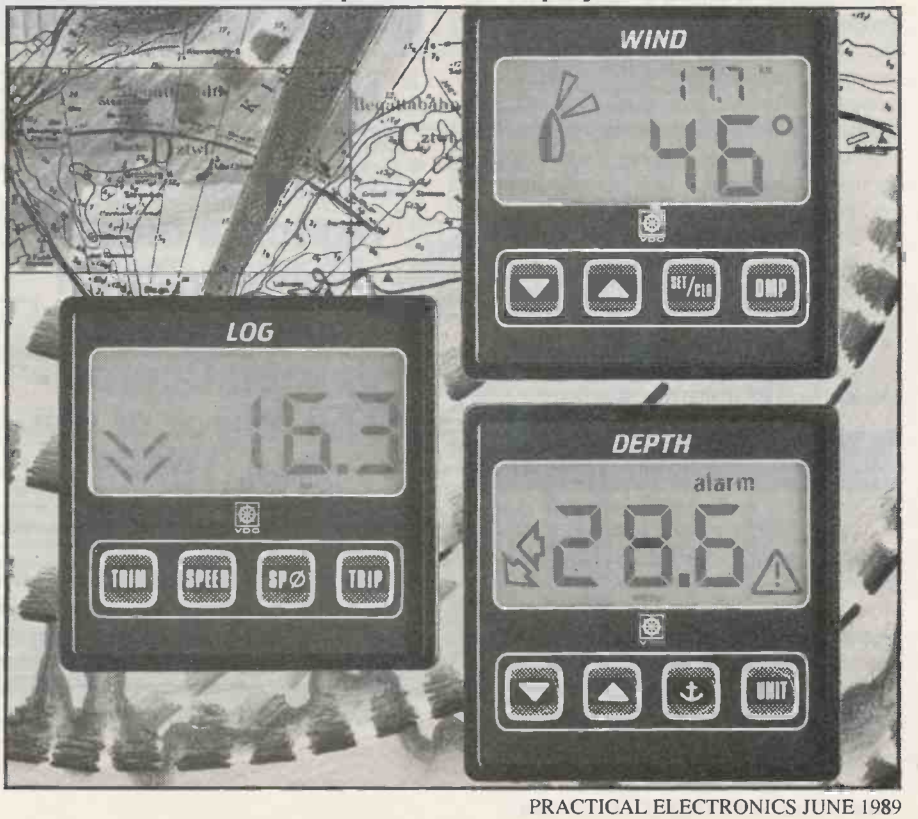
Typical of the more advanced electronic compasses is one of Rigel's. It uses a microprocessor controlled fluxgate sensor taking many thousands of readings per second, averaging them and displaying the bearing on an lcd in both digital and analogue format. It shows how far off course a craft may be on an analogue display, and an audible intermittent tone increasingly sounds if the vessel deviates from the selected course. It shows the direction and rate of turns, has selectable damping factors, automatic deviation correction and even automatic compensation for angles of dip up to 80°north or south. Just by turning the boat through one full circle it establishes the coefficients for calculating bearings, and then automatically locks the display onto the desired heading. It interfaces to satellite navigators, autopilots and on-board computers.

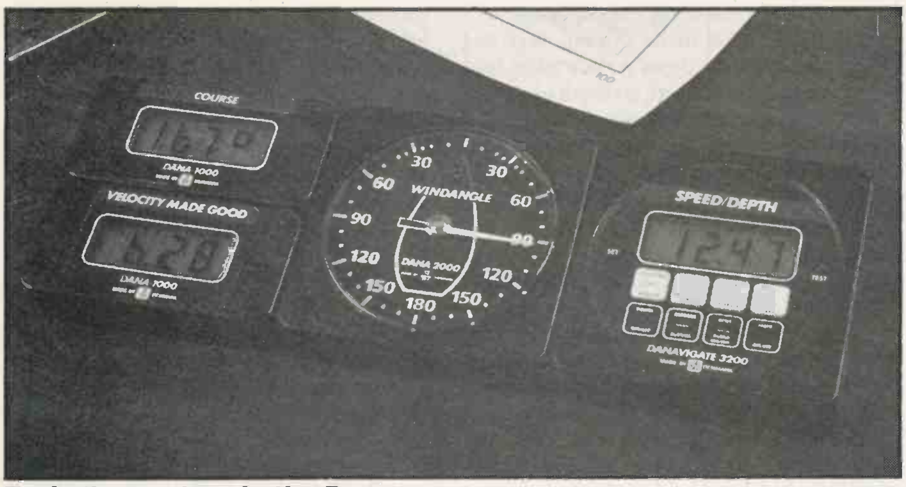
One of the more surprising compasses available is one for the blind! Apparently, there are many visually handicapped yacht sailors and Autohelm have produced a unit that provides a spoken output of the compass heading, updating it every few seconds. The target course can be set in 1°or 10° steps, and once on course a push button locks the heading into memory. Then a high/low pulse tone indicates off-course errors both in direction and magnitude. When sailing to windward a double push button is used to initiate a tack routine, automatically talking the skipper onto course for the new tack. Autohelm say that with this speaking compass the blind only need sighted help in order to keep a secure lookout.

CRAFT SPEED

Speed measurement is usually done by counting pulses generated by Hall effect sensors. In principle, this simply involves the use of a magnet attached to a rotating shaft inducing pulses across a fixed sensor. It is also possible to use shaft rotation for turning a motor, so producing an ac or dc voltage, either

A selection of VDU's compact sensor displays





Typical repeaters in the Dana range

of which can be readily measured. Speeds of up to 30 knots are allowed for by most instruments, though some are intended for powerboats and typically can monitor up to 50 or 60 knots. Some units record and display the peak speeds reached - always a good talking point!

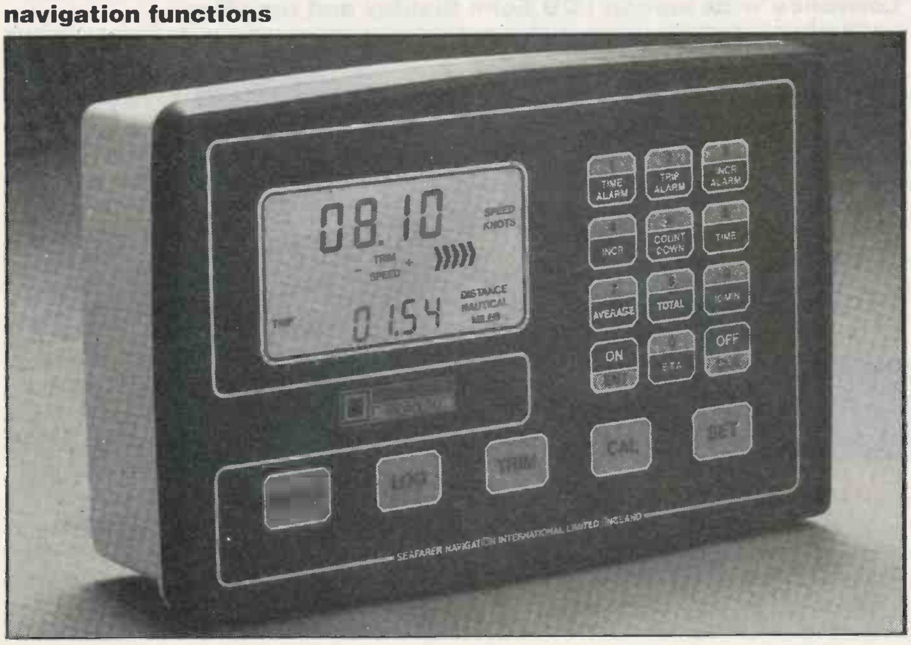
Two basic types of transducer appear to be in common use, the tunnel propellor and the paddle wheel. Both types are prone to non-linear reaction to the force of water driving them, largely due to the turbulence created along the hull. Electronics can be used to partly compensate for the effects and some models have calibration adjustments built in to fine tune readings to suit the craft. Different rates of sampling are selectable by many instruments, typically variable from one second to six seconds, so allowing for different sea and speed conditions. Electronics cannot yet solve the problem of rotor fouling by seaweed, but it can monitor the condition and some units have a "rotation stopped" sensor coupled to the display readout.

At the simple level, Autonnic have a speed monitor specially for wind surfers. It uses a tunnel propellor sensor, needs no cut-outs in the board, basically using a special tape bonding technique to hold it in place. It runs from a PP3 battery which can power it for up to 300 hours - typically representing a year's active use. Other speed monitors are specifically designed for training and regatta use. Some of these can also monitor a craft's trim and have facilities for plugging in a wind speed sensor.

DISTANCE LOGS

Most speed instruments combine distance readouts as well - it's relatively easy to convert the revolution data to represent both speed and distance. Distance logging commonly allows monitors to measure up to around 1000 nautical miles (nm), though 300 nm and 10,000 nm models are available. Most speed and log monitors provide a variety of memory mode and function options, usually keypad operated with suitable water resistance. So that data is not lost during battery changing, many models use a non-volatile memory (nvm), with data retention periods quoted from around three months up to five or more years.

Seafarer Microlog – provides 18 microprocessor controlled navigation functions



Several levels of memory storage and timing are common. For example, permanent memory stores for recording the total distance travelled; resettable trip distance memory; timers that count up in hours, minutes and seconds; timers counting down from a preset time for race starting purposes; and timers serving as stop watches for lap timing.

Many logs are designed for interfacing with satellite navigation equipment, typically producing 100 pulses per nm.

WIND SPEED

A wide variety of wind speed and direction monitors is obtainable for use in different situations. The impellors are normally designed for masthead mounting, frequently using Hall effect sensors. Data is usually transmitted by wires, though fibreoptic links are becoming common. Dana mention a rate of 1.65 pulses per knot, but otherwise data rates seem to be generally unquoted. The impellors and their monitors typically cater for speed ranges variably expressed in units of up to 40 m/sec, 80 knots, or 0-15 on the Beaufort scale. They are commonly designed for accuracies of up to +-1 knot within temperature ranges of -10° to +70°C.

Liquid crystal displays are used for both analogue and digital representation, some of them making use of colour. Models show information relating to such diverse functions as apparent wind speed (relative to the craft's speed), true speed, apparent wind angle, and the tack in degrees highlighted in red and green for port and starboard. Other functions include representations of the velocity made good, speed up-wind or down-wind, and trim control.

Some models allow maximum permissible wind speed and off-course limitations to be set, with audible and visual alarm outputs, and visual recall of maximum wind speeds experienced. Many wind monitors can be interfaced to other instruments for measurement of factors that build up a complete picture of a yacht's performance. At the simplest end of these options, Autonnic have a low cost handheld wind speed sensor accessory for plugging into meters such as their water speed unit.

Nearly as simple is a handheld wind speed monitor from Monro. It gives an instant digital readout in knots, and is probably of equal interest to those on land as well as at sea.

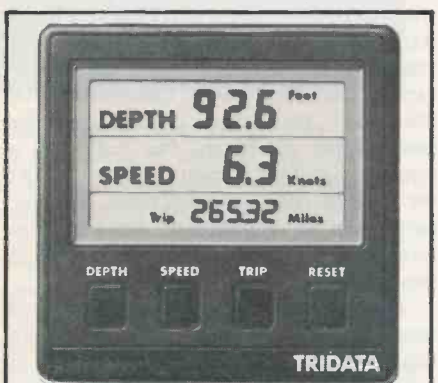
REPEATERS AND MULTIFUNCTIONS

Secondary display units for use in conjunction with main sensors are available from many companies. These can be positioned in any required convenient position on other parts of craft. Many of the single function units for speed, wind and depth etc, can be mounted together in purpose designed holders, with intercouplings enabling data to be relayed to master monitoring stations. Such arrangements also make better use of space, and look impressive!

DEPTH GUAGES

Numerous electronic depth gauges are now around, ranging from simple lcd readouts of water depth, to highly sophisticated echo recorders and fish detectors.

Simple models have sizes in the region of 4.4 x 4.4 x 1.4 inches and have maximum



Variations on a depth theme

ranges of between 100 and 1000 feet, with resolutions as good as six inches. Operating powers vary between about 250W and 600W peak to peak, and transmission frequencies for small units are usually around 150kHz, often accompanied by automatic gain controls. Although most units are for slower speed use, some have been specifically designed for powerboat use at speeds up to 60 knots, but with a reduced maximum depth range of around 100 feet. (A friend of mine says he doesn't care what the depth is, he's taken his powerboat at speed through no depth of water at all - right across a 50 yard stretch of dry sandbank! Reminds me of that hilarious sequence in a James Bond film in which powerboats keep racing across riverside lawns - "Live and Let Die", I think.)

A variety of extra functions are well provided for, such as displaying minimum depth since power-on, whether the trend is deeper or shallower, and alarms to back up these trends. Most units use digital lcds, though some have readouts expressed in analogue form, sometimes with logarithmic representation for greater discrimination. In most cases, the units are microprocessor controlled. At least one of the Stowe range is quoted as using a 4-bit microprocessor with 2K of rom, has an lcd readout using 18mm digits, and draws only 30mA. Its piezo electric crystal transducer measures 45mm and can punch its signal through a hull thickness of up to 38mm.

Those that use keypads for mode selection frequently use touch sensitive keys, and all the smaller units are fully waterproof. The Seafarer D800 dispenses with range switches entirely and has a 3.5 digit lcd readout in which the decimal point automatically changes position to suit the range.

ROTARY DEPTH READOUTS

A number of companies still manufacture the rotating led type of depth sounder and despite so many digital units around, there must still be a market for them. In these more conventional units a motor is used to rotate the led, illuminating it in synchronisation with the echo pulses so that its angular position represents the depth. There are also sounders of a similar nature in which fully solid-state techniques are used. In place of the rotating led, a series of leds is arranged in a circle, sometimes as many as 60 of them. Digital circuitry selects which led should be illuminated by the returning echo pulse. Nothing new about this though - I used the idea for my own depth sounder design over ten years ago. I had intended to publish it in PE, but never got round to writing the text - but it was used on a fair number of scuba diving occasions. One interesting fact relating to this is that my 40kHz transducer also responded to the ultrasonic overtones produced by diver's breathing apparatus.

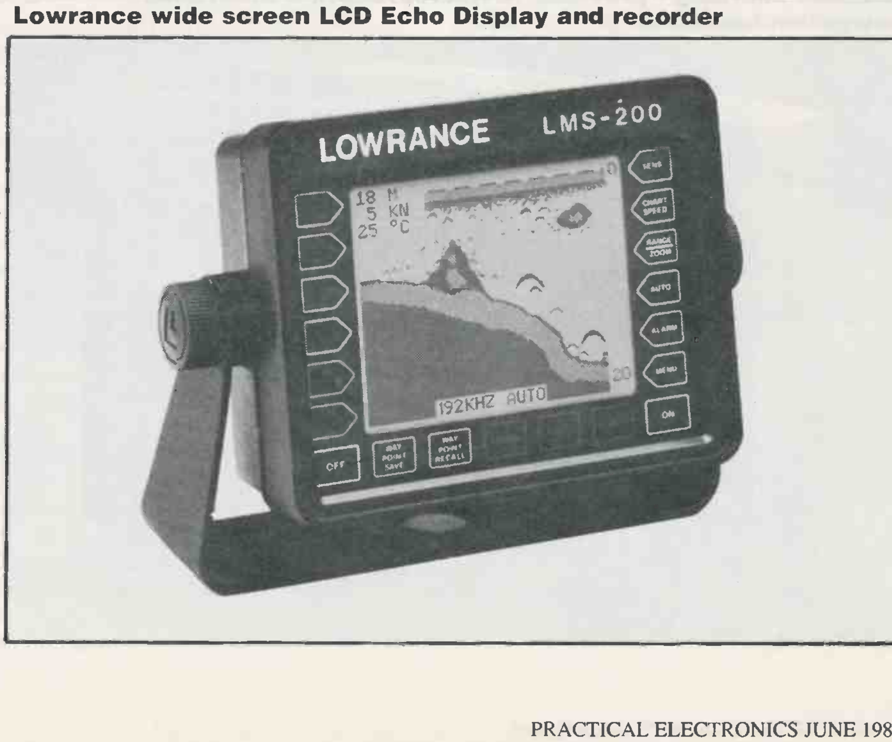
I must say that I find Spaceage's statement about their latest rotary led model somewhat surprising - "suddenly other echo sounders are becoming obsolescent". How can they justify that belief? The only higher-tech aspect that I can see in the model they refer to is that it uses twin high-brightness leds plus a digital readout on an lcd.

ECHO-RECORDERS

The good old paper chart recorder is still in evidence (indeed it is possible that marine regulations may perhaps require certain classes of shipping to still use them), but electronic displays with memory facilities really seem to be taking over.

Furuno are one company who still manufacture the paper readout models, but they make good use of hi-tech electronic devices within them. Firstly, the ultrasonic pulse is computer controlled to optimise its length and rate, and is interlocked with range selection for high definition of fish targets. Next, printing onto 6-inch wide paper rolls, the echo displays are processed so that they are digitally quantised to four levels of darkness, from white (no echo) through light grey, dark grey, to black for successively stronger returns. Additionally, lcd digital readouts are used to display bottom depth.

Lowrance wide screen LCD Echo Display and recorder



Lowrance LCD fish finder and recorder

Far more common now are recording sounders with microprocessor controlled memory storage, plus video or lcd displays. One of Lowrance's models uses a widescreen supertwist liquid crystal display graph having 128 vertical pixels. They say it is suitable even for high boat speeds and is as easy to operate as a bank's automated cash machine; the user does little more than answer on-screen questions to tune the unit to personal needs.

Koden claim to have invented the first colour video sounder and have a variety of models. One of them has 17 display modes, plus 12 split-screen modes. Such techniques require intensive use of computerisation and sophisticated software algorithms.

Multiple sonar sounders are available for simultaneous sideways and downwards scanning. These facilitate locating fish and underwater features such as ledges and rocks. They are ideal for navigating through narrow channels right up to the berth, even in zero visibility. Kelvin Hughes have a unit that uses three transducers, one looking downwards, and two for side scan operation each variable between +4° and -90° by remote control. The power output is an incredible 3300W rms reaching down to 4500 feet. Their display screen shows images in 16-colour detail.

FISH FINDERS

Many companies stress the importance they place on their units being able to detect fish from their echo shapes. In this way fish can be seen suspended in weed or holding close to the bottom and, apparently, expert fishermen are capable of telling the type of fish displayed. Some models can detect fish only three inches long and within three inches of the bottom. One depth recorder is specifically called a Fish Finder. It has a high resolution supertwist nematic lcd screen and a display-freeze function allowing the image to be studied at leisure.

Hummingbird say that they pioneered fish identification about two years ago. Their TCR model uses a thin film transistor screen having over 115,000 pixels and showing the fish in red! They go a couple of stages further still - they show bigger fish in red with a black dot behind them and have an alarm that sounds when they are detected. Many depth sounders have water temperature sensors as well since fish are often to be found in warmer waters. Kelvin Hughes' colour sounder MS705 resolves water temperature to within 0.2° between 0-50°C.

LOCH NESS

And talking of fish finders - Lowrance seem proud that their depth recorders were used to search for the Loch Ness Monster! In November 1987 a team of scientists led an expedition, Operation Deepscan, to sweep Loch Ness with sonar instruments. Twenty four boats equipped with Lowrance X16s (interestingly, these are paper chart recorders) were positioned across the one mile loch width and made two passes at slow speed over the entire 23 mile length. In many places the loch is over 200 metres deep and several sonar contacts were made with moving objects at depths below 46 metres, including one significant contact at 185 metres. But despite this concerted effort follow-up boats were unable to locate the same objects, and the results remain inconclusive. I don't think I'd feel safe to dive there, though!

MANUFACTURING INFO

Lowrance are particularly informative about their manufacturing techniques. They say they use streamlined robotic assembly procedures and make use of surface mounting devices (smds). The latter is interesting to know since I have previously commented that smds seem to be slow in finding manufacturing acceptance. Their products are all designed to withstand total submersion in water, and the displays are filled with nitrogen to prevent fogging. In their labs test samples are pounded, frozen, sprayed with both fresh and salt water, and heated to 150°C. Each product is thoroughly bench tested for eight hours, and samples from each week's production are further run for 500 hours - the

Furuno colour video sonar

equivalent of more than sixty 8-hour fishing days. Some of these units are then continuously tested for 5000 hours. No wonder they can safely offer a full three year warranty.

The same company advise that the key to higher definition and wider viewing angle on a liquid crystal graph display is the vertical count of high contrast blue pixels. These screens are designed not to black-out in high temperatures (I've had cheap in-car lcd clocks that do this on hot sunny days - a rare but aggravating phenomenon).

Their comments on transducer frequencies are valuable, especially to anyone thinking of making a depth sounder. 50kHz is satisfactory for deep water or where ground discrimination is important, but it suffers from poor definition. Frequencies of around 200kHz are best for use in depths under 150-200 feet and give better target separation and definition. 455kHz is even better! Wide angle sensors are best for broad bottom coverage, narrow angles are required for high definition. Transducers having various transmission angles and operating at all these frequencies are found amongst sounders right across the range.

DIVE COMPUTERS

No mention of depth would be complete without mentioning the decompression computers now coming in for scuba divers. As you probably know, in order to avoid decompression sickness (the bends), a diver can only stay under water for a given length of time, irrespective of the air available. The total duration is determined by the maximum depth, the time spent at that and intermediate depths, the temperature of the water, the lapsed time since an earlier dive, and the diver's physical make up (ignoring the diver's alcohol content - we like our beer!)

Previously, we would make estimations from printed charts or circular plastic "calculators", and try to remember the figures during the dive, not always with the greatest accuracy. Now electronics has come to our assistance and several companies sell decompression computers which are worn on the arm and show a variety of parameters.

One such model is the Edge, the electronic dive guide from Orca Industries, and probably the top of the range. The Edge does not merely read a set of tables, but continuously calculates and displays data for twelve different body groups. The display shows the remaining no-decompression time or remaining decompression time, the safe ascent depth, the dive time, maximum depth, water temperature, surface interval time, and scrolling repetitive dive table. Such aids to safety would have been unthinkable without microchip technology. Incidentally, underwater video cameras are also now available for scuba divers.

BAROMETERS

Much to my surprise, it seems that there are no electronic barometers readily available to the leisure cruising market. If you want one you can always build the barometer project we published in the Sep-Oct 88 issues - another first for PE, it seems!

ELECTRONIC MISCELLANY

Mains inverters which convert 12V and 24V dc boat supplies to mains voltages for powering domestic equipment, such as tv, video, hifi etc, are well catered for. Abbey Transformers enable you to monitor your electricity consumption with their Portometer - its ideal for caravans as well as boats. The Autolite, from Rochford Marine, is a light activated automatic switch specifically designed for marine applications, such as turning on anchor lights at dusk.

Ventilation is another subject that can be put under electronic control. Swiftech have a solar powered ventilator, additionally backed up by a nicad rechargeable battery.

Autonnic sextant computer

Home cooking at sea is becoming serviced by all mod-cons. Powamate have introduced what they claim is the world's first microwave cooker designed to run from 12V or 24V dc supplies.

Consideration to safe and fast battery charging has been given by TWC Systems. Their regulator is intended for use in series between a generator and the battery, and efficiently controls the full charging of batteries.

Solar panels for marine use are available from Ampair and PAG Solar Technology. Some of the feature points are that they are flexible, waterproof, robust, and non-slip. They come in a variety of shapes and sizes.

Ampair also go in for wind driven generators. They can be mounted to the mast, on deck, or even in your back garden at home.

SEXTANT COMPUTER

This computer does not do away with the need for a sextant, but it does take the chore out of the calculations. The software includes a full sun almanac to the year 2000, has six programs and holds data on up to ten stars of your choice. The star calculator program gives the azimuth and the intercept, and enables the unit to be used day or night. Basically, all you do is take two sights with a short interval between them, enter the dates, times and altitudes into the computer and it tells you where you are to within three miles, anywhere on earth. To the computer, the maths are a doddle - all it does is resolve the spherical trigonometric equations provided by the crossing of two Great Circles, and Neptune's your uncle! (but thank Autonnic for this goody).

PC NAVIGATION SIMULATION

Not surprisingly, software is available for yachtsmen who wish to practise navigation all the year round without getting their feet wet. Pilot Courseware have a software training package suitable for any IBM compatible PC, including the Amstrad 1512 and 1640, which enables you to become the armchair skipper of a 36 foot yacht with auxiliary engine. You sail round the challenging waters of the Channel Isles in realistic conditions with 3D seascape views from the yacht. Your tools are a hand bearing compass, a full range of cockpit instruments including Decca receiver and an electronic chart. Weather, tide, land, buoys, lighthouses and boat performance are all accurately modelled, and there are print, save and jump forward options. The program comes on disk and is equally usable with ega, vga and cga screens. PE

Next month we look at computerised navigation and plotting, radar, and global communications.

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SE6100 SIGNAL TRACER **£55**

FC5250 FREQUENCY COUNTER, 10Hz-150MHz **£65**

CM3300 CAPACITANCE METER 0.1pF-99.9mF **£65**
Full details of all above on request.

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Hundreds in Cat – look at these sample prices:
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W/W plugs	40p	50p	60p
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Z4116 24 way (8 x 3) membrane keypad. Large (200 x 90mm) area – they were used in a teaching aid. Overlay template and pinout supplied. **£3.00**

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Yes, only £4 for this Cherry keyboard – 67 full travel keys inc. function keys. Size 340x130mm. Pale/dark brown **£4.00**

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SOLAR HEATING CONTROLLER

BY ANDREW WILLIAMS

HOT WATER FROM THE SUN

High accuracy silicon temperature sensors make the most of the UK's weak sunlight.

For a basic solar heating system, such as that in Fig. 1, a heat transfer fluid (usually water) is pumped through the solar collector where the fluid gains heat. It then passes through a heat exchanger coil where most of the heat gained is transferred to the stored water. A temperature sensor is attached close to the solar collector output and another on the storage cylinder, and the electrical output from each of these sensors is fed to a differential temperature controller. The controller switches the pump motor on when sensor 2 output is greater than that of sensor 1 (ie, when the fluid in the collector is hotter than the stored water). Heat is thus transferred to the stored water through the heat exchanger. The controller switches the pump off when sensor 2 output is less than that of sensor 1, so preventing heat being transferred back to the solar collector and lost, during the night or when the weather is dull, for example.

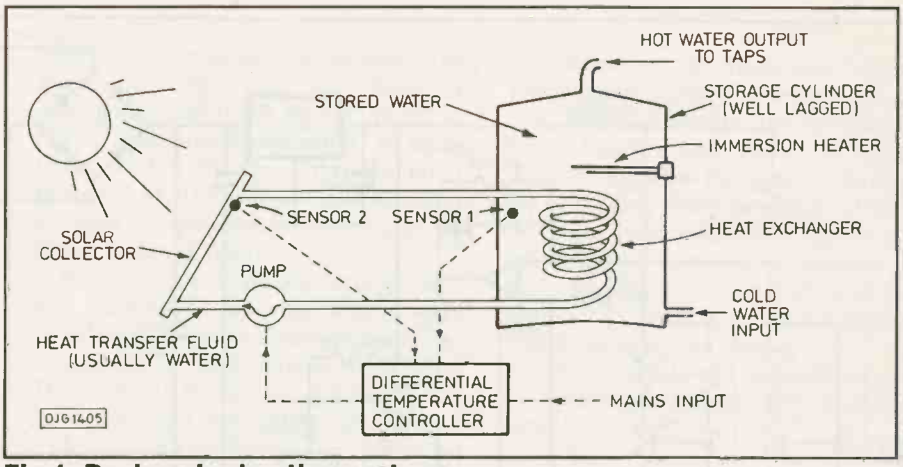


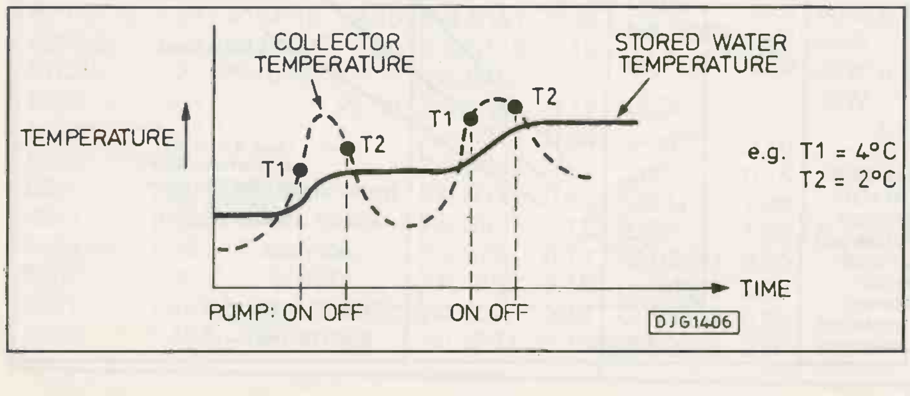
Fig.1. Basic solar heating system

Fig. 2 shows this operation in more detail.

You will notice that the controller switches the pump on when the temperature of the collector is (for example) 4°C higher than the stored water and off when the collector is only 2°C higher. This lag or hysteresis is essential to prevent the pump switching on and off almost continuously under conditions where the solar light intensity is only sufficient to raise the collector temperature slightly above the stored water temperature. When the pump operates, the relatively cool heat transfer fluid entering the collector cools it and so reduces its temperature, but the 2°C lag enables most of the hot fluid stored in the collector to be pumped through the heat exchanger before the pump switches off.

The rate at which heat is transferred to the stored water becomes greater as the temperature difference between the transfer fluid and the stored water increases. It will be seen that there is necessarily a minimum temperature difference to ensure that the rate at which heat energy is flowing through the heat exchanger is greater than the rate at which electrical energy is being used by the pump motor.

Fig.2. Typical solar heating pump on-off pattern



In the past differential temperature controllers often used thermistors for temperature sensors. One problem with this technique was ensuring that both sensors had almost identical characteristics, so that the controller would switch on and off at the required temperature difference irrespective of the actual stored water temperature. To overcome the variations in sensor characteristics the controller was often set to switch on with a relatively large temperature difference (eg 8°C at a stored water temperature of 30°C). This ensures that at all other temperatures the rate at which energy was being transferred to the stored water was always greater than the rate at which energy was being used by the pump motor.

HEAT LOSSES

The heat losses from the collector by radiation, convection and conduction all increase as the collector temperature increases. This results in heat input to the transfer fluid as the temperature rises. Consequently it is advantageous to keep the temperature of the collector as low as possible. This requirement conflicts with the method of setting up the controller in the previous paragraph.

In recent years semiconductor sensors have become available (eg LM 335) which, after an initial adjustment, have almost identical characteristics enabling the switching to be carried out at the minimum temperature difference.

It is often impossible to mount the collector very close to the storage cylinder because of the necessity of siting the

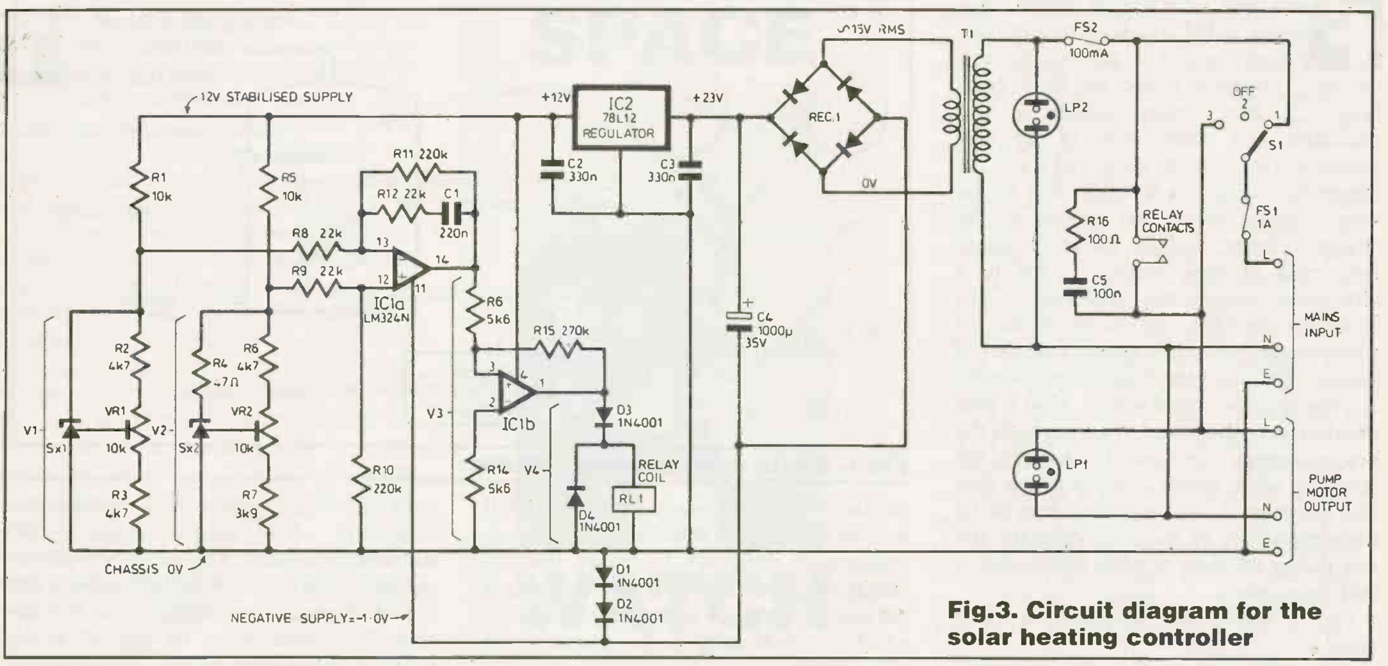


Fig.3. Circuit diagram for the solar heating controller

collector in a position where it will be in full sun for most of the day. This means that there will be some heat loss from the pipe joining the collector and the heat exchanger. Thus the temperature of the heat transfer fluid will be less when it arrives at the heat exchanger than when it left the collector. This temperature reduction will be very small when the temperature of the heat transfer fluid is low, but will increase as the temperature of the heat transfer fluid rises.

To offset this problem, the controller should switch the pump on with an increasing temperature difference between collector and stored water. This ensures that the minimum temperature difference across the heat exchanger remains relatively constant irrespective of the stored water temperature. The new semiconductor sensors mentioned above are ideal for providing this type of characteristic.

OPERATIONAL CONTROL

The sensors S1 and S2 in Fig. 3 behave like Zener diodes, where the voltage across the sensor is directly proportional to the temperature in degrees Kelvin. Adjustment of VR1 and VR2 enables the voltage across the sensor to be set to a precise value, eg if the voltage across Sx1 is set to 2.730V at 273K (ie 0°C) then the change in voltage across the sensor is 10mV for each degree Kelvin (or °C) of change.

IC1A is configured as a differential amplifier, ie, it amplifies the difference in the voltages across Sx1 (V1) and S2 plus R4 (V2). The dc and low frequency gain of this stage is 10, being determined by R11/R8 = R10/R9 = 10.

Thus V3 = 10 (V2-V1)

SETTING UP

Fasten Sx1 and Sx2 in close contact with a small metal sheet (the size of the sheet is not especially critical). Position a thermometer so that its bulb is in contact with the metal sheet and surround the sheet and lower part of the thermometer with some thermal insulation, such as expanded polystyrene, fibre-glass, cotton-wool etc. The sensors should be left with the control unit switched on for about a quarter of an hour to reach thermal equilibrium. The temperature is then noted, and V1 set by adjusting VR1 so that:-

V1 = (2.730+(temperature in °C)x (0.01))V eg, if the temperature is 18°C then

V1 = (2.730 = (18)x(0.01))V = 2.91V

A setting within ±0.05 V is sufficient.

Set V3 to -0.5V by adjusting VR2 to ensure that the pump will turn on when sensor Sx2 is 5°C hotter than sensor Sx1.

It is also possible to set to alternative switching temperatures:

eg -0.40V - 4.0°C, -0.60V = 6.0°C etc.

Note that in each case V3 is set to a *negative voltage* when Sx1 and Sx2 are at the *same temperature*.

FURTHER FACTORS

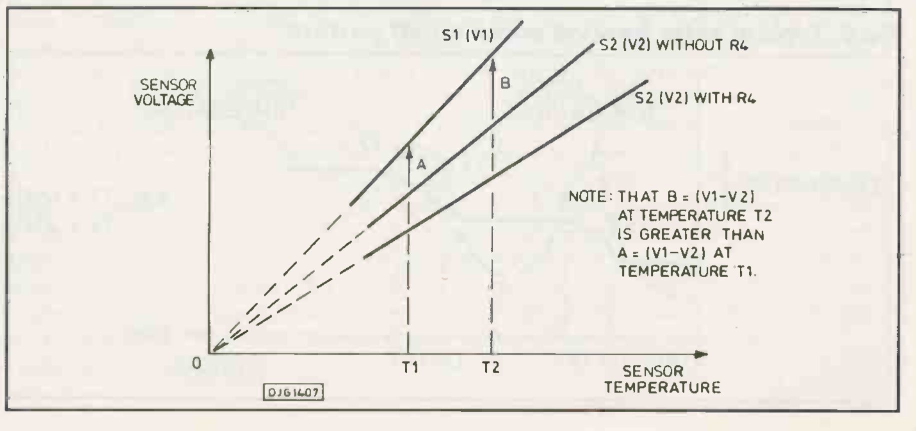
Pin 11 of IC1 is taken to a point below earth (chassis) potential via two diodes D1 and D2, to ensure that V3 and V4 are capable of going slightly negative.

IC1B is a regenerative comparator, thus when V3<0 (negative) then V4 is slightly negative, at about -0.35V, and when V3>0 (positive) then V4 is close to the positive 12V rail at about 11V. When Sx1 is at the same temperature as Sx2, then V3 and V4 are both negative, making D3 reverse biased so that no current flows through the relay coil. This ensures that the relay contacts are open and the pump is switched off.

When the collector sensor Sx2 becomes close to 5°C hotter than the cylinder sensor Sx1 then V3 becomes close to 0V, the positive feedback via R15 causes V4 to rise quickly to about 11V. D3 is now formed biased so that the relay coil is energised, hence the relay contacts close and the pump is switched on.

Diode D4 suppresses any back-emf through the relay coil when the current is switched off.

Fig.4. Graphical illustration of R4 function



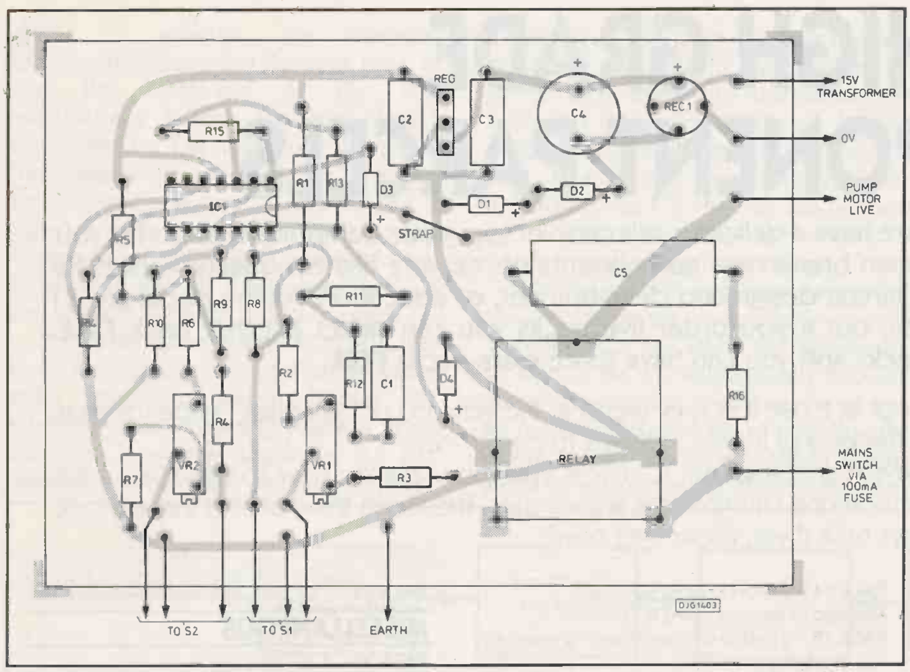


Fig.5. Printed circuit board layout

COMPONENTS

RESISTORS

R1,R5	10k
R2,R3,R6	4k7
R4	47k
R7	3k9
R8,R9,R12	22k
R10,R11	220k
R13,R14	5k6
R15	270k
R16	100k

All resistors 1/4W 5% or better

CAPACITORS

C1	220n
C2,C3	330n
C4	100n 35V elect.
C5	100n 250Vac working

SEMICONDUCTORS

D1-D4	1N4001
IC1	LM324
IC2	78L12
Rec 1	W005 bridge rectifier

SENSORS

SX1	LM335H
SX2	LM335Z

POTENTIOMETERS

VR1,VR2	10k 15-turn preset

MISCELLANEOUS

T1	mains transformer, 15V secondary, 100mA min.
RL1	Relay, 12V spco, 1640 Ω coil.
S1	1p 12w mains switch.
LP1,LP2	mains neon
F1	1A fuse
F2	100mA fuse

Printed circuit board, box, wire, to suit.

WHEREFORE R4

With both sensors at the same temperature V3 is set to -0.5V, making V2 0.05V smaller than V1.

Sensor Sx2 must become hotter than sensor Sx1 (by 5°C) to make V1 equal to V2; the condition required to operate the pump. Theoretically, both sensors would give zero output at 0° Kelvin, thus Sx1 is slightly more sensitive to temperature changed than Sx2 because of the initial setting difference. This effect is best shown graphically as in Fig. 4.

Note that B = V1-V2 at temperature T2 if greater than A = V1-V2 at temperature T1.

The potential drop cause by including R4 in series with Sx2, results in V2 becoming greater than the voltage across Sx2 alone. Thus, the voltage across Sx2 needs to be smaller during the initial line-up procedure, making Sx2 less sensitive to temperature changes, as shown in Fig. 4.

Consequently, R4 increases the differential as the temperature rises, and to an extent greater than the sensors alone would give.

Although in Fig. 3 the difference in temperature between switching on and off has been set at approximately 2°C, the differential can be varied by altering the value of R15, eg 200k = 3°C hysteresis; 620k = 1°C hysteresis.

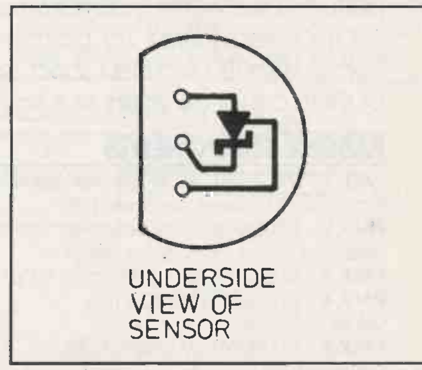


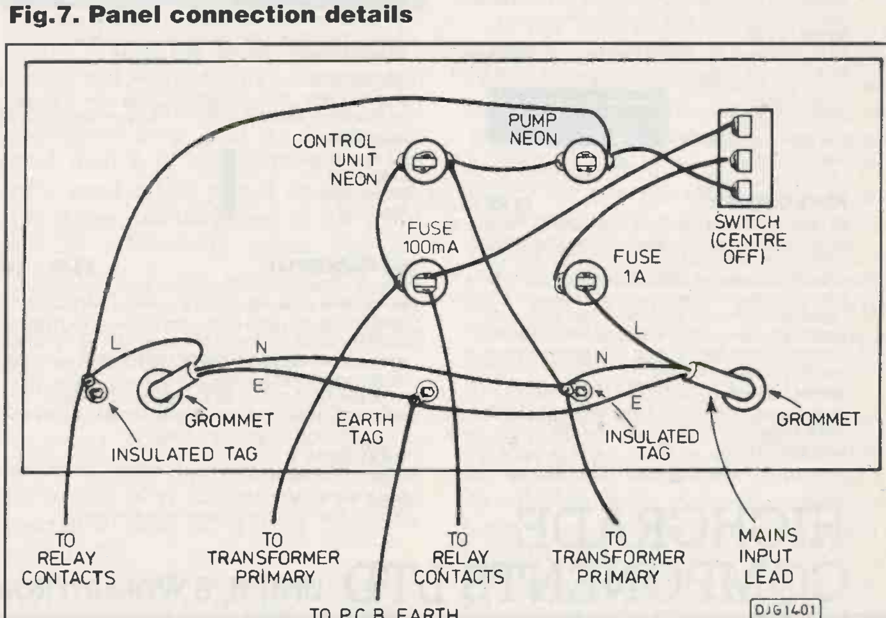
Fig.6. The sensor connections

FINAL COMMENTS

Although IC1 is a quad op-amp and only two of its amplifiers are used, it was chosen because it is capable of sensing input voltages right down to the negative rail, it has a low power consumption and is readily available at a reasonable cost. PE

Parts of this circuit are at mains potential and normal insulation and safety practices should be observed.

Fig.7. Panel connection details



ACORNS TO OAKS

Dear John,

Your editorial in Jan 89 reminded me that I too have been reading PE since the first issue back in 1964, and continue to enjoy it as much as I did then. During that time I spent several years working abroad, but I always managed to make sure PE followed me. In fact, I can probably thank PE, together with my earlier avid reading of PW and PTV for their contribution towards a successful career with IBM.

One of the first PE projects which I undertook was the scope featured in PE 1965. It gave me excellent service for many years, and was eventually given to a neighbour's son, who was just setting out in electronics.

Sometime after I had built this project I acquired a huge array of test equipment, built into a large unit. I noticed that one of the two in-built scopes had a marked similarity with the original one I had built. Digging out the March 65 issue, close examination of the cover photograph led me to believe that it was the author's original scope. Perhaps if the author, Mr Cairns, reads this he might care to confirm if this is the case. I still have this scope, now retired.

My interest then turned to an electronic ignition system, modifying some circuits from PE; it worked well, with a 1/4 inch spark gap! Soon my attention became focussed on the then emerging ttl chips. I was asked to build some automatic timing equipment for a local motor club, but such was the distrust then for digital electronics, I had to build a unit which operated a normal stopwatch via a solenoid!

If your have any comments, criticisms or suggestions, write and let us know. We are interested in what you think and say, especially regarding our new style and your views on our role for the 1990s.

The situation had changed by 1972 when I put together my own design for a digital stop clock with 3-foot 7-segment displays for the model flying club in Salzburg. The knowledge needed to design the timer circuits naturally came from PE. It worked well but within a month after finishing it the first integrated clock chip appeared - all that work now available in one piece of plastic encapsulated silicon.

The pocket calculator appeared on the scene. and I built several Sinclair kits. I also built the PE Feb 74 battery charger/inverter which many a time proved useful in keeping the gas central heating running during power cuts.

Along came microcomputers, and I purchased one of the first Radio Shack TRS80 machines, expanding it myself and building an interface to drive a typewriter. This machine taught me a lot about microcomputers.

Current projects at home are few and far between; the occasional special circuit for radio control, and I plan to add a-d capability to my IBM PC. I have often thought about building some satellite tv receiving equipment, but that will probably not now come about as commercial equipment becomes more readily available and cheaper.

I still read PE every month. It helps me to keep abreast of new developments as well as providing interesting articles on wider ranging subjects. Keep up the good work, and best wishes for the next 25 years. I wonder what you will be featuring in 2014 ...

Peter Short, Kings Worthy, Hants.

These are just extracts from a much longer, and extremely interesting letter. Peter Short has obviously been as enthralled by electronics across the years as I have. His comment on "all that work now available in one piece of ... silicon" reminds of my very early attempts to build what I then described as a computer. It was nothing more than a long series of divide-by-two circuits feeding into a neon counting display. But each divider was formed of many transistors, diodes and resistors, and was on its own wiring board, measuring at least 4 x 6 inches! I also recall building a valve driven divider once upon a time.

I'll be most interested to hear of other reader's reminiscences about electronics over the last 25 years, especially if they relate to PE in some way.

Ed.

FIRST COURSE

Sirs,

I would like to begin a course on electronics but the books in my library seem dated. What books would you recommend for a beginner, and where should I buy my "bits and pieces"?

L. Bird, Rugby.

I am often asked questions along these lines, this is why we recently updated the PE Armchair Bookshop and put books into rough categories. You will find a wealth of interest in all the beginners books (and the others) but I suggest you buy more than one to give yourself a wider variety of subject matter and the benefit of several authors' viewpoints.

We have many good advertisers who sell components and other "bits and pieces". It would not be fair for me to recommend any one in particular - study their adverts and ask for their catalogues.

Ed.

TRUMPET BLOWING

Dear John,

Just a short note to say thanks very much for the recent excellent mention of Revox Systems.

M. Cooper, F.W.O.Bauch Ltd.,

Dear John,

We were delighted to read your article 'Servicing an Era'! (PE Nov 88, P5)and would like to express our admiration and thanks for your ability to compose such an interesting and well-written tribute

G. Cohen, Service Trading Co.

Many thanks - it makes editing PE even more worthwhile when I know that advertisers and readers are happy.

Ed

KILOSCOPY

Dear Ed,

Many thanks for your recent article on building an oscilloscope. It's been well worth waiting for.

I have a double gun tube that requires a potential voltage of 1.5kV. Can you recommend a suitable power supply?

C.P. Williamson, Chessington.

The Battery to Mains and HT Converters articles in PE Jul-Aug 88 show ways of increasing voltages from one level to another. One method of ac voltage multiplication described is very simple when only low currents are required and does not need many components - just a few diodes and capacitors that will withstand the increased potential.

For your application you will also need to compare the data sheets for your tube and the one for which the project was designed to determine the changes you may need to make to voltages for the other control plates -a matter on which we cannot advise you as the subject is lengthy.

Ed.

BANANARAMA TELE

Dear Ed,

Further to the question of paw-paws being used as tv aerials (PE Dec 88 and Feb 89) *Electronic Engineering* of Jan 84 published a report confirming their reception ability. Other vegetation was also named, such as date, coconut and banana palms, and even ferns, as having antennic properties. Several reference sources were quoted, going as far back as 1961.

G.J.Lane, Chesham, Bucks.

Could this be an answer to the satellite tv reception dish problem of only being allowed one dish without planning permission? Now Astra is up and BSB is coming, it might speed up the reforestation following the Great Storm of 87. Just imagine Kent and Sussex full of steerable banana plants connected by coconut-fibre optics. And would more of us watch date-time television? Mind you, I think the Germans have been on to this for a long time - their word for television is "fernsehen" ...

Ed.

MORE COMPACT CD

Dear Ed,

Last year PE published a series on CD technology. Your author quoted a playing time of about 60 minutes, but I understand that 73 minutes is a more correct figure.

M.L. Peake, Bilston, W.Mids.

Technology moves on, 75 minutes can now be fitted in, and they're still working on more playing time.

Ed.

SUPERCHARGED

Dear Ed,

Your 'Beware Batteries' comment in PE Feb 89 reminded me of two Exide T20 1.5V batteries I have sitting on my desk.

Recently, I moved house and came across a box of my old childhood toys in the loft. Picking up a racing car powered by two batteries, I pressed the button and was surprised to see the wheels turn at full speed. Taking out the batteries, they were found to be in perfect condition, no leakage and still holding 1.5V. I estimate them to be about 26 years old, at least the same age as PE!

Ian Doble, St Agnes, Cornwall.

We're still supercharged too!

Ed.

The various integrated circuits that go to make up a computer system, from memory chips to microprocessors, have been described in Parts 7 & 8. This month we see how they are put together to make a computer system, and how the system is made to operate as a whole.

A computer is a device, usually electronic, that is designed to process data automatically. *Processing* consists of storing data in memory, performing mathematical operations on it, performing logical operation on it, and taking decisions based on the data. The *data* includes numerical values, text, graphics, and information of various kinds, such as the fact that an airline passenger Mr X has made a request to be served vegetarian meals during the flight. Since the computer processes the data automatically, the data also includes a *program*, telling the computer what processing it must do and how to do it.

Electronic computer systems are of two kinds, analogue and digital. Analogue computers simulate (or are an analogue of) a physical system. The aim is to discover how the physical system behaves without actually having to operate it 'for real'. For example, an analogue computer could simulate the behaviour of a river system with dams and reservoirs. The flow of electric charge in the computer is an analogue of the flow of water in the river system. The computer is used to predict the rates of flow, the losses due to evaporation, the amount of water available for domestic use or for irrigation, the risks of flooding etc – *before* the dams have actually been built at great expense. Analogue computers are also useful in designing mechanical structures such as bridges and airframes.

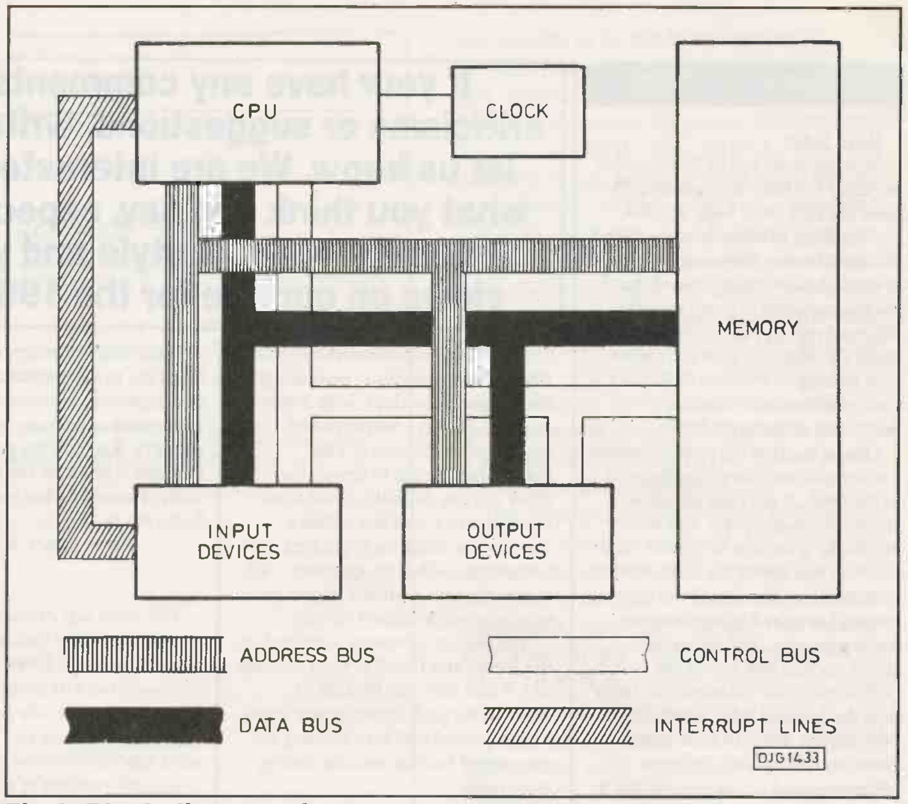


Fig.1. Block diagram of a computer system

DIGITAL ELECTRONICS

BY OWEN BISHOP

PART 9 – COMPUTER SYSTEMS

So, we've already examined the chips that go into a computer. Now we look at how they relate to a complete system.

In this series our main interest lies in things digital and so we shall study the digital electronic computer in some detail. In a digital computer, data is stored and handled in binary form. It may be represented as high or low voltage levels, or by flip-flops that are in either the 'set' or 'reset' states.

Digital computers are of two main types. Some of them (the kind we usually call to mind when the word 'computer' is mentioned) are able to perform a wide variety of tasks. This group includes everything from the pocket calculator to the main-frame computer. With the exception of the more elementary pocket calculators, they can be programmed for all kinds of applications including mathematics, word processing, acting as video-text terminals, and as games machines. Specialised word processors fall into this group since, though they are primarily designed for processing text, they are usually able to perform a number of other functions too.

The other main group of computers consists of those that we are less aware of because they don't have the typical 'keyboard plus video monitor' appearance. Indeed these computers are usually hidden away inside a device that looks nothing like a computer. We are referring to the computers used to operate such devices as washing machines, video recorders, cash registers, robot arms, and electronic toasters. The group also includes the computer systems used in aircraft and increasingly in road vehicles. These systems are all *dedicated* computers. They are programmed to perform only one task or a few closely related tasks.

COMPUTER ARCHITECTURE

Fig.1 shows the main sections of a computer system. This diagram applies to all computers from pocket calculators, video games machines, and the control circuits of an electronic kitchen scales to the mightiest of mainframes. Most of the actual work of the system is done by the *central processing unit* (cpu). It is here that data is processed – acted on mathematically or logically – and decisions are taken. In many computers the cpu consists of a single integrated circuit a *microprocessor*. As explained in Part 7 (PE, Apr 1989), this is driven by an astable circuit, acting as a clock. The frequency of the clock is high, perhaps 2MHz or more, so that the operations of the microprocessor are performed exceedingly quickly and in rapid succession. This high speed is what gives the computer its power. As we shall see later, it does not do anything very complicated but, what it does do, it does *fast*. The cpu of mini-computers and main-frame computers usually has more than one microprocessor and perhaps a special-purpose 'number cruncher' ic to help with the more involved parts of the calculations. This gives these machines the power to process more data and process it faster than micro-computers.

Memory often takes up the majority of the space on the computer board. Exceptions to this are some of the dedicated computer systems. These may require only a small memory. The memory may even be included on the same chip as the microprocessor. In some of the older micros the computer boards are covered in crowded ranks of memory chips, but with the development of chips capable of storing 256 kilobytes or more, memory is becoming less of a consumer of board space.

In the so-called 8-bit micros, such as the BBC Microcomputer, the Commodore 64, the Amstrad CPC series and the cheerful Speccy, memory is organised in *bytes*, each consisting of eight *bits*. Physically, each byte is represented on the memory chip by a set of eight flip-flops (or other devices such as capacitors). Each byte is identified by its *address*. When the byte is addressed, 8 bits of stored data can be read from it or (provided that the chip is a ram chip) written into it. In the micros mentioned above, as well as many others, an address has 16 bits. Addresses range from 0000 0000 0000 0000 (0 decimal) to 1111 1111 1111 1111 (65535 decimal). The maximum amount of addressable memory is thus 65536 bytes or 64 *kilobytes*, usually referred to as 64K. For convenience, addresses are usually written in hexadecimal. We shall indicate such numbers by prefixing them with '&'. In hex, the addresses in a 64K machine run from &0000 to &FFFF.

Some parts of memory are rom (read only memory). This is used for *permanent* storage of:

* ***Operating system programs*** – tell the computer how to perform its routine tasks. This includes what to do when first switched on, such as testing memory, clearing the monitor screen, displaying the name of the computer on the screen and the word 'Ready', then waiting for input from the keyboard.

* ***Resident programming language(s)*** – most home micros have a Basic interpreter program, which tells the computer how to understand instructions coded in the Basic language. Some do not have a language in rom. It has to be loaded into ram before programming begins.

* ***Data needed by the computer*** – for example, the patterns to be used for displaying alphanumeric characters on the screen.

* ***Special-purpose programs*** – examples include word-processing, spreadsheet and data-base programs. It is convenient to have such programs instantly available in rom rather than to have to wait while they are loaded from tape or disk. With some machines this rom is in the form of a plug-in cartridge. Cartridges are available for programming languages, utility programs and games programs.

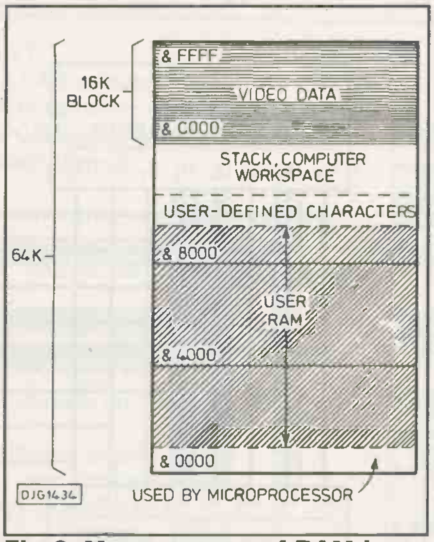


Fig.2. Memory map of RAM in Amstrad CPC series computers

Other parts of memory are ram (random access memory). This is used for *temporary* storage of:

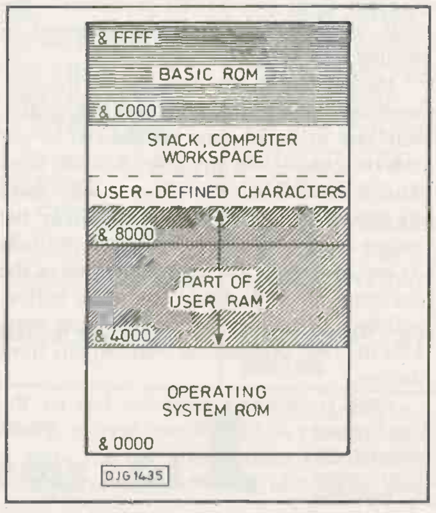
* ***Programs*** – loaded from tape or disk

* ***Data needed by the programs,*** such as lists of names, addresses, contents of spreadsheets, patterns of user-defined characters.

* ***Data used or produced by the computer*** – how long the computer has been switched on, what display mode it is in, what colours it is displaying, what was the last key pressed, the current position of the cursor, and many other such items essential to the operation of the computer. The part of memory holding this data is known as the *workspace*.

* ***Stack*** – here the computer stores data produced at one stage of an operation until it is required at some later stage in the operation.

Fig.3. Memory map of Amstrad CPC series computers when ROMs are switched in



* ***Video data*** – this is often a *bit map* of the screen. Each picture element (*pixel*, the smallest individual dot produced on the screen) is represented by one or more bits of video memory.

As an example of memory allocation, Fig.2 shows the *memory map* of computers in the Amstrad CPC series. All the addresses from &0000 to &FFFF are occupied by ram. A large portion of this ram is occupied by video data. In some other computers there may be an entirely separate video ram, so allowing more main ram space for the storage of other data. Certain areas are reserved for essential purposes such as the stack, workspace and the storage of user-defined characters. There is a small area at the lowest addresses reserved for use by the microprocessor. The remaining ram, referred to as the *user* ram, is available for storing programs, data etc.

Since *all* the possible memory addresses &0000 to &FFFF are occupied by ram, where is the rom? The Amstrad's rom consists of two blocks of 16K each. One block, the Operating System rom is given addresses &0000 to &3FFF. These addresses are the same as those of the lower 16K of ram. When any data is *stored* in memory it goes to ram. When data is *read* from memory, either the rom *or* the lowest 16K of ram (but not both) can be read from at any one time. When the microprocessor is supposed to be using the Operating System (perhaps to scan the keyboard for input) the rom is switched in (Fig.3). At that instant it is not possible for it to obtain data from the corresponding block of ram. However when the keyboard has been scanned, rom is switched out automatically and ram is switched in. The microprocessor returns to running a program stored in ram.

Similarly the other block of rom (holding the Basic interpreter program) has the addresses &C000 to &FFFF, coinciding with the top block of ram. Rom is switched in when the microprocessor has to interpret a Basic statement, ram is switched in when the video display has to be updated.

The switching in of different blocks of memory is a way of making more than 64K available without needing addresses of more than 16-bits. The same principle can be applied to allow other 'sideways roms', such as word-processors, to be called up as required. In the same way we may have a second block of 64K of ram that can be switched in to provide extra storage. The Amstrad CPC128, the Spectrum 128K machines and the C-128 are examples of machines that provide double memory capacity in this way.

INPUT DEVICES

These include keyboards, tape readers (eg a cassette recorder), disc drives, optical compact disc readers, bar code readers, joysticks, mice, and digital pads. With dedicated computers the input devices may include various push-buttons (as on a washing machine) switches and levers (as on a robot control panel), and sensors (eg temperature and water-level in a washing machine; a light sensor to detect how brown the toast has been cooked in an automatic toaster; thermal sensors in a heat-seeking missile.

All of these devices give a digital reading that can be transferred to the microprocessor. If the devices detect analogue data (such as the position of a joystick, or the amount of browning of the toast), an analogue-to-digital converter is an essential part of the device. Some computers (eg the BBC Micro) have on-board a-to-d converters for handling analogue input data.

The input devices of a computer are each allocated one or more addresses within the range of memory addresses. These devices appear to the microprocessor as locations in memory from which data is read in the usual way.

OUTPUT DEVICES

Output devices include video monitor screens, loudspeakers, tape recorders (these act both as input and output devices, as do disk drives), printers, plotters, robot arms, motors, led displays, and lcd displays. These too have addresses in memory to which the microprocessor sends data when the output device is to be activated.

INTERRUPTS

Fig.4 shows interrupt lines which run to the cpu from an input device. A signal (usually a logical low) on one of these lines causes the microprocessor to complete whatever operation it is engaged in and then to jump to a special part of its operating system program known as an *interrupt servicing routine.* The interrupt signal comes from an external device, such as a telephone modem or another computer. It may be that the external device has data that it wants to send to the computer. In this case the interrupt servicing routine would cause the microprocessor to accept data from the external device and perhaps store it in memory. Then, depending on what data was received, the computer might continue with what it was doing before, or take new action based on the newly-received data. These interrupts are usually handled so rapidly that the user of the computer is unaware that there has been any break in the machine's action.

BUSES

The operation of a computer depends on the transfer of data between the cpu, the memory and the input and output devices. The system adopted for this is known as the

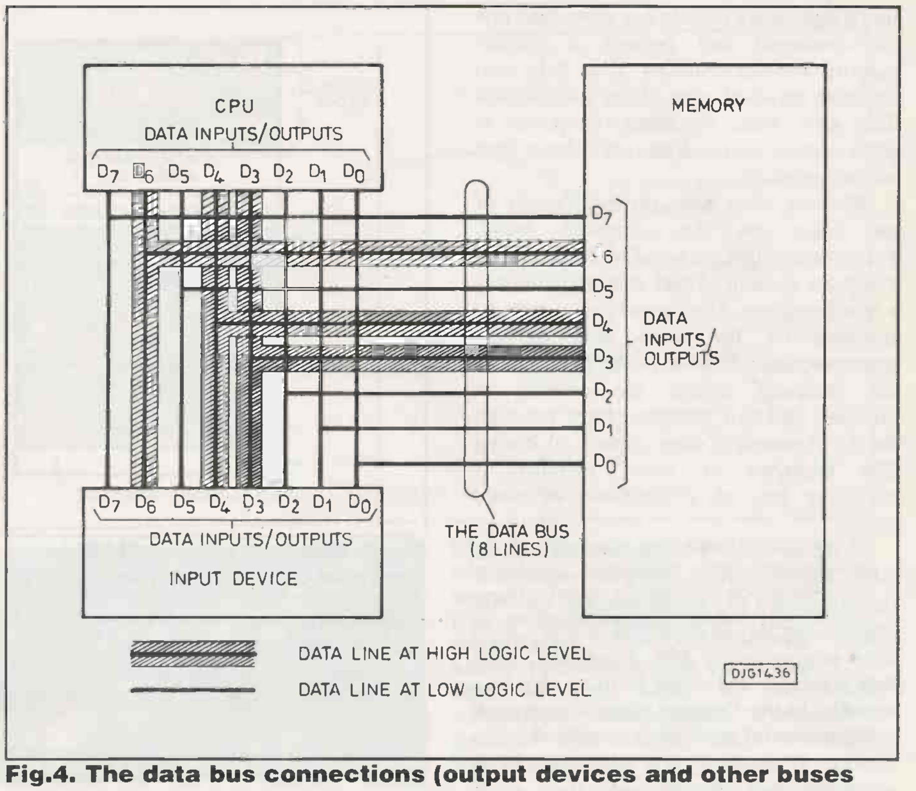


Fig.4. The data bus connections (output devices and other buses omitted for clarity

bus system. Taking the *data bus* as an example, this normally consists of a set of 8 lines. These may be wires or printed circuit board tracks. All relevant parts of the computer are permanently connected to the data bus (Fig.4). The data is represented by voltage levels (logical high or logical low) present on the 8 lines. Each line corresponds to one bit of data and the bus as a whole carries an 8-bit byte. In Fig.4 the bus is carrying the data 01011010. What this means to the computer depends on what is happening in the computer at that time. Voltage levels 01011000 might mean:

* a numeric value, equivalent to 88 decimal

* a code value representing the text letter 'X'

* an instruction code to the microprocessor (&58 in hex), telling it to transfer the contents of Register B to Register E (if it is a Z80 processor – the code would mean something different to another type of processor).

Data is put on the data bus by the cpu, memory and the input devices. Naturally, only one of these must be allowed to put data on to the bus at any given instant. They mustn't all talk at once! This is why there are sets of 8 *three-state buffers* joining the output circuits of these devices to the bus. At any instant the buffers of only one of the devices will be enabled. The other buffers will be in their high-impedance third state. This in effect disconnects their outputs from the bus.

Data is received from the bus by the cpu, memory and the output devices. These receive data continuously but act upon it only when told to do so. For example, a memory chip stores the data that is on the bus only when its chip-select input is low and the write-enable line is low.

Mention of the write-enable line (which we examined in Part 7 brings us to the *control bus.* This is a set of lines including the write-enable (WE) line that command different parts of the computer circuit to become active or to behave in some particular way. A memory chip stores data when WE is low, and puts data on the data bus when WE is high, for example.

Finally, the *address bus,* consisting (usually) of 16 lines enables the cpu to indicate which of the memory locations, or the registers in input and output devices, it wishes to communicate with. For example, when the cpu puts the address of an output device on the address bus, the data that the cpu simultaneously puts on the data bus is received by that device.

USING THE BUSES

Two of the ways the buses are used are illustrated in Figs.5 and 6. The numbers in each figure indicate the order in which the operations are performed, up to the point at which data has been transferred. Thus the sequence for inputting data (Fig.5) is:

1. The input device receives data (eg a joystick is moved to a given position).

2. The cpu places the address of the input device (eg the joystick interface) on the address bus. This address remains there while. . .

3. The cpu places a signal on the control bus to tell it to. . .

4. Place data (eg representing the

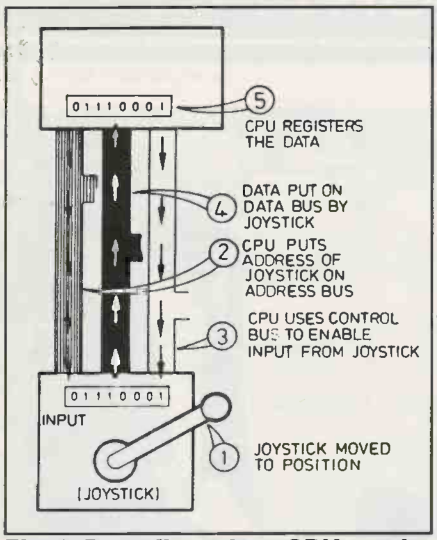


Fig.5. Data flow then CPU reads position of joystick

joystick position) on the data bus. This data remains there while. . .

5. The cpu reads the data into one of its registers. Data has now been transferred from the input device to the cpu. Three further stages follow, that are not shown in the diagram:

6. The cpu places a signal on the control bus to make the input device inactive.

7. The data from the input device is therefore removed from the data bus.

8. The cpu removes the address of the input device from the address bus.

This completes the operation. Although this sounds a very complicated sequence of events, its duration, from start to finish, is only a few microseconds. The other kinds of data transfer follow similar sequences.

INPUT-OUTPUT

One special type of input-output device is known as a *programmable input-output* chip or pio (Fig.7). It is sometimes called a pia, short for *peripheral interface adapter.* It is intended for connecting a wide range of input or output devices to the computer. These may include printers, joysticks, the keyboard, and many others. Even the simplest of micros may have two or three pios, perhaps one for the printer, one for the keyboard and one for the user to connect to any chosen device such as a modem, or Midi synthesiser.

A pio can be programmed for use either as an input or output device or for both purposes at the same time. Most pios have 8 independent input-output lines, each of which can be inputs or outputs. The pio has chip select inputs which are used to select the chip when a given address is put on the address bus by the cpu. The chip can be written to or read from, just as a memory chip. When it is being written to, data written in its registers appears on the output lines. It is sent to any peripheral device, such as a printer, connected to the pio. Conversely, when the pio is being read from data being sent to it from an external device (such as a joystick or mouse) is transferred to the data bus and registered by the cpu.

TEST YOURSELF

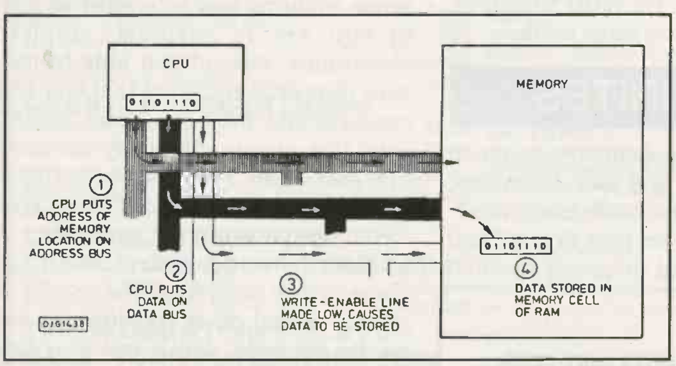
(Answers next month)

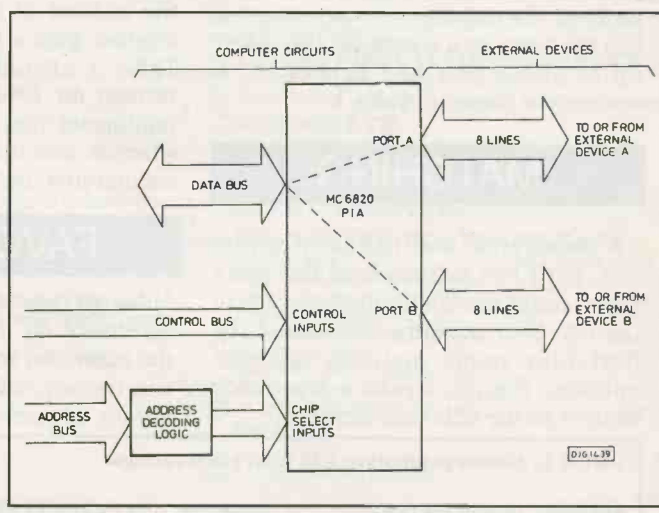
1. What does a computer do?
2. Which part of the computer does the data processing?
3. What do we call the part of the computer where data is stored?
4. Name the three kinds of bus in a computer
5. What is an interrupt service routine?
6. Name four kinds of input device and four kinds of output device.

NEXT MONTH we shall continue by looking at the way the CPU is instructed, via a software program. There will also be another module to build – a sound operated sensor

PE

Fig.6. (below). Data flow when CPU stores data in RAM
Fig.7. (right). The main features of a programmable input-output device. This one can send data to or receive data from two independent external devices (e.g. keyboard and printer).





REACH FOR THE SKY!

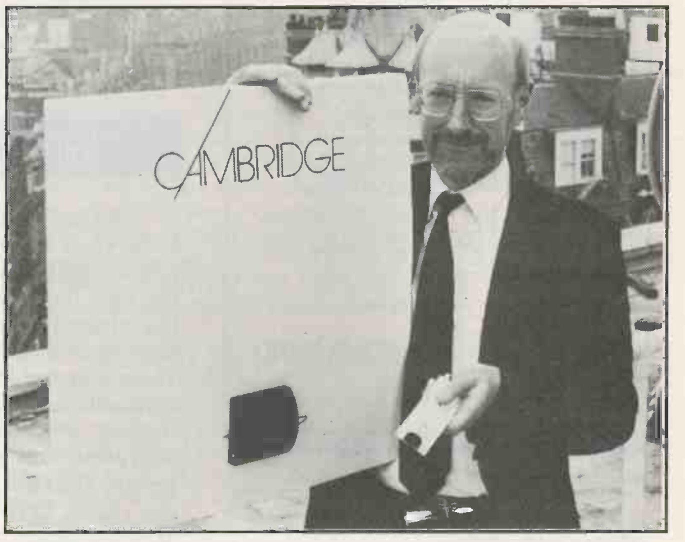
BUT IT'S BEAM-DOWN TIME NOT SHOOT-DOWN TIME FOR THE TRIUMPHANT THREE IN PE'S AERIAL CONTEST

ASTRA SATELLITE TV FLAT AERIALS HAVE BEEN WON IN THE HOT DRAW BY:

R.W.J.Marsh of Tunbridge Wells
D.F.J.Reeves of Swindon
N.Kemp of Boston

CONGRATULATIONS AND HAPPY VIEWING!

12 month's PE subscription goes to the runners-up.



In the PE Feb 89 competition we offered three of Sir Clive Sinclair's new flat aerials for receiving Sky satellite tv programmes. We asked you to say in which order you rated thirteen test-gear items. Those whose rating of the first six matched the majority view were entered into the draw. As a survey we also asked which items you had access to. A summary is shown in Table 1.

MATCHING

It's no surprise that multimeters rate first, but I had half-expected that more of you might put continuity tester top of the list. Your majority selection of the first four items matches my own opinion, though I rate a frequency counter as the fifth most important.

PRIMEORDIAL

To establish the primary order we awarded 13 points to the favourite, 12 to the second, etc. Multiplying points by the number in agreement and adding together gave a total number of marks. Table 1 also shows the percentage ratings for positions. So, 67% rated multimeter first, 21% rated it second, whereas less than 1% rated frequency counter first, but 14% rated it 6th.

FAVOURITES

Although there was distinctive common agreement on the first four favourites, the other two were insufficiently clear-cut. Consequently, for item five, we said anyone who selected frequency counter, signal generator or signal tracer would be put in the draw. Likewise, for item six, anyone saying frequency counter or semiconductor tester would be entered.

REVEALING

The percentages of you who have access to (or own) equipment is most revealing. 67% of entrants having the use of a scope confirms how interested so many of you are in seriously applying electronics. 48% of you able to make your own pcbs reaffirms that you enjoy constructing projects. From Table 2, with 10% of you apparently not having any gear at all, I am reassured that we have a fair proportion of newcomers to electronics amongst our readership. It's too lengthy to detail here, but I have done further analysis of the results and drawn several other conclusions, such as, for example, which test gear items you might be interested in constructing.

TABLE 1. Access percentage and final place ratings.

ACCESS	PLACE RATING		PLACES 1-13 PERCENT PRIORITY FAVOURED .												
			1	2	3	4	5	6	7	8	9	10	11	12	13
42%	7	Capacitance checker	0	1	4	8	10	12	16	9	9	9	7	8	4
59%	10	Continuity checker	4	4	4	4	4	5	6	7	12	7	9	11	20
20%	13	Eprom programmer	0	0	0	0	3	5	5	6	7	13	14	17	25
11%	12	Frequency analyser	0	1	2	3	5	3	7	11	14	13	13	17	7
40%	8	Frequency counter	0	2	3	5	11	14	10	8	13	10	9	6	4
18%	11	Logic analyser	0	1	2	1	6	6	8	12	11	13	14	12	10
88%	1	Multimeter	67	21	3	1	2	1	1	1	1	0	0	0	1
67%	2	Oscilloscope	16	35	20	8	6	5	4	4	0	0	0	0	1
48%	9	PCB making gear	0	3	4	5	10	9	7	7	7	11	8	10	16
82%	3	Power supply	10	27	27	13	7	6	2	3	1	1	2	1	1
41%	6	Semiconductor test	0	1	5	9	10	14	10	11	11	10	9	6	2
56%	4	Signal generator	0	3	24	30	14	11	7	3	2	2	3	0	0
31%	5	Signal tracer	1	1	3	13	11	9	13	14	7	8	7	7	4

Note that decimal places have been ignored.

TABLE 2 - Who has access to how many items.

ITEM QUANTITY	0	1	2	3	4	5	6	7	8	9	10	11	12	13
APPROX PERCENT OF ENTRANTS	10	4	5	7	8	9	13	10	10	11	7	3	2	4

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Access

bookmark

Your Ed looks at some of the new books recently received.

Remote Control Handbook. Owen Bishop. Babani BP240 £3.95. ISBN 0-85934-185-2. Owen Bishop will be a familiar name to PE readers, especially as at the moment he his author of the very successful Digital Electronics series we are running. He is the author of many books and this latest one is the successor to his Remote Control Projects published in 1980. This new book contains improved and updated versions of some of the previous circuits. Additionally, there are a number of completely new circuits included. Many of these are concerned with aspects of remote control that have increased in importance during the last few years. In particular, there are circuits for interfacing computers to remote control systems, as well as for using fibre optics and domestic mains wiring as transmission links. There are new circuits for stepper motors, plus v-f and f-v conversions. The systems have been designed in modular form enabling many to be linked together to form more complex networks. I definately recommend this book to the adventurous constructor.

Teach Yourself Electronics. Malcolm Plant. Teach Yourself Books (Hodder and Stoughton). £4.50. ISBN 0-340-42230-0. Anyone familiar with the Teach Yourself series will know their reputation for quality and reliable information. This addition to the series is intended as a first introduction which explains simply and clearly how electronic devices and circuits work, and how they are used in computer, communications and control systems. It describes the functions of devices such as resistors, capacitors, and semiconductors, explains the theory of logic gates and Boolean algebra. Finally, some of the specialist applications of electronics in instrumentation, control and telecommunications are described. It does not give a blow-by-blow account of everything you might want to know, but it will give you a basic understanding and background knowledge of today's electronics. A glossary is included.

Experiments With Eproms. Dave Prochnow. Tab Books. £13.20. ISBN 0-8306-2962-9. This book looks at the basic principles behind eprom technology and then describes 15 constructional projects for use in stand-alone and computer-based modes. They include a simple project that determines the logic present on digital ic pins, two eprom programmers, an eprom eraser, speech and music synthesiser. Although this book was written primarily for US readers and as such has areas that are less relevent to UK readers, much of the information should be universally of interest to experienced constructors.

Troubleshooting and Repairing TVRO Systems. Stan Prentiss. Tab Books. £13.10. ISBN 0-8306-2992-0. Stan Prentiss is a former NASA satellite engineer and is a member of the Satellite Operators and Users Technical Committee (SOUTC). In this guide he emphasises the uses and operations of the latest troubleshooting equipment, including spectrum analysers, oscilloscopes and digital multimeters. Specific diagnostic procedures for using this equipment are discussed and detailed operation of current receivers described. In addition to information on antennas, feeds, multi-cabling, block-down converters and scramblers, he gives much attention to Ku band and its advantages and disadvantages. This is very much a book for the specialist reader who should examine it first to assess its relevence to applications outside the USA.

20 Innovative Electronics Projects for Your Home. Joseph O'Connell. Tab Books. £10.80. ISBN 0-8306-2947-5. I am far from happy that some of the projects in this book should be offered to UK readers. Several of the projects shown are related to mains control and telephone circuits. In Britain we have different mains voltage requirements and more restrictive telephone regulations than in the US. Additionally, some of the components specified neither relate to, nor are likely to be available in Britain. I have repeatedly commented in these pages about Tab Books failure to make their published information relevent to UK readers. Copies of my comments are sent to their agents but I have had no indication that Tab Books have recognised that British readers will frequently find it difficult, if not impossible, to make use of varying amounts of information in their books. Though knowledgeable readers may well find academic interest from US-specific information, and may be able to modify circuits to meet different needs, sadly, those who are less experienced may at least run into constructional difficulties, and at worst be in danger from non-compatible mains power requirements. The solid state electric blanket control is one circuit that especially bothers me in this respect. In the case of a telephone accessory circuit shown, I believe that UK readers would be contravening Telecom regulations by using it. On the more positive side, there are a number of circuits in this particular book which will be of more wide-spread appeal, but the book should be examined before purchase.

An Introduction to Loudspeakers and Enclosure Design. Vivian Capel. Babani BP256. £2.92. ISBN 0-85934-201-8. Vivian Capel is another contributor to PE whose writings I find of interest – you may remember he did a series on compact discs from July-Sept 88. Having built my own high powered speaker enclosures some years ago I know some of the pitfalls that the inexperienced can encounter. This book should help constructors to avoid any major problems. It explores many types of enclosure and drive units looking at their good points and snags. The whys and wherefores are examined so that readers can make informed choices of design, or even design their own enclosures. Crossover units are explained, and a step by step description of a *Kapellmeister* enclosure is given. This stereo image design involves novel features which overcome many of the disadvantages of more conventional types.

Enhanced Sound – 22 Projects for the Audiophile. Richard Kaufman. Tab Books. £7.75. ISBN 0-8306-9317-3. A professionally produced book which lives up to its title and claim that you can "get better sound from your audio equipment without spending a lot of money". Eleven chapters cover basic components, semiconductors, tools and techniques, projects without psus, psus, preamps and amps, opamps, active filters, crossovers, fm antennae, and speaker design. The latter chapter, and that on filters, include programs written in Basic to assist in calculations. The book is liberally illustrated with circuit diagrams, keeps maths to a minimum, and the project components appear to be UK, though a list of US suppliers is quoted. A useful book.

Satellite Television Installation Guide. John Breeds. Swift TV Publications. £11.95. ISBN 0-948251 43 3. The recent launch of the Astra satellite and the imminence of BSB will create many more jobs for satellite tv receiver installers. Although satisfactorily installing a suitable antenna may be beyond the capabilities of many diyers, those who have the tools and patience necessary will reap benefits from the clearly illustrated information given in this 47 page booklet. It consists of fourteen sections, and the contents range from how to wire up the indoor unit via the video recorder, installing fixed and multi-satellite dish mounts, through to a handy site-survey planner. Swift say that this is an ideal study manual for trainees on CAI courses accredited by the City and Guilds of London Institute. I feel obliged to stress to would-be diyers that I have recently heard it said on several occasions that the alignment accuracy of receiving dishes is absolutely critical to obtaining the best reception. It is also vital that the dishes should be robustly mounted so that their weight presents no problems even in the highest winds. Dish installation is not a job for the casual bodger! Stop Press: We've just heard that the second edition has been released with even more information.

Publisher's addresses:

Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London, W6 7NF.

Swift Satellite TV Services, 17 Pittsfield, Cricklade, Swindon, Wilts, SN6 6AN. 0793 750620.

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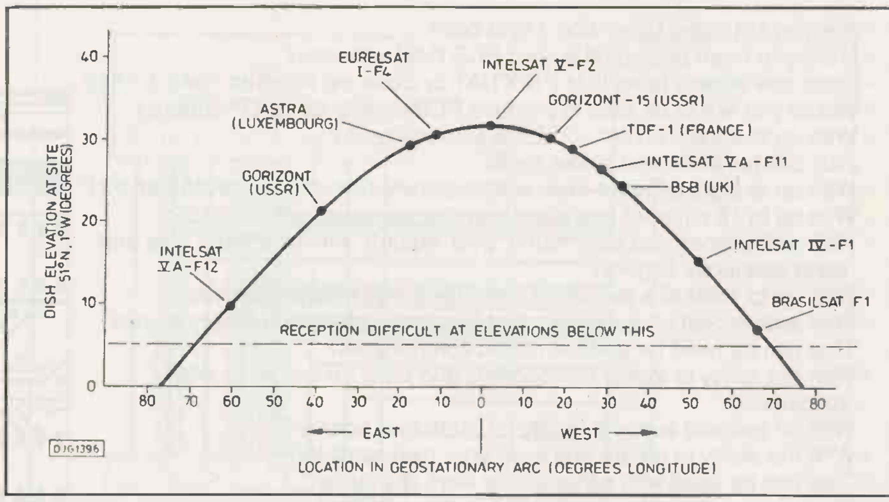
Teach Yourself Books, PO Box 702, Dunton Green, Sevenoaks, Kent, TN13 2YD. 0732 450111.

First, your find satellite, as Winnie-the-Pooh might have said. This is by no means as simple as pointing a television aerial in the general direction of your nearest tv station. To begin with the satellite transmitter is very much farther away – 36,000km or more in the case of geostationary satellites.

Because the satellites are spaced by only a few degrees from each other and the microwave transmissions are not very powerful, it's necessary to use a highly directional receiving antenna collecting as much electromagnetic radiation as possible – a parabolic dish antenna. This type of antenna has a receiving beam (radiation pattern) something like a searchlight beam. In effect you have to search for the wanted satellite with this beam, and it only has to be two or three degrees off the correct angle to miss the satellite altogether. Result: no signal at all, or a signal from another satellite nearby.

As I said in Part 1, this article is about receiving signals from satellites in the geostationary orbit (see Fig. 2 in Part 1). These geostationary satellites, about 150



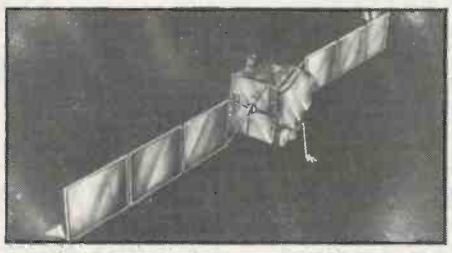


Fig. 2. Graph of dish angles of elevation needed for receiving signals from different locations in the geostationary orbit (de-grees longitude). This assumes the same receiving site as in Fig. 1. A few of the forty or so GEO satellites accessible from this part of the world are shown on the graph.

SATELLITE FUNDAMENTALS

PART TWO – RECEIVING SATELLITE SIGNALS

BY TOM IVALL

Direct broadcast satellite, cable television, electronic news distribution, reach earth from satellites in geostationary orbit. Before we can watch the tv, the tv (through satellite aerials) must watch them.

altogether, are used for a variety of tasks – telecommunications, broadcasting, navigation, military and meteorological being the main ones. But we'll confine ourselves here to the signals which PE readers can probably best make use of – television signals.

SIGNAL GROUPS

This means two main groups: low-power tv signals coming from communications satellites, and higher-power signals from direct broadcasting satellites (dbs). In both cases the microwave signals received – which have wavelengths in the region of 25 to 27 millimeters – are converted into a form suitable for feeding into the aerial socket of a standard tv receiver, so that they can be displayed as normal tv pictures.

So the tv signals of interest come from a number of different satellites. Each satellite carries a group of microwave relay stations called transponders. A transponder is basically a receiver feeding its output into a transmitter.

In the low-power communications satellites, some of the transponders are used for telecommunications (voice, data, etc) and some for television signals distribution. Of the last-mentioned group,

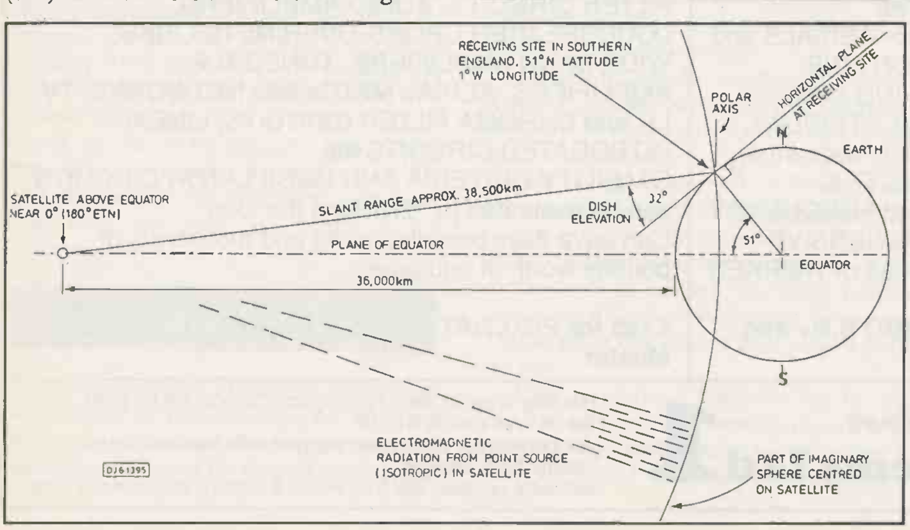


Fig. 1 Receiving conditions at a site in southern England for a geostationary satellite at an orbital position approximately above the Greenwich meridian (zero degrees longitude). Here the receiver dish antenna has to point due south, at an elevation of about 32°. Receiving other satellites on either side to the east and west would require different angles of dish azimuth and elevation. Also shown is part of an imaginary sphere in space centered on the satellite. This comes into the explanation about the rf power available at the receiving site.

some of the tv signals are internal to broadcasting organisations (news feeds, programme exchanges, etc) while the remainder supply programmes to cable television companies and various community systems and can also be received by private individuals using their own television receive-only (tvro) equipment.

In the high-power direct broadcasting satellites all the transponders are dedicated to broadcasting to the general public – mainly tv programmes but some radio and teletext as well. They use high power for this very reason, to make reception as easy and inexpensive as possible. Among them we must include the recently launched Astra satellite. Although this transmits at medium power, and on frequencies in a communications band, it is specifically designed for dbs. The comsats use low power because they were never intended for broadcasting in the true sense, only for broadcasting signal distribution.

But in both groups each transponder (or sometimes half of the capacity of a transponder) normally handles one television programme channel. So this is equivalent to a tv channel coming from a local terrestrial broadcasting station.

Signals from satellites have the following characteristics: position in space, radio frequency (rf) power, frequency and wavelength, wave polarisation, modulation of the carrier wave, and encoding of the information conveyed. This article will concentrate on the two most fundamental characteristics for reception, orbital position and rf power.

SATELLITES AVAILABLE

Before you can decide which signals and programmes you want to receive you must check on what GEO satellites are actually 'visible', in the electromagnetic-wave sense, from where you live. Microwaves behave much the same as light waves. This means there has to be a direct line-of-sight, or unobstructed straight-line path for the waves, between each satellite and your receiving antenna.

If you happen to live somewhere on the equator, some of the GEO satellites will be more or less above you and the others will be spread along an east-west arc in the sky down to the horizon. A large number of the satellites will be 'visible' because you are at the nearest position on Earth to the geostationary orbit (see Fig. 1) and there is no ground in the way to block your antenna's 'view'.

However, the majority of PE readers probably live in the northern hemisphere and a big group of these will be in the UK. *We have many readers who live in the Southern Hemisphere. Ed.* If you are in the UK, your situation will be more like that of the receiving site shown in Fig. 1. This, by way of example, is at a latitude of 51° North and longitude of 1° West, which happens to be near Petersfield in Hampshire.

From here you have to look towards the south to get a direct line-of-sight to part of the geostationary orbit. Obviously the equatorial plane of this orbit lies South of everywhere in the northern hemisphere. For a satellite due south of this position (eg the Intelsat V-F2) the line-of-sight from the receiving antenna is at an angle of about 32° up from the ground (elevation), as shown by the 'slant range' line in Fig. 1.

Looking east or west of this point, there will be other satellites 'visible' to the antenna, but at lower angles of elevation. The farther one looks east or west the lower is the angle of elevation, until at the extreme points of about 75° east or west no more of the geostationary orbit, and the satellites in it, will be visible.

The cut-off at these extreme points occurs simply because the surface of the Earth gets in the way and blocks the direct line-of-sight. Fig. 2 illustrates this by a graph which shows required angles of elevation for a dish antenna, located at 51°N and 1°W, for different points on the geostationary orbit. It also shows some of the satellites accessible between the two cut-off points.

The graph line, corresponding to part of the GEO, is cut off at the points where the antenna elevation is zero – that is, looking straight along the ground, horizontally. In practice, though, the antenna beam must have a minimum elevation of about 5° because below this level – shown by the broken line – the receiver picks up too much man-made electrical interference and natural electrical noise (from heat radiation) from the ground.

You can find what satellites are available from published charts corresponding to Fig. 2 for your geographical position, in conjunction with information in satellite tv programme magazines, which usually give the orbital positions of the satellites. The accompanying table is just a short list as a guide.

However, the actual availability of signals from these satellites depends

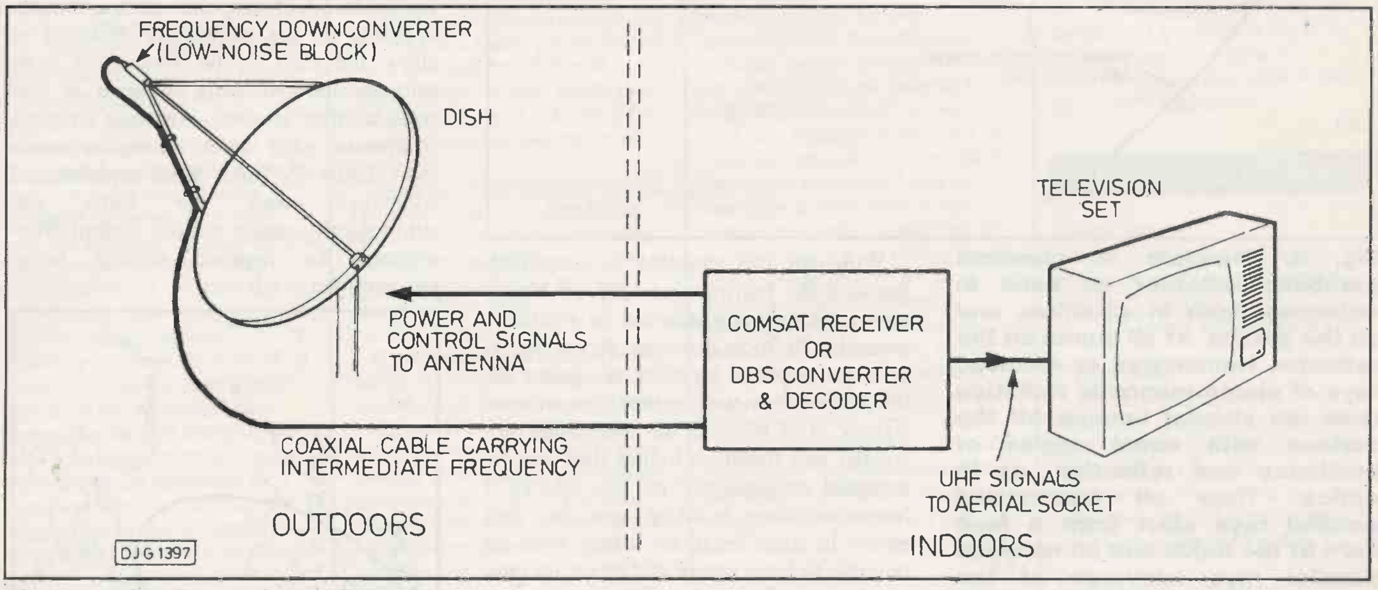


Fig. 3. Outline of equipment needed for receiving tv signals from GEO satellites, both dbs and communications spacecraft. In practice there are many variables, including dish area and pointing angles, signal frequency, wave polarisation and tv signal encoding, which determine what actual equipment is required for different satellites, and their transponders.

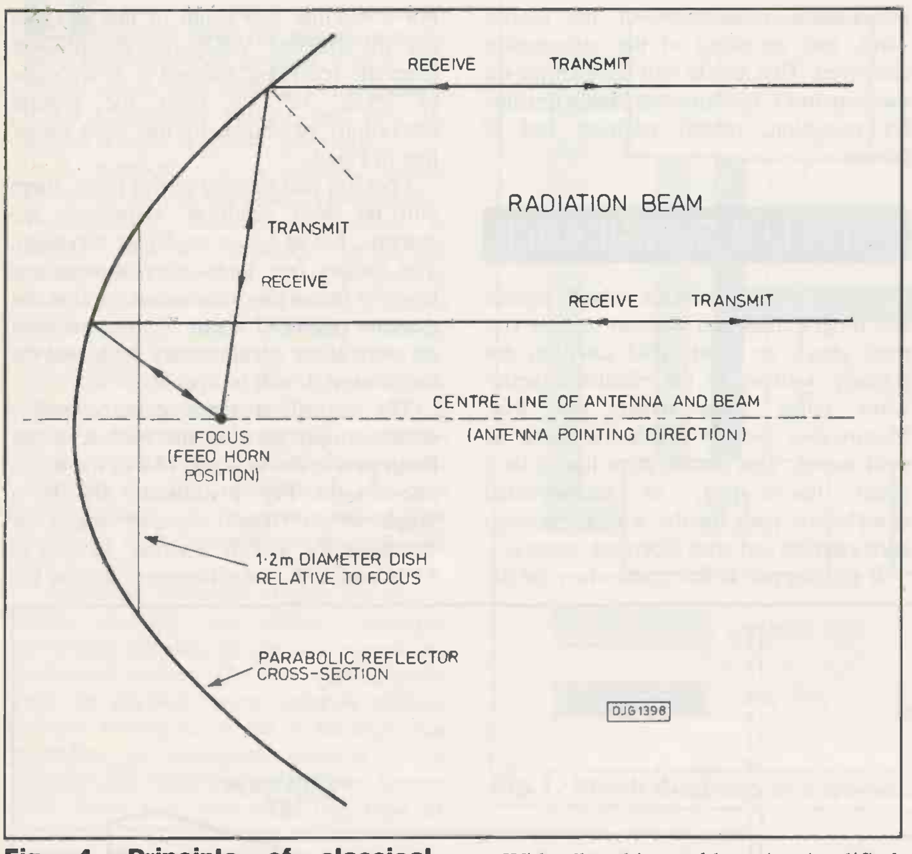


Fig. 4. Principle of classical parabolic reflector as used in antennas, both in satellites and on the ground. At all points on the reflector, transmitted or received rays of electromagnetic radiation (two are shown) bounce off the surface with equal angles of incidence and reflection, as in optics. Thus all transmitted parallel rays start from a feed horn at the focus and all received parallel rays converge at the focus. The part of the parabola occupied by a 1.2-metre diameter dish is shown. Other reflectors are designed to work from offset feed horns, to avoid the efficiency loss caused by equipment parts like struts being within the beam and blocking the incoming and out-going radiation. In practice the beam is not perfectly parallel but diverges slightly.

finally on where you can find a suitable place to set up your dish antenna. You must have a site from which there is a clear, unobstructed view of the southern sky at about 25° up from the horizontal, with as much angular deviation to left and right as possible. This may conveniently turn out to be in your back garden. But if it happens to be in your front garden you'll probably have to consult your family and neighbours to see if they'll agree to having a dish antenna on public view there. Failing these sites, it may be necessary to mount the dish on the site of your house.

With dbs this problem is simplified. Because the transmissions are on higher power the dish antennas can be smaller – generally 30-90cm diameter, depending on your geographical location, as against the 90-180cm diameter needed for comsat signals. And because the dbs dishes are smaller and therefore lighter they can be mounted conveniently on the side of a house or other building near the roof eaves. In some locations it may even be possible to have indoor dishes set up near windows. *(Remember, though, that microwaves are impeded by glass. Ed.)*

The equipment you will need for either comsat transmissions or dbs is shown in very general form in Fig. 3.

POINTING THE DISH

To point a receiving antenna accurately, the centre-line of the dish – which is a parabolic reflector as shown in Fig. 4 – must be made to point along the microwave beam coming from the satellite, up to the spacecraft itself. This means that the dish must be capable of being swung in two planes: in azimuth (horizontally, round the points of the compass); and in elevation (vertically, from the horizontal upwards).

Both of these angular distances are measured in degrees – azimuth from a north or south reference point, and elevation from the ground upwards. Some commercial dishes have mechanisms, called az/el mounts, which allow these movements to be made independently.

First you must decide which satellites and channels you wish to receive. With dbs you can't use the same antenna dish for Astra, BSB and TDF-1, even at different times, because these satellites are at different orbital positions, requiring different azimuth and elevation settings. Furthermore, Astra operates on comsat frequencies (around 11 GHz, see table) while the other two work in the dbs band (around 12 GHz). This, and the fact that the two bands use different wave polarisations, means that the same rf downconverter unit on the antenna (called a low-noise block or LNB) is not usable for all three dbs satellites.

But because Astra operates in a comsat band, it can be received by the same antenna equipment and receiver as used for the low-power comsats – tvro equipment. And here the antenna mounts available on the market are designed to allow the dish to be swung, in both azimuth and elevation, to point at one satellite after another. With the simplest equipment each az/el setting is made individually by hand. More sophisticated equipment does the same job automatically under remote control from indoors, the required settings being programmed in advance.

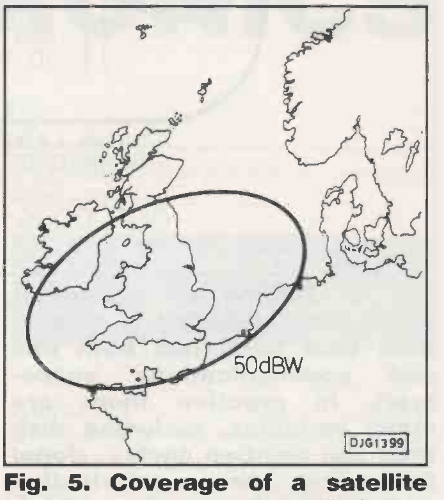


Fig. 5. Coverage of a satellite transponder beam or 'footprint', is shown by contour lines like this. Here the line encloses an area of signal strength corresponding to a beam eirp of 50 dbW (100 kW). Other such contour lines outside this one would show how the eirp tails off at the outer edges of the coverage.

Although the dish must be positioned in both azimuth and elevation there is one type of antenna mount, now widely used, which simplifies the process by reducing it to a single mechanical displacement. Robert Calaz, managing director of Race Communications Ltd, South Ascot, Berks, kindly showed me how this works.

As the mechanism swings the dish

round in azimuth, the elevation continuously changes at the same time, so that the centre-line of the dish automatically follows the geostationary arc in the sky. The input drive is a single linear movement, provided by a dc motor-driven linear actuator. This mechanism is called a polar mount, because the axis about which the dish swings in azimuth is fixed parallel to the Earth's spin axis – a line between the north and south poles.

The polar mount is similar in principle to the equatorial mounting of an optical or radio telescope, which enables the telescope to automatically follow a given star in its movement across the sky. But because geostationary satellites are very much nearer than the stars the difference in latitude between the two axes – antenna and Earth – is more significant than with telescopes. So a device for making an angular a correction for this, called declination offset, has to be built into the polar mount mechanism. In the UK, declination offset works out to an angle of 6-7°, depending on the latitude of the receiving site.

In practice the first step is to find a possible antenna site by simple observation and guesswork. Next, this position must be checked with a compass and inclinometer to make sure that it provides an unobstructed view of the geostationary arc (eg, as in Fig. 2) – or at least a useful part of it. A simple inclinometer can be made from card, plastic or wood with the aid of a protractor.

In setting up an antenna on a polar mount the most critical operation is to get the highest point of its azimuth-elevation swing to coincide exactly with the peak of the geostationary arc at due south. A compass is not accurate enough to find this point in the sky, but by using an almanac you can easily calculate the time of day, on any particular day, at which the sun is exactly due south. Alternatively, the Intelsat V-F2 shown in Fig. 2 is only slightly off the Greenwich meridian, at 1°W. From a site somewhere near the meridian in the UK the dish can be lined up on this by trial-and-error, using a signal-strength meter in the receiver.

With the polar mount, once the peak of the antenna swing is accurately aligned with the arc at due south, the mechanism, if correctly set, will automatically track the geostationary orbit. Fine corrections can be made to this tracking by adjusting the mount so that maximum strength signals are obtained, on the signal-strength meter, from a satellite somewhere to the east (say Eutelsat I-F4) and one somewhere to the west (say Intelsat VA-F11).

Some handbooks and some antenna suppliers provide helpful charts or tables for antenna pointing. *(We've one in our book service. Ed.)* These will show, for a particular satellite, the antenna angles of azimuth and elevation needed at different geographical locations in latitude and longitude.

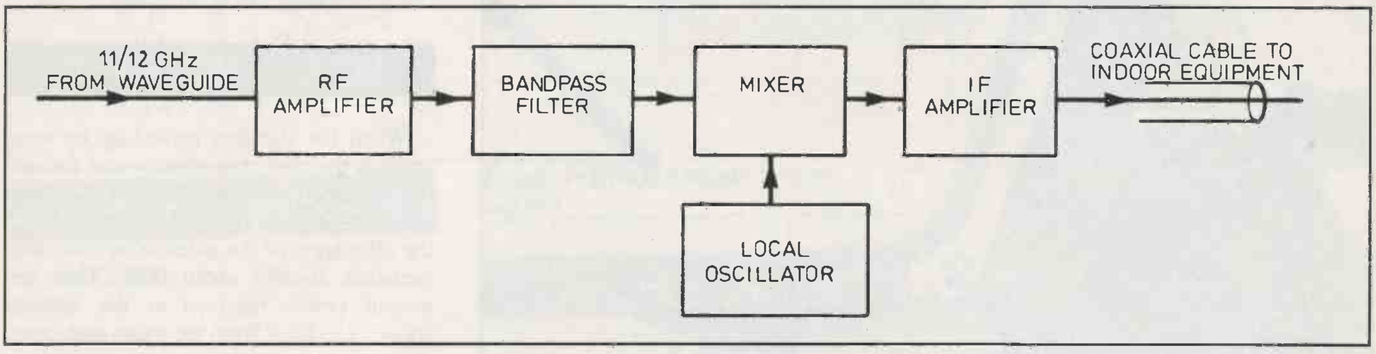


Fig. 6. Schematic of frequency downconverter or low-noise block mounted near the focus of a parabolic dish antenna (Fig. 4). This receives microwave signals via waveguide from a feed horn at the focus and converts them to a lower frequency for feeding along a coaxial cable to the receiver or converter unit indoors.

SIGNAL POWER

After finding the orbital position of a satellite and being able to point your dish antenna at it accurately, the next most fundamental thing is to get an adequate signal from it to operate a receiver and give a good quality picture on the tv set. This means that the power of the signal must be substantially greater than the noise power in the space-to-Earth link (downlink) so that when both are amplified in the receiver you don't see the noise as speckles on the tv screen.

In practice we must take whatever rf power is transmitted by the satellite. Then we collect enough of it, by using a sufficiently large diameter dish antenna, to give a ratio of rf carrier power to noise power (c:n ratio) of at least 2:1, or 3 decibels (dB).

Suppose a satellite transmitter generates an rf signal power of 45 watts – a medium value. If this were radiated uniformly in all directions (isotopically) it would evenly 'illuminate' the interior surface of an imaginary sphere. At some receiving site in southern England this sphere would have a radius of about 38,500km, as shown in Fig. 1, and therefore an internal surface area ($4\pi r^2$) of well over 10,000 million million, or 10^{16}, square meters. So a dish antenna with an area of about 1 square metre would receive the 45W divided by the sphere area (assuming no losses), which comes to about one five-hundredth of a picowatt – a completely inadequate power for practical purposes.

However, the spacecraft transmitter antenna actually has a parabolic reflector (Fig. 4) to concentrate the 45W into a narrow beam. This concentration is measured as the gain of the antenna, and a typical gain value of just over 2,200 times (or 33dB) would multiply the 45W by this amount to give an effective power in the beam of 100kW.

This effective power, which is real enough where received, is called the equivalent (sometimes 'effective') isotopically radiated power, or eirp for short. It is equivalent to the much higher rf power that would have to be radiated from an isotropic source to produce the same power as at the centre of the concentrated beam.

If you look at the coverage areas of 'footprints' of satellite transponder beams on maps you'll see contours of the kind shown in Fig. 5. The contour encloses an area within which the satellite transmitter is beaming down a certain eirp. The greater the eirp the stronger will be the signal received. But in practice the power contour is not labelled straightforwardly in watts or kilowatts but in decibels relative to 1 watt, or dB(1W). This is always abbreviated to dBW. So in the example shown 50dBW means 50 decibels relative to 1W, or 100,000 times 1W, or 100kW.

This apparent complication is actually a simplification for communications engineers, who find it more convenient to do calculations on rf powers, gains and losses (even bandwidth and noise power) by adding and subtracting the logarithmic decibels than multiplying and dividing. So the practice and terminology is used by everyone concerned.

Example of a frequency downconverter mounted on struts near the focus of a parabolic dish antenna. The cable at the bottom-right carries an intermediate frequency (if) signal to the indoor receiver and also brings in a supply of power to the converter electronic circuits. This maker calls the unit a low-noise converter (LNC) but others use the term low-noise block (LNB) for the same thing.

But what does this mean for you, in terms of signal strength coming into your dish antenna?

Well, what you receive is influenced by various losses in the space-to-Earth downlink, and there are also measured in decibels. The most fundamental one is the free space loss. It's what would occur in the theoretical condition of both the transmitting antenna and your receiving antenna being isotropic.

Here the power from the transmitter antenna would radiate uniformly in all directions, and at the receiving antenna could be considered as evenly illuminating the interior of an imaginary sphere, as discussed above. The amount of power falling on a given area of the sphere is important to know because the area of your dish (part of the imaginary sphere) determines how much power is collected for your receiver.

This value is the power density, measured in dBW per square metre, and is usually called the power flux density (pfd). The free space loss is due partly to the fact that the pfd is inversely proportional to the distance between the two antennas, r; this component is called the spreading loss and is actually 10 $\log_{10} 4\pi r^2$.

Overall, the free space loss in dB is given by the formula: 20 $\log_{10} 4\pi r/\text{wavelength}$. For example, with a distance of 38,500km between satellite and receiving dish and a carrier frequency of 12GHz, making the wavelength 25mm, the free space loss comes to 205.1dB.

In practice this free space loss is partly counteracted by the concentration into beams given by the transmitting and receiving antenna reflectors, so that the radiated power is not in fact isotropic.

Another unavoidable form of attenuation is due to the signal having to pass through the Earth's atmosphere. Losses in the various gases are negligible, but those due to water in the form of clouds, rain, mist, sleet and snow are more severe. Moderate rain causes a loss of about 1-2dB at 12GHz, heavy rain anything up to 10dB and torrential rainstorms anything up to 20dB.

POWER RECEIVED

When the signal is picked up by your antenna the dish concentrates and focuses the energy to provide a gain, as explained above. The gain figure takes account of the efficiency of the antenna in collecting radiation, usually about 60%. Thus the overall power received at the antenna focus, calculated from the gains and losses mentioned above is:

= eirp - free space loss - atmospheric loss + receiver dish gain dBW

As an example, assuming the satellite produces an eirp of 52 dBW, the atmospheric attenuation is 1 dB and the dish has a gain of 44 dB, the power received is:

= 52 - 205 - 1 + 44 dBW

= - 110 dBW

which works out to a power of 10 picowatts.

If the power flux density at the receiving point is known from, say, the satellite operator, you can work out how much power is being collected by your dish antenna. For example, under the international dbs plan the pfd is supposed to be - 103 dBW/m^2 in the centre of the beam. A dish of 1 square metre area would collect 50 pW and with a typical efficiency of about 60% it would give about 30 pW at the focus.

With such low power signals coming in, it's most important that the noise power generated by your receiving equipment is kept even lower. Otherwise you will get a lot of annoying speckles on the tv picture. This means that the first electronic circuits which amplify and frequency-convert the received microwave signal must use very low-noise transistors. Hence the descriptions 'low-noise block (LNB)' for these circuits – which in manufacturers' literature is partly a description and partly a claim!

Fig. 6 is a schematic of the standard LNB, which is mounted on the dish antenna itself close to the focus so that a length of waveguide called a feed horn just encloses the focus point. It consists of a low-noise transistor rf amplifier, a bandpass filter, a local oscillator, a mixer and an intermediate frequency (if) amplifier. The if output frequency for comsat transmissions is in the range 0.95-1.7 GHz, and the if signal is fed along a coaxial cable to the receiver indoors.

Typical noise figures being claimed for these LNBs are in the region of 1.6dB. Noise figure measures the amount of noise introduced by the electronic system itself. It is defined as the ratio of the input to output signal-to-noise power ratios (or noise factor) expressed in decibels. The lower dB value, the less noise is introduced, and 0 dB would mean no circuit noise introduced at all. A noise figure of 1.6 dB shows that the noise factor is 1.45. This would be given by, say, an input s:n power ratio of 6:1 and an output s:n power ratio of 4:1.

Finally, if you do decide to set up your own satellite tv receiving station don't forget that you need a licence to operate it, in addition to your ordinary tv licence. This costs £10 and is valid indefinitely. To get it you must first obtain and fill in a TVRO Licence application form issued by the Department of Trade and Industry, Radiocommunications Division, Room 513, Waterloo Bridge House, Waterloo Road, London, SE1 8UA (tel: 01-215 2221 or 2306). You then send the form and the £10 licence fee to an address given on the form. Incidentally, this doesn't clear you from any planning permission you might also have to obtain from your local authority to install a dish (or dishes) on your house or in your garden.

The next article will deal with more of the fundamental characteristics of satellite signals.

PE

Table: Some geostationary satellites transmitting television signals

Satellite name	Owner nationality	Type of Service	Orbital position	Band	Downlink frequency allocation
Astra	Luxembourg	dbs	19.2°E	Ku	10.7-11.7 GHz
Eutelsat I-F4	international	comsat	13°E	Ku	10.7-11.7 GHz
Gorizont-15	USSR	comsat	14°W	C	3.4-4.2 GHz
TDF-1	France	dbs	19°W	Ku	11.7-12.5 GHz
Intelsat VA-F11	international	comsat	27.5°W	Ku	10.7-11.7 GHz
BSB*	UK	dbs	31°W	Ku	11.7-12.5 GHz

* Due for launch in late 1989. See next article for more complete information on frequency bands

SPACE WATCH

BY DR PATRICK MOORE CBE

In a violent Universe even the Moon may not be passive

The Soviet probe Phobos 2 is now in orbit round Mars, and is sending back data. Meanwhile, Voyager 2 is on its way to Neptune, and is still functioning well, so that during the actual encounter, in August, we may hope for results as good as those already obtained from Jupiter, Saturn and Uranus.

Two supernovæ have been 'in the news' recently. Much has been heard of the Supernova 1987A, which flared up in the Large Cloud of Magellan in February 1987 and became visible with the naked eye – the first supernova to do so since Kepler's Star of 1604. Astronomers have been wondering whether it would produce a pulsar, made up of neutrons and spinning around very rapidly; pulsar material is amazingly dense – an eggcup full of it would weigh thousands of millions of tons – and the rotation rates are very high. The most famous pulsar is that in the Crab Nebula, known to be the remnant of the supernova of 1054.

So far as 1987A was concerned, it was assumed that after the explosion, the dense cloud of débris around the site of the outburst would hide the centre. It was even suggested that the end product might be a black hole. However, in February 1989 a group of American astronomers at Cerro Tololo, in Chile, announced the discovery of a pulsar rotating almost 2000 times per second. This announcement caused great interest, but it was not confirmed by other groups, so that either there has been some error in interpretation or else the pulsar is being intermittently obscured by material swirling around it.

The other old supernova is S Andromedæ, seen in 1885 in the Andromeda Galaxy (M.31). It reached the sixth magnitude, but its true nature was not appreciated, because at that time the so-called "spiral nebulæ" were generally regarded as minor features of our Galaxy rather than independent systems. The outburst soon faded away, but is now known to have been a Type I Supernova – that is to say, an outburst involving the complete destruction of the white dwarf component of a binary system rather than the collapse of a single massive star, as with the recent supernova in the Large Cloud of Magellan. The remnant of S Andromedæ has now been identified by astronomers at Kitt Peak, in Arizona, using the 4-metre reflector there. The expanding cloud spreading out from the old supernova is now about one light-year across, with an expansion speed of some 4,000 to 5,000 kilometres per second. It is a great pity that S Andromedæ did not flare up a century later, when we would have been able to take full advantage of it!

THE SKY THIS MONTH

Of the five bright planets, four are in the evening sky this month, but none is really well placed – apart from Mercury, which reaches its greatest eastern elongation (21 degrees) on May 1, and should be visible in the evening twilight for the first ten days of the month. Venus is emerging after sunset, and is becoming more and more evident, but the phase is still well over 95 per cent, so that no telescope will show definite features on the disc. Mars remains on view after dark, but the apparent diameter has now fallen to only between 4 and 5 seconds of arc and the magnitude to +1.7; the phase is 95 per cent. Jupiter will be lost in the evening twilight by the end of the month.

Saturn, Uranus and Neptune are fairly close together, in Sagittarius, and now rise around midnight, so that even though they are low down from British latitudes this is a good time to identify the two outer giants. They are easy enough to find. Uranus has an apparent diameter of 3.9 seconds, of arc and a magnitude of 5.6; any small telescope should be enough to distinguish it from a star, and it is decidedly green. Owners of adequate telescopes should look for the two senior satellites, Titania and Oberon. Neptune, with an apparent diameter of no more than 2.5 seconds of arc, is within binocular range (magnitude 7.9) and is bluish rather than green, but in small telescopes it does look like a star, and one has to identify it by its slow movement from night to night.

The Moon is new on May 5, and full on the 20th. The date of new moon coincides with the maximum of the meteor shower known as the Eta Aquarids, which will therefore be seen to advantage. These meteors represent the debris of Halley's Comet, and around May 5 there should be plenty of them. Of course, Halley's Comet itself has now been lost to view except with the world's largest telescopes; it will not next return to perihelion (its closest point to the Sun) until the year 2061.

The main spring constellation, Leo (the Lion) is still very conspicuous, now slightly west of south during the late evening; it is followed round by Virgo (the Virgin), one of the largest constellations in the sky, with its bright star Spica and its rather obvious Y-outline of moderately bright stars. It is here that we find the Virgo cluster of galaxies, over 50,000,000 light-years away. Not many of these galaxies are visible with small telescopes, but the cluster contains many hundreds of members, some of which are much larger than our Milky Way galaxy. High on the south lies Arcturus in Bootes (the Herdsman), which is orange in colour, and is actually the brightest star in the northern hemisphere of the sky; it is surpassed only by Sirius, Canopus and Alpga Centauri, all of which lie south of the celestial equator. In the east, the "Summer Triangle" (Vega in Lyra, Deneb in Cygnus, and Aktair in Aquila) is becoming prominent, and will dominate the evening sky throughout the summer.

Low in the south lies the immense, sprawling constellation of Hydra, the Watersnake. Below Spica in Virgo you will see a third-magnitude star, Gamma Hydra, and close to this is a famous variable, R Hydra, which reaches its maximum brightness on May 13, and should then be easily visible with the naked eye (magnitude 41/2). R Hydra is a red star, which was a period of variation of less than 400 days – it seems to have been nearer 500 days a century ago, so that it has changed its habits! It is thought to be about 350 light-years away, and to be as luminous as 250 Suns, so that it is not nearly so powerful as a red giant such as Betelgeux in Orion. This month is a good time to look for it; binoculars bring its colour out very well. Incidentally, the conspicuous little quadrilateral of stars making up Corvus, the Crow, lies closely to its west, and makes a good 'pointer' to it.

THE PROCLUS OUTBURST ON THE MOON

For many years it was tacitly assumed that the Moon must be totally inert, and that nothing has happened there for at least a thousand million years. Practical lunar observers were not so sure, and occasionally reported short-lived, localised outbursts due probably to gaseous emissions from below the crust. My own name for them – TLP, or Transient Lunar Phenomena – proposed in the 1950s has now been generally accepted.

TLP are not easy to see, and very difficult to record photographically. The only really good spectrogram of a TLP was obtained by the Russian astronomer N. Kozyrev as long ago as 1958, when he recorded an outburst in the large walled plain Alphonsus. However, new photographic confirmation has now been obtained by the Greek astronomer G. Kolovis, of the University of Thessaloniki, who has photographed a bright outbreak near the crater Proclus. It seems that the event covered an area about 22 x 18 kilometres wide, with a total energy of around 1017 erg. Very careful analyses have shown that it cannot have been due to a photographic effect of anything of the sort, and mundane phenomena such as aircraft in our own atmosphere have also been ruled out.

Proclus, near the border of the lunar Mare Crisium, is one of the brightest craters on the Moon, and has been the site of previously report TLP. The Kolovos photograph provides confirmation that the amateur observers have been right, and that the Moon is not so inert as used to be thought. Further confirmation may be forthcoming before long. In spite of the Apollo landings, the Moon can still provide us with plenty of surprises! PE

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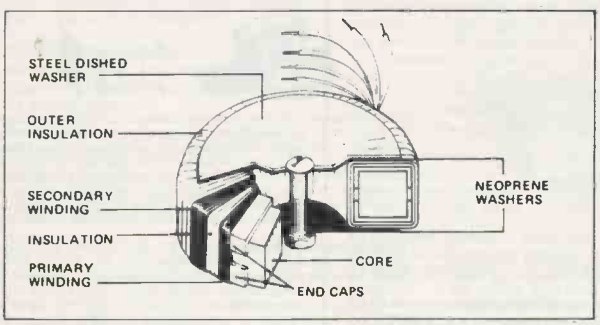

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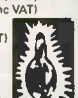

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TRUE RMS METER

A THERMAL CONVERSION AMMETER AND VOLTMETER FOR POWER ELECTRONICS

True RMS measurement is more useful than peak or average metering for non-sinewaves – but many meters don't give a true reading.

BY ROD COOPER

Using just a couple of 1N4148 diodes, a cheap op-amp and a 1mA meter, a true rms reading ammeter and voltmeter can be built for use with difficult waveforms.

✻ More accurate than the ac scales provided on multimeters.

✻ Can be used at higher frequencies than most other instruments.

✻ Works regardless of how distorted the waveform is.

✻ Gives better performance than true rms ic converters in respect of crest-factor.

✻ Gives isolation from signal source.

It is no longer just the traditional applications in power electronics, such as servo-motors and power supplies, that have solid-state controls. Many everyday devices like incandescent and fluorescent lamps, electric drills, all types of heating elements from soldering irons to storage heaters and domestic appliances such as food processors now have electronic controls. Often they handle large amounts of power – several kilowatts.

The application of electronic control is extending further and further, and it is often no longer adequate to use the ac scales provided on a multimeter for measurement. On both moving-coil and digital multimeters, the ac scales optimistically labelled "RMS" are more often than not false scales based on an averaging technique that is only true at 50 Hz and for pure sine waves. Try using these instruments on a 440 Hz switched-mode power supply and you soon discover your mistake. An explanation of how these scales are calibrated is included later.

However, some dmm (digital multimeter) instruments use a sophisticated ic which performs a rapid calculation of the rms value of an incoming waveform almost regardless of waveform shape, and which has good frequency response (into the MHz range). These designs of dmm are better, but they still have technical snags, explained later. Also, the ics used are expensive.

Another instrument used for rms measurement is the moving-iron meter, and the movements on some are far removed from the cheap and badly made meters usually associated with the name moving-iron, and are precision engineered. The final photo shows the Sangame-Weston moving-iron movement which has excellent design and engineering. Nevertheless, it still gives problems when the waveform is complex when the frequency rises beyond a few hundred Hz. Also, the coil which energises the movement introduces an inductance in the circuit being measured. This can pose severe difficulties.

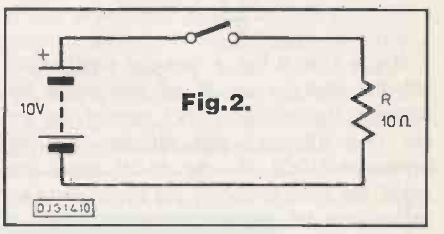
To illustrate the diversity of waveforms that have crept into everyday use, a few commonly-encountered examples are shown in Fig. 1.

In order to measure the true rms value of waveforms like these shown, the best method is to convert the signal to heat and then measure the heat in the form of temperature rise. To understand how this works, it is necessary to have a good grasp of what the words root-mean-square actually mean when applied to both ac and dc systems. If you already have a good grounding, you can skip this next section.

RMS DEFINED

Consider the simple circuit shown in Fig. 2. Suppose the switch is turned on and off every second to give a waveform across resistor R as shown in Fig. 3.

What is the *effective* voltage across R? At first glance, you may think that since 10V appears across R for only half a cycle, the effective voltage would be 5V. In other words, the effect on R would be the same as connecting a 5V battery straight to it without the switching.



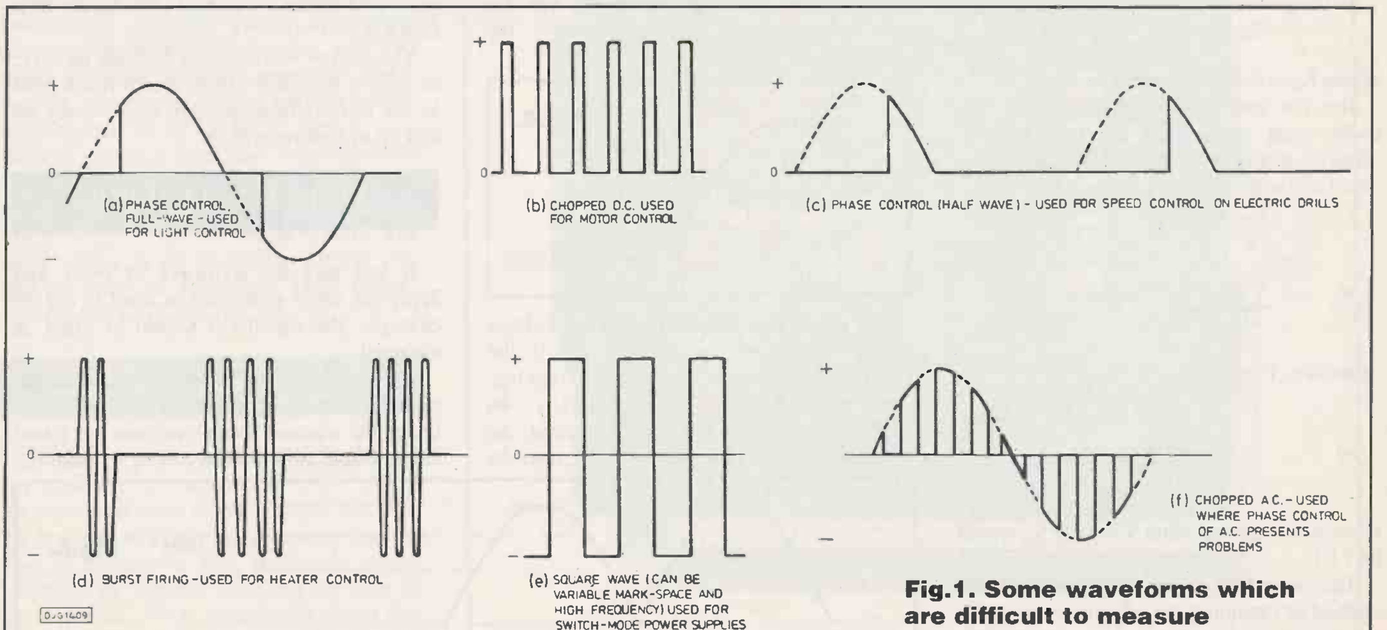


Fig.1. Some waveforms which are difficult to measure

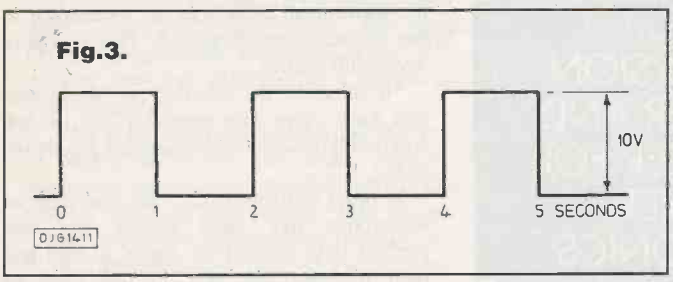


Fig.3.

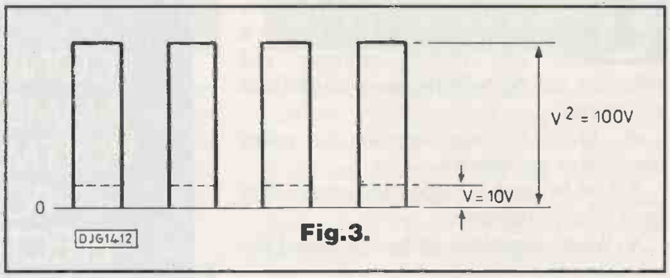


Fig.3.

But, if you connected a wattmeter to the 10V switched circuit you would find a power level of 5 watts, and if you then measured the 5V unswitched circuit, you would find a power level of only 2.5 watts. Clearly the effective voltage of the 10V switched circuit is *not* 5V but something in between 5V and 10V.

Before going further, note that this is a dc circuit and that rms values are not confined solely to ac systems – far from it. Also note that when the effective voltage is mentioned, this refers to a voltage equivalent to that steady dc voltage which would produce the same effect; in our example this means heat in the resistor.

Now, $P = \frac{V^2}{R}$

where P is the power level, V the voltage and R the resistance.

and $E = P.T$

where E is energy, P is power again, and T is time.

Combine these two equations:

$$E = \frac{V^2 T}{R}$$

If you look at Fig. 3, you can easily work out the energy content of one pulse by squaring the voltage (10V) multiplying by the time (1 sec) and dividing by the resistance (10Ω). As the on/off times are equal, the average energy per cycle could be obtained by dividing by 2.

In the general case,

$$E_{av} = \frac{V^2 T}{2R}$$

where E_{av} is the mean energy level.

But the mean, or effective, energy per cycle must be related to the mean or effective power level, P_e, which in turn must be related to the effective voltage V_e.

i.e. $E_{av} = P_e T = \frac{V_e^2 T}{R}$

so $\frac{V^2 T}{2R} = \frac{V_e^2}{R}$

cancelling T and R; $V_e^2 = \frac{V^2}{2}$

so $Ve = \frac{V}{\sqrt{2}}$

If we substitute the value V = 10V, V_e would be 7.07.

This round-about but easily understood method of obtaining the effective voltage by involving energy levels is particularly relevant when considering the thermal-conversion technique because the heat energy produced in resistor R represents the mean electrical energy level.

It should be clear from this example that the same result could be arrived at graphically. First, square the voltage pulse, as in Fig. 4.

Then, find the area under the squared pulse, divide this by the time for one cycle to get a mean, then take the square root to get the effective voltage.

This could be done even if the waveform was not regular by counting the squares under the graph, whereas the mathematical method would fall down. This method lucidly describes in fact what rms means – the root of the mean of the squared value.

Although there are instances where the effective or rms voltage can be arrived at graphically or by calculation, these methods are useless when it comes to waveforms shown in Fig. 1. Imagine trying to calculate or solve by counting squares any of these! Hence an instrument which reads true rms with *any* waveform, regardless of shape, is very useful.

MEASURING AC VALUES

Consider one cycle of a sine wave with peak voltage V_{pk}, as in Fig. 5. As the area under the positive curve is equal to the area under the negative curve, the sum of the two is zero; it follows that the average value of a sine wave is zero, ie not much use for practical purposes. We could rectify the waveform, as in Fig. 6.

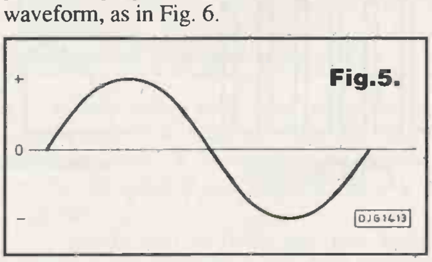


Fig.5.

We could now obtain an average voltage graphically or by calculation. Or, if the rectified voltage was applied to a moving-coil meter, which is intrinsically an averaging device, we could obtain an average reading. The scale could then be calibrated in average volts, but this would not be much use for subsequent calculations, and would not be very popular. Alternatively, the meter scale could be given a false calibration in RMS values. This would only be correct for the particular sine-wave in question. In the UK the most frequent measurement is of course 50 Hz on a reasonably respectable sine wave – the mains supply. So instrument manufacturers, of both digital and moving coil meters, make use of this so-called average-sensing rms calibrated display for this very reason. However, depart from the 50 Hz sine-wave criteria and you are in trouble; the average shown no longer has any relationship to the rms value.

It is here that thermal conversion and special calculating ics come into their own, but there are two differences between the two techniques. Thermal conversion meters can give electrical isolation between signal and meter. This is very useful if you are measuring 3-phase mains supply between phases of if you are measuring a supply which is floating, and which cannot be grounded.

Also, thermal conversion meters have good crest factor handling properties, whereas ic converters are limited to a factor of 6 or 7 at present.

Crest factor is defined as the ratio of peak value to rms value, any dc component being disregarded, and is best visualised by reference to a practical example, as shown in Fig. 7.

Here, the voltage peaks are 350V but the rms value is small – around 10V. So the crest factor is 350 : 10 = 35.

This sort of waveform is difficult for an ic to follow, but such spikes are so much grist to the mill to thermal converters – they all end up as heat regardless.

RMS FOR SINES

If you take the signwave of Fig.5. and apply the same technique as used in our dc example, the waveform shown in Fig.8. is obtained.

Note that squaring the negative part of this cycle results in a positive value. The area under the squared loops can now be found either graphically as before or by calculation.

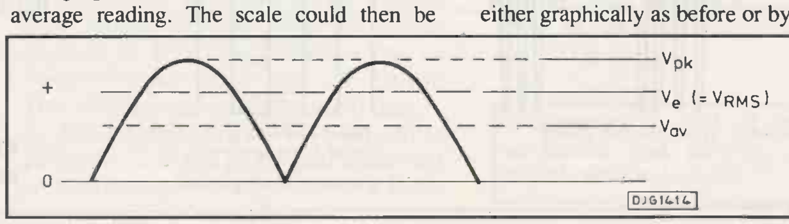


Fig.6.

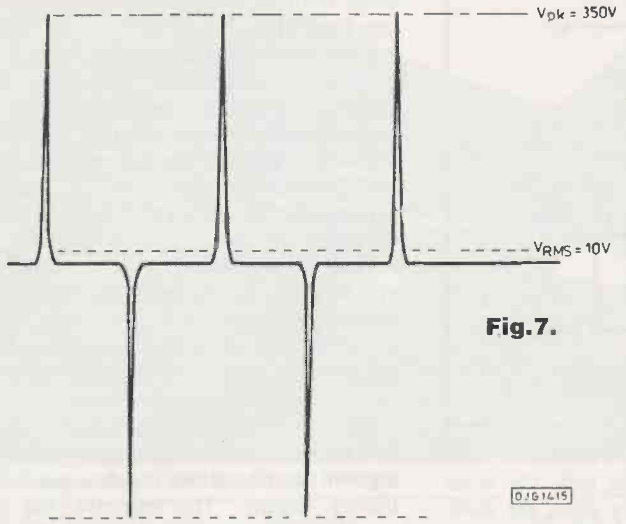


Fig.7.

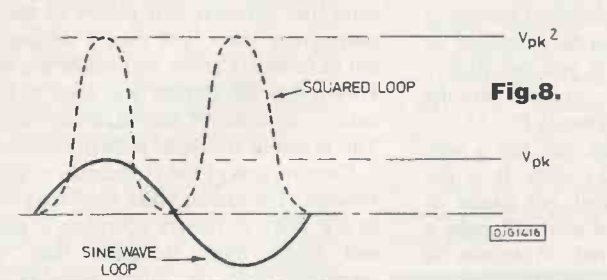


Fig.8.

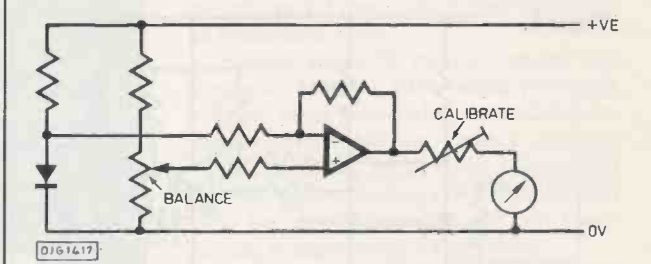


Fig.9.

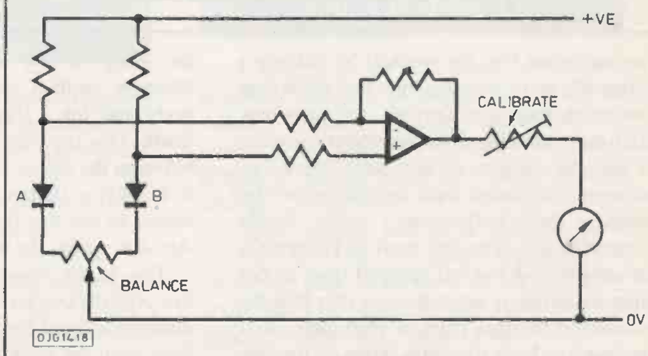


Fig.10.

The mean can be found, the square root taken to get the rms value' but whichever method you use the result will be that $V_{rms} = 0.707\ V_{pk}$ The mathematical proof of this well-known result can be found in most text-books on trigonometry. This formula can only be used on sine-waves and not on other ac waveforms.

When a device such as a motor is said to be rated at 5 amps, this refers to the rms current, not to the average or peak current, and makes no assumption as to the waveform shape. As we have seen from Fig. 1, if the motor was fed from an electronic control a truly complex waveform could be applied to it, but the primary limit would still be the rms rating. This should be borne in mind when using electronic controls. There would of course be other limits, such as the insulation breakdown limit and frequency limit, and these must be remembered as well.

Although voltage has been used in these examples, the same results are true for current measurement, eg $I_{rms} = 0.707\ I_{pk}$.

THERMAL-CONVERSION METER

When forward-biased, a silicon diode shows a voltage drop of about 2mV for every 1°C increase in temperature, and if connected to a suitable voltage amplifier it makes a good thermometer. A typical circuit is shown in Fig.9.

This circuit only measures one temperature quantity and would be fine for measuring ambient temperature, or the temperature of a particular object. For measuring temperature differences independent of ambient temperature, it is necessary to add a second diode to cancel out changes in ambient temperature, as in Fig. 10

Diode A can now be attached to the object whose temperature above ambient is required, and diode B can be left to sample ambient temperature. This is the basic circuit for the meters to be described. In the ammeter version, a few turns of relatively thick Nichrome wire are wound round diode A to form a low-resistance heating element, and the current to be measured is passed through it. Any temperature rise is registered by the meter, which can directly calibrated in amps.

The voltmeter version has a large number of turns of thin Nichrome wire wound round diode A to form a high-resistance heating element, and this is the only difference between the two meters, except of course the meter is calibrated directly in volts. Nichrome is the preferred material for the heater element because it has a higher resistivity compared to Constantan or Manganin, and this means fewer turns of wire for a given resistance and thus lower thermal mass, which it is important to keep low.

THERMAL CONSIDERATIONS

As it stands, the instrument would be very insensitive and innaccurate. This is because the heat generated by the input heating coil would be free to dissipate to the surroundings by radiating heat and by convection via the air. Very little heat would be available to raise the temperature of the diode body by conduction. Also, what little heat was conveyed to the diode would be influenced by the vagaries of random convection and random radiation. For these reasons, the sensor assembly is encased in insulation to stop these heat losses, to reduce their random nature, and to provide a carefully-controlled exit for the heat.

Heat has to have some exit from the insulated sensor, otherwise the sensor would be unable to reach a stable state – temperature would continue to increase. Also, when the input was removed, it would take an inordinate length of time to cool down. The insulation defines the heat exit path, in this design down the diode leads and heater coil leads by conduction.

To make the conduction a consistently reproducable quantity, the leads are terminated in copper heat sinks. The sensitivity of the sensor is determined by how long the conduction path is made. If the leads are long, sensitivity will be increased, and if the leads are short it will decrease. However, increasing the sensitivity also increases the time-constant of the sensor, the time needed to reach a stable temperature. This must be adjusted so that the meter can be read within a reasonable time – say 30 seconds.

Although this is a complex subject, insulating the sensor is easy. Two pieces of polystyrene sandwich the sensor on each side. Polystyrene is ideal for this purpose, in fact this project would be almost impossible to make if it were not for the excellent insulating and mechanical properties of polystyrene. The only small problem is that polystyrene is fairly transparent to radiation.

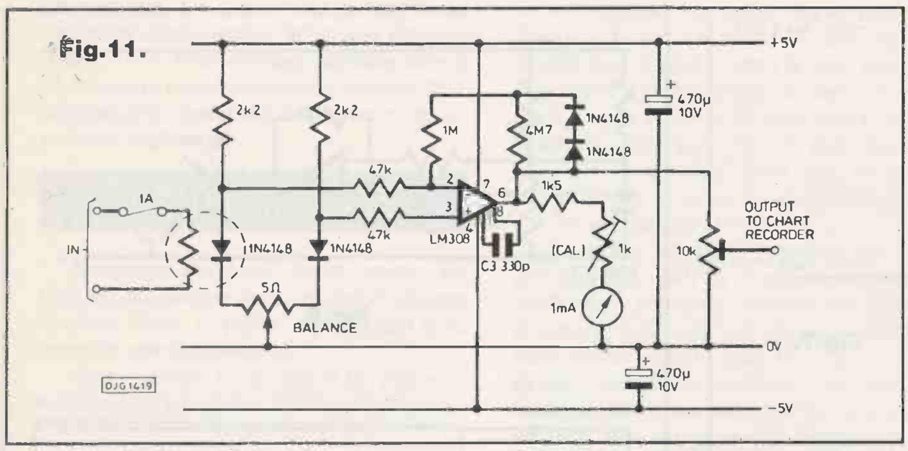


Fig.11.

You can prove that for yourself by holding a ceiling tile up to a strong light and observing how much light gets through, and also how much heat radiation. The polystyrene used to encase the sensor is not very thick, so radiation is reflected back into the sensor by coating the polystyrene with bright aluminium foil. The foil used in kitchens is not suitable, but the foil stripped from an old paper capacitor is since it is so thin that the increase in thermal mass is negligible. It is important to keep the mass down so that the time constant (ie the time taken to make a reading) is kept low.

After a period of operation, heat transferred along the diode leads and heater coil leads will warm up the heat-sinks. This could result in drift, so to compensate for this the second diode, diode B, is attached to the heat sinks. When the instrument is cold, diode B, registers the ambient temperature. When the heat sinks slowly warm up, the sensor, which is now insulated from the outside world by the polystyrene, sees the ambient temperature as that of the heat sinks. Diode B now corrects for this apparent increase in ambient temperature.

AMMETER CONSTRUCTION

The full circuit is shown in Fig. 11.

A short piece of bare 30 swg Nichrome wire is wound round a former of slightly less diameter than the body of the 1N4148 diode to be used. A wooden cocktail stick will do. There are only four turns, and these are wound as shown in Fig. 12 in order to render the coil essentially non-inductive. The coil is then slipped off the former and pushed onto

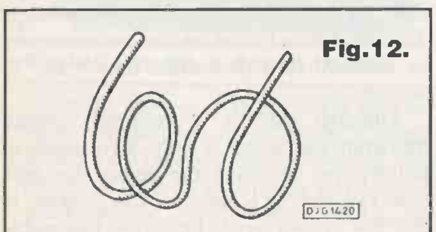


Fig.12.

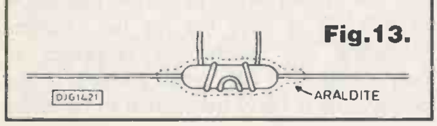


Fig.13.

the body of the diode. Araldite is then liberally applied over the coil, the diode body and for a short way along the diode leads. This provides the electrical insulation between the heater coil and the eletronics, so it is vital – particularly if you specifically intend to use this feature – to make sure the Araldite covers the area shown in Fig. 13.

This is the basic sensor, and has a very low resistance, around 0.1 ohm. It is not easily damaged by overload, but sooner or later even the most careful user will make a mistake and burn it out. Protection is therefore needed, and a 1 amp 20mm quick-

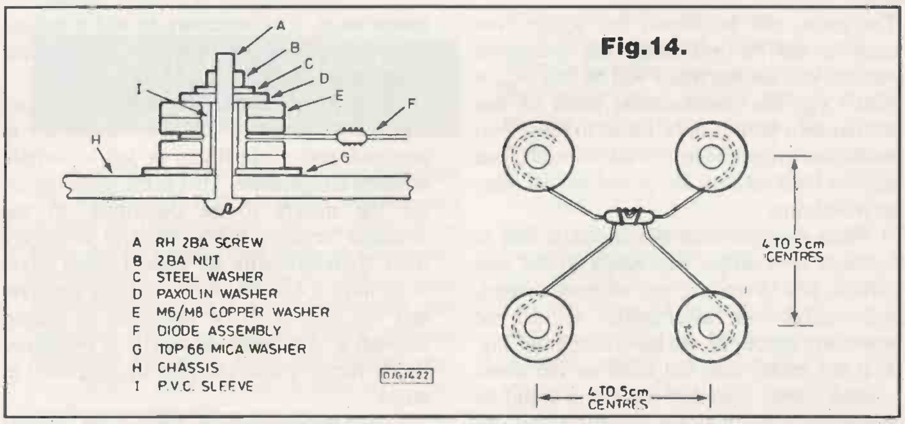


Fig.14.

blow fuse will give good defence. Unfortunately this fuse adds 0.1 ohm to the resistance at the input, but this is better than having to remake the sensor. There is no practical alternative to a fuse.

The Nichrome wire is clipped short, leaving about 0.5 cm for attachment of leads. 26 swg copper wire is soldered onto the two Nichrome stubs to make the electrical and thermal conduction leads.

The heat sinks are best made of copper, which has the best thermal conductivity of the commonly available materials, twice as good as aluminium and three times better than brass. I used four square cubes of 1.5 cm side and soldered both the diode leads and heater coil leads into fine holes drilled in the sides. The lengths of the leads from the diode and the heater coil were also about 1.5 cm. Since the meter was enclosed in an aluminium case, the copper heat sinks were clamped to the case base via mica washers and silicone grease in order to increase the thermal capacity. Electrical connections were made from the copper blocks with solder tags fixed to the blocks with a central screw which also acted as the clamping fastener.

Although using copper blocks gave good performance, drilling and soldering was a time consuming process. Later on, I discoverd that copper washers clamped onto the diode and heater leads gave just as good a performance but was a much quicker method of doing the same job, and this is the recommended system. Fig. 14 shows the set-up. Whereas the compensating diode was inserted into a drilled hole in the copper block, it must be attached to copper washer systems either with a clip or with an adhesive like Araldite and covered with insulation.

The polystyrene used was a 5mm sheet, as sold for wall insulation, but a piece of ceiling tile will do just as well if it is sawn into thinner sections. The reflective foil was cemented between two pieces of this thin polystyrene sheet, and then a rectangle cut out to fit neatly above and below the sensor. Polystyrene tile cement was used to fix the various sections of this sandwich together. This is readily available from diy stores.

Construction of the electronics is straight-forward. The circuit takes very little current (a few mA), so battery operation is possible and much more desirable than mains operation from the safety point of view, especially if you intend to float the meter above ground potential. Also, if you intend the latter it is wiser to use a plastic case instead of a metal one. The heat sinks can still be attached to a metal chassis inside the case to give similar thermal performance.

The reason I used a mains supply was that I intended to run a chart recorder for very long periods, using the ammeter as a signal processing unit, so it had to remain switched on for days on end. If you want use the mains, a suitable circuit is shown in Fig. 15.

As I used a metal case, I made certain of the insulation between input and the case using a 500V insulation tester ("Megger").

You will notice that the feedback path in Fig. 11 is different from that in Figs. 9 and 10, both these circuits being linear-response. The temperature rise in the sensor follows a square-law response, since the power level is defined by I^2R, where I is the current being measured and the R the resistance of the heating coil. Such square-law responses are inconvenient when it comes to practical

Fig.15.

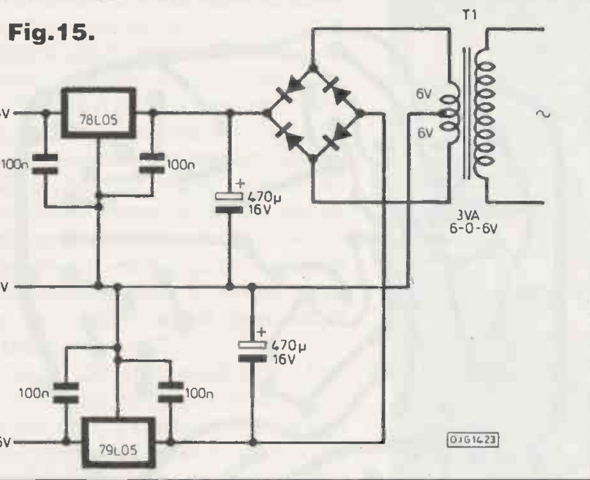
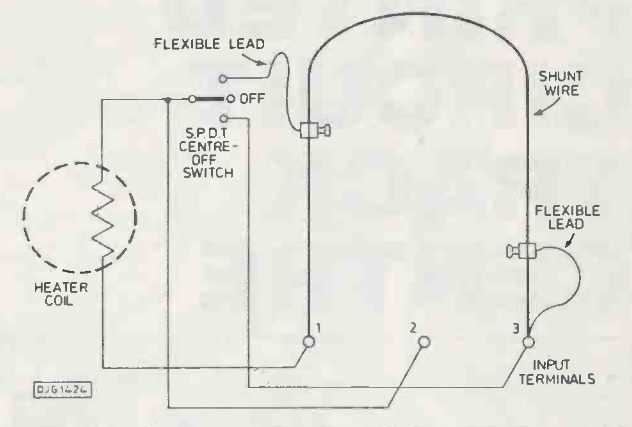
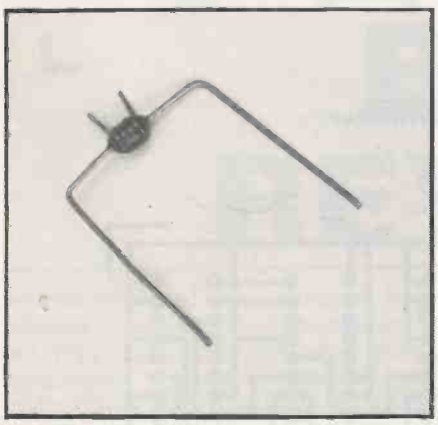


Fig.16.



measurement, so the output from Fig. 11 has been modified to overcome this difficulty, by making the op-amp respond in a complementary manner. The two diodes and two resistors in the feedback path achieve a fair degree of linearisation by decreasing the gain of the opamp as the output voltage increases. Note that complete linearisation would need a complex circuit, and that this circuit is the simplest consistent with good results.



Diode and heater coil assembly after applying araldite

CALIBRATION

Because the scale is not completely linear, as already explained, the existing figures on the 1mA meter must be removed. This is quite easy if you set about it the right way. First, remove the glass/plastic cover and the meter scale. These are usually held by screws, but sometimes clips are used and these may have to be bent back to release these parts. Next, scrape off the figures, but not the scale itself, with either a razor blade or art knife. It is not necessary to scrape off every bit of the numerals, so do not overdo the scraping. Small bits and pieces are readily removed using a hard rubber type eraser. When this is done, the scale plate is returned to the meter, but not the cover. The figures are replaced with Letraset during calibration.

Calibration is achieved by comparison with the dc scales of an accurate ammeter. I used the dc current scale on a Solartron 7045 dmm for example and this was more than adequate. A variable voltage psu capable of giving at least 1 amp, and a 3.3 ohm 10 watt resistor are needed. The two ammeters and resistor are connected in series and the psu set to show 1A on the accurate meter. The meter under test is then adjusted to fsd with R_{cal}. Make sure the zero is set before you do this.

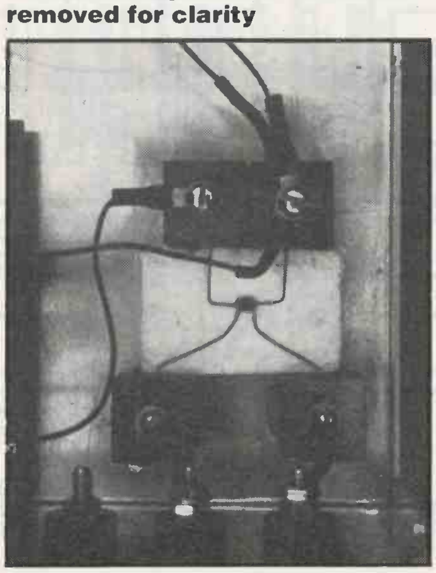
The fractions of 1A are then set up the same way, and the positions on the scale marked with Letraset. Needless to say, do not touch the zero control while this is done. It is tempting to do this because of the thermal time-constant, but is not necessary.

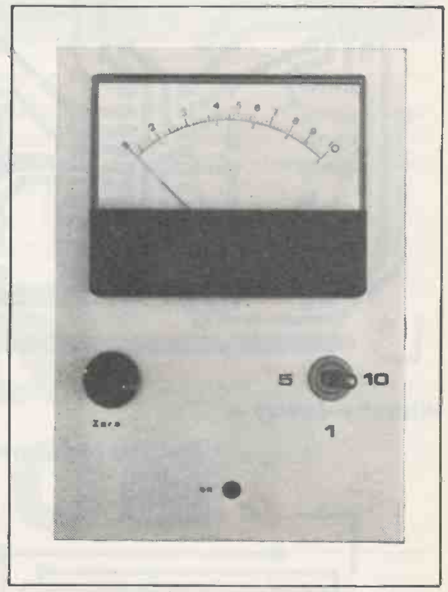
EXTENDING THE RANGE

A simple shunt circuit is shown in Fig. 16 and this has the advantage of using readily-available components. The switch only has to handle 1 amp and is a spdt type with centre-off position (Electrovalue S 7103 for example). In the centre-off position the meter reads 1A with input via terminals 1 and 2, that is with the shunt out of circuit. In the two other positions the meter reads 2A or 10A, with the input via terminals 1 and 3. The sliding contact for calibrating the shunt is the metal screw connector taken from a terminal block, and is the sort that has a central tongue contact, rather than a screw acting directly onto the wire.

The wire used for the shunt was a 12 cm length of 20swg Nichrome, but a similar length of 24 swg Constantan could be used instead. The correct length has to be found by experiment, starting with a length longer than is required. Calibration is the same as before, using a psu and dc ammeter. PE

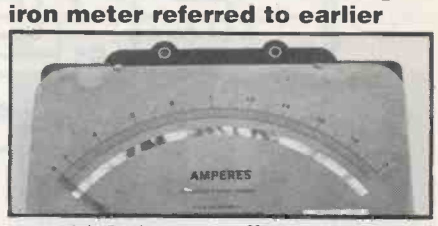
Heat sinks, diode sensor and connections, and lower polystyrene layer just prior to adding upper layer. Note that shunt and input fuse have been removed for clarity



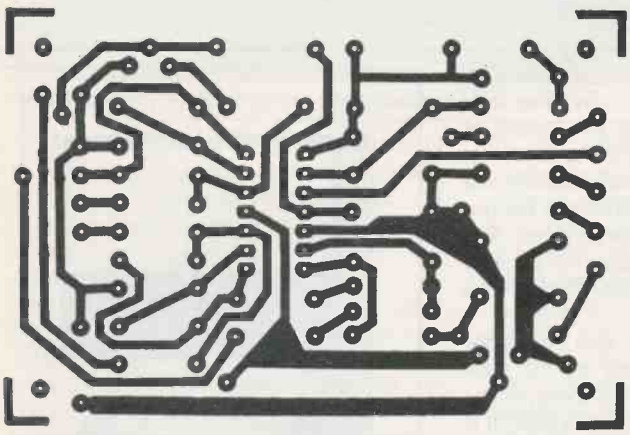


The completed instrument. Note the recalibrated scale on the meter

The Sangamo-Weston moving iron meter referred to earlier



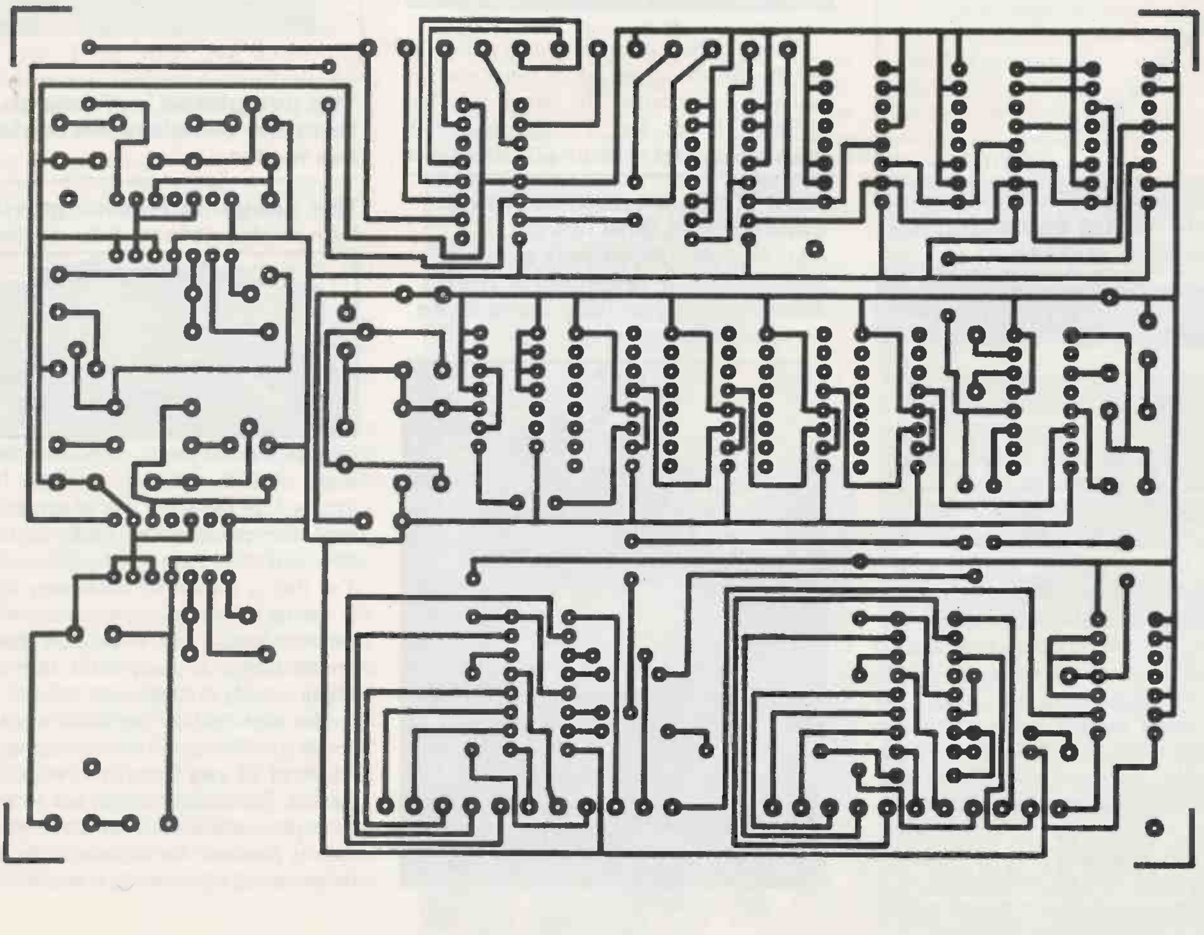
PRINTED CIRCUIT TRACK CENTRE



Wheeby-Jeeby ▲

▲ Solar Heating Controller

▼ Deluxe Metronome



WHEEBY JEEBY SIRENS

BY JOHN BECKER

Let the sirens lure you to plug in your soldering iron again!

Each time a new school electronics course is about to start, I receive a flood of letters from pupils who want a simple circuit to build for their project. As a quick guesstimate I reckon that at least half of those students are looking for circuits that make noises or cause lights to flash.

For anyone who is an early starter in the great fun game of electronics, any circuit that falls into these two categories has obvious attractions since, barring acute failure to do things right, it is immediately obvious that the circuit is working. For most circuits of this type, you don't need any special test gear to set them up. You just twiddle any of the preset or panel controls until you can see or hear that things are happening.

So, as this month's theme I'm offering you noise maker - in the form of a siren generator. Well, to be strictly honest, it doesn't on its own directly produce noises, but if you plug it into a separate amplifier module, it most certainly will! Practically any amplifier will do, whether it's the home hifi unit, or one of those low cost modules available from many of PE's advertisers. It will need a speaker of course! Alternatively, the unit can be plugged directly into headphones, or into a simple piezo electric audible warning device. You could even plug it into a cassette recorder and tape the sounds.

As well as having the pleasure of building the circuit, you will also discover two ways in which a circuit can be made to oscillate, and how a simple mixer can be made. With only minor modifications, any of these circuit blocks can be extracted and used for other purposes.

BLOCK BUSTING

Have a look at Fig.1. It's not as complicated as it might appear to the inexperienced eye. There are four main sections to it, each based upon one opamp. The circuit around IC1a is a sine and squarewave generator, IC1b and IC1d are each squarewave generators, and IC1d is the mixer stage.

I'm not going to overload you with technicalities on the precise theory of how things work, but briefly point out a few essential facts that should help you to modify things if you want to.

SINE TIME

With S1 closed, the circuit around IC1a is in the sinewave mode, or rather, it produces a waveform that can be loosely termed as a sinewave. It actually requires a somewhat more complex circuit to produce a true sinewave, though for our purposes here, the shape is good enough to deserve the term.

The rate of oscillation is determined by the values of C1 and C2, and the twin resistances of VR1a and VR1b, plus the series resistances of R2 and R5. The frequency will also be affected by the action of R3 and R4, and the two back to back diodes D1 and D2. It's really only the capacitors and VR1 that need concern you.

Turning VR1 for maximum resistance across its twin tracks will produce the lowest frequency signal. Minimum resistance will, as expected, produce the highest frequency. VR1 does not need to be a log pot, it could equally well be a linear one - indeed for interest, you might care to try both log and lin and discover how these types affect the rate at which the frequency responds to pot rotation position. You could also use a pot value of less than 1M - this would reduce the overall frequency range.

Should you want to completely change the range of oscillation controlled by VR1, C1 and C2 may be changed for different values. They should, though, have roughly identical values to each other. Increasing their values will produce a lower frequency range, and vice versa. With S1 open, C1 is taken out of circuit and the oscillator produces a roughly square-shaped waveform.

FIELDING FETS

Ignoring VR2 and the two transistors for the moment, the circuits around IC1b and IC1d form virtually identical oscillators. The only difference is that the capacitor values are dissimilar. In each case it is the capacitor value that sets the basic frequency range; C9 is smaller than C4 so the oscillator around IC1d has a slightly higher frequency range than that of IC1b. As with the oscillator around IC1a, the frequency can be varied by altering the value of the resistance of a potentiometer, in this case, VR3 and VR4 respectively. The pot values are not critical, and may be increased or decreased to suit your own choice. They may also be either log or lin.

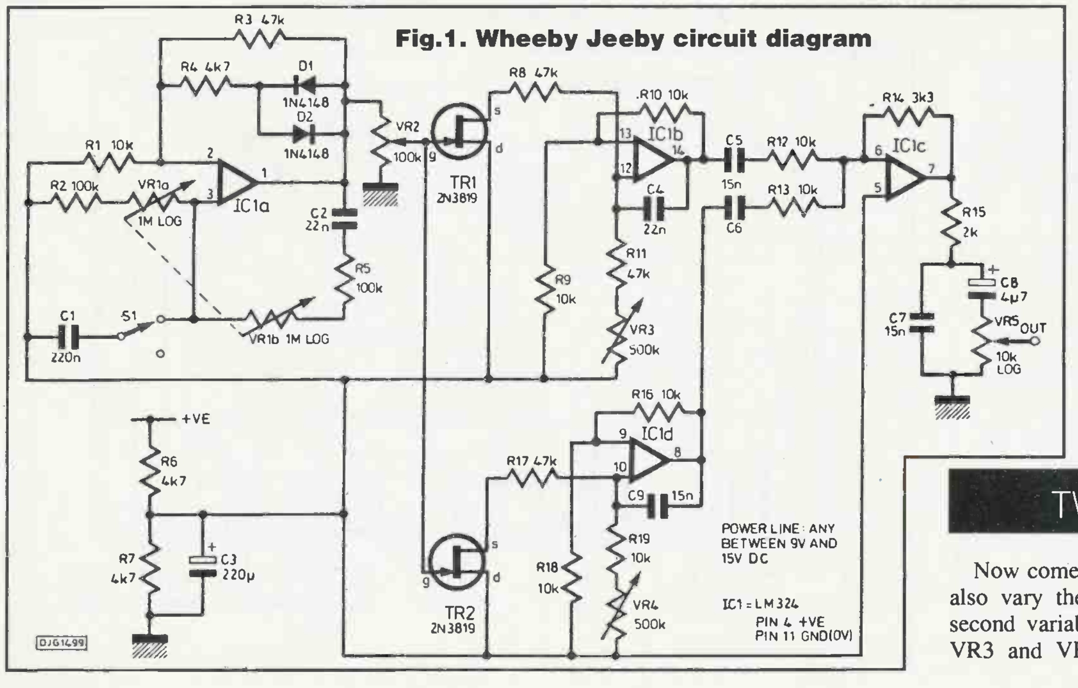
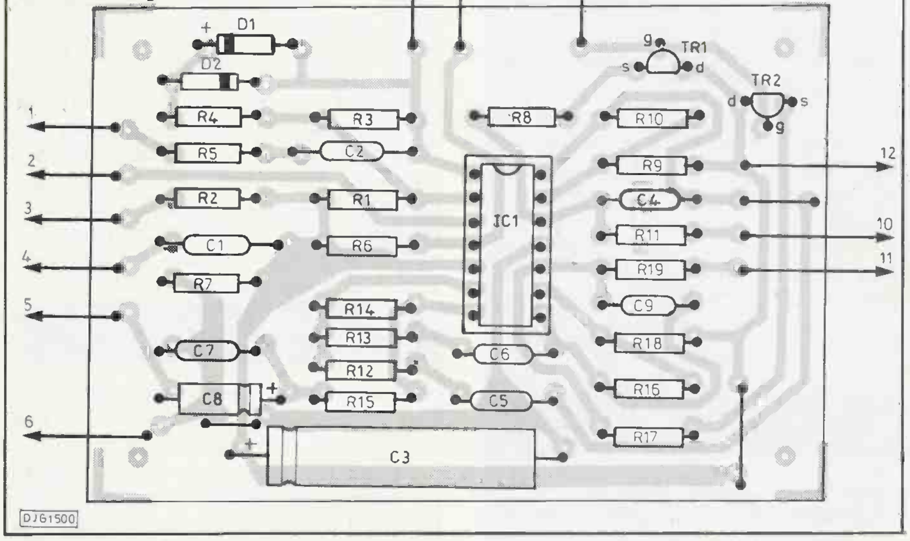


Fig.1. Wheeby Jeeby circuit diagram

TWIN FREQS

Now comes a slightly clever bit! We can also vary the frequencies by means of a second variable resistance in parallel with VR3 and VR4. In this instance we take

Fig.2. Printed circuit board layout



advantage of one of the characteristics of a field effect transistor (fet), that it can be used as a variable resistance. That resistance will vary depending on the voltage present at its gate input. By changing the voltage TR1, for example, will behave in a similar fashion to VR3 being varied, in other words TR1 can control the oscillation frequency. By connecting the fet gate to the first oscillator, the fet's effective resistance will change in sympathy with the oscillator's frequency output. Consequently, the frequency produced by IC1b will also vary in sympathy with the control frequency.

To give even more flexibility, VR2 has been included between the control oscillator and the fets to allow panel variation of the depth of modulation control. The net result is that the oscillators around IC1b and IC1d will produce a frequency that sweeps up and down within the range set by VR2, VR3 (or VR4) and at a rate set by VR1.

MUTUAL MIXING

The outputs from IC1b and IC1d are mixed together at IC1c. The composite signal is then taken via VR5, the volume control, to any amplifier as mentioned above. The purpose of R15 and C7 is to slightly smooth the corners off the square waveform to make it a little less harsh to the ear. They may be omitted if preferred, and VR5 taken directly to the output of IC1c.

What you will hear is two sirens running at different frequencies which are independently variable from the panel, in terms of rate, tone and depth.

If you think of using the mixer on its own for other purposes, there are couple of things you should note. First, in the application here I have restricted the bass end of the frequency response by use of a smallish value for C5 and C6. For a better bass response their values should be increased; 100n will allow more bass through, and 1µF will allow even more. If electrolytic capacitors are used, their positive ends should face R12 and R13 respectively. Secondly, the signal amplitude across IC1c is determined by the ratio of R12 to R14. Here it is set for a reduction to about one third. Making R14 33k would give an increase of about times three.

BOARD LODGING

I've been exceptionally kind to you this month - I've shown a pcb instead of a stripboard layout, and a suggestion on how you might wire up the circuit in a box. If you prefer to build the circuit on stripboard you should find the pcb layout very easy to follow and reinterpret to suit the different construction method. If you have the stripboard and pcb layout side by side horizontally, the component positions can be practically identical, cutting the strip tracks as necessary.

I hope to have another interesting simple project for you next month. PE

COMPONENTS

RESISTORS

R1, R9, R10, R12, R13, R16, R18	10k (7 off)
R2, R5	100k (2 off)
R3, R8, R11, R17, R19	47k (5 off)
R4. R6, R7	4k7 (3 off)
R14	3k3
R15	2k2

All resistors 0.25W 5% carbon film

CAPACITORS

C1, C2	220n polyester (2 off)
C3	220uF 25V electrolytic
C4	22n polyester
C5-C9	15n polyester (4 off)
C8	4.7uF 16V electrolytic

SEMICONDUCTORS

D1, D2	1N4148 (2 off)
TR1, TR2	2N3819 (2 off)
IC1	324

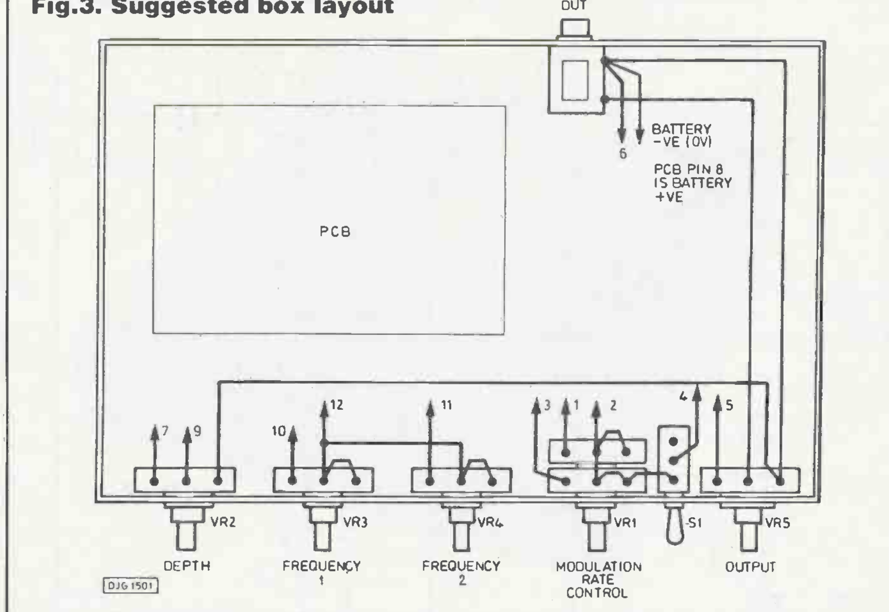
POTENTIOMETERS

VR1	1M log dual rotary
VR2	100k lin rotary
VR3, VR4	500k lin rotary (2 off)
VR5	10k log rotary

MISCELLANEOUS

PP3 battery and clip, pcb supports (4 off), 14-pin ic socket, mono jack socket, spst switches (2 off - S1 and for battery on-off), knobs (5 off), Phonosonics pcb number 151A, box and wire to suit.

Fig.3. Suggested box layout



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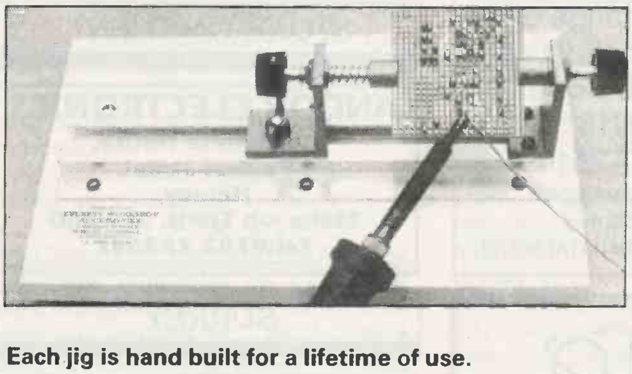

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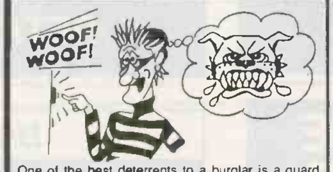

One of the best deterrents to a burglar is a guard dog and this new kit provides the barking without the bite! The kit when assembled can be connected to a doorbell, pressure mat or any other intruder detector and will produce a random series of threatening barks making the would-be intruder think you have a guard dog and try his luck elsewhere. The kit is supplied complete with high quality PCB, mains transformer, all components and instructions. The kit even includes a horn speaker which is essential to produce the loud sound required. The "dog" can be adjusted to produce barks ranging from a Terrier to an Alsatian and contains circuitry to produce a random series of barks giving a more realistic effect. Don't delay, fit one before you go on holiday and let our dog help you guard your home.
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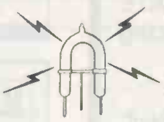

Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz, this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator.
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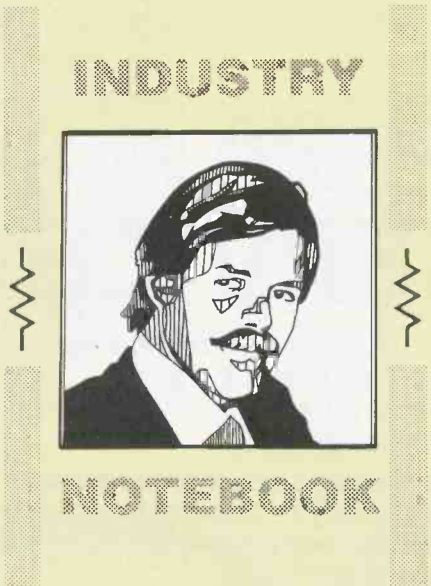

MIPS FOR THE MINORITY

BY TOM IVALL

TRICKLE CHARGING DOESN'T FILL THE COFFERS

Are we grabbing more and more trivia while the other half gets less and less of what it needs?

A new socio-economic indicator which seems to have emerged from the electronics field is 'mips per capita'. Readers familiar with computer jargon will know that mips in an abbreviation for million instructions per second. In this case it measures each person's 'consumption' of digital processing power, through computers or other electronic systems using digital information processing. So it's rather like that measurement unit 'energy consumption per capita' one finds in tables of socio-economic statistics put out by international bodies like the World Bank.

Although mips is well established as an engineering measure of processing speed, the idea of bringing it into a social context as a commodity which can be used by the individual, or 'consumed', is something new. The concept, I believe, is due to Professor I. Runge of the Fraunhofer Institute for Microstructure Technology in Munich, West Germany. He has recognised, quite rightly, that digital signal processing is now introducing technical criteria once exclusive to computer technology into a much wider field.

He has a chart, for example, which shows the increasing demand for information processing in terms of mips that will result from such developing electronic systems as digital television, the videophone, high-definition tv, pattern recognition in automobiles and man-machine interfaces for computers. By the turn of the century, he reckons, each human being in the industrialised countries will be producing on average a demand for 100,000 mips.

But the operative phrase here is, of course, "in the industrialised countries." These number about twenty in all. One can hardly imagine the kind of applications listed above as having any relevance to the lives of the majority of the world's population, spread mainly among the hundred or so developing and third world countries. The situation parallels that of energy consumption mentioned above. In the USA, for example, on average each citizen consumes 70 times as much energy (in joules) per day as a person living in the forty or so poorest countries of the world, and 12 times as much per day as someone living in the fifty slightly richer countries. Yet the USA represents only 4-5% of the world's total population.

Our plentiful supplies of mips and joules – and all the sophisticated equipment they make possible – are very nice for us in the industrialised countries. There seems nothing wrong in using and enjoying what has been provided for us. All the same, what I find an almost indecent spectacle is our incessant demand for more and more, against the drab background of poverty and deprivation lived by the majority of mankind.

Technology advances can be seen in an academic or professional sense, like scientific discoveries, as pure additions to the common stock of human knowledge. But the real motivation behind them, of course, is commercial competition and its built-in necessity to sell newer and newer products and services. So we find ourselves locked in a feverish cycle of innovation and obsolescence that gets shorter and shorter. Meanwhile the waste and pollution pile up.

Today, when there are no longer any technical reasons for failing to supply all the world's inhabitants with adequate food, clothing and shelter and health and education services, it sems to me deplorable that in Western Europe, America and Japan we have huge productive resources locked up in catering for the buying power of an already affluent minority. Part of the system is to keep persuading this minority that they really do have 'needs' which, in their benighted state of ignorance, they had never realised before. The discovery of these needs is presented as a form of enlightenment. Looking over one's shoulder to see what the Joneses have got is considered quite natural. Life can be perfected. Living in a permanent state of debt to achieve this is positively virtuous.

For those who are misguided enough to question this doctrine there is a throughly sensible answer. There always is. Everything will come right in the end because of the process the economists call 'trickle down'. The idea is that if a minority of countries – or persons – is allowed and encouraged to become extremely rich it will act as a motor for economic growth. Its wealth will not remain entirely with itself but, through activities like consumption or investment, will percolate down to others who are less well off. As a result of this process, the theory goes, the present stark inequalities between people will eventually be smoothed out by improvements in capital investment and productivity in the poorer countries.

It's obvious that 'trickle down' does work in particular cases. For example, an entrepreneur with a desire to become rich sets up a new business in some town. If he is successful – and he will have a strong motivation to be so – his activity will provide work and income for employees, perhaps additional sales for suppliers to his firm, and extra business for local shop serving the employees. But in the world at large it doesn't function at all well. In the developing countries there is still widespread undernourishment, poverty, ill-health and crippling indebtedness to the richer nations.

Apart from the way it works, 'trickle down' has two pernicious effects on human beings. First, it creates enormous disparities in income and wealth between individuals. This can lead to envy and strife. Secondly it sets up the acquisition of wealth and power, or a life given over to getting and spending, as a desirable model for all to copy. When people are excessively preoccupied with the means to life, in place of life itself, they become dehumanised into production machines. Pursuit of the means actually destroys the end.

To return to mips, I've studied the technology of hdtv with great interest, and written about it in this journal, but I have to confess that I could manage without this particular enhancement in my own life. And I suspect that many other people would be happy to give up future gratifications of this kind in goods and services if they felt that the productive resources needed to provide such facilities could be diverted to more urgent and humane purposes.

When filing this report, Tom warned me that it was "A bit subversive in places." True, but as much as I am devoted to technology, I am also conscious that humanitarian considerations on a broader scale must not be overlooked. **Ed.** PE

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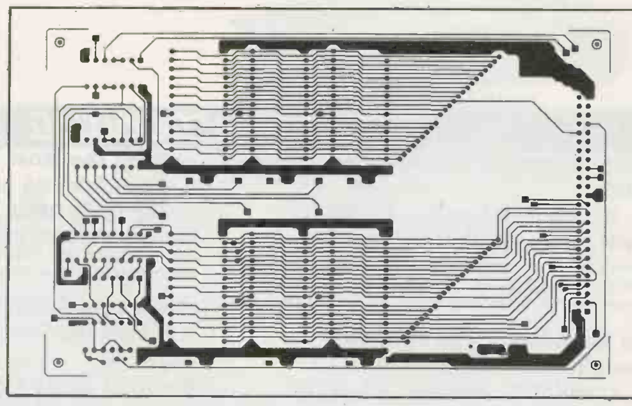

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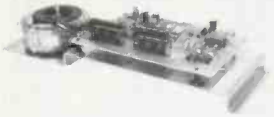

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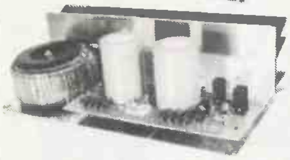

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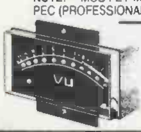

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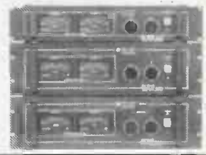

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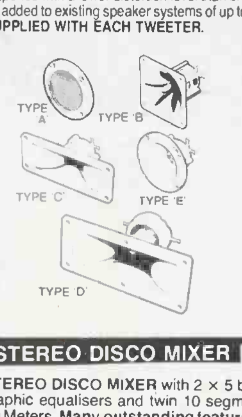

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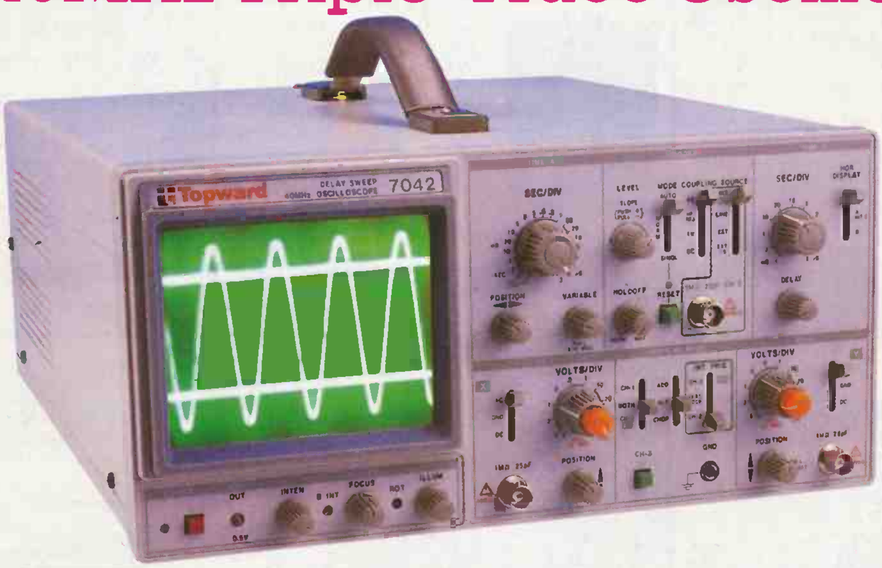

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