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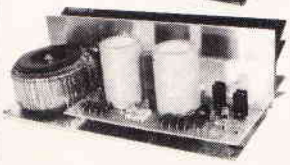

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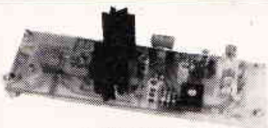

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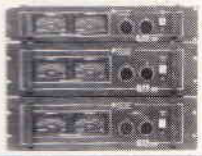

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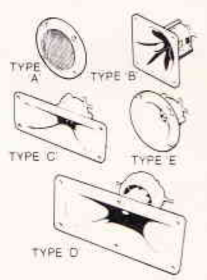

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JANUARY 1991

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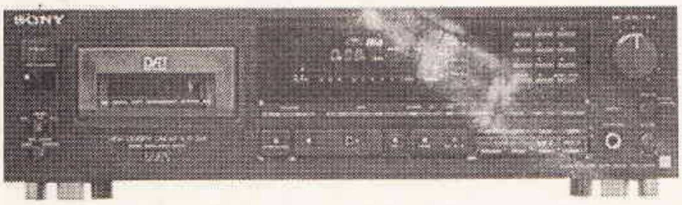
A Christmas Message

The Editor and Staff at ETI would like to wish all our readers a joyous and peaceful Christmas and a prosperous New Year.



Page 52

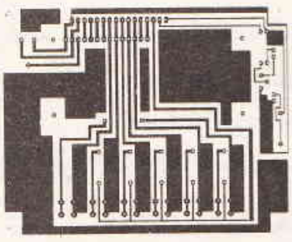
ISSN 0142-7229

ABC Member of the Audit Bureau of Circulation

ETI is normally published on the first Friday in the month preceding the cover date.

● Subscription rates — UK: £19.20. Europe: £24.10. Middle East: £24.40. Far East: £26.80. Rest: £25.85 or US$48.00.

AN ARGUS SPECIALIST PUBLICATION
Argus House, Boundary Way,
Hemel Hempstead HP2 7ST
Tel: (0442) 66551 Fax: (0442) 66998



Published by Argus Specialist Publications, Argus House, Boundary Way, Hemel Hempstead HP2 7ST. Tel: (0442) 66551. UK newstrade distribution by SM Distribution Ltd., 6 Leigham Court Road, London SW16 2PG. Tel: 01-677 8111. Overseas and non-newstrade sales by Magazine Sales Department, Argus House, Boundary Way, Hemel Hempstead, HP2 7ST. Tel: (0442) 66551. Subscriptions by Select Subscriptions Ltd., 5 River Park Estate, Berkhamsted, Herts HP4 1HL. Tel: (0442) 876661. US subscriptions by Wise Owl Worldwide Publications, 4314 West 238th Street, Torrance, CA90505 USA. Typesetting and origination by Project 3 Filmsetters, Whitstable. Printed by Acorn Web Offset Ltd, Bradford, W Yorks.

ETI
ELECTRONICS TODAY INTERNATIONAL

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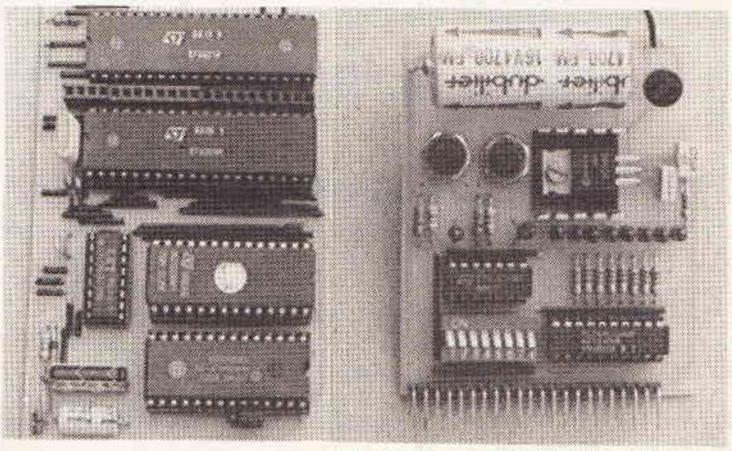
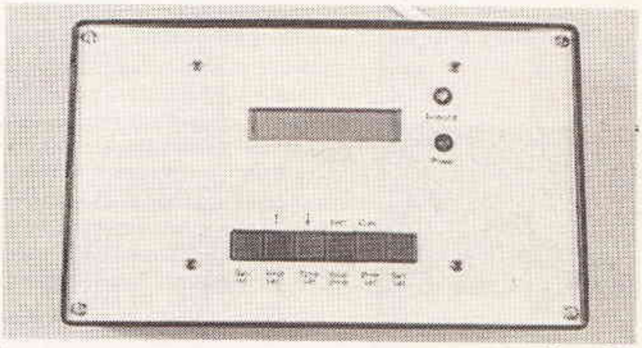
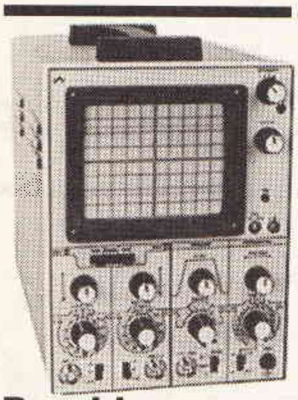
VOLUME 20 No 1

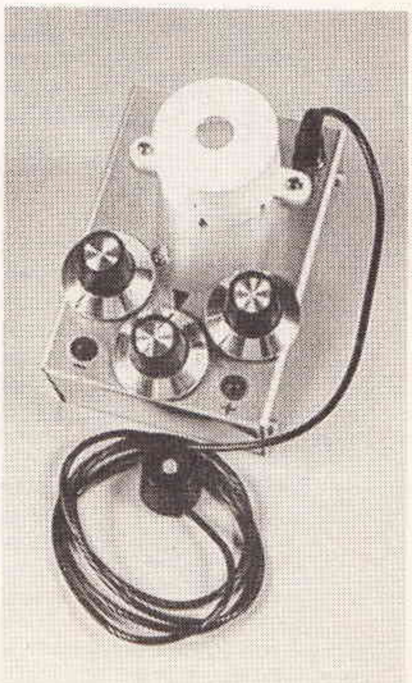


Page 46



Page 37





Page 58

BLUEPRINT

Blueprint is a column intended to provide suggested answers to readers' electronics design problems. Designs are only carried out for items to be published, and will not be prototyped by the columnist. Circuits published in Blueprint are believed to work, but may need minor alteration by the reader after prototyping. Individual correspondence will not be entered into, save as necessary to prepare items for publication.

Blueprint is expanding. One page is only enough to answer readers' enquiries very briefly, without looking at ways in which the solutions can be used by other readers with different applications.

Often a piece of circuitry in one design can be lifted out and used, perhaps slightly modified, in another class of design. It is my aim in future columns to explore circuits in a way that will make it easier to adapt parts for other uses. In this, the transitional month, I will complete the design of the furnace controller started last month.

Timed Reduction

The block diagram published last month showed in outline how to reduce the power of the heater over a period of 24 hours. Figure 1 shows the details of the circuitry, using 4000 series CMOS.

You will notice the power supply here is shown as 5V, although I showed a 12V supply in the previous issue. When I actually came to work out the details, there was nothing which could not run efficiently on 5V, and why use a higher voltage when a lower one will do the job? It turns out that 5V is convenient for the next phase of the design as well.

The top row of counters, IC2 and 3, are wired as binary up counters, and are cascaded via the carry out and carry in connections to give an 8 bit synchronous counter. If these were clocked at near the maximum speed of which CMOS is capable with a 5V supply, there could be a propagation problem, in which the carry out from IC2 would not arrive at IC3 in time; but with 50Hz clocking there is no problem.

If counters are to be cascaded in this way in an application requiring high speed clocking, it is important to read the data sheet carefully to find out whether the chips are at one end of their tolerance, if that's the case, the carry signal could arrive too late. The problem is greater the more counters there are in the row.

Possible solutions could be to increase the power supply voltage to increase speed, to use 74HC (or even 74LS) logic, or, if the application permits, to ripple cascade the counters. In this type of cascading, each counter is clocked from the final Q output of the preceding one. Don't forget, that the counter at the far end could be clocking much later than the one at the near end. Indeed, the system may never settle between one clock pulse and the next. Though adequate for frequency dividers, this will not do for any application requiring valid parallel data.

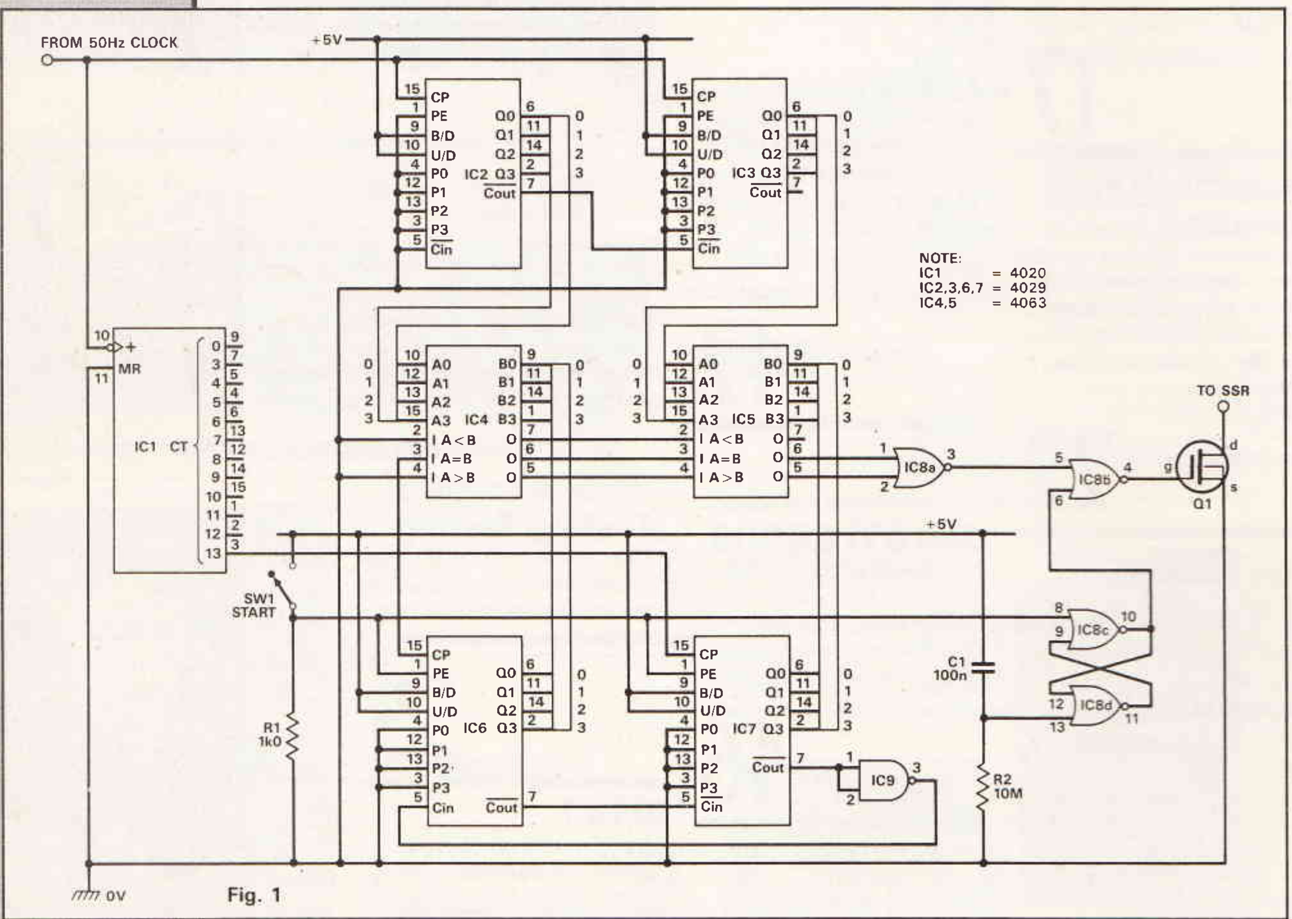


Fig. 1

The lower row of counters, IC6 and IC7, are wired similarly, save that when the counters reach 11111111, they are prevented from counting round to 00000000 by means of feedback from the carry out of IC7, to the carry in of IC6. These signals are both active low, so inverting the second carry out signal prohibits further counting via the carry in, just at the point at which the next counter in the chain, if there were one, would clock on one. The upper set of counters, clocks round and round continuously.

The block diagram last month showed a divide by 18000 circuit providing the clock signal for the lower counter. For the sake of simplicity, I have used a divide by 2^{14} (which is 16,384). This will surely be close enough for the process control required.

Digital Comparison

The binary outputs of the two 8 bit counters are fed to an 8 bit binary comparator consisting of two 4 bit comparators cascaded. Note that, as with the counters, the order of cascading is from least significant to most significant. The significance of this is that if the most significant 4 bit comparison is unequal, then the output will immediately assume the correct state, and carry signals from less significant comparisons cannot affect this. Only if the most significant 4 bits are equal can the output change due to a carry propagation, and only the 'equal' output can glitch.

When the power is first applied to the circuit, the upper counter will immediately start to clock round. It may start in any condition, because no power up reset is supplied, but in this application that does not matter.

The lower counter may also start up in any condition, and, if not at 11111111 will count up, but this does not matter either, because the output of the whole circuit is initially inhibited. On power up, the flip flop made with two parts of IC8, is set via the time constant of C1 and R2 so that pin 10 of IC8 is at logic 1. This forces pin 4 to remain at 0, leaving Q1 switched off. This feature ensures that a brief power failure, which would scramble the contents of the counters, cannot cause a sudden dramatic increase in heater power.

When the heater is required to be activated, the Start switch should be pressed. This will reset the flip flop, and will also load the lower counter chain with 00000000. As the greater than and the equals outputs of the binary comparator are gated together, the heater will remain on all the time in this initial condition, even when the upper counter chain passes through all zeros.

If, as I suggested last month, it is necessary to start the power reduction sequence with the heater at less than maximum power, it would be possible to rewire the parallel load inputs of IC6 and IC7, to load a binary word which sets any specific lower power. Alternatively, a pair of hex thumbwheel switches could be used to set the starting power.

Automatic Adjustment

The querant initially expressed doubts that a thermocouple controlled system would be practical. I would suggest it will be easier to guarantee an even thermal profile over time if thermocouple control is used because of the uncertainty as to exactly how much heater power is needed to maintain thermal equilibrium at any given temperature.

The circuit of Figure 3 does exactly this. In this design, an 8 bit counter, just like IC6 and 7 in Figure 1, is used to provide a digital word which specifies the required temperature at a given time. This is converted to an analogue signal which is compared with the temperature measurement signal from the thermocouple, and the result of this comparison controls an analogue burst firing circuit. The overall complexity of this circuit is no greater than in Figure 1, although the presence of a digital to analogue converter may make it slightly more expensive.

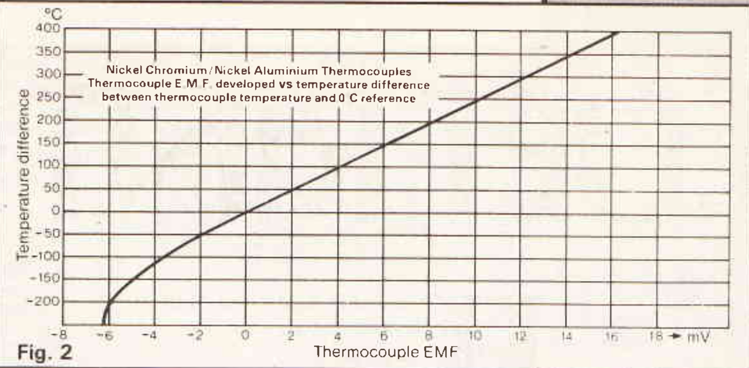


Fig. 2

Figure 2 shows the typical response of a thermocouple. As can be seen, the output signal over the normal range of operation is 40V per °C. While measurable, this signal is too low for most electronic applications, so the first task is to amplify it. The circuit shown in Figure 3 incorporates on its input an amplifier which raises the signal level to approximately 2mV per °C.

Before proceeding further with the circuitry, we must consider what the thermocouple is actually doing. At the junction of two dissimilar metals, where electrons are bound more strongly in one than the other, any thermal excitation will cause a transfer of electrons from one metal to the other. This transfer will continue until the voltage between the two metals is sufficient to counteract thermal transfer.

Of course, any attempt to measure this voltage with circuitry at the same temperature will prove fruitless, because in any complete loop all at the same temperature the sum of all the thermocouple voltages will cancel. If this were not the case, conservation of energy would be violated.

In practice, a thermocouple can be used to measure temperature because it is used in situations where one end of a pair of thermocouple wires is at a very different temperature from the other end, and the net voltage in the loop corresponds to the temperature difference between the two ends. Thermocouple wires have high melting points, so the business end can measure the temperature of an environment for most other temperature measuring devices, while the other end remains at room temperature.

This property of measuring temperature difference can give rise to errors. If the room temperature changes, then the reading will change. It is possible to incorporate circuitry to measure the room temperature and compensate for this, but this is not necessary in the application here, because that level of precision is simply not required. If it were, then one would probably add in a signal from a semiconductor temperature sensor such as the LM335 to compensate for the 'cold junction temperature'.

The Circuit

The input amplifier uses an OP07 to amplify the very low thermocouple signal without adding significant offset or drift. This is probably the cheapest op amp suitable for the job. A 10M resistor, R1, pulls up the input to give an apparent high temperature reading if the thermocouple becomes disconnected. This is a safety feature to prevent overheating in the event of a fault.

The output from the OP07 is summed with the output of the DAC (digital to analogue converter) which determines the aiming temperature. The gain of the summing amplifier, IC2, is set to give a 2V output swing for a 10°C difference between aiming temperature and measured temperature.

The output from IC2 is fed to a comparator, the other input of which receives a triangle wave signal of 2V peak to peak. It is the comparison of these two

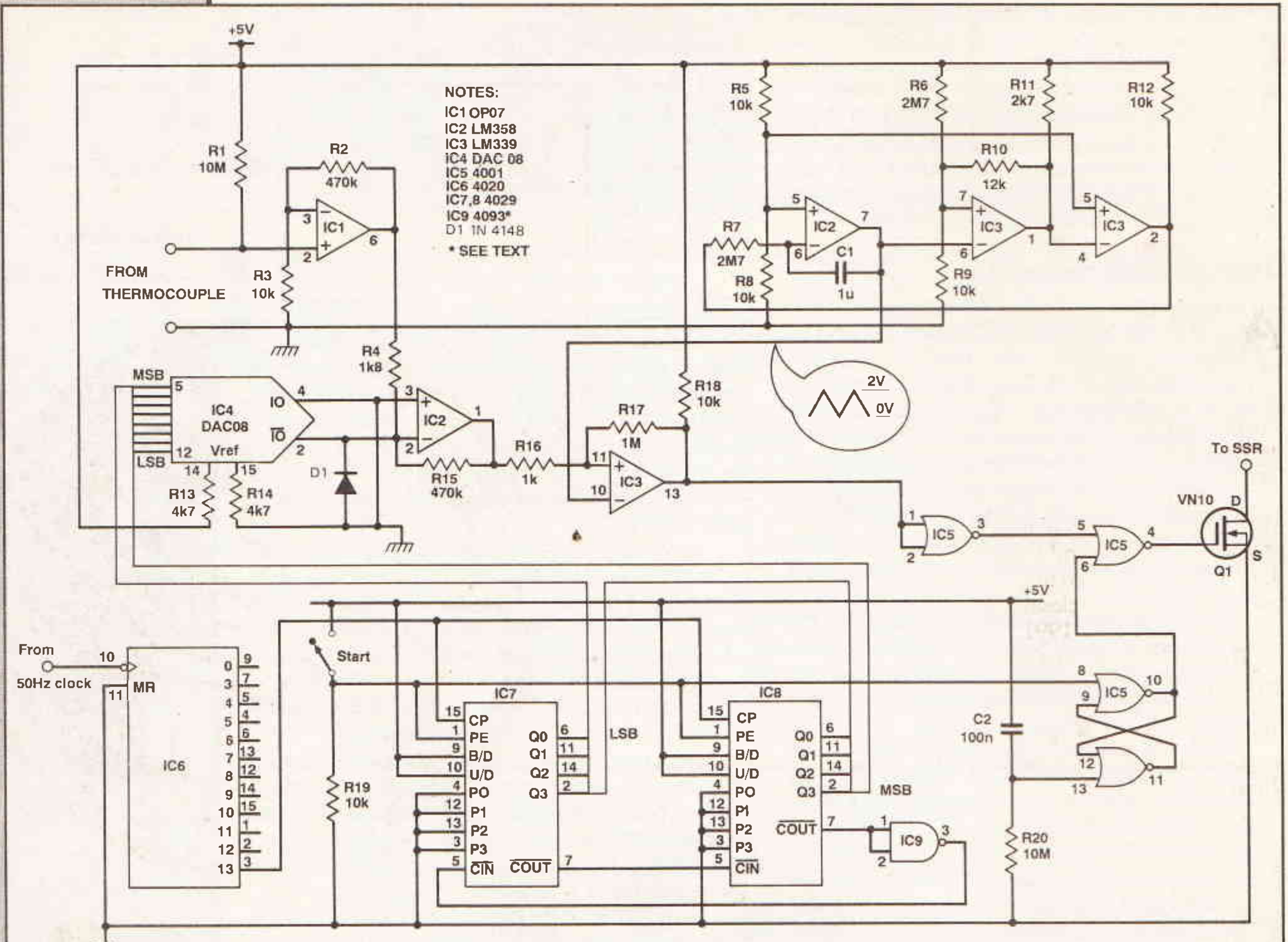


Fig. 3

signals which sets the burst firing ratio, with a period equal to that of the triangle wave, over a 10°C span.

The ramp generator consists of an integrator using IC2 pins 5,6, and 7, followed by a comparator with hysteresis set so that its switching points occur at close to 0V and 2V. The output of the comparator is inverted to give the correct phase, and fed back to the input of the integrator. The comparator changes state when the output of the integrator falls close to 0V or rises to 2V, thus setting the limits of the waveform.

The frequency divider and counter which sets to aiming temperature, with the surrounding reset and output inhibit circuitry, has been recycled from Figure 1, so needs no further explanation. As with the other circuit, the inputs of IC7 and IC8 can be rewired to give a different starting temperature. This does control temperature rather than heater power, and the heater power will adjust itself to maintain the desired temperature regardless of exactly how much power is required.

You will notice the counter is an up counter, even though the requirement is for a steadily reducing temperature. Seeing there was a choice, I used the negative current output of the DAC so the DAC works on negative logic, thus avoiding the need to redraw the counter circuit.

Hunting

Several other design points need to be made. First of all, depending on how much thermal delay there is between the heater and the thermocouple, the system may tend to overcorrect itself before information about the change of temperature has percolated as far as the thermocouple. If this happens, and there is no better place for the thermocouple, then the gain of the feedback loop should be reduced by reducing the value of R15.

This reduces the change in heater power for a given temperature error, and therefore reduces the tendency of the system to oscillate. This is much the same effect as an amplifier oscillating from too much negative feedback. The mathematics is of the same form. The same reasoning can apply to any control system which incorporates feedback, which shows that if you have a good enough knowledge of electrical engineering you can easily understand a number of other areas of science and technology.

Important Note

The power requirements of this circuit are different from those of the completely digital design. Most of the ICs still run on 0 and +5V, but IC1 and IC4 must run on −/+5V. Note also the reference for IC4 is derived from the power supply, so the supply must be well decoupled and properly regulated. I have not shown a split rail power supply circuit because this is so simple. Perhaps the best approach would be to use an LM317 adjusted to exactly 5V for the positive supply, and a 79L05 for the very low current required for the negative supply.

The DAC has a logic threshold connection (pin 1). Because the logic operates relative to 0V, this pin should be connected to 0V.

All this circuitry should work, but has not been prototyped. Therefore some component values may need to be changed for optimum performance, or there may be an error of logic polarity somewhere. On past history, there is an 80% chance that the circuit will work as shown, and very little chance that major alterations will be needed.

ETI NEWS

£7000 PRIZE

A £7000 Prize for the best application of electronic, electrical or software engineering techniques for helping disabled people was announced by the Institution of Electrical Engineers (IEE).

The Prize will be awarded in 1991. Applicants need not be Members of the IEE and applications will be welcomed from any part of the world. The closing date for entries is 31 May 1991.

The aim of the Prize is to promote awareness of the needs of disabled people and to highlight the vital role that electrical engineering can play in meeting these needs.

This is the fourth IEE Prize to be offered since its launch in 1982 and Sir James Redmond, Chairman of the Prize Adjudicating Panel is confident that entries for the 1991 award will be of the same high quality as those for previous years.

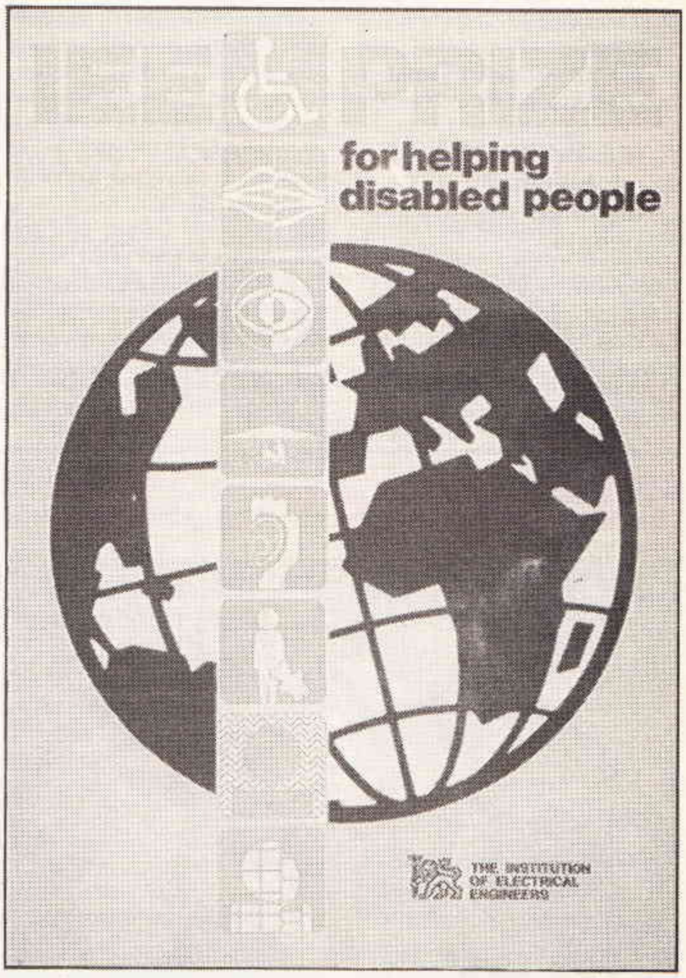
"Advances in technology" he said "have transformed almost every aspect of our daily lives, both at home and in the workplace. These advances offer immense benefits for us all. For the disabled they can provide the key to a richer and more fulfilling quality of life".

The first award made in 1982, was for a joystick control system which enables severely disabled people to drive. In 1985 a joint award was made: one for an electronic bladder control device for paraplegics; the other for an eyegaze operated computer developed in Australia.

The Third IEE Prize was awarded in 1988 for a Swedish radio distributed electronic newspaper for blind people. As a result of this IEE Prize, the system has been modified and introduced into the UK by the Royal National Institute for the Blind. (See ETI Aug).

An Adjudicating Panel under the chairmanship of Sir James Redmond, Past President of the IEE, will judge the applications for the 1991 award.

Further details on the IEE Prize and information on how to apply is available from: Christina Dagnall, IEE, Savoy Place, London WC2R 0BL. Tel: 071-240 1871.



COMPUTER SPELL

The Elementary Spellmaster contains the complete database from the Oxford Children's Dictionary. This latest electronic dictionary will allow a child or mum and dad to spell check words quite speedily. A unique feature of the Spellmaster is a page index which provides the child with an on screen page reference number to enable them to quickly find the word definition in the companion Oxford Children's Dictionary (included).

There are games too. Learning has to be fun and the Spellmaster makes learning fun for the child by incorporating several games like Hangman, Spelling Bee and Anagrams . . .

Another unique feature will allow the child to enter his or her weekly spelling list so that they can test themselves against the Spellmaster.

Franklin Computer have experience in the field of Linguistic Technology and their spelling devices have an exclusive phonetic capability.

They have been designed for 6 to 12 year olds with the full backing of the Oxford University Press.

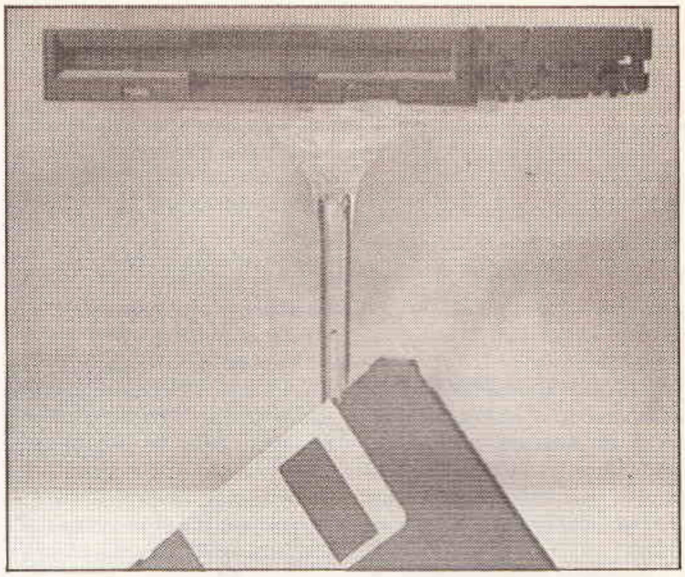
SIMPLE MICROWAVE SAFETY

Alpha Electronics announce the availability of a new Microwave Leakage detector that is simple to use. The model meets RS 5175 requirements relating to the Safety of Commercial Electrical Appliances using Microwave Energy for heating foodstuffs. This new tester is a hand held, battery operated device with both visual and audible warning devices and self test.

The unit is handy for Industrial and Household microwave appliances.

Simple visual indication of Ready, Safe and Danger is via a series of coloured LEDs together with an audible warning when levels are above the safety limit.

SMALLER SIZE DISC DRIVE



Mitsumi's new 2Mbyte 3.5in floppy disk drive is being launched in the UK by Southern Peripherals for applications ranging from notebook and portable computers to standalone drives and peripherals.

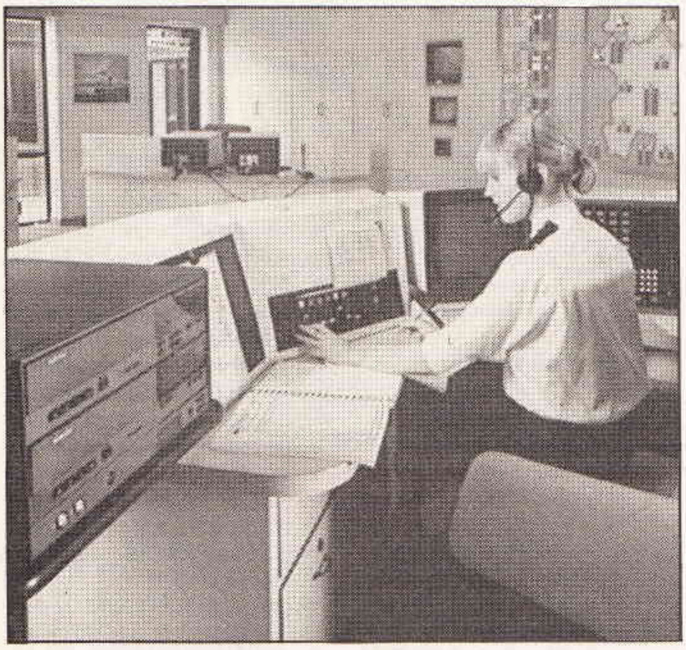
The low cost disk drive is UL and GSA approved and has a formatted storage capacity of 1474.56kbytes. Power consumption is just 1.15W in operation or 0.025W in standby. SuperThin operates from a single 5V supply, making it ideal for portable applications.

The drive rotates at 300rpm and provides a track to track access time of 3ms with an average access time of 94ms.

The disk drive has a soft read error rating of 10^9/bit and a hard read error rating of 10^{12}/bit. Seek error rating for the drive is 10^6/seek cycle. Design life is five years with an MTBF of 10,000hr.

Further information, contact either Derek Southern or Richard Etheridge at Southern Peripherals, 17C London Street, Basingstoke, Hampshire RG21 1NT. Tel: 0256-819221.

HELICAL SCAN VOICE LOGGING RECORDER



Wordsafe, the world's first desk-top multi-channel voice logging recorder incorporating helical scan technology, has been unveiled by Racal Recorders Limited. Wordsafe is the first communications recorder to provide up to 32 channels and more than 24 hours' continuous recording on a standard VHS cassette in a compact machine.

Wordsafe is suited to general office environments where there is a need to record all telephone transactions, and space is restricted — for example, in financial institutions or despatch offices. The high level of security offered, will also appeal to longer-established users, such as the emergency services and air traffic, harbour and seaway control installations.

Wordsafe is less than half the size of the nearest comparable recorder. This permits the recorder to be positioned on a desk-top or to be rack-mounted.

There is 25.5 hours recording capability and a choice of channel configurations — ranging from 4 to 32 voice channels.

All units include a real-time clock, recording time-code generator and automatic search facilities. Additional fast record location facilities are given by an activity search feature and a new feature, Marker Search, which marks the tape during recording so that a passage can be easily located for replay. Any number of channels may be replayed simultaneously through either of two independent outputs.

Prizes range from around £5,000 to £15,000, depending on the number of channels.

RADIO 3

Businesses within the M25 area now have access to a new high-technology mobile-communications system, following a remote-control switch-on of the London-based network from an exhibition in Telford, Shropshire.

Now in commercial operation, Radionet offer business users all the benefits of the latest 'Band III' trunked mobile-radio technology, but unlike other 'Band III' networks is not limited to vehicle-mounted radios. Instead, users access the network through compact, lightweight handportable radios, allowing them to communicate via Radionet when on foot, in buildings or out on site. This extra flexibility is expected to make the network especially popular among business users such as security companies and courier operations. Compared to older-generation mobile radios or 'walkie talkies', the new Radionet handportables offer high speech quality, more reliable communications and wider coverage. Also, compared to handportable mobile phones using cellular radio networks, they offer extremely cost-effective communication based on just a flat-rate monthly subscription — there are no call charges for individual calls made over the network.

Unlike 'walkie talkie' users, businesses using the Radionet network do not have to apply for a government radio-operating licence, and can start using the network simply by signing up with any of Radionet's newly appointed 'service providers' within the

London area.

The first of these, Commend Communication System (UK) has already signed up courier operator, World Courier as one of the first major users of the new network.

Radionet users can also access the network using any of the new 'Band III' handportable radios now coming onto the market. The first of these, from UK radio manufacturer Key Radio Systems, is being used extensively on the new network at the moment. Radionet is operated by leading mobile-communications operator RT Radiophones, which also operates several other mobile-radio networks around the UK.

It is believed that it has been the success of the company in operating regional networks that has persuaded the government to license it to operate Radionet in London, the first 'Band III' network to be geared exclusively to the new handportable radios.

MINI TV

A new entrant into the home entertainment market, Epson is launching a family of high quality, portable, colour LCD televisions. Top of the range is the 'Vision System' — a Mini TV with 3.3" screen combined with active speakers on a speaker stand.

The TVs are the first consumer electronics product to take advantage of Epson's leading role in liquid crystal display technology developed for its portable computer systems. The range consists of the 2.6" screen Pocket TV priced at £199.99; the Mini TV at £299.99, and the Vision System at £369.99.

The Vision System uses two high efficiency, wide range, active loudspeakers which widen the 'sound stage', enchancing programme content.

Using Epson's own Active Matrix image system, the TVs give a better picture quality far superior to other small screen LCD TVs available. The SAM system packs a much higher density of pixels into each screen, giving a wider viewing angle, sharper image and brighter colours. The display element is a transmissive twisted nematic LCD with an MIM active matrix, backlit by a built-in cold cathode fluorescent lamp.

TV channel selection is via a touch-button auto tuning sytem, which scans to locate an acceptable signal for a station. The TVs can also be connected through a jack socket to a video camera or video cassette recorder.

Both TVs and speakers are powered by dry or rechargeable Nicad batteries, or run from a car battery or AC power via adaptors. Each has a telescopic rod aerial. In addition, the Mini TV comes with an AC mains adaptor and external aerial cable to take full advantage of the existing domestic aerial system.

PANEL METER

The recently enhanced DPM 8000 Series of panel meters from Anders Panel Instruments now includes a 4-20mA input version, true RMS and 4½ digit display options. These improvements, coupled with existing high specifications, mean greater accuracy and resolution with no change in size.

Input ranges, for the 4-20mA type are switched and an exitation voltage output terminal is provided for powering transducers and sensors.

True RMS versions make the units ideal for non-sinusoidal waveforms, typically associated with electronic and thyristor controllers.

Power supply is from 110/220V AC and sample rate is 2.5 times per second. Accuracy is 0.1% plus one digit. The DIN size panel cut out is 96 × 48mm.

Contact, Anders Panel Instruments, Bayham Place, London NW1 0EU. Tel: 071 388 717.

FIBRE OPTIC TRIALS

British Telecom, and its partners BICC Cables, Fulcrum Communications and GTP, today took the wraps off communications for the 21st century with 18-channel TV, phone calls, and videotex.

Up to 400 homes and businessess in Bishop's Stortford, Hertfordshire, will be taking part in the world's first practical demonstration of the networks of the future.

Phone calls, TV pictures and text are sent direct to the home down hair-thin strands of ultra-pure glass as high-speed pulses of laser light. The TV pictures will include satellite and cable TV programmes as well as the four broadcast channels; all will be free to viewers during the trial.

The homes and businesses are taking part in a multi-million pound, two-year trial to demonstrate the technical feasibility of these advanced systems which have been developed at British Telecom's Research Laboratories at Martlesham Heath, near Ipswich, and are being provided in collaboration with the other partners in the project; BICC Cables and GPT.

During its two year run, the trial will provide valuable data for planning advanced commercial communications systems for the next century. It will enable British Telecom and its partners to compare and contrast the operation and cost of two distinctly different fibre network systems developed by its research engineers.

BICC Cables designed and made all the optical cable being used in the trial.

In the first phase of the trial,

TV pictures are being sent to more than 100 homes. The system is also being tested to confirm its ability to carry telephone calls as well.

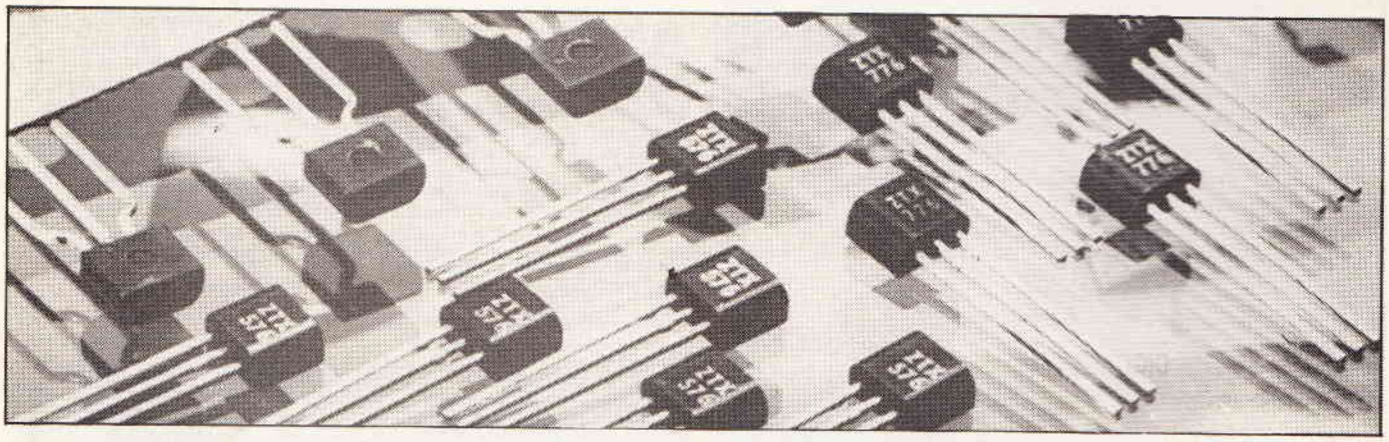
While these tests are being carried out, customers will continue to make calls over their existing copper cables.

The fibre for the network was installed by the end of February using an award-winning blown-fibre technique.

Installation of the electronic equipment was completed in July and testing started immediately afterwards.

An optical fibre centre has been built at Biship's Stortford to demonstrate the advanced communications services made possible by fibre networks. It is now able to show domestic and business uses of the advanced technology being used in the trial.

NEW TRANSISTORS



News has come to us of the latest in PNP transistors.

The new ZTX776 200v transistor from Zetex has a maximum saturation figure of 0.5V at 1A and a gain of 50 at 500mA, is designed with telecomms applications in mind. Besides being significantly smaller than TO92, the silicon packaging provides excellent thermal transfer properties and high resistance to severe environments.

Despite its small size, given an ambient temperature of 25°C the 776 can dissipate 1W, while on a lin^2 PCB its dissipation rises to 1.5W. Mounted on a PCB, thermal resistance of the junction to ambient is 116°C/W.

Under pulsed condition, the 776 handles up to 2A of collector current. It has a 30MHz transition frequency and an output capacitance of 20pF, given a collector-base figure of −20V and a frequency of 1MHz.

With a maximum operating temperature of 200°C, the device is suitable for a wide range of military, industrial and commercial environments. ETI

PENTA SHOW REPORT

The annual Hi-Fi Show at the Heathrow Penta Hotel is a surreal experience; people lurk in darkened bedrooms, trying to entice you in to listen to their latest products. It's the audio equivalent of an Arabian bazaar.

At this year's show 'Lifestyle' hi-fi seemed ready to take off in a big way. **Meridian, Bose, QED** and **Revox** all had multi-room, 'life enhancing' products on display, for those wanting to control the hi-fi from the jacuzzi... Meanwhile, **Arcam** and **Yamaha** were integrating audio and video (Arcam with a neat NICAM decoder, which slots into a system like any other source component).

The star of the show was the new turntable from **SME**. Bold, black and apparently mounted on suspender belts, this was so new and exciting ... that you couldn't hear it. It was displayed on a plinth, in the middle of a room, and you were expected to worship in silence.

There was the usual helping of overkill products. Vast, heat-producing power amps and huge loudspeakers dominated tiny hotel bedrooms, making the worst of already poor acoustics. I assume somebody buys these Leviathans. In healthy contrast, there were more smaller-cottage-industry companies than I remember from recent shows, including a few kit and component manufacturers:

PM Components must be doing good business; I lost count of the number of tube amplifiers I encountered. PM launched their own Gold Dragon valve range, manufactured by Shuguang in China. Available through dealers or direct to the public via mail order.

Lynwood Audio exhibited a range of mains conditioners (which were cleaning up the poor quality 240v supply in several other rooms), plus an interesting looking valve RIAA preamp.

Peering at the innards of the **Audio Synthesis** preamp, you wouldn't suspect it was a kit. Designed by Ben Duncan, AMP-02 is very professionally produced, each PCB looked good enough to frame and hang on your wall. The preamp consists of a slim mainframe case and a number of plug-in Eurocards offering RIAA, line and headphone stages, plus full remote control. The latest board is a digital-to-analogue converter which accepts the digital output from CD or DAT players. You can build either a Bitstream or a 16 bitx4 oversampling version. Comparing them over Stax headphones, I thought Bitstream won hands down. Each AMP-02 module can also be built as a stand-alone unit.

Graham Nalty of **Audiokits** was exhibiting under the guise of **Sonic Link**, the name of a new integrated amplifier and a range of audio cables. The £30 mains cable was going down very well. To confuse matters further, he was also displaying the 1kVA, a 100 watt all-MOSFET power amp, under yet another name — **Care Music.** Research into the 1kVA led to the MOSFET Virtuoso power amp featured in ETI.

Bandor Designs manufacture 50mm aluminium cone mid/treble and 160mm metal cone bass units and these were cropping up in loudspeakers by **Pentachord, Seventh Veil, Welsh Esoteric Audio** and **Nefer** (the latter using sixteen 50mm units per channel in a 5' high line source to create an extraordinary sound). Similar to the units pioneered by Ted Jordan (whose own 160mm metal cone bass unit appeared in the **Elite Townshend** speakers), the results seemed a bit variable. But the drivers are available to the DIY market so you can experiment for yourself.

Excellent news for inveterate loudspeaker fiddlers with the arrival of **Madisound**, the US speaker kit suppliers. Many of their drive units are manufactured specially for them and their very professional approach extends to running a computer bulletin board for audio enthusiasts. A British version will be available when they open an office in London early next year.

Madisound's catalogue lists some interesting kits based on Dynaudio drive units and **Dynaudio** themselves were just across the hall, seeking a British distributor for their finished speakers. As this room produced some of the most pleasant sounds at the show, I look forward to trying one of the kits.

Also making music (as opposed to noise) was the Petite, a small, two way design by Darlington specialist dealers, **Neat Hi-Fi.** The aim of the designers, Dererk Gilligan and Bob Surgeoner, was to emulate the sound of their favourite panel speakers - Magnaplanars and Quad ESL63 — in a smaller box.

Wittiest exhibit? A video screen flanked by a huge pair of **Cerwin Vega** loudspeakers. At one point, their simulation of an earthquake had protesters emerging from rooms all down the corridor. When I went to investigate, I was greeted by a deafening pop video. A sign by the video screen read: QUIET PLEASE, DEMONSTRATION IN PROGRESS.

Colin Shelbourn

READ\WRITE

ETI LETTERS

Tuner Mods

Having read Mr Ohlendorf's letter in your August issue, I thought I'd pass on my own observations on the excellent Linsley Hood tuner design, on the off chance that they might be of some interest to constuctors.

I built the Hart kit recently, and found it audibly superior to my 'audiophile' tuner; needless to say there were gremlins to be dealt with, but that's half the fun of electronics isn't it?

Since I have a very good signal reception in my area, I encountered Mr Ohlendorf's signal meter problem; in fact I could get a stereo signal without the aid of the aerial! Not only was it impossible to set the AGC level, as even weak signals put a crowbar down across the front end, it was also impossible to mute the bursts of noise at the skirts of the main stations. So I decided to reduce the IF amp's gain. This is best achieved by means of a potential divider at the output of the ceramic filter CR3 and kept loaded by about 300R. The attenuator needs to be capacitor-coupled. Components can be squashed around the redundant CR4 position. In my case dividing by about 30 proved suitable.

The omission of the centre tuning meter was a bit too spartan even for me, so I drilled a hole in the front panel for the LED and drove it from a simple junkbox circuit which gives a narrow passband (circuit is available by sending an SAE to ETI-Ed). I hasten to add here that I built the FM only tuner and so have plenty of room for the scattering of auxiliary circuits.

Lastly a minor detail; if the tuner is supplying a pre-amp with a lower input resistance (mine is about 15k with the tape deck in circuit) this will alter the 50µs de-emphasis time constant significantly as R17 and R23(3k3) will now be shunted. So a slight increase in the values of the de-emphasis resistors or capacitors will be necessary to preserve the tonal balance. Also the output DC blocking capacitors might need to be raised in value if a very low bass response is required and the pull down resistors reduced accordingly.

All in all, I'm quite pleased. The implementation of the tuner's innovative circuitry was clearly no mean feat for either the designer or the kit manufacturers. The choice of tuner head seems a good one and of-course adding one's own modifications always affords inordinate self satisfaction.

D Fleet
Beccles, Suffolk.

The Parts that Others Can't Reach

I write regarding the correspondence in November's ETI concerning Graham Nalty's earlier letter on amplifier parts. I'm sure Mr Nalty's quite capable of defending himself, but I'd like to voice an opinion on the subject. My only connection with Mr Nalty is as a satisfied customer.

Firstly, I don't think Mr Linsley Hood needs to feel insulted at the suggestion that his amplifier could be improved. I don't recall him saying anywhere in his text that it was perfect. In his letter he mentiions the need for compromise in design. One area of this is cost versus performance. If someone later makes a different decision on that point, it doesn't invalidate the original one. As there is no way of measuring the sound quality of an amplifier, there is no way of quantifying, in those terms, the cost of using a component considered 'adequate' by other criteria. If it's later found that an equal-value-but-better-quality replacement improves the sound, why should the designer by upset? The idea that "the designer knows best so don't tamper" (also hinted at by Mr Milligan of Hart Electronics), is not strictly true. His decisions may have been based on different criteria.

Secondly, the suggestion that careful tests should be performed after the changes have been made, to verify the performance hadn't been degraded, is crazy. Higher quality, closer toleranced components cannot degrade the performance of a properly designed amplifier. Therefore, no such verification is necessary. All one then need do is listen, and if it sounds better it's improved! Where's the problem? Tests of this type have been reported in hi-fi magazines in the past (UK and US). It seems that the people complaining either haven't read them or haven't done similar tests.

Thirdly, much is made of the cost of the upgrade components. Surely, Messrs Linsley Hood and Milligan are aware that high quality components cost more than standard types partly because of the greater care taken in manufacture and/or the use of better materials. Bulk foil resistors were designed for applications where closer tolerance, lower temperature coefficient, lower noise and the like are required. Designers don't quibble at their cost when high-performance measuring equipment is being designed as they know that quality has a price. As these are also the best 'sounding' resistors around (for reasons I haven't seen fully explained, but probably to do with quality of materials and construction), they are recommended for use in high-performance amplifiers. But, in this application their cost compared with standard types, is considered outrageous. Why? Surely, here too, quality has its price!

Mr Banham must have misread the letter. The stripping of the PVC insulation was suggested as an experiment to show the effect it has on the sound of the cable, not as an alternative way of using the cable. I'm sure Mr Nalty knows why cables have insulation!

Mr Banham also states that in a well designed circuit there should be no need for exotic components. Mr Nalty, and others, are saying that there IS a need and the difference is audible, though it doesn't show up in conventional measurements. Presumably, this means it doesn't exist! Interestingly, Messrs Banham and Linsley Hood agree with the use of capacitors with low dielectric loss. To the best of my knowledge, this property has never been shown to improve the measured performance of an amplifier, but many articles and reports have testified to their superior sound. Aren't these gentlemen being a little inconsistent here?

What's wrong if a supplier publicises his services on the letters page of a magazine? Especially if his letter is in response to a point raised in that same section by someone else. Maybe he should have said "In reply to your letter, see my ad. on page xxx." Very helpful.

I too, disagree with Mr Nalty's use of the word 'disastrous' in describing the sound of the PVC-insulated cable. But surely we can forgive him! There can't be many hi-fi enthusiasts out there who, on upgrading a component and comparing old with new, haven't wondering how they managed to listed to the previous 'noise' for so long. Obviously this is because it wasn't noise, just less good than the new sound. It seems that through spending a lot of time listening to components and cables, Mr Nalty has developed a high sensitivity to their differences and an obvious liking for the better sounding ones. It's a pity he hasn't developed an equally high sensitivity in his use of the language to describe them.

In my 22 years as a hi-fi enthusiast, I have built amplifiers and speakers from magazine articles, using the recommended components. Out of curiosity I first modified an amplifier about 13 years ago. The results were a complete shock as my electronics training had conditioned me not to expect any change. I haven't looked back since. over the years I've built and modified many amplifiers using higher quality components and each time there has been a genuine improvement, readily discerned by myself and non-technical friends. Others have reported similarly in hi-fi and electronics magazines. Respected engineers such as Martin Colloms, Ben Duncan and Dr Malcolm Hawksford have published technical articles either reporting the results of controlled tests or proposing theories to explain the differences reported. I've seen no letters or articles refuting the theories, yet people continue to demand 'proof' that differences exist and/or question the statistical value of published figures. So, 15 or more years after starting, the Great Amplifier Debate is no nearer a settlement! Do engineers ever learn from experience, or only from text books and technical journals? Can they hear sound quality differences between any two pieces of equipment or can they only see the meter on a measuring instrument or percentage points on a spec. sheet. Are they afraid of hearing something they can't explain, thereby eroding their status as 'experts'?

I'm sure Mr Nalty would be more than willing to demonstrate the superiority of his version of the Audio Design amplifier over the standard item, but I wonder if Messrs Linsley Hood and Milligan would be interested.

Lancelot Dow, London.

Ringing The Changes

With reference to Mr Finbarr Ring's (!) letter (JULY 90) regarding the phone lock. I would like to cover his points one by one.

First of all BABT approval, while he is right that equipment connected to the line should have BABT approval, users of non approved equipment have never, to my knowledge, been prosecuted. What I was attempting to do, by making the unit BABT approvable was to create a safe unit that would not harm the network. The only reason that this unit would not get approval would be because it was not built in a BABT inspected factory, which by it's very nature it can't be, it is after all a project for an electronics enthusiast. I am not advocating that people actually connect it to the line, but if enough people want it and it is commercially attractive I will get it's successor (more of this later) approved.

At no point in the Phone Lock and Logger article was the disassembly of the master socket envisaged, let alone encouraged. This unit was designed as an additional unit and may even be plugged into a parallel socket with, say, a fax so the fax can have unlimited access to line and the phones could have limited access. It is not a good idea to disassemble the master socket as there are various terminating components within that could effect ringing or the protection of subsequent equipment.

Regarding the 999, yes he is right, in fact just after the article went to press I came to the same conclusion which is one reason why I have not sent out any kits (the other is that no-one could find me, the address is printed in full at the end of this letter if you want to contact me). In fact I am working on a new version which will be line powered, rather than powered from an external supply. This one will allow 999 calls and operator/fault/enquiry calls (even at 40 odd pence each!) and may be connected to a PC via a special RS232 link, so a time/date record can be kept on disc. It is hoped that this PC will be able to monitor quite a few units, so a complete record of, say, an office block is possible.

The design is ongoing so I would appreciate any ideas/comments/suggestions etc to make the unit into something that suits your needs.

Either contact me direct or via ETI.

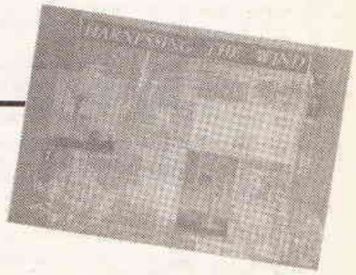
Kevin Kirk, Pendre, Hafod Pontrhydygroes, Dyfed SY25 6DX

An Ill Wind

I would like to complain over having some difficulty in reading an article in ETI. The item concerned was Harnessing The Wind in your July 90 issue. The heaviness of the printed background made the enjoyment of an otherwise excellent article somewhat tiresome to read. Please avoid this in future.

D Oaks
Peterborough.

I agree entirely. The intention was to create a very pale background of 5% printing density against a 100% printed word. It seems that tolerances in the printing industry are at times very large on a cold-set press. Sometimes I think we ask for the impossible. C'est la vie! Ed.



Interesting Books

With great interest, I read your Book-look section in the November issue on Tesla as I am especially interested in his work. I tried to order these two books from a large bookshop in York but they cannot trace any address for 'Camden Miniature Steam Services' as mentioned in the text, and can only suggest ordering it from the States direct, which would undoubtedly cost more and take ages!

Any chance you could let me have their address?

G Smith, York.

Yes certainly, but before that let me just say Camden Miniature Steam Services is not a publishing house but a book importer and they regularly advertise in our sister magazine Model Engineer. For those of you interested in the work of Tesla (and that seems to be a growing band of readers) there are at least four to five books available on the subject. The best way to find out the ISBN numbers and any other books available is to look them up yourself on 'microfiche' in any large reference library or large bookseller. Ed.

The address for the two books reviewed is:
Camden Miniature Steam Services,
13 High Street,
Rode, Nr Bath,
Somerset BA3 6MZ
Tel: 0373 830151

A Merry Christmas to all our readers, contributors and advertisers from the staff at ETI

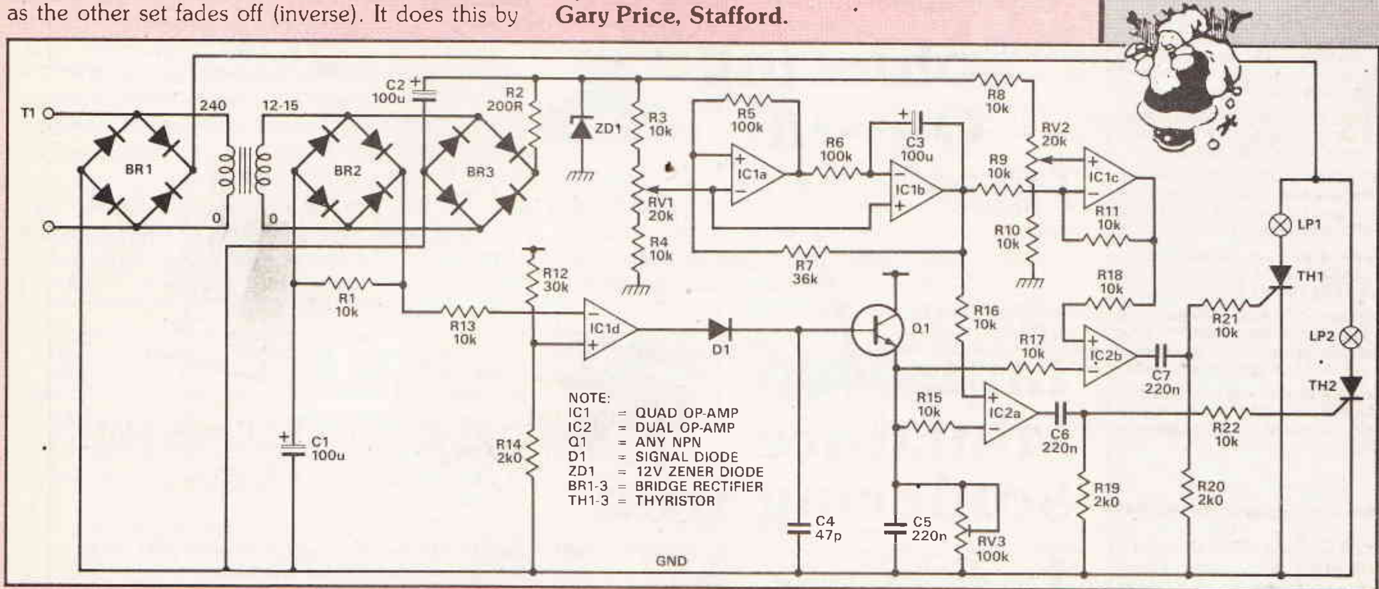
Christmas Tips

Fading Lights

Here is an original circuit, designed primarily for use with Christmas decorations, but it could be used for any application where two lights would be required to fade on and off alternately (a beacon or warning light for example).

The circuit works with two sets of Christmas lights which both fade on and off, with one set fading on as the other set fades off (inverse). It does this by comparing a very slow ramp waveform (generated by IC1a and IC1b) with a sawtooth waveform which has a frequency of 100Hz (generated by IC1d, Q1, C5 and RV3), this is then fed through a differentiator and into the gate of the thyristor. The opposite channel compares an inverted slow ramp waveform (IC1c) with the same saw-tooth waveform, this then goes through another differentiator and into the second thyristor.

Gary Price, Stafford.



Flashing Tree Lights

This circuit was originally designed to flash two sets of Christmas tree lights on and off, so that when one set was on the other was off and visa versa. This circuit can be used to flash any kind of lights on and off.

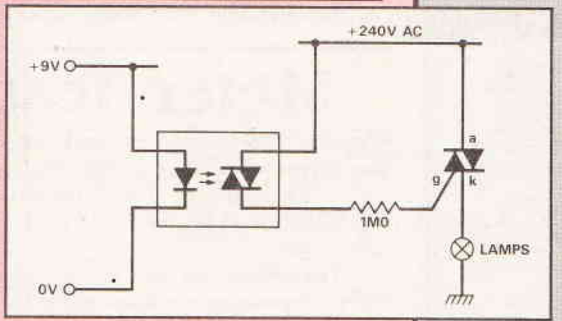
When considering the idea of designing the circuit the obvious answer seemed to be to use a relay to switch the lights, but after giving the idea more thought I found that the relay has two major drawbacks. They use large amounts of current and have a maximum electrical life of around 100,000 operations, which may seem like a lot but when the relay is being used once every two seconds for 5 hours a day this electrical life is soon reached.

So a different device will have to be used namely an optically isolated triac. This works in the same manner as a relay, but uses an infra-red emitting diode to activate a light triac, which will switch 240 volts AC, up to 100mA. This component needs 3 volts at 15mA to trigger it, and can always be used to trigger an additional triac, (as shown in Figure 2) to achieve higher current ratings.

The main circuit consists of a 555 timer, used in its basic astable mode to supply an output pulse, the timing of which is set by R1, R2 and C1, to control each opto isolated triac. The formula for the frequency is:-

$$\text{Frequency} = \frac{1.44}{(R1+2R2)C1}$$

As the output pulse of the 555 timer goes high Triac 2 is activated, and when the output falls then Triac 2 goes off and Triac 1 is activated. This gives the flashing effect, and can be controlled by adjusting R1.

If the flash rate is still too fast try replacing C1 with a larger value capacitor.

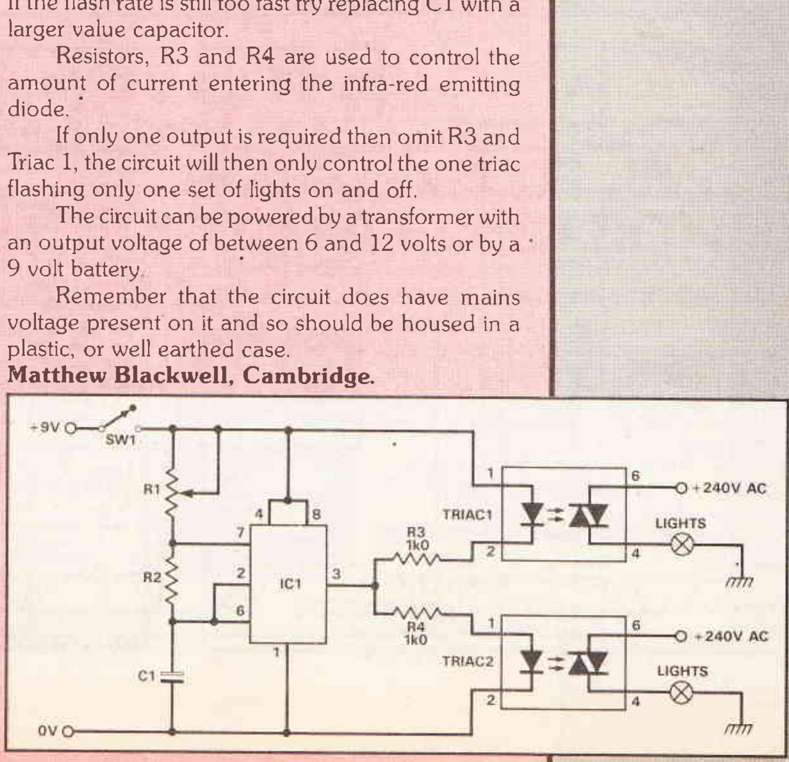
Resistors, R3 and R4 are used to control the amount of current entering the infra-red emitting diode.

If only one output is required then omit R3 and Triac 1, the circuit will then only control the one triac flashing only one set of lights on and off.

The circuit can be powered by a transformer with an output voltage of between 6 and 12 volts or by a 9 volt battery.

Remember that the circuit does have mains voltage present on it and so should be housed in a plastic, or well earthed case.

Matthew Blackwell, Cambridge.



Etching of Printed Circuit Boards

The removal of copper from a PCB by chemical-etching with ferric chloride hexahydrate crystals in solution, can be hastened substantially by warming the etching fluid.

This poses a problem to those who prefer to process their own circuits at home, where the etching bath is usually a shallow tray of surface area such that heat-loss is significant during the time taken for the etching process.

The use of an electrically powered hair-drier speeds up the process to the point where the copper removal is clearly visible.

Simply play the warm air-stream from the drier onto the exposed surface of the etching fluid, whilst slowly sweeping the surface by moving the drier from end to end of the bath. This creates a shallow wave which precedes the air-stream, so ensuring the copper face is continually traversed by warmed etching-fluid whilst also keeping the fluid refreshed by the mixing action of motion.

Bearing in mind the corrosive nature of the etching fluid, care must of course be taken to avoid splashing by over-zealous application of the blower.

Soldering Outside

How many of us have suffered those frustrating occasions when it is necessary to solder an electrical connection whilst out-of – doors, such as on an antenna wire or when working on the car electrics, only to find that the external environment defeats the heating-effect of the electric soldering iron?

A simple remedy is to wrap the cable-joint in resin-cored solder after first having ensured that the wires are clean and bright, then encase it in kitchen-foil, and apply heat from the flame of a match or gas-lighter for a few seconds.

The heat generated within the foil wrapping is sufficient to raise the wire-joint to the appropriate temperature whilst melting the solder and flux which 'flows' into the strands and tins them, to create a perfectly soldered connection.

Improved Miniature Soldering Iron

There are occasions when the 'bit' of the electric soldering – iron is too large, cumbersome or hot for a delicate task.

An effective yet simple alternative to an expensive sub – miniature iron is to tightly wrap a few turns of say 12-18 swg tinned copper-wire around the existing 'bit' while it is unheated, leaving about 10mm of free wire protruding from the tip to act as an extension-bit.

Heat flows by conduction from the main-bit to the extension – bit. The remote end of the improvised 'bit' must be pre-tinned with resin-cored solder before use.

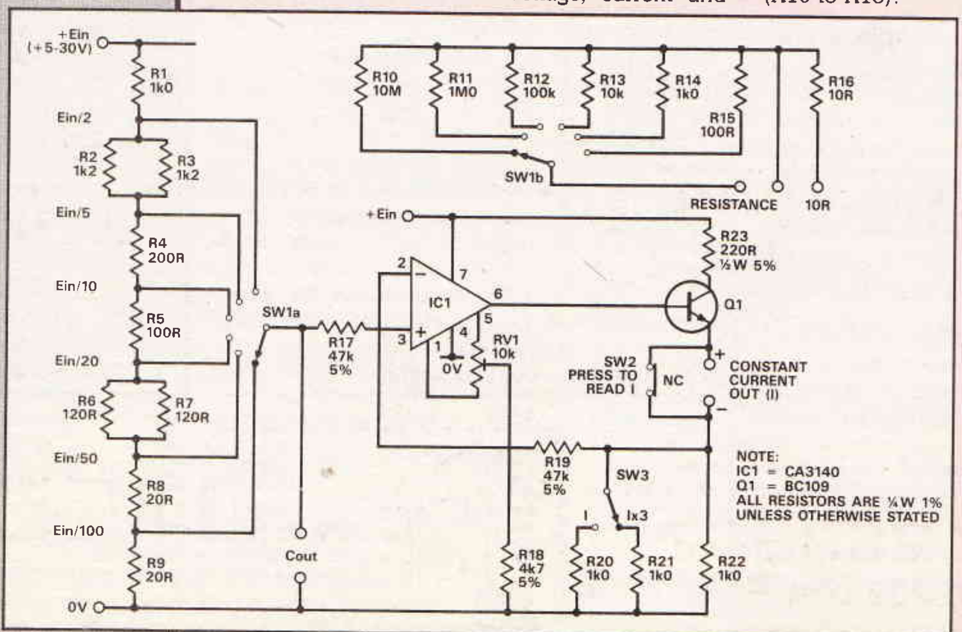
E Chicken, Morpeth, Northumberland.

Meter Tester

I wonder how many electronics hobbyists like myself continue to use their multimeters year after year with hardly a thought to having them checked. It was this thought that prompted me to build this simple meter tester.

The device was built to allow quick and easy testing of analogue and digital multimeters. The tester enables a number of DC voltage, current and resistance values (accurate to 1%) to be presented to the meter under test. Analogue meters can be checked at or near full scale deflection as well as at low or medium scale readings.

Figure 1 shows the complete circuit diagram. Resistance range testing is achieved by simply switching in the appropriate resistor via switch S1b. An extra resistor (10R) is provided on a separate socket to give a total of seven close tolerance resistors (R10 to R16).



Precise DC voltages can be set up using resistors R1 to R9 which form an accurate potential divider chain. The input voltage (Ein) can be derived from a stabilised supply with digital readout, or it can be set up with an existing digital multimeter. Note that such a multimeter could then be tested on its lower voltage ranges. The total resistance of the potential divider chain is reasonably small. This avoids any significant loading effects when used with meters of 20,000 ohms per volt or greater sensitivity.

The remaining components form a precision constant current generator. The reference voltage for this generator is provided by the potential divider chain (C out). One of the reasons why a CA3140 was used for IC1 is that this reference voltage can go very close to the zero volts line. Since IC1 and Q1 form a unity gain amplifier, the voltage appearing across R22 is the same as the reference voltage on pin 3 of IC1. R22 is a close tolerance 1k0 resistor, therefore by Ohm's Law the current through it in mA will be numerically equal to the refrence voltage. If R20 and R21 are switched into the circuit by SW3, the constant current is multiplied by three. The circuit provides for a range of currents from a minimum of 50μA to a maximum of 45mA. Connections to a milli. or microammeter is made within the feedback loop of the amplifier. This arrangement ensures that the value of the constant current is not effected by the resistance of the meter under test. Having connected the meter, a reading is taken by pressing the normally closed press button switch SW2.

R17 and R19 limit the input current to IC1 in the event of any abnormal operating conditions. Under normal operation these resistors have no effect on the circuit because their values are miniscule in comparison to the MOSFET input resistance of IC1.

Provision is made to balance out the offset voltage by RV1 and R18. This is necessary because an offset of 3 or 4 millivolt on top of a low reference voltage will produce a considerable error in the value of small constant currents. It is quite easy to set up RV1. Apply 5V to the device, switch SW1a to Ein/100 and switch SW3 to I×3. Now, with the aid of the digital meter on a millivolt range, adjust RV1 so that the voltage across R22 is the same as C out. If you do not possess a millivoltmeter it would be worthwhile breadboarding a non-inverting op-amp amplifier with a voltage gain of 50 and an input resistance of about 100k or more. This could then be used with an analogue meter on the 3 or 5V range to set up RV1. Note that such an arrangement does not need to accurately measure the voltage, since it is only necessary to compare the reading across R22 with that at C out and adjust RV1 so that they are the same.

During the testing of the device, it was found that with E in at 5V and SW1a switched to Ein/2, the constant current value showed a large error. It would seem that the particular IC used requires a clearance of more than 2.5V between the input terminals and the positive supply lines. Therefore, for current checking, do not use the Ein/2 setting with anything less than a 6V supply.

A S Hughes, Holywell, Clwyd.

Beeper Timer

I hope the following little electronic cameo will interest readers. It's one of those things that can be adapted for many different purposes, depending on your inclination.

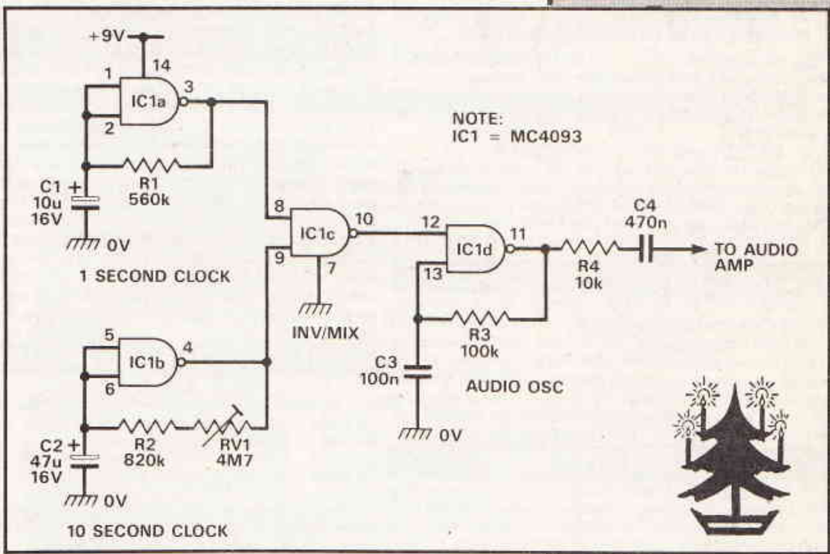
My intention in building it was for "eyes off the clock" situations when making adjustments to timing circuits, or dark room processing, or as a test tone source for rigs.

The whole thing can be built with scrap box or off shelf components on a piece of strip board 2" square and costs less than a fiver (excluding battery, case, audio amp). The construction time is a couple of hours with plenty of coffee and QSO breaks.

The heart of the wee beastie is a quad nand schmitt IC (4093). Each 2 input and gate of this four gate chip is used in the configuration of three oscillators, and one mix/invertor. The output from the board being fed to a small amp.

A few seconds after switch on (settling/start up period) one second beeps can be heard lasting for 15 secs, then a continuous beep for 10 secs, repeated so no matter what job you are doing some idea of time elapsed can be appreciated without having to clock watch.

P Wilkinson, Alford, Lincs.



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MONITORS

MONOCHROME MONITORS

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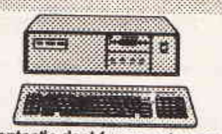

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APPROACH AND LANDING

Brian Kendal describes aircraft landing systems — past, present and future.

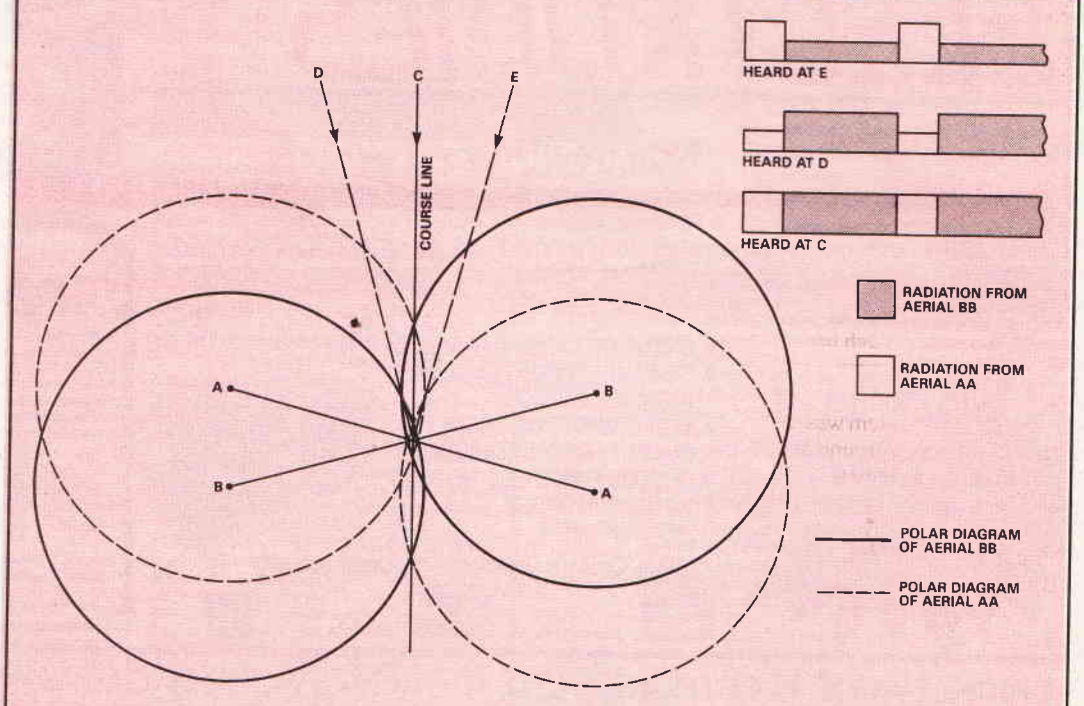

Fig. 1 The Scheller Course Setter Of 1907.

The travelling public has long since come to expect that their flights will be punctual and safe with even the most inclement weather conditions causing only minor inconvenience.

Because the greater proportion of any modern jet flight takes place at high altitudes, far above all but the most severe weather, this expectation tends to be encouraged.

But every flight must end with a final approach and landing, when the pilot must, regardless of weather conditions, place the aircraft accurately on the destination runway.

For this, the pilot's most useful assistant is the Instrument Landing System (ILS), the internationally approved approach and landing aid which is installed at all the major airports in the world.

This equipment was originally introduced in the second world war, and has been in civilian use since the mid 1950s. However, the accuracy of the early ILS equipment bears little resemblance to that of its modern counterpart which now has the ability, when coupled to the aircraft flight director, to land the aircraft more than ten times more accurately than a human pilot.

Although ILS is very accurate, it does suffer from certain disadvantages and in the next decade it will probably be replaced by Microwave Landing System (MLS).

In The Beginning

Although the ILS system was originally introduced in the second world war, its roots go back to 1907 when O. Scheller, an engineer with the Lorenz company, was granted a patent for a 'Course Setter'. This, for the first time enabled a straight line course to be defined by a radio beam. See Figure 1.

The principle of this system was that two horizontal aerials (AA and BB) were erected such that their alignments varied by a few degrees. Each aerial was energised such that a 'null' appeared at right angles to the wire.

Due to the variation in alignment, the polar diagrams intersected and a straight line could be drawn where the radiation from each aerial was of equal intensity. To either side of that line, the radiation from one transmitter or the other predominated. Scheller also suggested that, in order to identify which transmitter was being heard, one should transmit dots and the other, dashes. The dots and dashes were interlocked such that when both transmissions were of equal strength, a steady tone would be heard.

This principle was used widely over the next thirty years, with the Lorenz company introducing a landing system operating on 35 MHz in the early 1930s which was used throughout the world.

The United Kingdom further developed this into Standard Beam Approach (SBA) which was used by the RAF throughout the war and was only withdrawn from civilian use in 1960.

The basic principle of this system is shown in Figure 2. A vertical dipole was located at the down-wind end of the runway. At either side of the dipole was mounted a reflector with a relay contact at its centre point. The relays were wired such that when one was closed, the other was open. The effect of this was to direct the radiation from the dipole first to one side and then to the other, with the equi-signal zone accurately aligned with the runway.

As an aircraft travels in three dimensions, both horizontal and vertical guidance are necessary for a successful approach. To achieve vertical guidance Lorenz made use of the vertical polar diagram of the transmitting aerial.

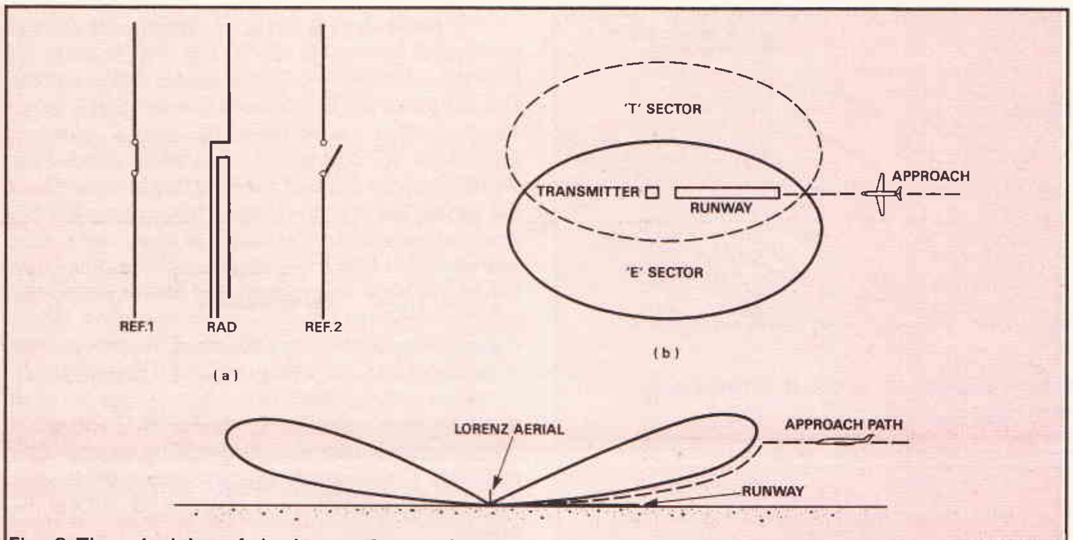

Fig. 2 The principles of the Lorenz Approach and Landing system which were also used in the Standard Beam Approach used in the UK.

The aerial system was mounted at the downwind end of the landing ground at a height such that a single vertical lobe was radiated. The aircraft was equipped with a sensitive signal strength meter. Distance indication was given by two marker beacons, operating on 38MHz and located approximately 1000ft and 2 miles from the aerodrome boundary.

The pilot approached the airfield on the alignment indicated by the beam at a height of about 600 ft. As he passed the outermost beacon, he commenced descent so as to maintain a constant reading on the signal strength meter until either the ground was visible or the wheels touched down. Although this was the limit of what was achievable at the time, it was never very satisfactory and was never used in the United Kingdom.

Although the Lorenz system gained the highest acceptance, many others were developed, one of the more notable being the Dunmore system. The azimuth guidance, operating on 330kHz, radiated interlocking tones of 65Hz and 86.7Hz instead of dots and dashes, which made meter presentation easier. As with the Lorenz system, vertical guidance was provided by flying a contour of equal field strength from a dedicated 93MHz transmission.

On Sept 5th 1931, Pilot F S Boggs used the Dunmore system to make the first of over a hundred totally blind landings onto a 2000 by 100ft runway.

For a test pilot to achieve a totally blind landing is one thing. Acceptance of the system for general operations was another. Whilst adequate azimuth guidance was available from both MF and VHF systems, the use of a contour of constant signal strength for a glide slope was highly unsatisfactory. It required the aircraft to begin descent at an unnatural angle and this angle was not constant throughout the approach.

The azimuth guidance was also subject to problems, because the Lorenz system required the transmission to be beamed alternately from one side to the other of the runway. The radiated energy could therefore impinge on hills, buildings or hangars which would reflect the signal, enhancing it in certain areas and causing an apparent bend in the approach path. There used to be a severe 'kink' in the approach path to Stansted Airport caused by the hangars to the north of the runway.

As a result of the dissatisfaction with the systems available, a requirement was raised in the United States in 1938 for a system operating on VHF which would give both instrument presentation and a straight line glide slope. It was also required that the signal carrying the directional information should be beamed along the approach path in order to minimise interference effects caused by signal reflections.

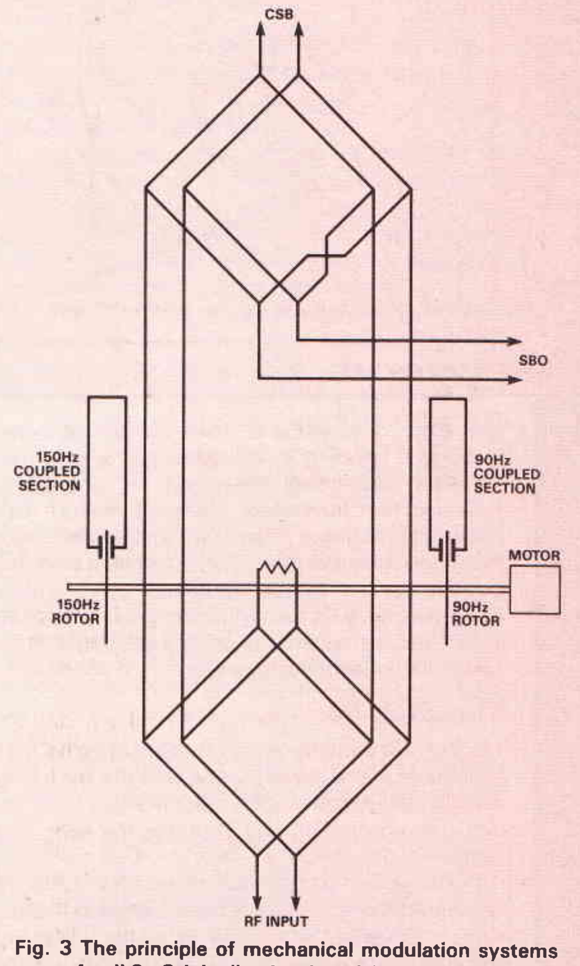

Fig. 3 The principle of mechanical modulation systems for ILS. Originally developed in the late 1930s, these remain in use today.

Extensive work on this project was carried out by the U.S. Army Air Force and consequently for many years the system was known by its service designation — SCS 51.

The SCS 51 system was used by the USAAF throughout the war and for long afterwards throughout the world. It was eventually replaced by a post war

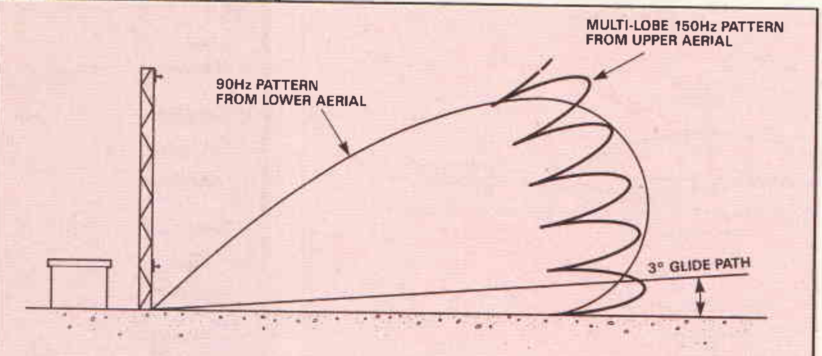

Fig. 4 The use of the vertical polar diagrams of aerials at different heights to achieve a straight line glide slope.

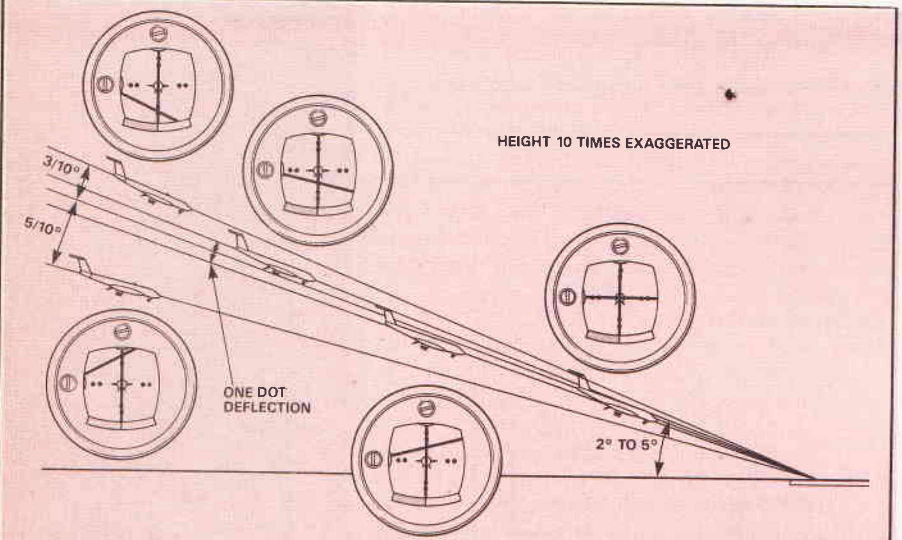

Fig. 5 The indicator needle action during approach.

generation of equipment, when the generic name Instrument Landing System came into general use.

The succeeding generations of equipment reflected the technology of their times, with consequent increase in accuracy and reliability, but the general principles remained constant. It would be possible for an aircraft equipped with wartime equipment to land on an airport using a modern installation, or for a modern aircraft to land at an airport with wartime equipment.

The SCS 51

The required azimuth radiation pattern of the SCS 51 equipment was a beam aligned with the runway in which a modulation of 90Hz predominated to the left of the approach path and 150Hz to the right. See Figure 3.

This pattern was produced from a linear array of ten Alford Loop aerials. These were fed with a mixture, in varying phase and amplitude, of Carrier and Sidebands (CSB), a normal amplitude modulated transmission, and Sidebands Only (SBO), double sideband suppressed carrier. These combined in the air to produce the required radiation pattern.

In the aircraft, the signal was received and passed to filters on 90Hz and 150Hz. The output of these drove DC amplifiers which in turn were used to deflect the vertical needle of a cross pointer meter. The direction of the needle indicated the direction necessary to attain the centreline of the beam.

The localiser (azimuth) equipment operated on six frequencies between 108.3 and 110.3MHz. Present day ILS uses the same frequency band, but the band has now been extended, and ranges from 108.1 to 111.9MHz.

Of particular interest in this equipment was the method of generating the 90 and 150Hz tones for both the amplitude modulated carrier (CSB) and the Double Sideband Suppressed Carrier (SBO) transmissions. This was achieved by using a system of parallel line RF Bridges. The first bridge divided the signal into two paths and a second bridge recombined the signals. Between the bridges, next to each line was a quarter wave section, at the top of which was a vane, one of which had three blades and the other five. When the vane was rotated, the blades alternately tuned and detuned the quarter wave section. When the section was on tune, it absorbed the energy from its adjacent line, but when detuned it had no effect.

Due to these absorption effects, when the shaft to which both vanes were attached was rotated at 30Hz, one path was modulated at 90Hz and the other at 150Hz. On recombining in the second RF Bridge, the result was CSB at one output and SBO at the other.

This mechanical modulation system proved extremely reliable and was used on almost all subsequent ILS designs until the mid 1980s, when they were superseded by microprocessor-controlled systems. Even today, the most ILS systems in use in the world still use mechanical modulation.

It was, however, in the design of the glide slope transmitter that the greatest breakthrough was achieved. Instead of a contour of field strength, the glide slope transmitter uses the characteristics of the vertical polar diagram of a horizontal aerial. Such an aerial radiates a number of lobes, the number being equal to the height of the aerial measured in half wavelengths.

Two aerials were mounted at different heights on a mast, the lower at about 1.5 wavelengths and the upper at about seven wavelengths above the ground. Due to their relative heights, the lower aerial radiated three vertical lobes and the upper fourteen. Of these, the lowest lobe was from the upper aerial. However, at an angle of elevation of about 3 degrees, this was of equal intensity to the lowest lobe of the lower aerial. It only remained to radiate a carrier modulated by 150Hz from the upper aerial and one modulated by 90Hz from the lower and the requirement for a straight line glide slope would be met.

The same condition also occurred at several higher angles, but an aircraft attempting to use any of these would soon be aware of its error due to the extremely high descent rate necessary on all but the correct path. This system is known as the equi-signal glide slope.

The glide slope equipment operates on frequencies in the 330MHz band which are 'paired' with the localiser frequency in use.

The SCS 51 system was completed by three distance markers operating on 75MHz, located at approximately 3.5 miles, 1 mile and 200 feet from touchdown point.

The SCS 51 airborne glide slope receiver operated in a similar manner to the azimuth except that the output was coupled to the horizontal needle of the cross pointer meter. See Figure 5.

Post War Development

The SCS 51 system was a major advance on all previous approach and landing systems, but nevertheless, certain weaknesses remained. For example: although the localiser beam was much narrower than those previously used, its width was still sufficient to impinge on other objects and the subsequent reflections cause course bends.

Furthermore, the glide slope equipment was very susceptible to the ground conditions for a considerable distance in front of the aerials. Much of the subsequent

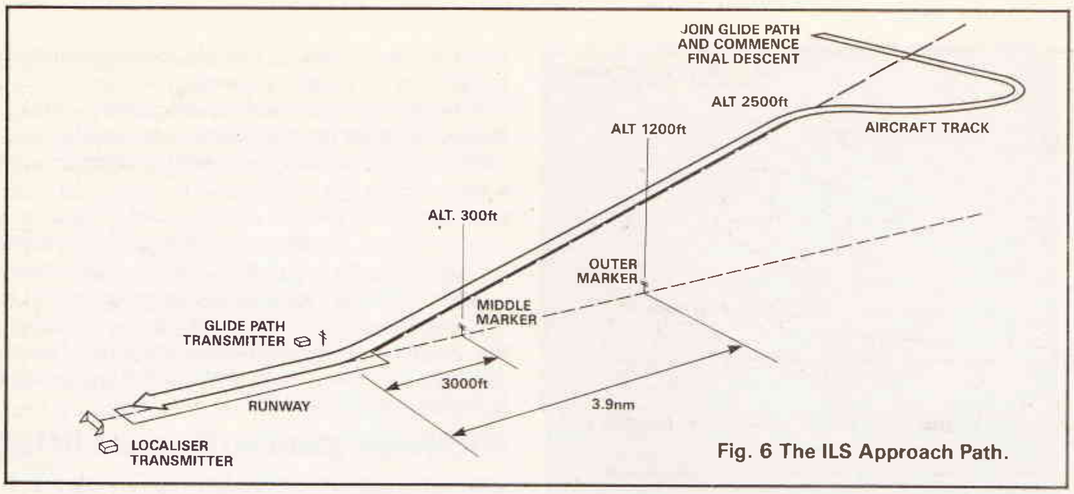

Fig. 6 The ILS Approach Path.

development has been to minimise these problems.

In the early post war period, several firms attempted to develop systems using electronic modulation in order to avoid paying royalties to the American firms who held the patents for the mechanical system. This proved unsuccessful until the introduction of digital electronics.

The first major improvement was to reduce localiser course irregularities by narrowing the transmitted beam. This was achieved by dispensing with the loop aerials and replacing them with an array of horizontal dipoles mounted against a vertical reflector transmitting a narrower unidirectional beam. The number of dipoles which may be used depends largely on the site and the accuracy required, twelve being a common number and twenty four being installed when maximum immunity from reflections is required.

With this improvement other problems came to light. One of the most serious of these was 'beam-push'. As the aircraft entered the beam, the beam apparently moved away from the aircraft. This was eventually deduced to be due to the vertical polarisation component on the horizontally polarised transmission. Many years ago, I carried out tests which showed that errors up to 20 degrees were possible due to this cause. Redesign of the transmitting aerials eliminated this problem.

In more recent equipment, the dipole and reflector arrangement has been replaced by a similar number of aperiodic beam aerials which give an even narrower beam, but the principle remains the same.

With the achievement of very narrow beams, navigational guidance outside the main beam was very poor, making location of the beam difficult. This was overcome by radiating an additional very wide beam on a closely adjacent frequency. This is known as the 'clearance' signal. Both signals are within the bandwidth of the receiver. When outside the main beam coverage, the clearance signal predominates, giving a full scale fly-left or fly-right indication. On the final approach, the main beam predominates, delineating an accurate approach path.

The clearance signal may be radiated from the three centre aerials of the localiser array or alternatively from a separate aerial system located behind the main array. The photograph in Figure 7 shows such an array.

The original design for an equi-signal glide slope equipment, although a major advance on all previous designs, was still unsatisfactory, being particularly susceptible to siting difficulties. This resulted in a number of different designs, all of which depended on the original concept of the interaction of the radiation patterns of two aerials at different heights. Even today several types of system are in use, the type chosen for any particular location being largely dependent on site conditions.

The most common systems in use today are:

- **The Nul Reference**

This is the simplest of current systems and is used on relatively unobstructed sites. SBO is radiated from the upper aerial and CSB from the lower.

- **The M-Array**

This array is characterised by a third aerial. The complex pattern is less susceptible to ground reflection signals due to an absence of radiation below 0.8 degrees elevation.

The Sideband Reference

This type of aerial may be easily recognised by the location of the aerials on the mast. The upper is about three times the height of the lower and both are significantly higher than with other systems. Sideband reference systems are particularly suited to sites where the terrain falls away in the vicinity of the airfield.

The 75MHz approach markers are still used at most installations, although most large airports also provide Distance Measuring Equipment, a secondary radar system, as an additional distance-to-run aid.

The accuracy of present day ILS installations is such that the centre line of the runway will be delineated with an accuracy of better than 12 inches. The touchdown point can be determined to an accuracy of about 50 feet, although this will vary with the position of the receiving aerial on the aircraft. Such accuracies make landing possible in conditions of extremely poor visibility. However, for various reasons, not all airports need to meet the highest standards. For example, some airports in the tropics will only experience fog or a cloudbase below 500 feet perhaps once a year. To maintain equipment for visibilities of only a few hundred yards is not economically viable. In contrast, airports in Northern Europe regularly experience very poor weather

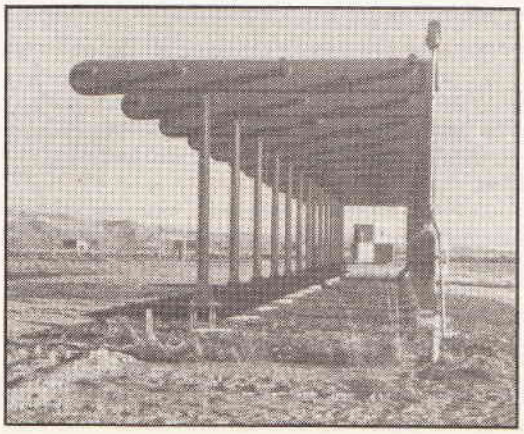
Fig. 7 An ILS localiser aerial, using multiple aerials to generate the azimuth beam. (Photograph courtesy of Racal).

GUIDANCE

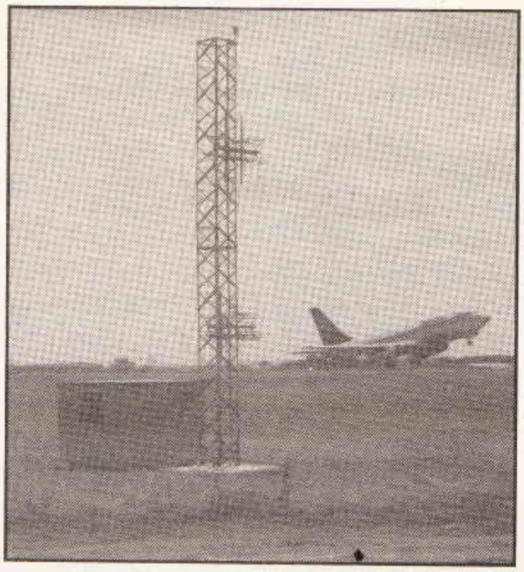

Fig. 8 A typical glide slope aerial. (Photograph courtesy of Racal).

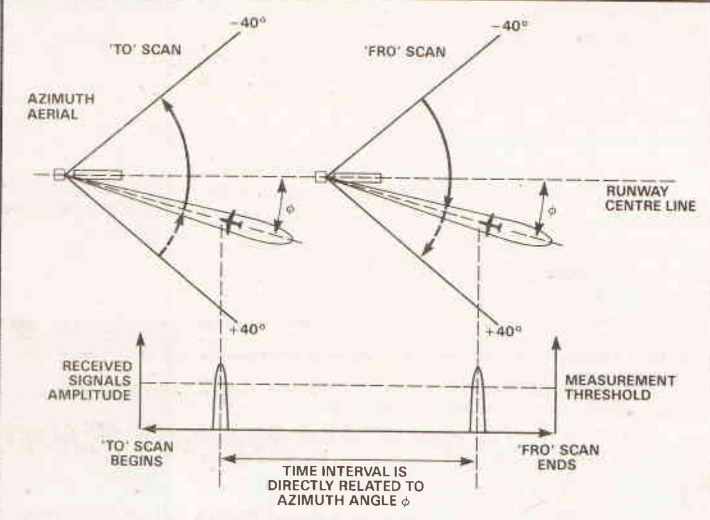

Fig. 9 The principle of TRSB Microwave Landing System.

conditions and the maintenance of the highest possible standard is essential if regular services are to be maintained.

For this reason the standard of the ILS equipment is categorised at one of three levels. Category 1 equipment is suitable for approaches down to a decision height of 60 metres with a visibility of 800 metres along the runway and Category 2 for a decision height of 30 metres with a visibility of 400 metres. Category 3 is again divided into three. Category 3A has no height restriction but requires a visibility of 200 metres, Category 3B has no height restriction but requires a visibility of only 45 metres, and provides guidance along the runway. Category 3C has no height or visibility restrictions and has guidance both along the runway and to the parking bay.

Most northern European airports are now equipped to Category 2 standard and major international airports, such as Heathrow and Gatwick, to Category 3A. As far as I am aware, there are no airports equipped to higher standards.

With such close tolerances on the airport equipment, the aircraft have to be equipped to similar standards. Most public transport aircraft are cleared for Category 2 operations, which require duplicate receiving equipment coupled to the flight director. On the approach path, the aircraft is effectively flown by the ILS equipment down to decision height. However, in this simple form it is not considered to be of sufficient integrity for an automatic landing.

For aircraft to be deemed suitable for automatic landing, triplicate receiving equipment must be fitted, with the flight director system taking instruction from a two receivers in agreement. If one of the three receivers fails or provide erroneous information at a critical stage of the approach, it is ignored and the approach may be completed. The possiblility of two receivers failing is considered to be so low as not to merit consideration, but should this happen, the flight director will cause the aircraft to overshoot and return control to the pilot. The possibility of this is calculated to be less than 10,000,000 to one.

Microwave Landing Systems (MLS)

Despite the advances which have been made in ILS, the system still has some disadvantages, notably that only a straight line approach path can be provided, insufficient frequencies are available for all the installations which are required and that, due to mountainous terrain, some airports cannot be equipped with the system.

In 1972, the International Civil Aviation Organisation published a requirement for a new system operating in the 5GHz waveband. Various proposals were examined in 1978 and the American Time Referenced Scanning Beam (TRSB) was selected.

Despite the decision having been made, implementation has been very slow and only very few airports, mainly in mountainous areas, have yet been equipped.

The basic principle of the TRSB system is shown in Figure 9. A highly directive beam of energy is swept across the approach path and then back, known as the 'to' and 'fro' scans. Any aircraft within the coverage of the system will therefore receive two pulses at a time interval which corresponds to the bearing of the aircraft from the facility.

The same sequence is then repeated in the vertical plane, enabling the aircraft to determine its elevation angle. Distance from the facility is determined from an associated DME installation.

Having determined its azimuth, elevation and range, the receiving equipment can then calculate the required course and descent angle for a successful approach.

At present the ground facility provides only information, enabling the aircraft to determine its position accurately. The aircraft equipment can then use this in any way required. In its simplest form this may be a meter presentation for manual control or it may be coupled to the flight director for an automatic approach. In either case the crew may select the angle of approach and descent. However, it is anticipated that future generations of equipment will have the facility to provide guidance for curved approaches.

The system also provides guidance for flare and missed approach procedures, in addition to basic data which includes the installation parameters such as: minimum selectable glide slope, azimuth coverage limits, and so on. Further information is transmitted for suitably equipped aircraft, which can include runway conditions and siting data.

In order to economise on frequency space, only one frequency is used, with the various elements of the transmission being radiated using a time division multiplexed format as shown in Figure 10.

The whole sequence occupies 84ms with each scan (to or fro) taking only 4ms. With such scanning speeds, mechanical methods are impractical and electronic scanning is necessary. The signal is radiated from an array of horns energised from a system of electronically controlled phase shifters which control the beam position and movement. The number of horns can vary widely, and depends on the site and the consequent beam width required.

MLS will be categorised in a similar way to ILS but at present few installations exist and I know of none cleared for better than Category 2 operation.

Future Development

MLS has many advantages over ILS, but installations are expensive and most airports have heavy investments in ILS. This is leading to a 'chicken and egg' situation. Airports do not feel justified in investing in the new technology until the majority of aircraft are suitably equipped, while aircraft operators will not equip with MLS until it can be used at a majority of airports!

A further factor has recently arisen which may be detrimental to the MLS programme. The Global Positioning System (GPS) satellite navigation system is proving to be both reliable and highly accurate. This provides a long term accuracy base for updating Inertial Navigation System (INS) equipment which is carried by many long haul aircraft. The accuracy of the combination of these two systems is being examined and it is anticipated that at least Category 1 accuracy will be available over the vast majority of the world. This will eliminate the necessity of ground based approach and landing systems at many of the world's airports.

With the consequent reduction in demand, this puts the future of MLS in question.

MLS is a brilliant concept, but the time taken for its development has been such that it may well be overtaken by events, leaving the older ILS systems in situ until they are no longer economically viable to maintain.

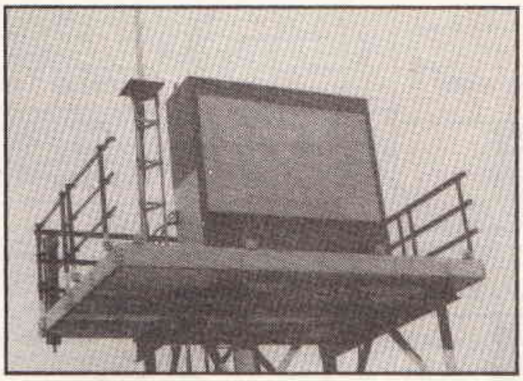

Fig. 11 The Azimuth transmitter of the MLS installation at Port Hawkesbury, Nova Scotia. The equipment is mounted on a tower to ensure coverage over a hump in the runway. The vertical aerial to the left of the main array is for Distance Measuring Equipment which gives the aircraft its distance from touchdown.

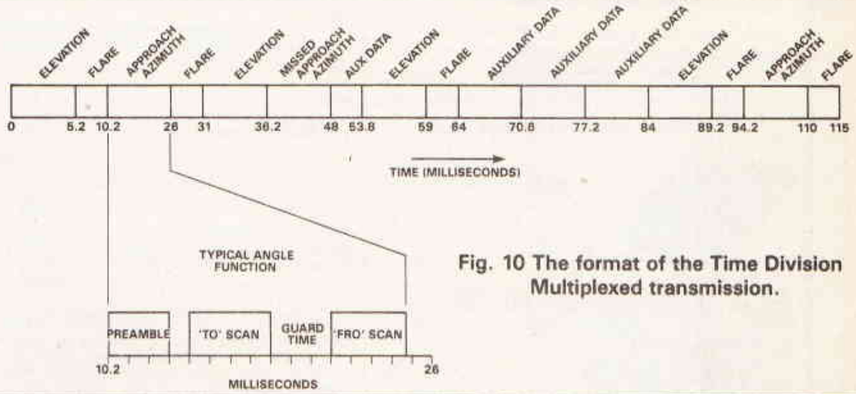

Fig. 10 The format of the Time Division Multiplexed transmission.

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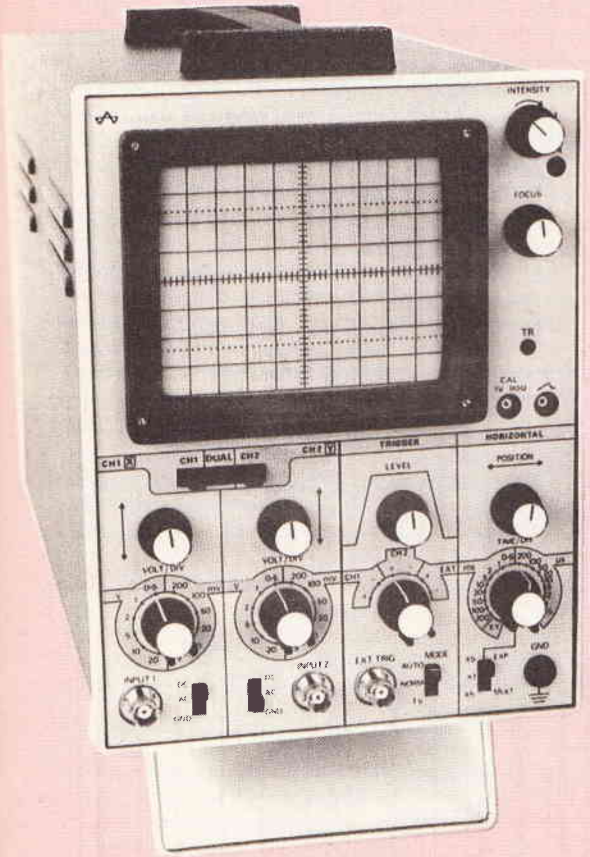
Bringing an old 'scope to life can be very rewarding and a bargain too! Simon Russell presents the final part on giving life to a valuable service tool



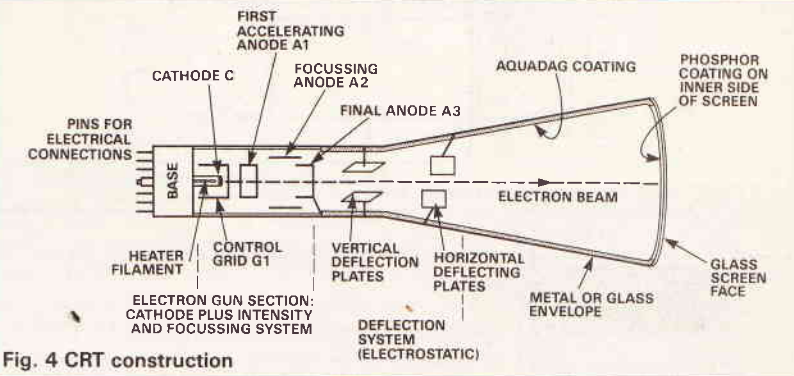


Fig. 4 CRT construction

CRTs are just big valves, and as such need to be biased in the same way. They have a cathode exactly the same as a valve. They have a single grid (actually a disc with a hole in it). They also have two or three anodes, labelled Al, A2 and A3. Al is closest to the cathode and A3 the furthest. These anodes form what is called an 'electron lens', a means of focusing the beam to converge at the face of the tube. The entire assembly so far described is called an electron gun and it's purpose is to generate a beam of electrons. The electrons generated by the gun are sent towards the face of the tube. The tube face is covered with phosphor, a substance that glows when hit by electrons. As the beam travels towards the tube face it can be bent or deflected by the use of metal plates. These plates run parallel to the beam and have a voltage applied to them. As the beam carries a negative charge it will be repelled from a plate with a negative charge and attracted towards a plate carrying a positive charge. In practice there are two sets of two deflection plates (see Figure 5). One set shifts the beam in the X axis and the other shifts in the Y axis. As the beam is affected by charge, no current is drawn by these plates. Any CRT will have a 'deflection sensitivity' in mm/V. This is the spot deflection on the face of the tube for 1V across the plates. A typical figure is 0.5 mm/V, this means that a signal of several hundred volts peak-to-peak is required to give a trace that spans the tube face. This form of deflection is knovn as 'electrostatic', the other kind being 'electromagnetic'. Electromagnetic is only used on TVs, scopes always use electrostatic.

The brilliance of a CRT is dependant on it's grid-cathode voltage, the grid always being negative, just like a valve. The practice on early 'scopes was to keep the grid at a fixed voltage and vary the positive voltage on the cathode. As this also affected the cathode-anode voltage, this meant that changing the brilliance often affected the focusing and even the deflection sensitivity (see 'Scope Performance'). Better quality valve 'scopes and most transistor types use a variable negative voltage on the grid whilst keeping the cathode fixed.

Whichever type of intensity control is used, the remaining circuitry is very similar. Each electrode, as you progress away from the grid, requires a successively higher positive voltage. Al is always at a fixed level. A2 is the electrode that controls focusing, the value of DC on this anode determines the focal length of the beam. A3, if the tube has one (small or early ones may not), can be at a fixed level. It can also be used to control 'astigmatism'. This changes the shape of the spot and is used in conjunction with the focus control that adjusts the size of the spot. In practice there is always some interaction between these two. The astigmatism control might be on the front panel next to the focus control or it might be inside the equipment as a preset adjustment. Sometimes Al is connected to A3.

The cathode-anode voltage might be anything between 1-2KV. Older 'scopes generated this by

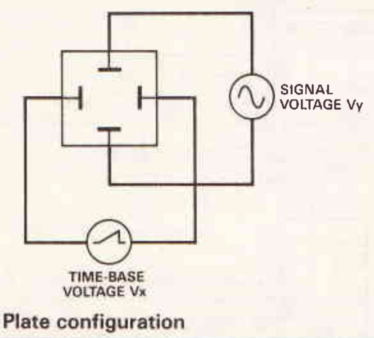


Fig. 5 Plate configuration

stepping up the mains. Working on these circuits tends to concentrate ones attention due to the large currents available.

After about 1960 this fell out of favour and hence after the EHT (Extra High Tension, 'tension' being an archaism for voltage) was developed by inverters

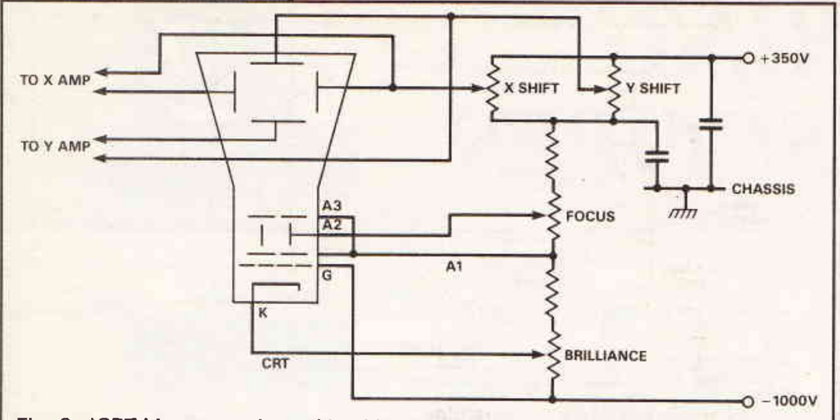


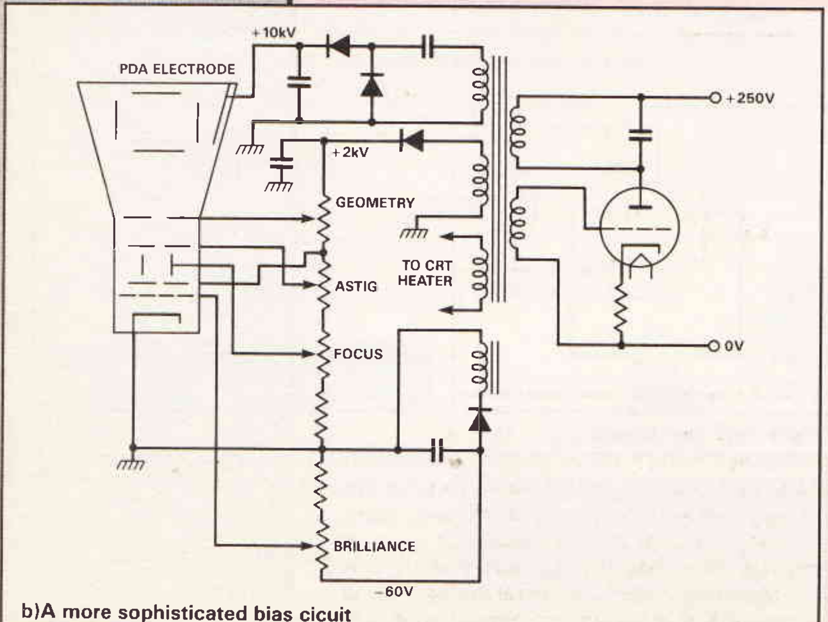
Fig. 6 a)CRT bias network used in older 'scopes

similar to the line output stages in monochrome TV sets.

Some larger tubes require PDA (Post Deflection Acceleration). This, again, is very similar to TV tubes in that the inner surface between the deflection assembly and the face is covered by a carbon deposit (sometimes called 'Aquadag'). This is kept at an very high voltage (typically +10kV). It's purpose is to give enough energy to the electrons to strike the face of the tube. This is always generated by the use of inverters, as in TVs and is taken to a separate connector on the side of the tube.

Another feature that is only found on more sophisticated tubes is a 'geometry' electrode. This appears after the deflection assembly and compensates for pin cushion or barrel distortion, see Figure 7. This electrode will have a high voltage applied to it which is set by the geometry preset.

All tubes have a metal casing around them. This is to prevent external magnetic fields (from mains transformers and the like) from causing unwanted deflection of the spot. The metal is of very high magnetic permeability so as to 'short circuit' any magnetic field, in a similar way to lightning hitting an aeroplane and carrying on towards earth. The metal is a special alloy of nickel called mu-metal. Any dents in this screen will cause magnetic fringing and will allow interference to take place. If your screen is dented then you must very carefully straighten it to make as smooth a surface as possible. If there is no trace or spot on the face of the CRT when the initial tests are made then you may have a fault in this area.



b)A more sophisticated bias cicuit

One of two things could be causing a problem. Either the electron gun has not got the correct voltages on it or the spot is being deflected off the face of the tube. To check that the latter is not occuring you must measure the voltage across the Y deflection plates. Use an analogue meter if you have one, set to it's highest range (this goes for all CRT tests as unexpected high voltages are the kiss of death for a DMM). Adjusting one (or both) Y shift controls you should be able to set this voltage to zero. Do the same to the X plates. If, in either case, you are unable to get a null then there is a problem in the respective X or Y amplifier. To confirm this you might care to short out the offending plates with a jumper, switching the equipment off first. When you switch on again and wait for the tube to warm up you should see something on the CRT, unless there is also a fault around the gun (this has happened to me). If you find a fault in the deflection amplifiers then go to the 'X and Y deflection amplifiers'.

Let us now assume that there is no deflection

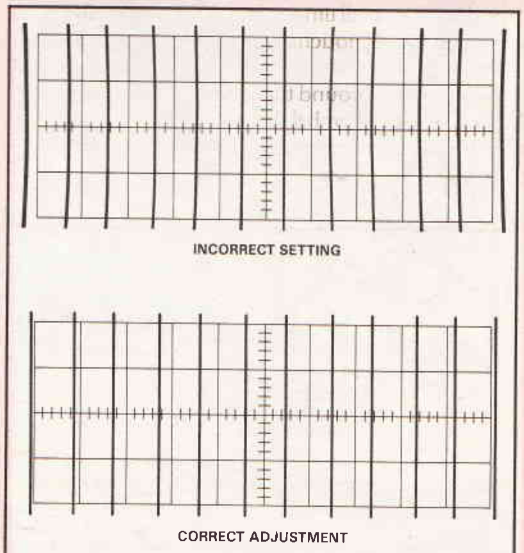


Fig. 7 Effect of geometry control

fault. The very first thing to check is that the heater is intact. Switch on the 'scope and wait about a minute. You should then be able to see an orange-yellow glow around the base of the tube. If you do not then there is no heater current flowing. Switch of the 'scope, remove the tube socket and do a continuity check across the heater pins on the CRT. If no reading is obtained then the CRT is burnt out and there is very little you can do about it apart from fitting a new one. If the heater checks out okay then check continuity between the heater pins on the tube socket. As the tube heater is merely supplied by a separate winding on the mains transformer you ought to get a low resistance. If you don't then the winding could be burnt out (new transformer), the wiring between it and the socket could be faulty or the socket could simply be dirty. What ever the problem, you must get the heater going before the CRT will work correctly. If the heater glows then carefullv check all anode voltages with reference to the cathode. There should be at least a couple of hundred volts on each. The voltage on A2 should vary with adjustment to the focus control and that on A3 should be affected by changing the astigmatism control. Check the grid voltage with reference to cathode. This should always be negative, though not by more than, say, 70V. Adjusting the brilliance control should affect this voltage, it being most negative when the control is fully anti-clockwise.

Check the voltages on all other electrodes of the CRT and compare them to what the circuit diagram says they should be. If your tube uses PDA, this must be checked. If you have a high voltage multiplier probe then simply pull off the cap on the side of the tube and measure the voltage. If you have no probe then there is no way of checking the voltage accurately. You can, however, use an old TV engineer's dodge to check there is something there. You will need a long (at least 10") screwdriver with an insulated handle at least 1.5" thick. With the equipment switched off, carefully pull off the cap on the CRT and bend the wire so that you have clear and easy access to the clip on the end of the wire. Keep the clip at least two inches away from any part of the 'scope. Switch on the scope and, holding the insulation of the screwdriver handle, touch the tip of the driver against the clip which should now be at some 10kV. As the tip comes into contact with the clip you should see a dark blue/violet spark appear between the two. At all times whilst making this test, keep the metal shaft of the driver at least 1.5" from any other part of the 'scope. If the spark appears then it is more than likely that EHT is being generated correctly. Switch off the equipment and refit the clip onto the 'scope. At all times, even when switched off, you should avoid touching any part of the EHT circuitry.

If all voltages around the tube appear to be okay then you have, in all probability, a fault within the CRT itself. This is something equivalent to a horse with a broken leg.

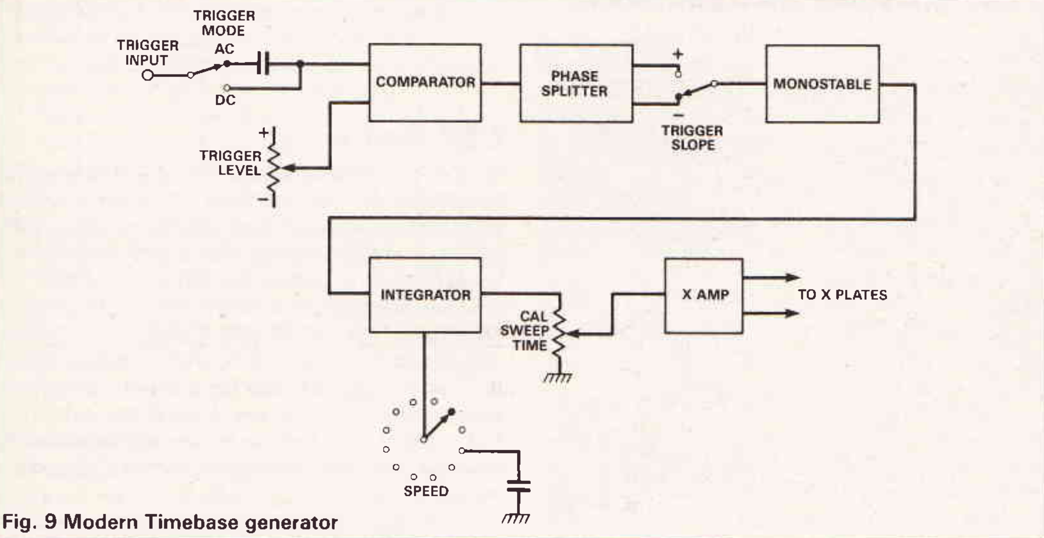


Fig. 9 Modern Timebase generator

Timebase and trigger circuits

There are two basic types of timebase generator circuits that were in common use. One of these was dependent on a valve characteristic and so is not used any more. This is the simplest and is to be found on most older valve scopes. It was known as the Miller-transitron or Phantastron oscillator and a general circuit is shown in Figure 8. The pivot point of this circuit is the capacitor between the screen and suppressor grids, this gives the pentode a negative resistance that is required for the circuit to work. All normal electrode voltages are present so this circuit should be easy to get working. It is triggered by the cathode of the diode being pulled to earth, or to be more precise, the circuit is allowed to start sweeping the instant the cathode is taken up to the supply rail. If your 'scope fails to trigger then there will probably be no square wave or pulses at this point. The preceding circuitry is just a very high gain amplifier used as a clipper with a variable threshold. This circuit had serious drawbacks, the two biggest ones being slow flyback and poor linearity. It stopped being used

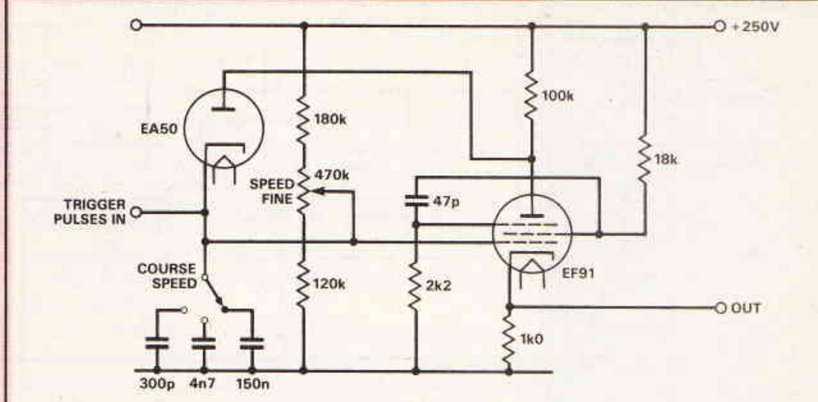


Fig. 8 Miller-transitron timebase generator

about 1960.

The second method for generating a sawtooth is shown in general form in Figure 9. This was used for the better valve 'scopes and all transistor types. This setup has the trigger circuit as an integral part of the timebase generator. The trigger circuit generates a pulse waveform that is integrated to produce a sawtooth.

If you cannot get a trace then the fault could lie in the trigger circuits or the integrator. The best way for determining which is at fault is to set the trigger select switch to 'EXT', inject a 1kHz square wave at

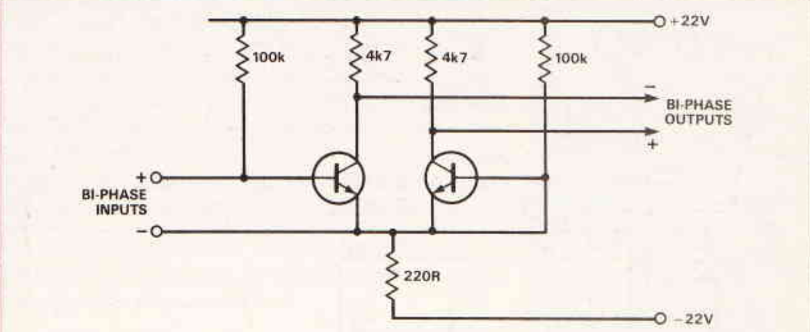


Fig. 10 A typical long tailed pair circuit

10V p-p into the trigger input and observe the waveform appearing at the input of the integrator. It ought to be a pulse or square wave. This form of timebase generation is much more sophisticated than the first and there isn't enough space to give proper description other than the diagram. Note that in 'AUTO' triggering mode the pulses at the Input of the integrator are free running when there is no signal to

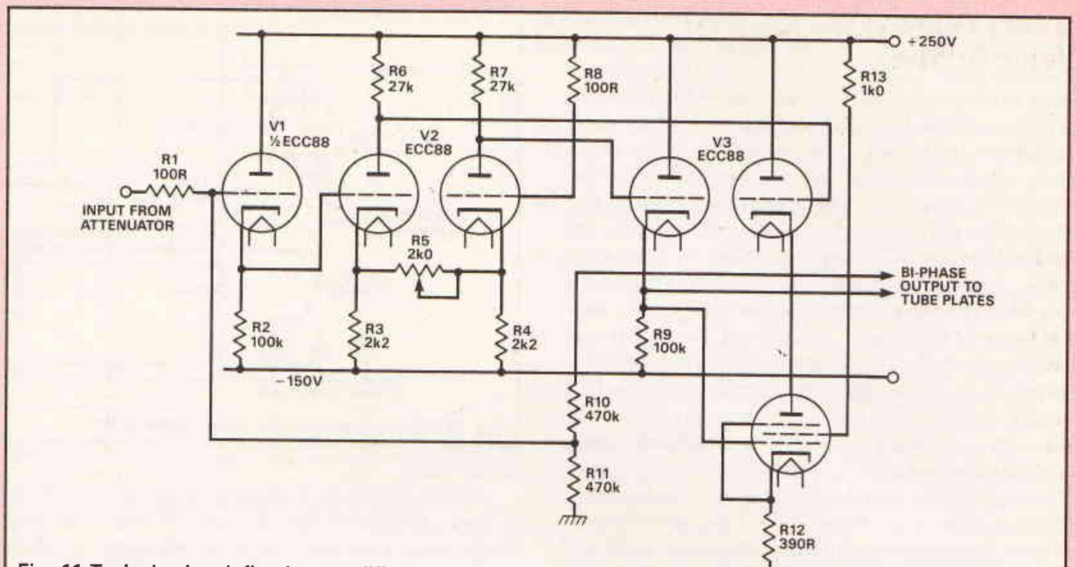


Fig. 11 Typical valve deflection amplifier

trigger from.

A common fault with timebase generators of both types is non-linenrity of the trace. This is normally due to leaky timing capacitors in the ramp generator. Apart from this problem, timebase generators are qenerally quite reliable.

X and Y Deflection Amplifiers

These are amplifiers that take the low voltage signals to drive the deflection plates and bring them up to levels suitable for that purpose (typically 100V RMS). These are basically DC coupled high gain amplifiers (whose output stage can operate at high voltages, in the case of solid state equipment). There are generally two outputs, one for each plate and they operate in a push-pull relationship. The circuitry has not really changed much over the years, the basic building block being the long tailed pair (Figure 10). A typical valve deflection amplifier is shown in Figure 11. If a fault is suspected within either the X or Y amplifiers then you will have to use another 'scope to follow the signal, stage by stage, to the deflection plates.

If there is no display on the CRT face then you may have come to the conclusion that there is an offset on one set of plates. This indicates a biasing fault and can be found using a DMM. With valve equipment the most common cause of this sort of fault is open circuit cathode, anode or screen grid resistors. With transistor based equipment it is far more likely that a semiconductor device has failed. In the case of the Y amplifier you might well find that the actual sensitivity bears no relationship with the front panel indicator. This might be due to a shift in gain within the amplifier or it could be symptomatic of low tube EHT. The reason for this is quite simple. A reduced EHT will mean that the electrons that make up the beam travel slower than intended, and thus spend more time in the influence of the deflection plates. The more time they spend there, the further they will be repelled or attracted, thus increasing the deflection sensitivity and so the apparent gain of the deflection amplifiers. A clue to this situation is an increase in gain of both amplifiers and possibly reduced brilliance. Try not to get caught out by this one.

Generally the deflection amplifiers are quite trouble free apart from noisy pots and switches. This more-or-less completes the description of the main circuits of a scope and their quirks.

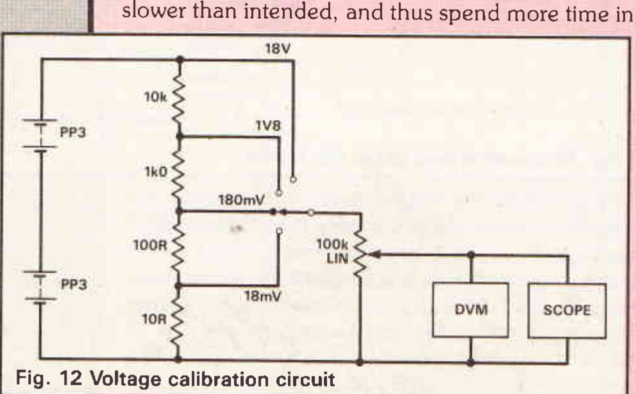


Fig. 12 Voltage calibration circuit

CRT Faults

What if your CRT is faulty? This is not quite as bad as first appears. Obviously, the only thing to be done is to replace it. New tubes can be obtained from commercial suppliers (see 'Useful addresses') but this could cost you anywhere between £30 and £60. The next best thing is to look out for another 'scope of the same type. This will probably be faulty as well but you ought to be able to get one working 'scope from two duff ones. You will also have spares should the equipment fail again. Quite often, it pays to buy any CRTs you should happen to see at junk sales and auctions, you can normally get them for a matter of pence.

The above comments also apply to any custom made components that you will not be able to replace easily. A common one is the mains transformer.

The mains transformer in most 'scopes has multiple tappings and windings. If this fails it is extremely unlikely that you will get a new one. Another common problem with valve 'scopes is that of matched valves. Sometimes it was necessary to select valves that had a particular gain. These will eventually fail. Unless you have access to a valve tester, you can only put in a valve of the same type and hope for the best. I have had to do this in the past and the degradation in performance is usually negligible.

Some 'scopes use delay lines between the Y plates and the output of the Y amplifier. This enables the observation of the rising edge of the waveform you are triggering from. If one of these should go open then you may be able to rewind the coil that forms the part that failed.

If the worst comes to the worst and you cannot hope to repair the 'scope then keep it in its entirety until you see another one of the same type. You should then be able to use the parts from one to repair the other.

Notes On Performance Of Valve Scopes

So, you've got your 'scope working. There are a few things you might notice about the performance of the equipment. If the 'scope is of the early valve type then you might find that altering the brilliance control has an affect on focus, or even a shift in the beam. This is a combination of CRT and circuit design and, so long as the effect is not to pronounced, must be lived with.

On some valve 'scopes I have also noticed that it is possible to saturate the Y amplifiers before the trace is deflected off of the face of the tube. Again, this may have to be put up with.

Older equipment may have very rudimentary triggering and this may give poor performance compared with modern 'scopes.

A word about calibration. Once all parts of the 'scope appear to be working you must check the calibration. This is not as difficult or as complicated as it might sound, the two most important parameters being sweep times and vertical sensitivity.

Normally you should not attempt to calibrate a 'scope unless you have a manual that will give the correct procedure. If you have an accurate source of frequency and voltage then calibration should be simplicity in itself. It is more likely that you will only have a DVM and a signal generator. To check the Y circuits use the test circuit shown in Figure 12. Each input sensitivity setting on the 'scope may have a different attenuator so, starting at the lowest range, set up a suitable voltage across the DVM and check that the 'scope gives a corresponding deflection. Repeat this procedure for all ranges as necessary.

The sweep times are just as easy to set up, but you must use a frequency counter or another 'scope. Set up as in Figure 13. Set the generator to produce a square wave at exactly 1kHz (use the counter or 'scope to set this accurately). Adjust your scope to give a correct display (i.e two horizontal squares per cycle when set to 0.5 ms/div). Note: when making time measurements always use the tube face between the first and ninth horizontal square, any non-linearity in the trace will appear at the beginning or end of the trace.

Appearance

When repairing a 'scope, your prime concern should be getting the equipment electronically perfect. Hopefully, you will be able to do this. You might then turn your attention to the appearance of the front panel and the case.

In all probability the 'scope will have been neglected for many years and will, at the very least, be extremely dusty. Another common problem is missing or broken knobs, there seems to be a preoccupation amongst amateurs to use the knobs of perfectly good equipment for their own projects.

If you intend to clean up the front panel then you should first remove all knobs and any other part that will come off easily. The knobs may be the push on type or they may be the collet type. It is most likely that they will be kept on by grub screws, either slotted head or hexagonal 'Allen key' type screws. These may be particularly difficult to remove as the knob tends to seize up on to the shaft. The best way to remove these is to place a flat bladed screwdriver under the knob and apply some freezer spray to the shaft. Hopefully the freezer spray will cause the knob and shaft to contract and so allow you to very gently lever the knob off.

Once the front panel is as clear as it can be you should use a weak solution of washing powder (yes, washing powder) to clear all the muck off.

Once the front panel is clean you can turn your attention to the tube face and graticule. This tends to get very dirty and a bit of window cleaner generally does the trick. Try to clean the knobs up by soaking them in a weak solution of washing up liquid over night. Tarnished metal can often be cleaned up by wire wool followed by metal polish. Quite often sticky labels will have been put on. These are fairly easy to remove, if you are patient, by gently rubbing with a toothbrush and a solution of washing up liquid.

With patience it is not difficult to get the kit looking like new.

This just about concludes my little discussion on an often overlooked source of cheap test equipment. A lot of the comments I have made apply equally well to all valve test equipment. Just because it's the size of a telephone box and needs a small power plant to run it, doesn't mean to say that it will not perform all the functions of a solid state equivalent.

I have tried to cover most eventualities but this is only a small article and by far the best way to learn is to spend a few hours actually working on a piece of equipment.

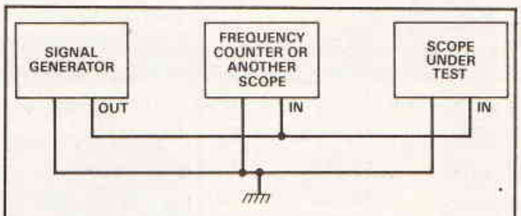


Fig. 13 Timebase calibration circuit

Useful addresses.
Two suppliers of new valves are:
P. M. Components Ltd
Selectron House
Springhead Enterprise Park
Springhead Road
Gravesend
Kent
DA11 8HD
Telephone 0474 560521
and
Colormor (Electronics) Ltd
170 Goldhawk Road
London
W12
Telephone 081 743 0899
They both offer an excellent range of valves and CRTs.
P. M. Components will accept Access and Visa orders 24 hours a day.
A useful source of manuals and/or circuit diagrams is:
Mr Bentley
27 De Vere Gardens
Ilford
Essex
IG1 3EB
Telephone 081 554 6631 most evenings.
The information is always a photocopy but a good size manual will cost around £5.

ETI 1990 PROJECT INDEX

INDEX

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BD252	1	Panostat, controls output of boiling ring from simmer to boil
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BD263	2	Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress
BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor
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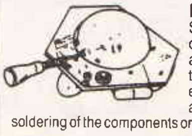

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SINCLAIR C5 WHEELS

Including inner tubes and tyres. 13" and 16" diameter spoked polycarbonate wheels finished in black. Only £6 each. 13" ref 6P20. 16" ref 6P21.

PC STYLE CASES 18"×18"×6". Complete with fan and grill illuminated power switch and IEC filtered power input plug. Priced at only £15.00. Ref: 15P38.

VERY POWERFUL 12 VOLT MOTORS. 1/3rd Horsepower. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £20. Our ref 20P22.

PC POWER SUPPLIES. Brand new with built in fan and power switch on the back +5 −5 +12 −12 150 watt made by AZTEC. £25.00 each. Ref: 25P18.

PHILIPS LASER

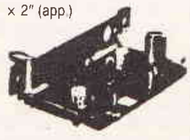
This is helium-neon and has a power rating of 2mW. Completely safe so long as you do not look directly into the beam when eye damage could result. Brand new, full spec, £40.00. Ref 40P10. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

ORGAN MASTER is a three octave musical keyboard. It is beautifully made, has full size (piano size) keys, has gold plated contacts and is complete with ribbon cable and edge connector. Can be used with many computers, request information sheet. Brand new, only £15 plus £3 postage. Our ref 15P15.

HIGH RESOLUTION MONITOR. 9in black and white, used Philips tube M24/306W. Made up in a lacquered frame and has open side. Made for use with OPD computer but suitable for most others. Brand new, £20. Ref 20P6.

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape 41/2in × 41/2in × 13/4in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each.** Our ref 8P26.

MINI MONO AMP on p.c.b. size 4" × 2" (app.) Fitted Volume control. The amplifier has three transistors and we estimate the output to be 2W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of **£1.15 each, or 13 for £12.**



NEW MAINS MOTORS. 25 watt 3000 rpm made by Framco approx 6"×4"×3" priced at only £4. Ref 4P54.

SHADED POLE MOTORS. Approx 3" square available in 24V AC or 240V AC, both with threaded output shaft and 2 fixing bolts. Price is £2 each. 24V ref 2p65. 240V ref 2P66.

MICROWAVE TURNTABLE MOTORS. Complete with weight sensing electronis that would have varied the cooking time. Ideal for window displays etc. Only £5. Ref 5P165.

SURFACE MOUNT KIT. Makes a super high gain snooping amplifier on a PCB less than an inch square! £7. Ref 7P15.

INDUCTIVE PROXIMITY SWITCHES. Made by Honeywell these units are brand new and offered at only £12 each which is a fraction of their normal price. 10-36V DC model ref 12P19 or main version 12P20.

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POPULAR ITEMS — MANY NEW THIS MONTH

JOYSTICKS for BBC, Atari, Dragon, Commodore, C64 only. All £5 each. All brand new, state which required.

BOSCHERT SWITCHED MODE POWER SUPPLIER. +5 at 15A +12 at 3A −12 at 2A +24 at 2A 220v or 110v input. Brand new and guaranteed. Retail price is £180!! ours £20. Ref: 20P30.

SUB-MIN PUSH SWITCHES Not much bigger than a plastic transistor but double pole. PCB mounting. Three for £1. Our ref BD688.

AA CELLS. Probably the most popular of the rechargeable NICAD types. 4 for £4. Our ref 4P44.

20 WATT 4OHM SPEAKER With built in tweeter. Really well made unit which has the power and the quality for hi-fi. 6½in dia. Price £5. Our ref 5P155 or 10 for £40 ref 40P7.

MINI RADIO MODULE Only 2in square with ferrite aerial and solid dia tuner with own knob. It is a superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1. Our ref BD716.

BULGIN MAINS PLUG AND SOCKET. The old faithful 3 pin with screw terminals. The plug is panel mounted and the socket is cable mounted. 2 pairs for £1 or 4 plugs or 4 sockets for £1. Our ref BD715, BD715P or BD715S.

MICROPHONE. Low cost hand held microphone with on/off switch in handle, lead terminates in one 3.5 plug and one 2.5 plug. Only £1. Ref BD711.

MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES 140v 100w pair made by Hitachi. Available in H pack Ref 2SJ99 and 2SK343 £4 a pair. Ref 4P51.

TIME AND TEMPERATURE LCD MODULE. A 12 hour clock, a Celcius and Fahrenheit thermometer, a too hot alarm and a too cold alarm. Approx 50 × 20mm with 12.7mm digits. Requires one AA battery and a few switches. Comes complete with full data and diagram. Price £9. Our ref 9P5.

REMOTE TEMPERATURE PROBE FOR ABOVE. £3. Our ref 3P60.

600 WATT AIR OR LIQUID MAINS HEATER. Small coil heater made for heating air or liquids. Will not corrode, lasts for years, coil size 3in×2in mounted on a metal plate for easy fixing, 4in dia. Price £3. Ref 3P78 or 4 for £10. Our ref 10P76

EX EQUIPMENT SWITCHED MODE POWER SUPPLIES. Various makes and specs but generally ⅟e5, ⅟e12v, ideal bench supply. Only £8. Our ref 8P36.

ACORN DATA RECORDER. Made for Electron or BBC computer but suitable for others. Includes mains adaptor, leads and book. £12. Ref 12P15.

NEW PIR SENSORS. Infra red movement sensors will switch up to 1000W mains. UK made, 12 months manufacturers warranty. 15-20m range with a 0-10min timer, adjustable wall bracket, daylight sensor. Only £25.00. Ref 25P16.

GEIGER COUNTER KIT. Includes tube, PCB and all components to build a 9V operation geiger counter. Only £39. Ref 39P1.

BBC JOYSTICK INTERFACE. Converts a BBC jotstick port to an Atari type port. Price £2. Our ref 2P261.

TELEPHONE EXTENSION LEAD. 5M phone extension lead with plug on one and socket on the other. White. Price £3. Our ref 3P70 or 10 leads for only £19! Ref 19P2.

LCD DISPLAY. 4½in digits supplied with connection data £3. Ref 3P77 or 5 for £10 Ref 10P78.

CROSS OVER NETWORK. 8 ohm 3-way for tweeter midrange and woofer. Nicely cased with connections marked. Only £2. Our ref 2P255 or 10 for £15 ref 15P32.

BASE STATION MICROPHONE. Top quality uni-directional electret condenser mic 600r impedance sensitivity 16-18KHz −68db built in chime, complete with mic stand bracket. £15. Ref 15P28.

MICROPHONE STAND. Very heavy chromed mic stand, magnetic base. 4in high. £3 if ordered with above mic. Our ref 3P80.

SOLAR POWERED NI-CAD CHARGER. 4 Nicad AA battery charger charges 4 batteries in 8 hours. Price £6. Our ref 6P3.

MAINS SOLDERING IRON. Price £3. Our ref 3P65.

SOLDERING IRON STAND. Price £3. Our ref 3P66.

C5 GEARED MOTORS. Complete item giving a 4 to 1 reduction and a toothed cog output. £40.00. Ref 40P8.

CAR IONIZER KIT. Improve the air in your car, clears smoke and helps prevent fatique. Case req. Price £12. Our ref 12P8.

NEW FM BUG KIT. New design with PCB embedded coil 9v operation. Priced at £5. Our ref 5P158.

NEW PANEL METERS. 50UA movement with three different scales that are brought into view with a lever. Price only £3. Ref 3P81.

STROBE LIGHTS. Fit a standard Edison screw light fitting 240v 40/min flash rate, available in yellow, green, complete with socket. Price £10 each. Ref 10P80 (state colour reqd).

ELECTRIC SPEED CONTROL KIT. Suitable for controlling our powerful 12v motors. Price £17. Ref 17P3 (heatsink required).

EXTENSION CABLE WITH A DIFFERENCE. It is flat on one side, making it easy to fix and look tidy. 4 core, suitable for alarms, phones etc. Our price only £5 for 50m reel. Ref 5P153.

METAL PROJECT BOX. Ideal for battery charger, power supply etc., sprayed grey, size 8" × 4" × 4½", louvred for ventilation. Price £3. Ref 3P75.

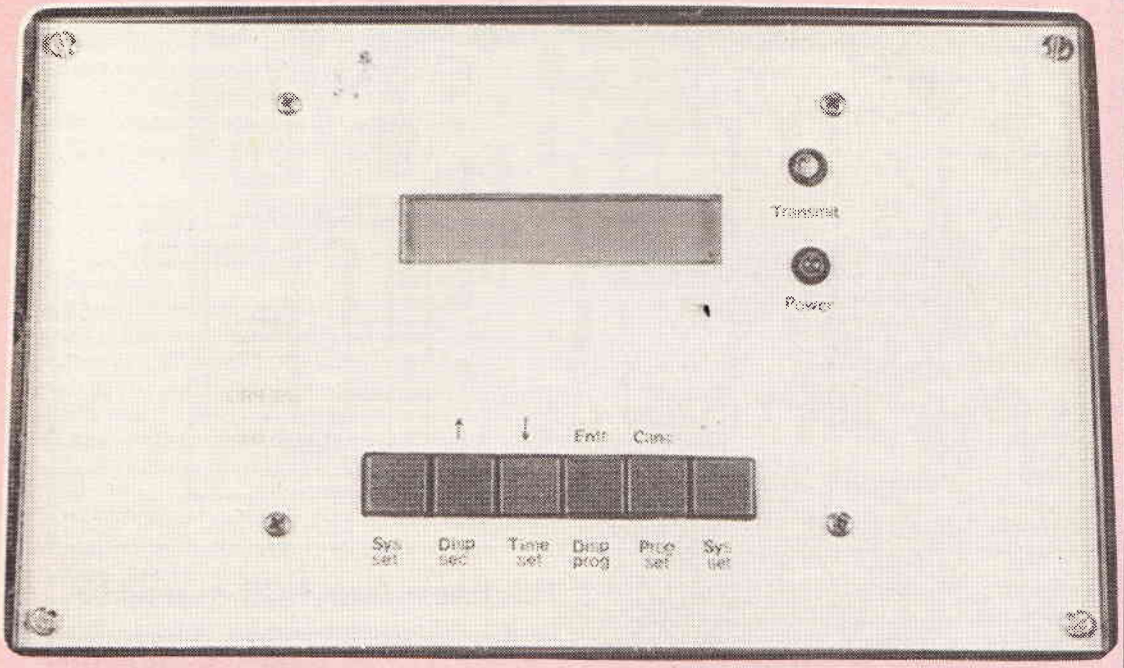
WISPER 2000 LISTENING AID. Comes complete with headphones and cased to look like a personal stereo. Enables you to hear sounds that would otherwise be in...ble. Our price £6.00 ref GP37.

VIDEO SENDER UNIT. Tran...ts both sound and audio signals from a video recorder or camera to a tel...sion. Max range 100' £12.00 ref 12P35.

RADIO TRANSCEIVERS. Pair of walkie talkies with a maximum range of 1.5 kilometres. Complete with aerials and cases. Our price £30.00 ref 30P12.

REMOTE CONTROL TIMESWITCH

2



The Main Control unit Construction.

Kevin Browne continues with his electrical house manager

The assembly of the main PCB is straightforward. First, fit the 15 wire links as shown on the component layout in Figure 13. It is essential these links are fitted first, and checked, because some of the links go beneath the IC's and it would be difficult to make any changes later. The components can then be fitted to the PCB, starting with the smaller components such as resistors and diodes. IC sockets should be used for all the integrated circuits, but at this stage, don't fit the IC's into the sockets. Lengths of stranded wire should be soldered to the eight connection points as shown. The wiring to the display PCB (connection numbers 15 — 28) may be terminated on 0.1" push connectors or soldered directly to the PCB, if desired.

At this stage it is advisable to do a number of preliminary checks. First, check the PCB for short circuits and dry joints very carefully, as any faults, particularly on the address and data lines of the CPU are very difficult to trace, and could prove fatal. Insert IC1 into its socket, then connect up the transformer, or an AC bench supply to the circuit. Check the 5 and 12 volt supplies and that the 5 volt supply is present to all the IC sockets.

Disconnect the power, then insert IC's 2,3,4,9 and 10 into their respective sockets. Reconnect the power and check for the following pulses using either a logic probe or a 'scope:

- A 1.8MHz clock pulse to pin 6 of IC5 socket.
- 3.125kHz very short duration pulses to pin 17 of IC5 socket.
- 50Hz very short duration pulses to pin 16 of IC5 socket.

The next step is to disconnect the AC supply and connect a 7.5 Volt DC supply to the points 3 and 4 on the main PCB (+ve to 3), then check the following:

- No 3.125kHz pulses to pin 17 of IC5 socket.
- 50 Hz very short duration pulses to pin 16 of IC5 socket.

The Display PCB Assembly

Fit all the components to the display PCB (except the LED's) as shown in Figure 14. Start with the resistors, diodes and capacitors. Next fit the key switches, complete with capacitors ensuring the correct orientation. The pins of the switches should be pushed through the PCB only far enough to enable them to be soldered. You may find it easier firstly to solder only two diagonally opposite pins. Once the switch alignment is satisfactory the remaining pins may then be soldered.

Mount the LCD display unit to the PCB with 4 small nuts and bolts, using 1/8" spacers between the module and the PCB. Connect the LCD module to the PCB using short lengths of tinned copper wire.

PLEASE NOTE:- the LCD display unit is a CMOS device and the same anti static precautions should be taken. You should discharge yourself to an earth point before handling the device, and use an earthed soldering iron. Once the LCD display is wired to the PCB, treat it with the same care.

Finally, wire the display PCB to the main board with stranded wire as shown in Figure 15. Then check the wiring and soldering very carefully.

Further Testing

At this stage in the assembly further testing is advisable. The remaining IC's should be inserted into

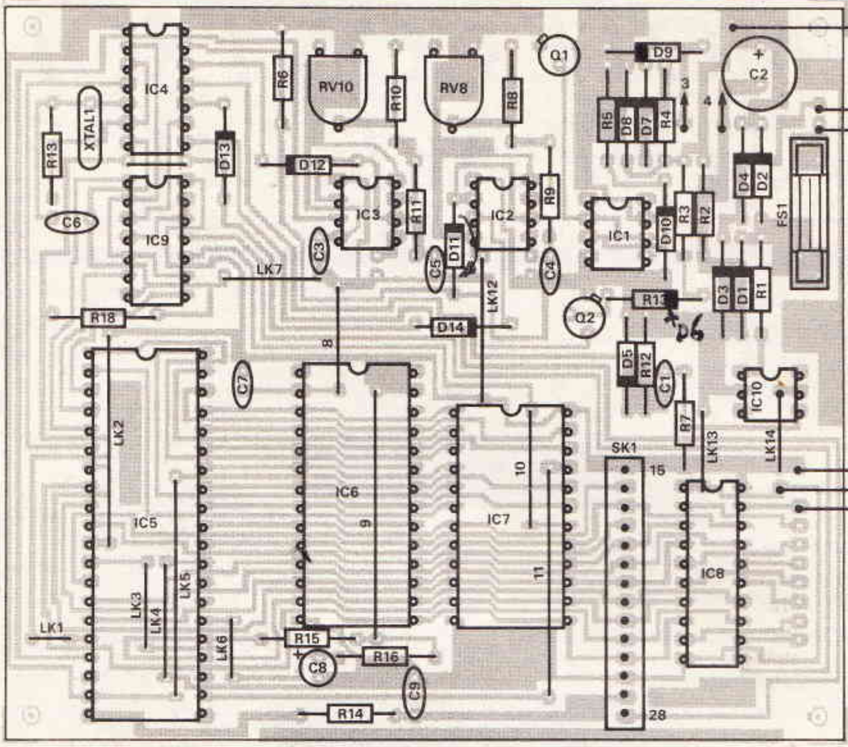


Fig.13 Main PCB Layout

their respective sockets on the main PCB.

Connect up the power and check the LCD module for the display message — (C) 1990 .... If the display remains blank, or shows black squares, adjust the contrast with RV30 until displayed message is clear. The usual setting for RV30 is close to the minimum. Should the display show random patterns or remain totally blank, regardless of the contrast adjustment, then switch off and check both PCB's for short circuits and dry joints. The data and address leads are particularly suspect at this point.

If all is well, the timing circuits can now be calibrated.

Calibrating the Timing Circuits

For the circuit to function correctly, the frequency of the two CPU interrupt signals must be accurately adjusted. Built into the timeswitch software is a calibration program. The setting of these signals must be carried out in the correct order, as the accuracy of second adjustment is dependent upon the first.

Connect the power to the timeswitch, and ensure the copyright message — (C) 1990 ... is scrolling across the display. Press both system set keys together. The display will change to — 'Adj to ZERO — 000'. Adjust the variable resistor RV10 until the digits show a constant zero. The arrows next to the number indicate if an increase, or decrease in resistance is required. Allow the circuit to settle for a few seconds between each adjustment.

Once you are satisfied with the adjustment of RV10, disconnect the power. Now carefully remove diode D11 and capacitor C1 from the circuit. Now reconnect the power and the message (C) 1990 ... should again scroll across the display. Press both system set keys together to re-enter the calibration mode. The display should again change to — 'Adj to ZERO — 000'. This time adjust the variable resistor RV3 until the display is zeroed.

Finally disconnect the power and replace diode D11 and capacitor C1. The calibration of the timing circuits is now complete.

The Transmitter PCB Assembly

There are no problems with the assembly of the transmitter PCB. Again assemble the components in size order, starting with the smallest. Take care to insert the isolating transformer coil (T20), the correct way round as shown in Figure 17. For safety reasons it is advisable to insulate the leads of capacitors C20 and C21 with sleeving, and also to make a cover for the fuse FUSE 20 with a small piece of plastic. Again check the PCB carefully for faults, once assembly is complete.

Testing the Transmitter PCB

Connect a +5V supply to the PCB. Also connect the transmit control lead to +5V. DO NOT connect the mains supply to the transmitter output. Monitor the output of IC20 with a logic probe or 'scope, checking for a 180kHz square waveform. Connect a digital meter or a 'scope to the junction of resistor R20 and capacitor C22. Adjust the core of the transformer T20 with a plastic trimming tool until the signal is maximised. This should be around 2V peak to peak on a 'scope or around 30mV on a digital meter.

Final Assembly

Complete the inter-PCB wiring as shown in Figure 15 noting the connecting numbers in Fig.14. Fit the transformer, transmitter and main PCB in the case and secure with small nuts and bolts as shown. ¼" spacers should be used to support the PCB's. The mains cable should enter the case through a small hole in the rear, and be fitted with a rubber grommet.

The top panel should be cut as shown in Figure 18. Transfers can be used to label the panel as shown. Next fit the two LED clips to the top panel and push the LED's into place, ensuring the leads are the correct for the PCB. Don't fit the securing collars. Glue a thin piece of acrylic sheet to the inside of the panel to form a protective window for the LCD display.

Position the display PCB behind the top panel, feeding the LED leads through the appropriate holes in the PCB at the same time. Secure the PCB using 4 small nuts and bolts with the appropriate spacers as required, so the display module is pressed against the window. Finally solder the two LED's into position, to complete the assembly.

HOW IT WORKS

REMOTE SWITCH UNIT

The Tone Receiver.

The 180kHz carrier tone superimposed on the mains supply by the main control unit, is filtered out by the tuned circuit formed by the transformer T2 and capacitor C3. This tone is applied to the amplifier section, formed by transistors Q1 and Q2.

The amplified signal, now in the form of large positive going pulses is fed to the integrator circuit and is formed by resistor R5 and capacitor C5. Transistor Q3 switches in response to the output from the integrator, to re-create the coded signal. Transistor Q4 inverts this signal to provide the correct logic levels for IC2.

The Signal Decoder.

The logic signal received at the input of IC2 is shown in Figure 9. This signal is decoded by the IC and compared with the code preset by the DIL switches SW1 – SW8 and the links LK9 - LK12. If a match is achieved in 4 consecutive received frames, the output of IC2 will go low for 60ms. If further matching frames are received within this time the output will remain low for 60ms after the last correct frame is received. The timing of this output is important to determine if an 'ON' or 'OFF' command is being sent by the main control unit.

Resistor R16 and Capacitor C7 provide the timing reference frequency for the received signals.

The ON/OFF Detector.

The ON/OFF control detector is formed by IC3 which is a dual D type flip-flop. IC3a along with transistor Q5, resistor R17 and capacitor C9 outputs a pulse of fixed duration, every time it is triggered. The circuit is triggered by the output of IC3 changing from high to low level.

This pulse is fed to the clock input of the second flip-flop IC3b. The 'D' input of IC3b is taken from the output of IC3. The effect of this arrangement on the output of IC3b is as follows:-

If the output of IC2 remains low for a period longer than the pulse generated by IC3a, then the output of IC3b will go high at the end of the fixed pulse period.

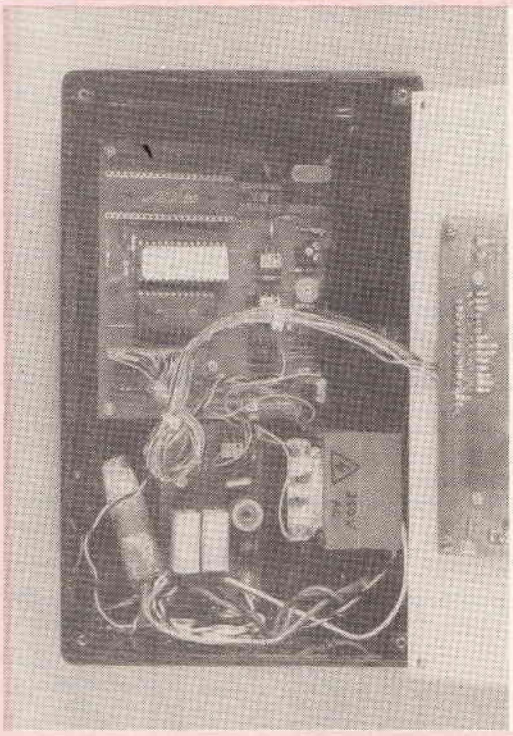
If the output of IC2 remains low for a period shorter then the pulse generated by IC3a, then the output of IC3b will go low at the end of the fixed pulse period.

Figure 21 shows this more clearly. An override switch SW1 is provided to toggle the output of IC3b, and thus the switching relay.

The Switching Relay and Power Supply.

Transistor Q6 provides a driver circuit for the mains switching relay. The LED indicates when this relay is operated.

The power for the remote switching unit is derived from the mains by transformer T1. This reduces the voltage to approximately 12V which is rectified by diodes D3-D6. The resulting voltage is smoothed by capacitor C6. IC1 provides a regulated +5 volt supply for all the other IC's in the circuit.



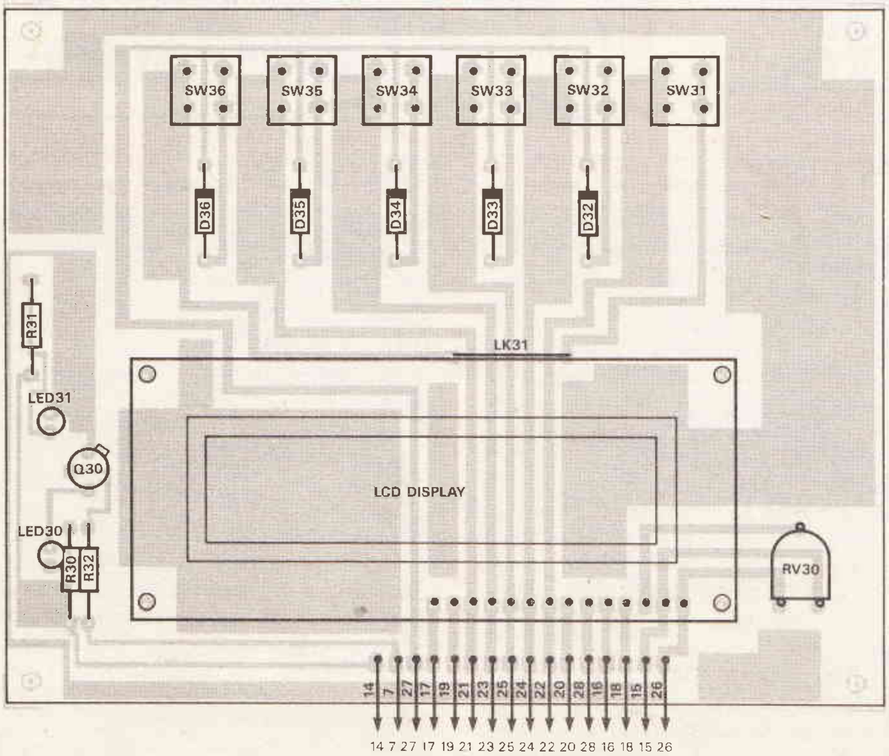


Fig.14 Display PCB Layout

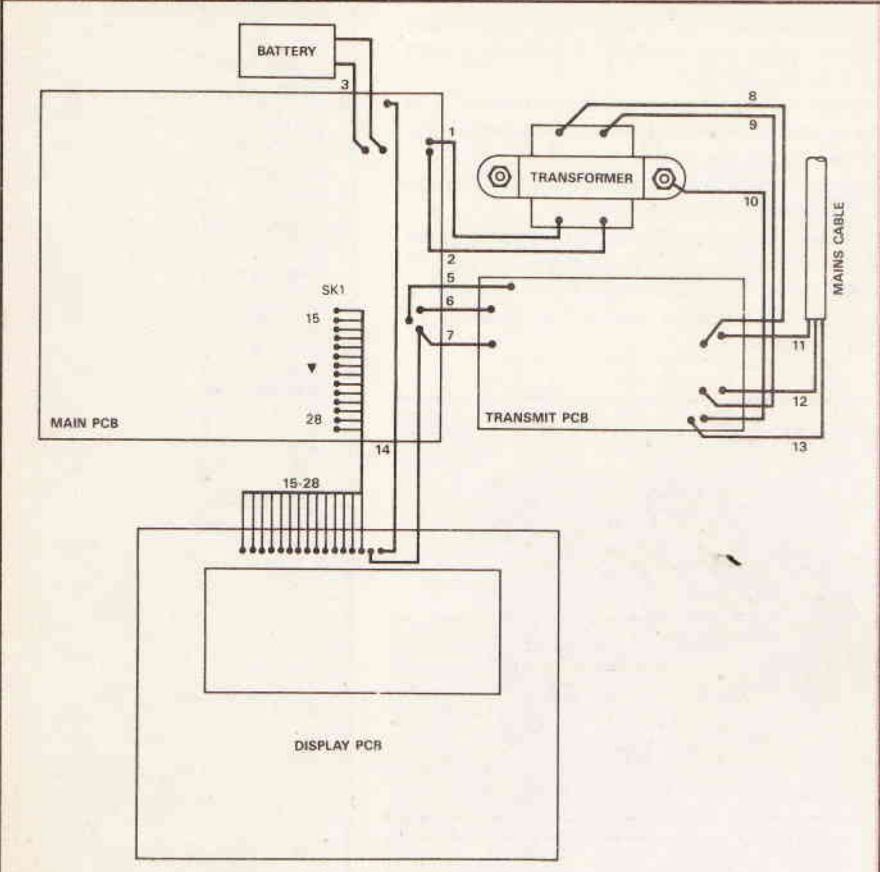


Fig.15 Main Control Unit — Inter PCB wiring

No.	USE		No.	USE
1	12V AC SUPPLY		15	+5V
2	12 AC SUPPLY		16	ADDRESS A1
3	BATTERY +VE		17	DATA D7
4	BATTERY −VE		18	ADDRESS A0
5	−5V		19	DATA D6
6	0V		20	DATA D0
7	XMIT CONTROL		21	DATA D5
8	240V AC LIVE	TO TRANSFORMER	22	DATA D1
9	240V AC NEUTRAL	TO TRANSFORMER	23	DATA D4
10	240V AC EARTH	TO TRANSFORMER	24	DATA D2
11	240V AC LIVE	FROM MAINS SUPPLY	25	DATA D3
12	240V AC NEUTRAL	FROM MAINS SUPPLY	26	0V
13	240V AC EARTH	FROM MAINS SUPPLY	27	KEY
14	+12V		28	ENABLE

PROJECT

PARTS LIST

MAIN PCB

RESISTORS (all 0.6W 5%)

R1	1k
R2,11,17	1k
R3,6,7,15	47k
R4	*see text
R5,13	680R
R8	220k
R9	1k2
R10,16	22k
R12	27k (Fig. 4 R12 should be labelled 27k)
R14	330R
RV8	47k (horizontal min preset)
RV10	10k (horizontal min preset)

CAPACITORS

C1,5	10n disc ceramic
C2	220µ/25V single ended elec
C3,4,7	100n disc ceramic
C6	330p ceramic
C8	22µ/25V single eneded elec
C9	1n disc ceramic

SEMICONDUCTORS

D1,2,3,4	1N4001
D5,7,8,9,11,12,13,14	1N914
D6	BZY88C 9V1
D10	BZY88C 5V6
IC1	741 op-amp
IC2,3	TLC555 CMOS 555 timer
IC4	74HC14 Hex schmitt trigger
IC5	Z84C00A CMOS Z80 Microprocessor
IC6	27C64 CMOS 64K EPROM (Programmed)
IC7	6116/446 CMOS 16k static RAM
IC8	74HC373 Octal Latch
IC9	4011 Quad 2 i/p NAND
IC10	Opto isolator
Q1	BFY51
Q2	BC108

MISCELLANEOUS

XTAL1	1.842MHz crystal
FS1	250mA 20mm fuse
Fuse clips	(2 off)
I/C sockets	1×40 way 1×28 way 1×24 way 1×20 way 2×14 way 2×8 way
Case	M1005 156×91×47mm (Maplin LH63T)
Transformer	miniature 12 Volt 250mA

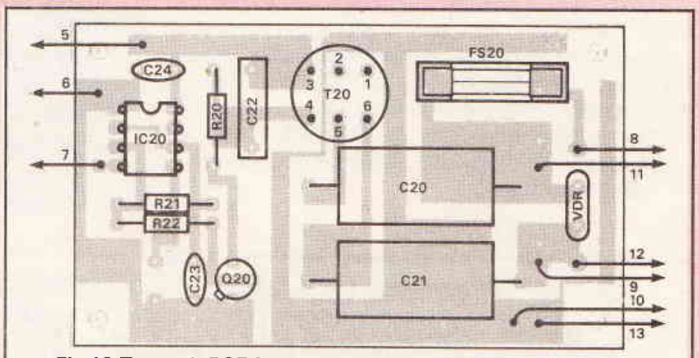


Fig.16 Transmit PCB Layout

PARTS LIST

TRANSMIT PCB

RESISTORS (all 0.6W 5%)

R20	56R
R21	3k9
R22	4k7

CAPACITORS

C20,21	220n 250V AC working (Maplin JR35Q)
C22	47n polyester
C23	1n disc ceramic
C24	100n disc ceramic

SEMICONDUCTORS

Q20	BC108
IC20	TLC555 CMOS 555 timer
VDR	Transient suppressor (Maplin HW13P)

MISCELLANEOUS

T20	Transformer coil (Maplin FT55K)
FS20	250mA 20mm fuse
IC socket	1×8 way

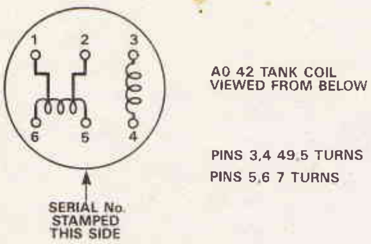


Fig.17 Coil Transformer pin layout

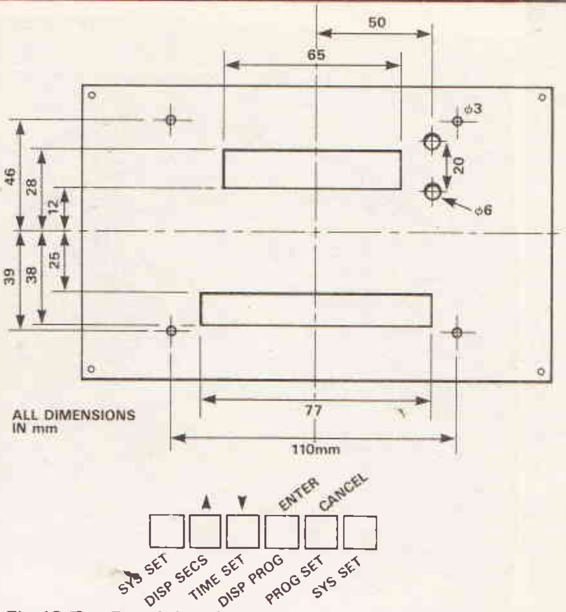


Fig.18 Top Panel details

PARTS LIST

DISPLAY PCB

RESISTORS (all 0.6W 5%)

R30,31	820R
R32	22k
RV30	10k (horizontal min preset)

SEMICONDUCTORS

D32,33,34,35,36	1N914
Q30	BC108
LED30	5mm yellow
LED31	5mm red

MISCELLANEOUS

Display module	EA-D16015AR (stc part No. 029662B)
SW31–SW36	Click effect push switch. (6 off) (Maplin FF87U)
Caps for switches	Black (Maplin FF88V) (6 off)
LED clips	5mm (2 off)

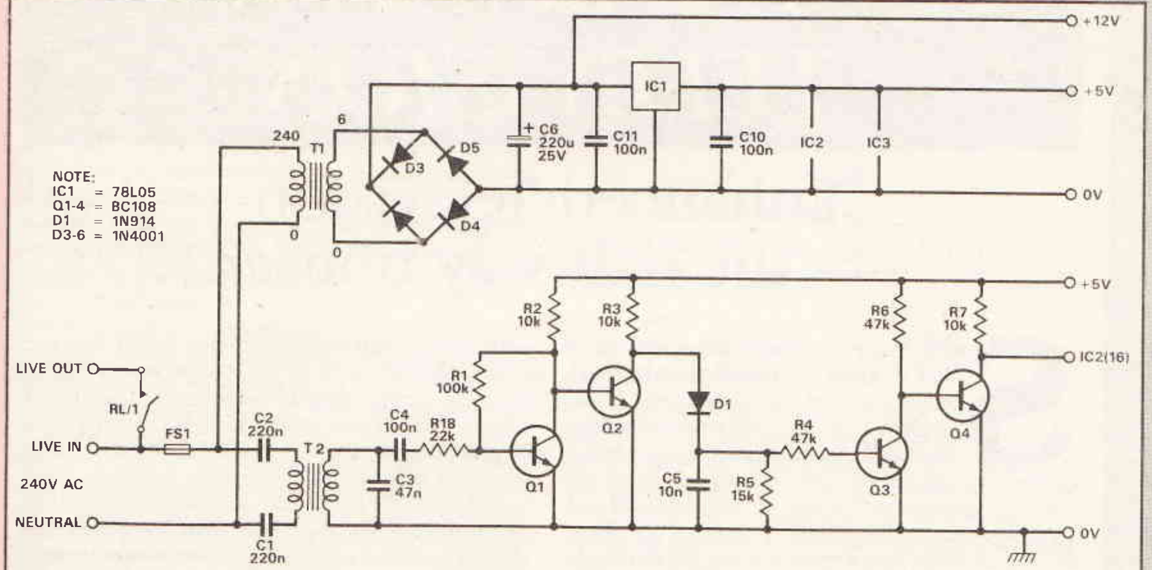


Fig.19 Remote Switch Unit — PSU and Tone Decoder

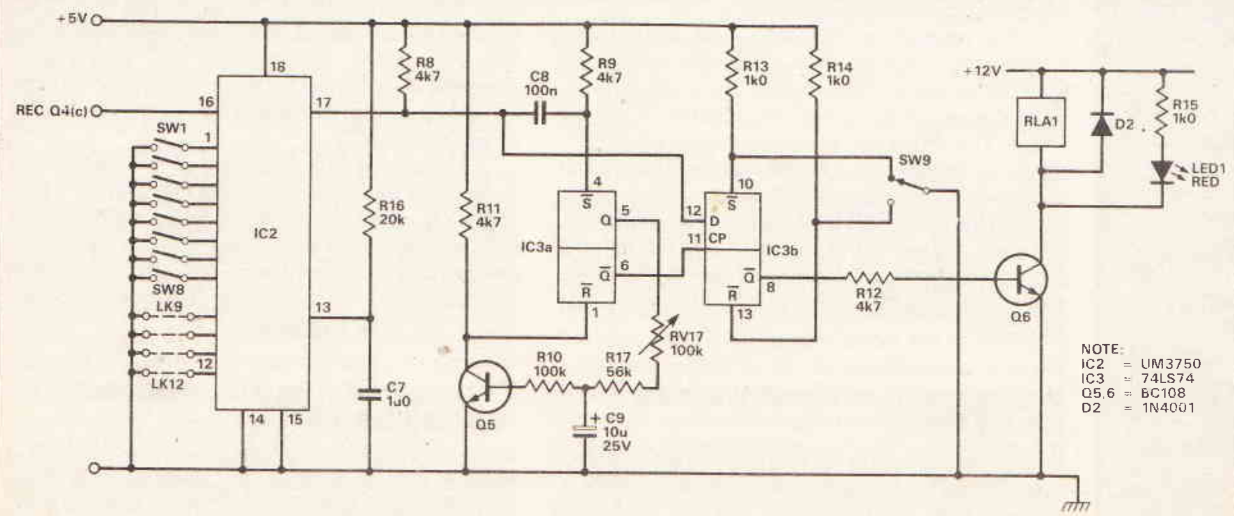


Fig.20 Remote Switch Unit — Decoding and Switching

TO BE CONTINUED

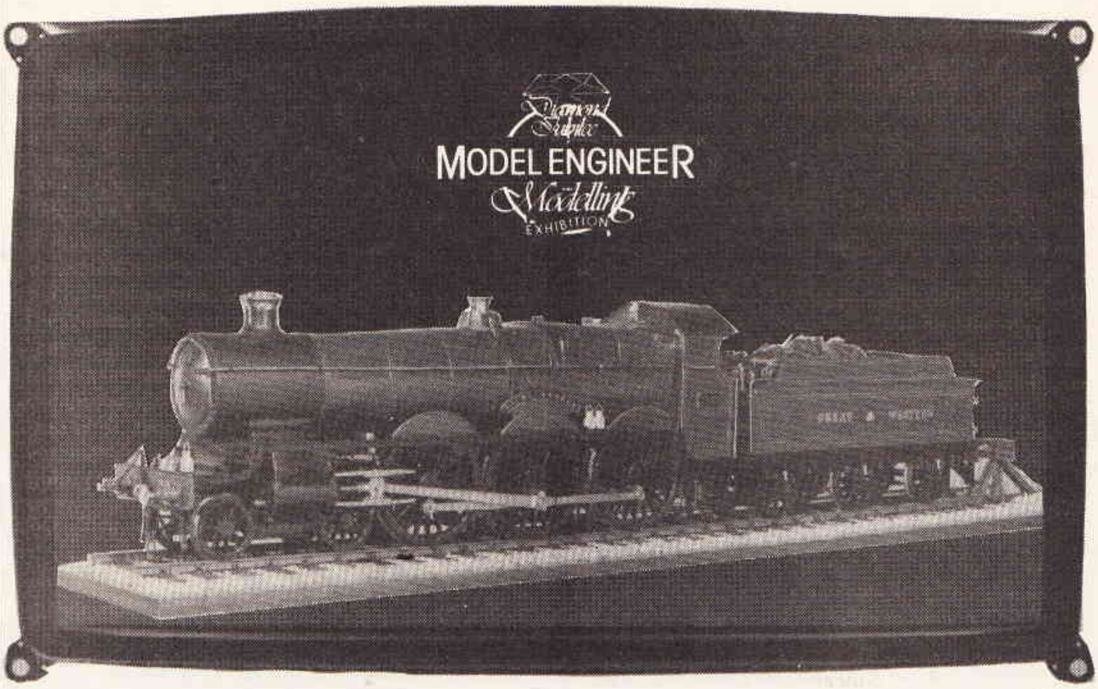


Fig. 1 Widescreen (16:9) aspect ratio tubes are now being manufactured for use in enhanced systems. Courtesy Philips Components.

4

HIGH DEFINITION TELEVISION

Enhanced Television — the half way house?

James Archer looks at the possible intermediate, steps the television industry is taking to the ultimate goal of HDTV.

Since it will be several years before an HDTV system providing widescreen pictures can be introduced, and it will probably be some years after that before reasonably priced receivers appear in the shops, manufacturers are looking at ways of introducing receivers that can provide improved and enhanced pictures before HDTV appears. We saw in a previous article that source and display standards can now be independent of each other, and one method of taking advantage of this is already appearing in domestic receivers.

If a receiver is fitted with field storage and interpolation circuitry, then a 625-line progressive scan picture can be built up from the incoming interlaced signals, using the technique shown in the last article. This enhanced television picture provides a significant improvement in perceived resolution, and eliminates inter-line flicker, without any change being made to the basic MAC transmitted signal. Effectively, this is making use of the second step of the step-by-step approach to HDTV explained last month, where an improved system using a 625/50 display was introduced.

Widescreen without waiting for HDTV

The marketing men in the receiver industry are keen to see the early introduction of widescreen receivers, because they are convinced that the noticeably different shape of the screens will persuade those people who must have everything that is new and different to rush out and buy such receivers. One of the more cynical salesmen was heard to say that 'the Joneses' would buy such a receiver because their neighbours would be able to tell the difference, even when it is switched off! Fortunately there is no need to wait for HDTV before such widescreen pictures can be transmitted, and the British DBS operator BSB is already providing widescreen transmissions of feature films, which being originally intended for the cinema, are already originated in a widescreen format. We have seen earlier that as far as viewers with MAC receivers are concerned, widescreen transmissions are fully compatible with ordinary 4:3 aspect ratio receivers, so audiences for these films should be high, since they will not be restricted to viewers with wide screen receivers.

After seeing demonstrations of 16:9 aspect ratio widescreen pictures on receivers that provide a progressively scanned 625-line display, many viewers have expressed the view that these pictures are as good as they could want, and some people even feel that there is no need to make the final move to 'proper' HDTV for home receivers.

Extended definition without waiting for HDTV

It is even possible to extend the definition of 625-line MAC pictures so as to provide some increase in the horizontal resolution of the 625-line widescreen MAC pictures, with no loss of compatibility. This work was

HDTV

pioneered by the research engineers of the IBA , and the basic idea is to increase the transmitted luminance bandwidth from its normal 5.6MHz to around 8MHz, which results in a channel base bandwidth after compression of about 12MHz, rather than the 8.4MHz of a normal MAC transmission. Special non-linear pre—and de-emphasis circuitry has been developed, which automatically alters the amplitude/frequency response according to the level of the signal, and using this technique the extended MAC signals can be transmitted over a normal satellite channel with no significant increase in noise or interference to other channels. A standard MAC receiver, which may not initially be fitted with the modified de-emphasis circuitry, still provides first class pictures, which actually appear slightly sharper than normal MAC transmissions because of an edge-crispening effect which occurs.

This type of enhanced 625-line MAC system can provide good results when viewed on screens with a diagonal of about 1 metre at a viewing distance of three times the screen height, some people, including a technically knowledgeable Member of Parliament, have suggested the UK government should stop contributing money to the EUREKA EU95 project, and should instead concentrate its resources on encouraging British industry to concentrate on the development and production of enhanced television. The argument is that most viewers will not be able to tell the difference between true HDTV and the enhanced pictures, so it might make sense to begin compatible enhanced 625-line transmissions very soon, delaying the jump to a full HDTV system until such time as new digital HDTV systems are developed. A completely new digital system would not suffer from the political disadvantage of being associated with any current system, so it might be possible to gain agreement on a single world standard, and even CCIR groups that are currently working towards a common analogue HDTV system recognise the long term future for HDTV lies in the digital domain. Possibilities for future digital HDTV systems are discussed later.

Whatever the suggested final outcome to go no further than extended definition before taking a digital path to HDTV, and it seems to me most unlikely that the UK would take such a different line from its European neighbours, it is beyond doubt that first class results can be obtained from 625-line MAC pictures, with the techniques described, and it may well be that large-screen improved definition images of this type will prove to be the next commercial step along the road to our eventual goal of HDTV. The EUREKA EU95 system with its goal of HD-MAC has many advantages over other systems, but its trump card must surely be that it has compatibility at every step. We have seen the steps up to HDTV from the production point of view, so now we end this article with the step by step approach as it may affect the viewer. We must remember that viewers (and manufacturers) will not necessarily have to take every step, they can stay where they are or can jump over one or more steps, as they wish; they can choose the improvements they want and are willing to pay for, at a time to suit their needs and budgets. We can only hope viewers will be able to obtain all the information they surely need to help them to make informed choices; at least the MAC chip set will provide the full choice of all the available sound systems, so the viewer will not have to choose between them!

A step by step guide to receiver improvments towards HDTV for an HD-MAC viewer are:

1. 625-line MAC interlaced 4:3 aspect ratio display, perhaps using an existing PAL receiver with a satellite adaptor feeding the receiver with signals via a peritelevision socket.
2. 625-line MAC progressively (sequentially) scanned 4:3 aspect ratio display.
3. 625-line widescreen interlaced 16:9 aspect ratio display.
4. 625-line widescreen progressively scanned 16:9 aspect ratio display.
5. 625-line widescreen progressively scanned 16:9 aspect ratio display with extra processing in the receiver to improve the display of moving parts of the image.
6. 1250-line HD-MAC HDTV widescreen interlaced display.
7. 1250-line HD-MAC HDTV widescreen progressively scanned display.
8. 1250-line HD-MAC HDTV widescreen progressively scanned display with extra processing to improve the display of moving parts of the image.

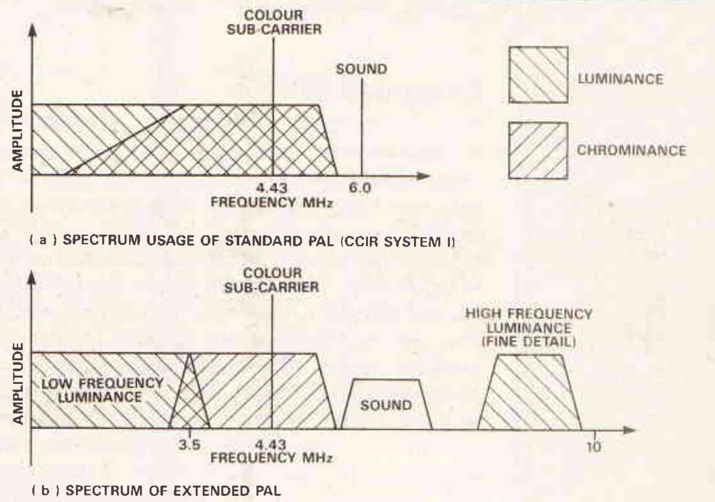


Fig. 2 Principles of the Extended-PAL system.

Enhanced television — The Japanese have it too

In parallel with the European work on enhanced television, the Japanese have been developing a method of providing better quality pictures from their 525-line NTSC system for those viewers who are prepared to buy new television receivers equipped with extra processing circuitry. The system is called Clear Vision (their HDTV system is Hi-Vision) and the pictures are actually originated using the HDTV 1125/60 studio standard. These pictures are down-converted in the studio to 525-line form, and generally have higher resolution than conventional 525-line pictures. Special signals are inserted in the vertical blanking period of the 525-line pictures, to eliminate reflections and ghosting which are picked up along the transmission path.

The Clear-Vision receiver is fitted with frame stores to display a 525-line progressive scan picture, giving increased perceived vertical resolution in enhanced MAC receivers. The ghost-cancelling circuitry in the receiver compares the timing (position) of the received pulse that was transmitted in the frame blanking interval with the sync pulses and an internally generated pulse. The circuitry calculates the delay of the reflected signal and cancels out the ghost image. Receivers are also fitted with sophisticated filtering to give better separation of the NTSC colour from the black and white image. The overall impression is of very much better pictures than are normally seen from NTSC. These transmissions are of course totally compatible with the existing 525-line receivers; apart from the ghost cancellation pulses the transmitted signals are virtually the same as normal NTSC transmissions. Just as with the European enhanced MAC transmissions, some Japanese pundits are already saying that Clear-Vision pictures are so good there is no need to progress to the Hi-Vision 1125/60 system. Work has already begun on finding ways of adding extra sides to the 525-line pictures in a compatible way, so widescreen pictures can be transmitted.

Enhanced Television — It doesn't have to be MAC

Enhanced television systems with many different characteristics are being looked at in broadcasting research laboratories throughout the world, as broadcasters realise that if their existing PAL, SECAM, and NTSC services are not as 'second-class' in comparison with widescreen HDTV pictures from cable and satellites, something must be done to improve them.

Extended PAL

As far back as 1981 the BBC described and developed an extended PAL system which virtually eliminated cross-colour from the PAL signals, and gave an improvement in resolution for viewers who were prepared to buy new receivers. The BBC intended these signals to be carried over DBS satellite channels, but as mentioned earlier, the UK government eventually decided that MAC would be used for this purpose. The system made use of the extra bandwidth, available over a DBS satellite channel, and it was reasonably compatible as far as viewers with existing receivers were concerned, but reduced the visible detail in some pictures. The system gave rise to a small reduction in the signal to noise ratio of the pictures.

The basic idea was to sharply filter the luminance signal at 3.5MHz, which meant the viewer, with a conventional receiver, would see no luminance detail above this frequency. Although this gave him the disadvantage of seeing less picture detail, in practice this disadvantage was overcome by the fact that no cross-colour patterning occurred. The luminance band frequencies above 3.5MHz were not discarded after filtering, but were frequency-shifted above the normal video band to the region 8-10MHz above the carrier, used in higher quality receivers, and could provide higher resolution pictures, again without cross-colour. The noise in an FM satellite channel is concentrated at the high frequency end, and since the high-frequency luminance parts of the extended-PAL signals extend as high as 10MHz, these pictures would be subject to a higher level of noise than ordinary PAL pictures.

Other TV techniques

Recently the BBC has come up with ideas for applying the newer techniques developed for higher definition MAC-based signals, to PAL pictures. One idea uses the technique of digital assistance, and at its simplest, the terrestrial transmitter would beam a basic 625-line picture, derived from a higher definition picture by subsampling. Digital signals transmitted along with the ordinary 625-line picture, in the field blanking period, tell the receiver what information from the original picture was thrown away in the subsampling process, also some information about the movement of various areas of the picture. Using this type of technique, it may be possible to transmit 625-line pictures from our terrestrial sources providing almost HDTV quality, and giving viewers normal PAL pictures.

Q-PAL

The University of Dortmund has built some prototype equipment based on theoretical work originally suggested by the BBC, for a system known as Q-PAL, short for Quality-PAL. This manages to eliminate cross-colour and cross-luminance on specially designed receivers, whilst providing standard PAL receivers with compatible signals. To achieve this, multidimensional filtering techniques are used at the source, giving a true three-dimensional frequency multiplex between the luminance and chrominance parts of the signal. The Q-PAL receiver is then able to separate the two components cleanly. It has been found that such a receiver even provides improved quality pictures from standard PAL transmissions because of improved filtering circuitry. Q-PAL signals can be received on conventional receivers.

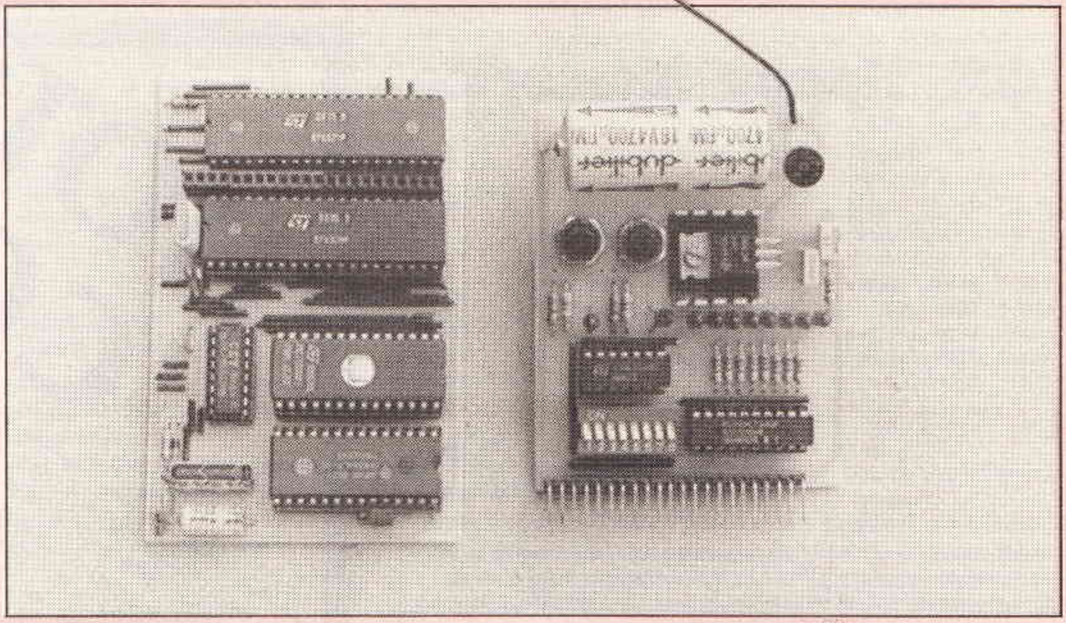
I-PAL

The I-PAL system, developed by the German Institute for Radiotechnology, (IRT), uses the novel technique of carrying only full bandwidth luminance information, without any colour, on alternate lines of the television picture. The other lines carry low frequency luminance, up to about 3MHz, frequency multiplexed with a quadrature modulated chrominance subcarrier, similar to a standard PAL system. In the receiver, information for each line is delayed and then added to the following line. This gives increased luminance resolution and eliminates cross-effects. Some problems in compatibility have been found, and a modified version called I- PAL-M has been developed to try to overcome these.

PALplus

Work on improved PAL systems such as Q-PAL and I-PAL but which can also provide wide aspect-ratio pictures has led to the idea of a PALplus system, which could be transmitted compatibly over existing networks and yet allow those viewers who choose to buy enhanced receivers to obtain better quality widescreen pictures. A PAL strategy group has been formed to try to reach a consensus amongst European manufacturers and broadcasters about the best ways of moving towards the adoption of such a system.

Many other different methods of compatibly providing improved quality pictures and widescreen displays are being worked on with great zeal in different parts of the world. Much of the technology described in the following part of this article, about plans for American Advanced Television services, can be applied to existing terrestrial transmissions, not only in America, but in other countries as well.



The ETI SBC-09

A general purpose 6809 Micro-Controller by Mike Bedford

PROJECT

A microprocessor can be viewed in two different ways. For the electronics/computer enthusiast it is the heart of a computer, the alternative is an electronic component and is not necessarily a computer in the normal sense of the word. In presenting a microprocessor control board, this article stays clear of the normal domain of home computing and adheres to this second definition.

Using a microprocessor in something other than a home computing application is not new to ETI but this project does, nevertheless, break some new ground. We have previously published some projects with a dedicated microprocessor, the firmware for which was available as a "plug in and go" component. We have also presented some control boards without dedicated firmware which can be programmed to carry out any conceivable application limited only by the builder's imagination. This project is such a general purpose microprocessor module but gives the following ETI 'firsts':

- This is the first control board to use the Motorola 6809 processor, considered by many to be the most powerful 8 bit micro-processor, having a number of 16-bit registers and instructions.
- This is the smallest control board so far at 4.15" x 2.9" yet includes 20110 bits, 2k or 8k of RAM and 16k of EPROM.
- This is the first time we have guided potential constructors in the art of firmware development and assembler programming of the appropriate processor.
- This is the first time we will have actively encouraged design of dedicated projects using a control board as a component with the intention of publishing some of these, contributions permitting.

Features At A Glance

The SBC-09 uses the Motorola 6809 microprocessor. This is one of the later generation of 8-bit processors. Those more familiar with the concept of a microprocessor as the heart of a personal computer, an 8-bit project may seem rather dated when viewed in the light of most of today's home computer offerings. Let's justify this choice. The features which we expect to find on a 16-bit or 32-bit processor which differentiate them from the 8-bit counterpart (other than the obvious one of a wider data bus) are high speed, ability to access large amounts of memory, a more comprehensive instruction set and as we go further still up the ladder, support for multi-tasking and virtual memory. Most rules have their exceptions and, in a control application, the processor is taking the place of a handful of logic ICs to do a comparatively simple task and so long as the outputs change in somewhat less than human reaction time when the controls are operated then everybody's happy — so much for speed! A simple set of rules doesn't give rise to a long program and it really is surprising how much assembler code can be crammed into 2k, let alone the 16k of program space we are offering. Similarly most control applications don't need large amounts of data storage. Clearly sophistication such as multi- tasking support and virtual memory would find application in only the most esoteric of control applications and

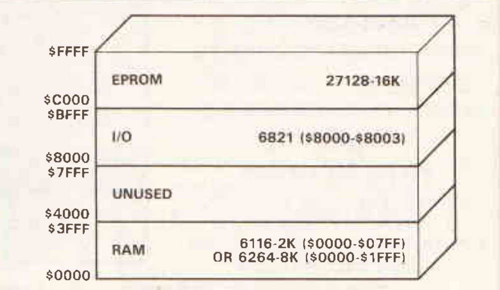


Fig.1 Memory map

so we are left with the larger instruction set. This would be nice, especially since the board will most likely be programmed in assembler language — but is this alone really worth the higher price tag, the larger package size and a longer code which would result? We have chosen the 6809 as a compromise between 8-bit and 16-bit processors. This contains two 16-bit index registers, a pair of 8-bit arithmetic registers which combine to form one 16-bit register under certain circumstances and the instruction set contains 16-bit versions of the load, store, add, subtract and compare instructions and even an 8-bit x 8-bit multiply, certainly a rarity in the 8-bit world.

Turning to the EPROM, we have gone for the 27128, 16k x 8 device here and very much doubt if anyone will fill it. We could have put links in to allow smaller EPROMs to be fitted but when you look at today's pricings you'll see why we didn't bother —it actually costs more now for some of the smaller, less used devices.

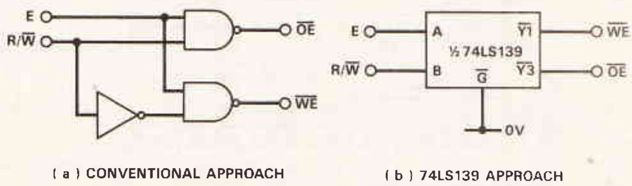
The pricing situation regarding RAMs is not the same as that just described for EPROMs and accordingly, working on the assumption that control applications don't need much in the way of data storage area, it was originally intended to provide just the 6116, 2k x 8 static RAM. However, since one of the author's first intended applications of this board is the exception which proves the rule, at the expense of a link, the board can now alternatively take the 6264, 8k x 8 RAM.

The one feature, without which a control computer could not control is its input and output facilities. These are provided by the 6821 PIA (Parallel Interface Adapter). This chip has 16 general purpose input/output pins and 4 rather more specialised pins. The general purpose pins may be programmed by the processor such that each may be an input or an output whereas the other four have some additional facilities such as being able to generate interrupts. All input and output is at TTL levels but the 6821 has quite a limited drive capability. This being so, there is a likely need for some extra circuitry in the form of buffers, Darlington drivers and the like, but since this will vary from one application to another it has not been included on board. Connection to the 6821 is via 20 ways of a 22-way 0.1" pitch socket strip and it is expected that this will be used to connect to a further application specific card. This can contain all the interface circuitry and the mains power supply.

The memory map is shown as Figure 1 and this information will be required when it comes to writing the firmware. It may be seen that RAM starts at $0000 and runs through to $07FF if the 6116 is fitted or to $1FFF for the larger 6264 chip. Since this card has a very simple memory map, which is not fully decoded, this memory will repeat within the block $0000-$3FFF. In other words the 6116 will be 'seen' again at $0800, $1000, $1800, $2000, $2800, $3000 and $3800 whereas the 6264 will have just one other occurrence at $2000. The next 16K block is unused and the 6821 is found at $8000. The second part of this series will describe the PIA in more detail from a programming point of view, contains 6 internal registers and occupies only 4 bytes in the address map due to non-standard register addressing. Since this simple map allocates 16K to it, it repeats 4,096 times within the $8000-$BFFF block. No volatile memory must exist at addresses $FFF0-$FFFF of a 6809 processor since this is where the vectors are stored. This being so, the EPROM has been put at the top of the address map. The 27128 completely fills its 16K block so there are no "ghosts" here!

Construction

This is a simple board to construct and no difficulties are anticipated. To keep the cost of the PCB down it is a single sided design and it is recommended that the first task is to fit the insulated wire links which inevitably result from such a design. The various passive components should then be fitted, leaving the ICs until last. It would be wise to use sockets for all the ICs but if it is decided not to do this then do remember that a socket is a must for the EPROM. If the firmware is to be developed using an emulator then an ordinary socket will suffice for the EPROM. If firmware development is to consist of repeated erasing and re-programming of the EPROM then a good quality (ie turned pin) IC socket should be used as repeated un-pluggings and pluggings could easily destroy (or make un-reliable) a lesser socket. If this question of the method of firmware development is a mystery to you then you'll have to wait until the next part of this article covering firmware development. A point which should be borne in mind when fitting the sockets and subsequently the ICs is that contrary to



(a) CONVENTIONAL APPROACH

(b) 74LS139 APPROACH

E	R/$\overline{W}$	$\overline{OE}$	$\overline{WE}$
1	1	0	1
1	0	1	0
0	1	1	1
0	0	1	1

(c) TRUTH TABLE

Fig.2 OE/WE Cicuitry

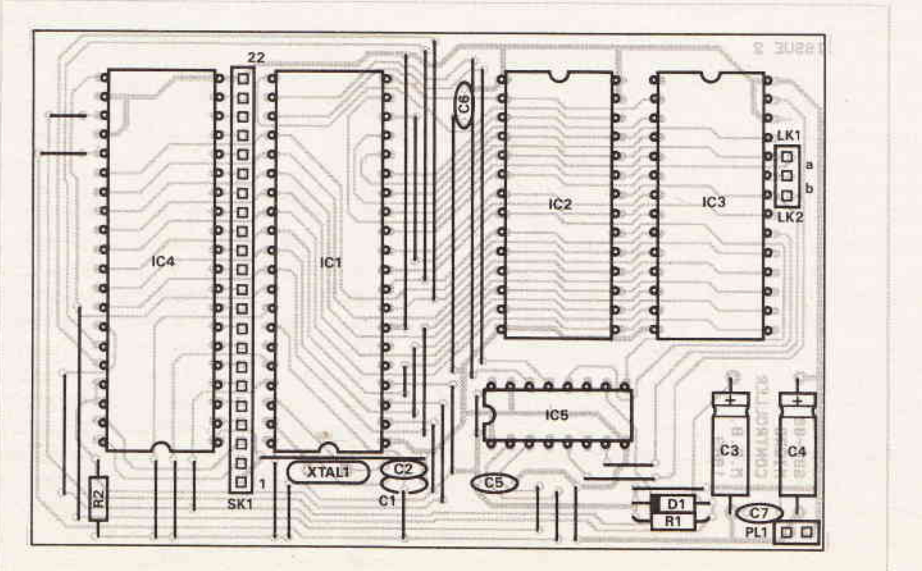


Fig.3 Component overlay of SBC-09 Micro-Controller

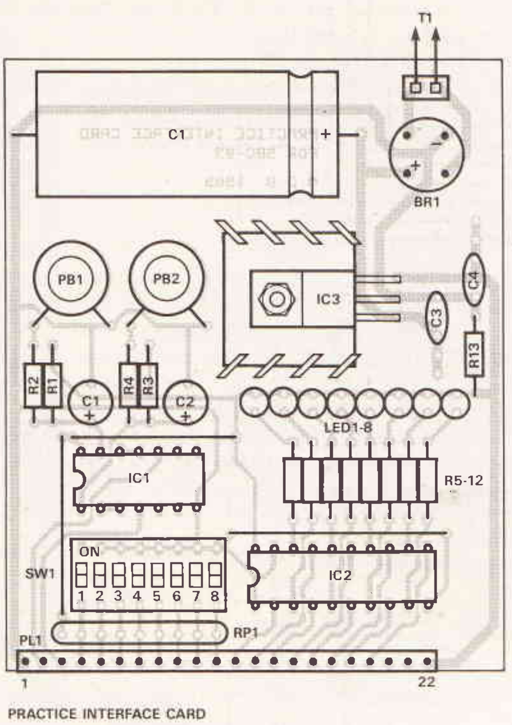


Fig.4 Component overlay for Practice Interface Card

normal practice, in order to simplify the artwork and accordingly keeping the board size to a minimum, the processor and PIA are rotated through 180° with respect to the EPROM and RAM (ie pin 1 is at the opposite end). Failure to notice this will most likely result in some fried chips! Care should also be taken if using a 28-pin socket for IC3 to allow either the 6116 or the 6264 to be fitted. In this case, when the 6116 is used, 4 pins of the socket will be unused and the IC should be plugged into the bottom portion of the socket (ie socket pins 3-26). Since the board is quite compact, the tracks run fairly close together, increasing the likelihood of generating shorts with solder blobs. It is therefore recommended that the finished board is subject to more than a cursory glance before plugging in the ICs and connecting a power supply. Having built the SBC-09, how is it possible to tell if it actually works ? This is where the practice interface board comes in. Assuming that the would-be constructor of the SBC-09 intends to learn something of the art of firmware development and 6809 assembler in particular then he will need to build this small practice card as its use is assumed in the forthcoming instalment on firmware development. Testing is described in the following paragraph, following which are details of the practice interface card.

Testing

In order to test the SBC-09, the data shown in Table 1 should be programmed into the 27128 EPROM which is then plugged into its socket. The practice interface card is now attached to the SBC-09 card and power applied. When the switch is thrown, all the

HOW IT WORKS

All this is really very simple with the complicated circuitry being confined to the insides of the various chips. Most of the connections are between pins of the same name on the different ICs, so, the data bus, D0-D7, is paralleled on the processor, RAM, EPROM and PIA. The same is true of the address bus but since the space occupied in the address map is different for the EPROM, RAM and PIA (and in no case is it the full 64K), not every address bit goes to every device. As an example, the PIA, only needs 2 address bits (A0 and Al) as it occupies only 4 bytes (2^2). It should be noted that the 2 address inputs on the 6821 PIA are not called A0 and Al but instead are referred to as RS0 and RS 1 (Register Select 0 and 1). The EPROM, RAM and PIA each need a $\overline{CE}$ (Chip Enable) signal, known as $\overline{CS}$ (Chip Select) on the RAM, and these are not available directly from the processor. Instead, circuitry needs providing which generates these active low signals to give the required address map. So long as we don't require a fully decoded address map (ie one where devices don't repeat at extra positions) which leaves the maximum of unused space for further memory or peripheral devices, this can be achieved with half a 74LS139, dual 2 to 4 line decoder. This functional block takes in the top two address bits, A14 and A15, and gives a low at one of its 4 outputs for each of the possible binary combinations. We use only 3 of the outputs, $\overline{Y0}$, $\overline{Y2}$ and $\overline{Y3}$ for the RAM, PIA and EPROM respectively. Since these are low for (A14=0, A15=0), (A14=0,Al5=1) and (A14=1, Al5=1) respectively it is clear that the 3 chips are enabled for the required address ranges \$0000-\$3FFF, \$8000-\$BFFF and \$C000-\$FFFF. Each read/write device also needs a further 2 control inputs to initiate memory accesses whereas read only devices need only 1 signal. In the RAM these signals are $\overline{OE}$ (Output Enable) and $\overline{WE}$ (Write Enable) but the EPROM doesn't have this latter one. $\overline{OE}$ and $\overline{WE}$ initiate read and write respectively, are active low and are required after the address has been set up.

Unfortunately the 6809 processor does not generate such signals as outputs but does have a R/$\overline{W}$ signal which changes state at the same time as the address bus and indicates whether the current memory cycle is a read or a write. The 6809 also outputs an E clock signal which becomes low in the second half of every memory cycle (ie after the address has been set up). Figure 2a shows the textbook approach of combining these two 6809 outputs to give $\overline{OE}$ and $\overline{WE}$. In order to keep the chip count down we haven't done this but instead have used the previously unused half of the 74LS139 to do the same job, as shown in Figure 2b. The two are equivalent. The 6821 PIA is a part of the 6800 family and is therefore easier to interface to the 6809, having R/$\overline{W}$ and 02 (equivalent to E) instead of $\overline{OE}$ and $\overline{WE}$. These inputs are connected directly to the processor. The 6821 is the only device which can generate interrupts, it has two such outputs, $\overline{IRQA}$, and $\overline{IRQB}$ for port A and port B respectively. To simplify the design it was decided to cause these two signals to generate the same interrupt on the 6809, namely $\overline{IRQ}$ as it is easy for the firmware to determine the exact source of any interrupt by reading the appropriate 6821 registers. This being so we have connected the two interrupt outputs together (which is permissible as they are open collector) and routed them to $\overline{IRQ}$ on the processor. Since the interrupt outputs are open collector, a pull-up resistor is used. The other two interrupt inputs on the processor ($\overline{FIRQ}$ – Fast Interrupt Request and $\overline{NMI}$ – Non Maskable Interrupt) are unused are therefore connected to the +5V supply. The 6809 has a built in clock, further reducing the chip count, and only requires a crystal attaching between XTAL and EXTAL and a 24p capacitor between each of these pins and 0V. For a 1MHz processor a 4MHz crystal is required. The $\overline{RST}$ input needs to be pulsed low to reset the processor hence causing the code at the reset vector address to be executed. This shoul happen at power on and the circuitry comprising, D1, R6 and C8 is the standard data sheet configuration to provide power-on reset. $\overline{RST}$ is also routed to the 6821 to reset this at power on. Various unused inputs are held in their inactive states which in all cases happens to be high and is therefore achieved by connection to +5V. These signals are $\overline{DMA}$ (Direct Memory Access), $\overline{HALT}$ (self evident) and $\overline{MRDY}$ (for slow memories) on the 6809, $\overline{PGM}$ (Program) on the EPROM and extra active high chip selects on both the RAM and the 6821. C4 and C5-C7 are reservoir and decoupling capacitors respectively and serve to pervent harmful glitches on the power supply.

LEDs should be extinguished. PB1 should now be pressed and released. This will cause the LEDs to count in binary, LED1 being the least significant. Subsequent presses of PB1 will alternately stop and start the LEDs counting. If all this works as described then there's a reasonable chance that the board is fully functional. At the very least, you will be able to say with confidence that the processor can 'talk' to the EPROM, the RAM and the PIA. If it doesn't work, there really isn't too much that could be wrong except for shorts and open circuits. A few minutes looking at the processor pins with a logic probe and a magnifying glass should reveal any such problems.

1FF0	C0	07	C0	07	C0	07	C0	07	C0	00	C0	07	C0	07	C0	07
0000	7D	80	00	73	01	01	3B	10	CE	01	00	7F	01	01	7F	80
0010	01	7F	80	00	86	05	07	80	01	7F	80	03	86	FF	07	80
0020	02	86	04	07	80	03	7F	80	02	1C	ET	7D	01	01	27	TO
0030	7C	80	02	8D	02	20	F4	10	8E	20	00	31	3T	26	FC	39

Table 1 : EPROM Data for Test Program

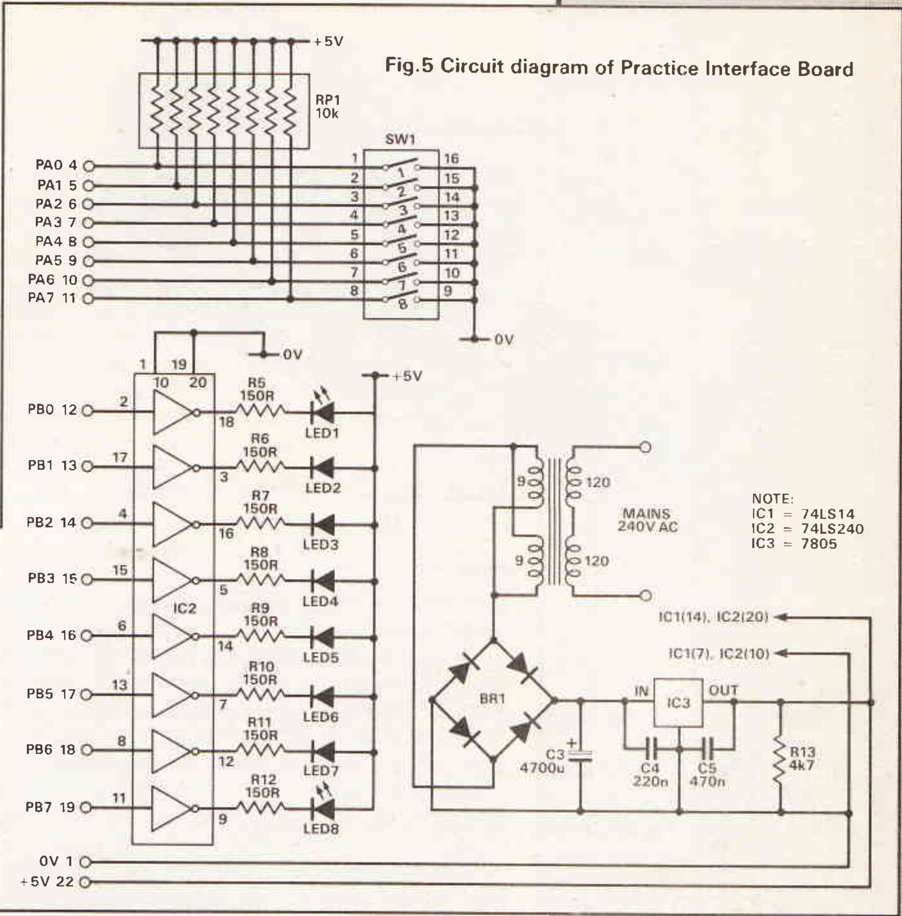
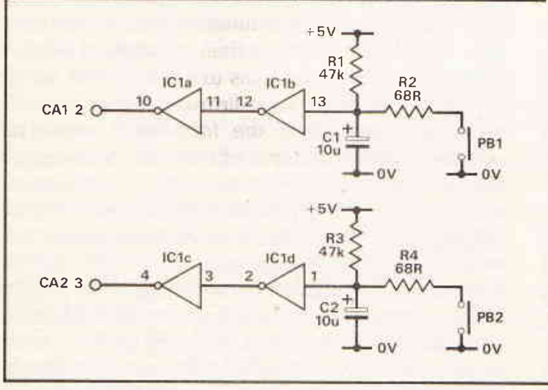


Fig.5 Circuit diagram of Practice Interface Board



PARTS LIST

INTEGRATED CIRCUITS

IC1	6809 (NB not 6809E)
IC2	27128
IC3	6116 or 6264
IC4	6821
IC5	74LS139

See alternatives given in section on the power supply

SEMICONDUCTORS

XTAL1	4MHz,HC18
D1	1N914

RESISTORS (all ¼W 5%)

R1	4K7
R2	10k

CAPACITORS

C1,C2	24p, Ceramic Plate
C3	100μ, 10V, Axial Electrolytic
C4	47μ, 10V, Axial Electrolytic
C5-C7	10n, Disc Ceramic

MISCELLANEOUS

PCB	
IC Sockets	2 x 40, 2 x 28, 1 x 16
0.1" Socket Strip	1 x 22 way (SK1)
0.1" Pin Strip	1 x 2 way (PL1), 1 x 3 way (LK2)
0.1" Jumper Link (LK2)	

PRATICE INTERFACE BOARD

INTEGRATED CIRCUITS

IC1	74LS240
IC2	7805
IC3	74LS14

SEMICONDUCTORS

B1	1A Bridge Rectifier (0.2" pitch square pin out)
LED1, LED-8	miniature red LEDs

RESISTORS (all ¼ W 5%)

R1,R3	47k
R2,R4	68R
R5-R12	150R
R13	4k7
RP1	10k, SIL pack, 8 commoned resistors

CAPACITORS

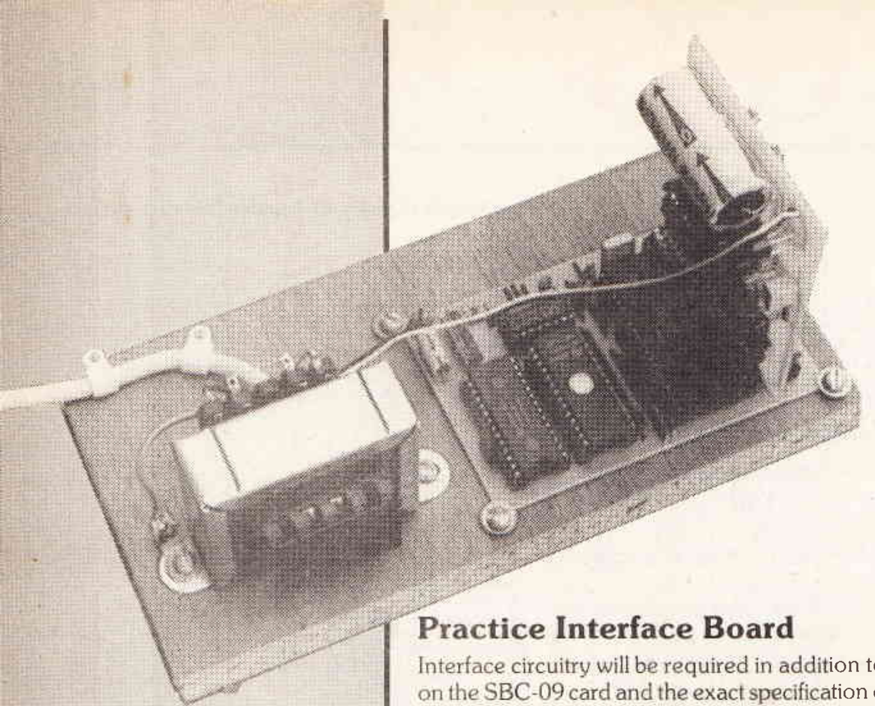
C1,C2	10μ 16V, Tantalum
C3	220n
C4	4,700μ 25V, Axial Electrolytic
C5	470n

TRANSFORMER

T1	0-9V, 0-9V @ 0.6A Mains transformer

MISCELLANEOUS

PCB	
0.1" Right Angle Pin Strip	1 x 22-way (PL1)
IC Sockets	1 x 22-way, 1 x 14-way
Heat Sink	TO220, 21°C/W
SW1	8-way, single pole DIP switch
PB1,PB2	momentary action, normally open push buttons



Practice Interface Board

Interface circuitry will be required in addition to that on the SBC-09 card and the exact specification of this will vary from one application to another. In order to get hands-on experience whilst learning to develop firmware for the SBC-09, we have designed a very simple circuit which has 8 LEDs to indicate the status of outputs, an 8-way DIP switch which provides inputs and 2 momentary action push buttons (with debounce) which provide interrupt inputs. This board also contains the circuitry (less transformer) of a suitable mains power supply. This card is so simple we really don't need to say much about its construction — just one point and a safety warning should suffice. First the constructional point. The push buttons are not intended for circuit board mounting. These should therefore be attached to the board through large diameter holes in the same way is if they were being fixed to a panel. Connections to the pads are then made with short lengths of insulated wire on the rear of the board. Now the safety warning. Since the combination of the SBC-09 and this interface card is used only for practising firmware development and 6809 programming it is unlikely that it will be housed in a case. This means that extra care should be taken to avoid contact with live parts. This means well sleeving the mains contacts on the transformer and ensuring that it has a good earth connection. It is also strongly recommended that both the SBC-09 and the transformer are screwed to a piece of chipboard to prevent stress on the interconnecting wires, that strain relief is provided for the mains cable to the transformer and that a plastic cover is placed over the mains transformer.

Design Of Interface Circuitry

The principles seen in the practice interface card may well be useful in the majority of applications, the major difference being the numbers of inputs and outputs. A 74LS240 has sufficient drive capability for LEDs but if something more substantial is to be interfaced then Darlington drivers would be required. On the 6821 PIA, Port B is able to source 2.5mA and is therefore able to drive a transistor base without TIL buffering whereas both Port A and Port B outputs are able to drive 1 TTL load. It may be necessary to debounce some inputs as are two of the inputs are on the practice board. This is most likely for interrupt inputs driven by switches/push-buttons so as to avoid multiple interrupts for the same depression. If non-interrupt inputs are driven by switches, the de-bounce could be carried out by the software — this will happen automatically if they are polled infrequently. Since there is no timer on the SBC-09, it could be that an oscillator driving one of the interrupt inputs is required on the interface board. This will generate regular, periodic interrupts and could be used for various purposes including regular polling of inputs. One point about the physical design of the card: On the

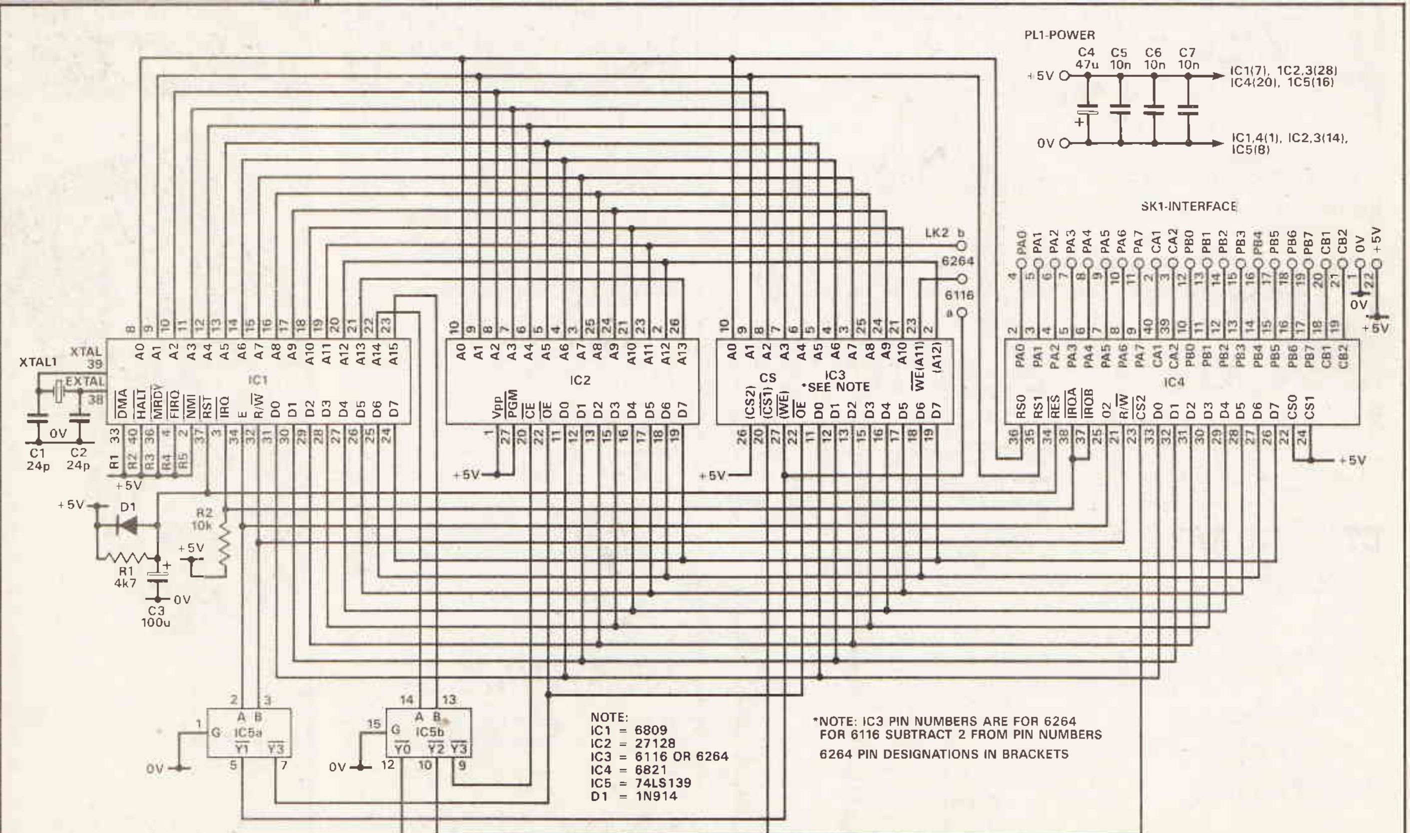


Fig.6 Circuit diagram of SBC-09 micro controller

the practice card, a right angle pin strip was used to make the board stand up from the processor card. In the majority of cases, LEDs, switches etc would be on a front panel rather than the interface card and in the interests of compactness, the interface card would therefore be required to lie flat (ie parallel to the SBC-09). Use of a straight pin strip will achieve this. Alternatively, use of ribbon cable would allow the two boards to be more widely separated.

Power Supply

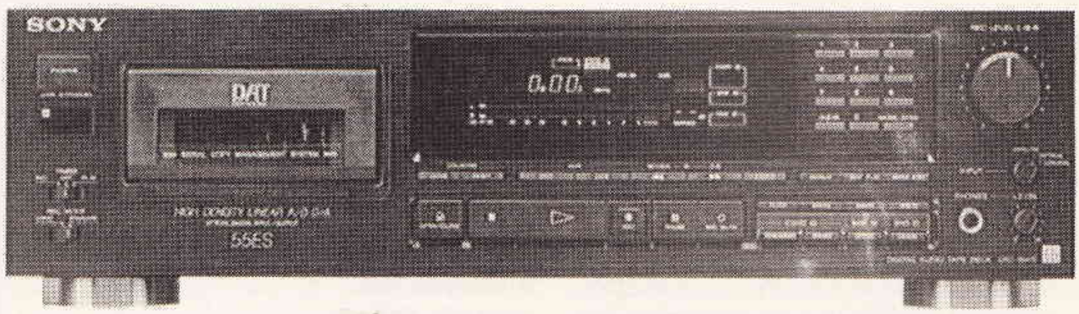
We haven't produced a power supply PCB for the SBC-09 although the practice interface board does have a built in supply. Most readers would not want a 3 board solution and would prefer to incorporate the PSU circuitry onto the application specific interface board as we have done for the practice board. The socket strip on the SBC-09 has 2 more contacts than that required for the 6821, these extra 2 being for power connections to a supply on the interface card. If the PSU is not on the interface card or if the equipment is to be battery powered, the power connections can be made to the alternative connector (PL1). In designing an interface card with PSU, it is suggested the power supply portion of the practice board is used as this has been conservatively designed (the heatsink may need upgrading) so it will easily power the SBC-09 with plenty spare for the interface circuitry. The maximum current drawn by the SBC-09 is in the region of 500mA. Allowing a bit for the interface and for some LEDs it becomes clear the battery will not last long, unless very large types are used. So a few component changes are made, substituting the NMOS parts for their (more expensive) CMOS equivalents. The specified RAMs are CMOS but 61 16s and 6264s with the -LP suffix have a particularly low standby current and should be selected. The 27128 should be changed to a 27C128, the 6821 to a 6321, the 74LS139 to a 74HC139 and the 6809 to a 63B09 (as with the 6809 do ensure that it isn't the version with the E suffix as this is not interchangeable). This CMOS version of the processor is actually a 2MHz part, the 1MHz version no longer being made but, will run at the lower 1MHz speed, provided the 4MHz crystal is not changed. The control board should draw no more than 100mA (according to the data sheet —the author hasn't built a CMOS SBC-09 yet).

While on the subject, one other option should be mentioned. Although provision for a battery backed-up supply has not been built into the SBC-09 in the interests of minimising cost and size, the RAM could be made non-volatile hence allowing settings to be retained even when the equipment is switched off. This is achieved by substituting the RAM chip for an equivalent device with an integral lithium battery but is more expensive.

BUYLINES

Most of the components are readily available from all the usual sources. The transformer specified actually comes from Rapid Electronics but very similar ones will be available from just about anywhere. The one component which can't be obtained from any of the normal suppliers (and not even from Farnell and RS) is the CMOS version of the processor, the 63B09. This can be obtained from Anzac Components Limited on 0628 604411 who have indicated that they will supply to private individuals even though they are primarily trade distributors. CMOS static RAMs with integral lithium batteries are by no means as common as the standard memories but may be obtained from RS / Electromail or from Farnell Electronic Components. The PCBs are available from the ETI PCB service.

THE FIRST DOMESTIC DAT RECORDER FROM SONY



Innovation in recording equipment has been Sony's business for a long time. In 1974 the company developed the X-12DTC professional stationary-head digital recorder, followed in 1977 with PCM-1, the world's first PCM processor. This was the first chance music lovers had to sample digital audio. In 1978 Sony marketed the PCM1600 a two channel digital audio processor, designed for use with professional VTR's for broadcast application. The PCM1610, which followed in 1980 was not only the worlds first compact disc mastering system, but to this day over 95% of CD's are mastered on the Sony PCM — 1600 series, now the world standard. The same year digital recording became an affordable, portable reality with the Sony PCM-F1.

In 1982 Sony originated a new idea for a dedicated digital audio tape format based on the company's experience with rotary tape deck video and advanced digital semiconductor research. The first prototype of a rotating head DAT recorder was then produced.

In June 1983 manufacturers gathered to begin discussion on the establishment of a DAT format, 85 are now members of the DAT Standards Conference with agreed test and technical specifications. For audio professionals 1987 saw Sony introduce studio and portables machines like the DTC1000ES and TCD-D10.

In 1978 Sony introduced DASH (Digital Stationary Head), a multitrack format for professionals. Towards the end of 1987 Sony UK began to offer the DTC1000ES to professionals as a low cost digital mastering medium. This was not as a replacement of the 1610/1630 CD mastering system but as a digital alternative to ¼-inch reel to reel. Since then over 22,000 DAT recorders have been bought by professional users worldwide.

Reliability in the professional market is reportedly high and BBC Radio 1 has recorded its entire "Golden Oldies" collection onto DAT for broadcast. A concurrent development, between Sony and Hewlett Packard, is the Digital Data Storage (DDS) computer back-up medium.

Now in 1990, Sony is pleased to announce the launch of the first UK domestic DAT recorder, model DTC-55ES. The new machine continues in the same tradition of audio excellence, with a Serial Copy Management System and High Density Linear recording — allowing for the first time direct digital taping.

The DTC-55ES uses a newly developed vertical loading and transparent compartment system where tape operation can be seen through the compartment lid. A high accuracy tape guide system is employed with chromium plated fixed guides and the drive mechanism's base unit is made of non-magnetic alluminium alloy.

Two Direct-Drive motors power the capstan and head drum while an independent BSL motor drives the reels with direct earthing applied to the drum and RF amplifier. A digital fader permits fades to be set anywhere between 0.2 and 15 seconds during digital or analogue input recording. The DAT format allows use of many sub-code functions and these are exploited in nine different ways. For example, Start ID sub-codes can mark the beginning of each programme or selection on a tape. This can be performed automatically or manually to allow the user to write random start ID's during post recording editing. During recording, Programme Number automatically numbers sequentially the start ID's written at the beginning of each selection. This allows direct access to any given selection for playback by entering the programme number via the numeric key pad. If start Id's have been added or deleted this can upset the continuity of previously allocated programme numbers. The facility RENUMBER, changes these ID's to give a proper sequence. Also included are Skip ID, End ID, Rehearsal Function, Erase Function, Shift Renumber and Absolute Time Codes.

Time Search allows a tape marked with absolute time to be fast forwarded in one minute intervals for fast searching. RMS play changes the order of selection playback by entering the track numbers in the way you want, with up to 60 selections programmable. There's also AMS Play, Numeric Keypad and AMS Search/Play Search, Music Scan, Repeat and End Search. An infra-red commander controls the majority of DTC-55ES functions. It also synchronizes a CD Recording when used with a CD player. Point the handset at the DAT unit and CD player and it starts playing as soon as the DAT units recording pause is released. The basic DAT format uses a sampling frequency of 48kHz with 16 bit linear quantization. This standard arrangement allows digital recording of analogue sources after analogue to digital conversion. The 44.1k mode records digital signals directly from a CD, and the 32k LP mode offers a longer recording time.

DTC55ES — The Technology

Two RDAT LSI's are employed in the DTC-55ES. One functions as a PCM signal processing LSI, while the other is a software servo/system control CPU. The

DAT

DTC-55ES also features a 1-bit A/D converter with an internal digital filter and a Pulse D/A converter.

All random and burst errors that could occur in the head system have to be thoroughly analyzed. To minimise these effects, a double encoded Reed-Solomon code was chosen as the most suitable signal processing method for all kinds of error correction and compensation. Error correction can be performed lengthwise if burst errors occur even if one of the two heads malfunctions during playback.

The CXP-80524 consists of three parts, an 8 bit CPU, 24 Kbyte ROM and 576 byte RAM, so high speed processing can be performed around 425ns at 9.408 MHz.

An 8 bit A/D converter within the device enables the conventional analogue values of the ATF pilot signal to be processed digitally in the micro processor. This makes the use of resistors and capacitors unnecessary, the performance of which vary with temperature. Reliability is also improved.

The serial I/O with RAM buffer reduces the amount of time the CPU must be used with the CXD2601 signal processing LSI for subcode and mode operation even during high speed search.

Servo operations are performed digitally, so time and temperature dependent variations are eliminated for more stable servo operation. The quality of the recording system is fundamental to any recording equipment. The key element in the recording system of the DTC-55ES is the newly developed High Density Linear analogue to digital converter. In the case of DAT without oversampling, A/D conversion would require steep filtering from the ninth to eleventh order. The use of such steep analogue filters results in phase distortion, and degrades transient response, both of which are bad elements in terms of musical fidelity. Oversampling promises benefits here, but because of technical limitations of the LSI, two to four times is the typical maximum amount of oversampling with multibit A/D converters commercially available. Analogue circuitry occupies a physically large portion of conventional multibit A/D converters, and it is difficult to integrate digital filters onto the same chip. Multibit A/D converters also require laser trimming and adjustment to enhance conversion accuracy, and a large coupling capacitor. A single bit A/D converter is an entirely new product that performs accurate conversion that, due to the very principle of its operation, does not require additional elements.

Space precludes a more detailed examination of the principle of this device, but the single-bit A/D converter within the DTC-55ES uses a fourth-order delta-sigma modulator at 64 times oversampling. This permitted the analogue low pass filter employed in this A/D area to be of a simple first order type. Due to the high order noise shaping some quantization noise still exists in inaudible frequency bands, the Sony system uses three stage (124) order FIR type digital filters. The result is a ripple level of less than ±0.001 dB in the audible sound spectrum. Total harmonic distortion is around 0.0015%.

Just as the A/D converter is the key component of the recording section, so the D/A converter is critical to the playback function. The machine uses a pulse D/A conversion system free from glitches, zero cross distortion and differential non-linear distortion. The pulse D/A converter consists of a PLM pulse converter, an Extetnded Noise Shaper and a Direct Digital Sync. Sound is expressed by an ever changing density of different pulse lengths activated by a one bit switch. The operational speed is approximately twice as high as that of ordinary 'high speed' CMOS IC's, at 45 MHz modulating pulses in high density resolution. High timing accuracy is achieved by a Direct Digital Sync. incorporated with the IC, operating at the very boundary of D/A conversion. Other user features include a four mode selectable linear counter. This displays accumulated playing time, time of current selection, remaining playing time and absolute time.

Optical digital input/output terminals are provided along with gold plated digital coaxial out and line level input/output.

Cue and review for playback at 2.5 times normal speed can be increased to 8 times if required. The display panel can be adjusted to three different levels, timer standby and a headphone socket is featured with independent level control. Display off function gives three meter lighting modes — peak level meters and margin indicators on or off and display off auto, in which all the indicators go off immediately after recording or playback starts.

The retail price of the Sony DAT recorder is £549.99.

SPECIFICATION

Tape	Digital Audio Tape
Recording Head	Rotary Head
Recording Time	Standard: 120 minutes Long Play mode: 240 minutes (with DT-120)
Tape Speed	Standard: 8.15mm/s Long Play mode: 1,000rpm
Error Correction	Double Reed Solomon Code
Tape	
Track Pitch	13.6μm (20.4μm)
Sampling Frequency	48kHz, 44.1kHz, 32kHz
Modulation System	8-10 modulation
Transfer Rate	2.46 Mbit/sec
Number of Channel	2 channels/stereo
D/A Conversion	Standard: 16 bit linear Long play mode: 12-bit non-linear
Frequency Response	Standard: 2-22,000Hz (±0.5dB) Long Play mode: 2-14,500Hz (±0.5dB)
Signal to Noise Ratio	Standard: more than 92dB Long Play mode: more than 92dB
Dynamic Range	Standard: more than 92dB Long play mode: more than 92dB
Total Harmonic Distortion	Standard: less than 0.005% (1kHz) Long Play mode: less than 0.08% (1kHz)
Wow and Flutter	Below measurable limit (±0.001% W.PEAK)

Input

	Jack Type	*Impedance*	*Rated Input Level*
Line In	Phono Jack	47k	−4dBs
Digital In	Phono Jack	75R	0.5Vp-p, 20%
Digital In	Optical Jack	—	—

Output

	Jack Type	*Impedance*	*Rated Output*	*Load Impedance*
Line Out	Phono Jack	470R	−4dBs	>k
Headphones	Stereo Phone Jack	220R	0.6 mW	32ohms

Digital Out (optical jack): wavelength 660 nm

TESTING TESTING

Mike Barwise probes around the analogue input of the oscilloscope for any problems

Our final look at analogue testing covers some common problems encountered when using a basic oscilloscope, and suggests some solutions. I should make it absolutely clear that the solutions given here are not finished designs to be copied blindly: they are starting points for development to suit individual circumstances.

There are three main areas where add-ons have to be used with the average oscilloscope: firstly, when the signal level is too low for the Y amplifier at maximum gain, secondly, where the circuit impedance is near to or greater than your probe impedance, and finally, where the signal is very complex. The point of interest is not near enough to the trigger event to allow display at adequate resolution. There are of course, a whole lot more problems which are very job-specific, but these three are quite common, and some idea how to solve then would be useful.

The theoretical solutions to the first two are really very simple. If your signal is too small, amplify it by a known amount before it reaches the 'scope input. If your probe impedance is too low for the circuit test point, increase the probe impedance. The third problem is substantially more complex and will be discussed later, but let us look at practical ways to solve the two simple problems first.

Small Signals, High Impedances

To increase the 'scope probe impedance we normally resort to one of the *divider probes* (×10, ×100). These work by incorporating a series resistor in the probe tip which acts with the parallel input resistance of the 'scope to form a potential divider. The larger of the two resistances is at the probe tip, thus the series resistance of the probe looks greater to the circuit under test. The practical divider probe also includes a capacitor to compensate for the 'scope input capacitance, and this is what you have to adjust when calibrating the probe. The problem with divider probes is that increasing the input resistance of the probe we have also proportionately *attenuated* the signal: a X10 probe reduces incoming signals to 10% of their original amplitude. In ordinary (amateur) electronics, the majority of high impedance test points present small signals, so it is possible to lose on the 'swings' what you gained on the 'roundabouts'. Our ideal add-on should provide as a minimum an input resistance of 10M with either unity or better still ×10 gain up to at least 20MHz.

The simple answer to a lack of signal amplitude is to add an amplifier in series with the 'scope probe. However, there are practical problems which make the actual choice of amplifier quite critical. The factors which have to be considered are GAIN, BANDWIDTH, SLEW RATE and INPUT IMPEDANCE. Supposing for the moment that we are using an operational amplifier (a simple solution). The gain is under the direct control of the user and the device data sheet provides a figure for gain/bandwidth product (GBP) which interrelates the chosen gain and the resulting bandwidth (nominally inversely proportional). The amplifier should be chosen so that you are not working at its absolute limits; it should have a bandwidth at least twice as great as your expected signals at the gain chosen.

The slew rate factor is a little less obvious. Quite a few op-amps with very high gain/bandwidth product have relatively low slew rate, and some 'slower' ones (lower GBP) actually have a higher slew rate. You have no control over slew rate except by choosing your amplifier carefully, but it is an important measure, as it predicts how well the amplifier will reproduce transients.

The input impedance of an op-amp depends on your circuit configuration, but is approximately limited to a maximum by the input bias current quoted in the data sheet for the device. A nominal figure for input *resistance* can be obtained by dividing the maximum input voltage by the input bias current. The result will vary from around 2M for a 741 to in excess of 1G for a FET input op-amp. It is useful that the non-inverting configuration maximises the input resistance. There is one tiny problem though, which is that the real IMPEDANCE seen at the op-amp input will also consist of an element due to the reactance of the device input capacitance. This will only be significant at high frequencies, but that's when you most need your 'scope.

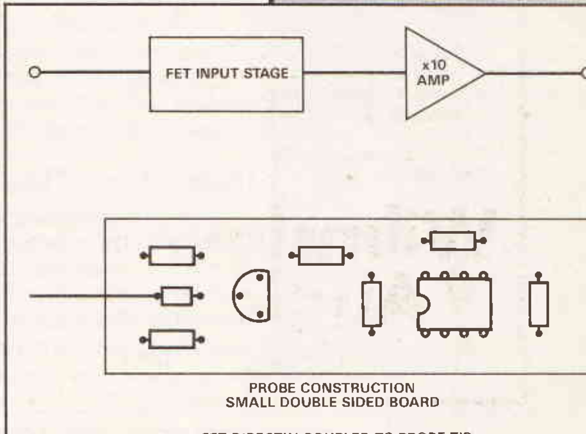


Fig. 1 FET directly coupled to probe tip.

Bearing in mind all these points, we can look through various op-amp data sheets. Our aim is to find a device which will give us firstly a gain of 10× from zero to 20MHz+ and then an input resistance of at least 10M.

Rapid scanning of the available devices (with the exception of fearfully expensive military components) shows us that no one device will do both. High bandwidth amplifiers tend to use bipolar (low input resistance), and FET input amplifiers, while satisfying our input resistance criterion, generally cannot come near our bandwidth requirements.

The only solution which does not conflict with our bandwidth requirement is the use of a fast bipolar op-amp (typical input resistance 100k), so we must find some way of boosting the input resistance. The obvious answer is a FET used as an input stage. The FET is not required to provide voltage gain: it is simply and impedance changer. The very low input leakage

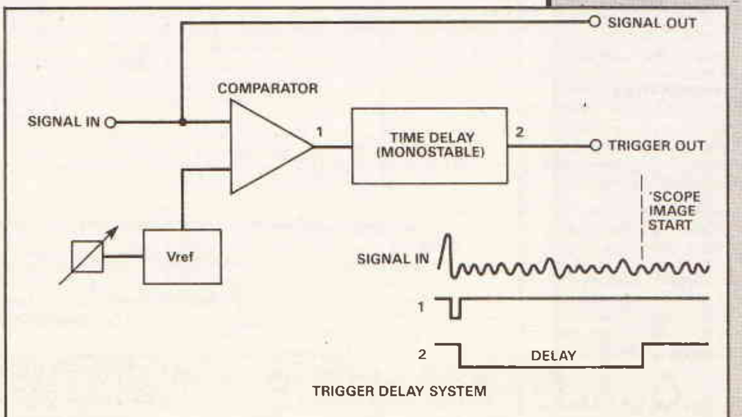


Fig. 2 Trigger delay system.

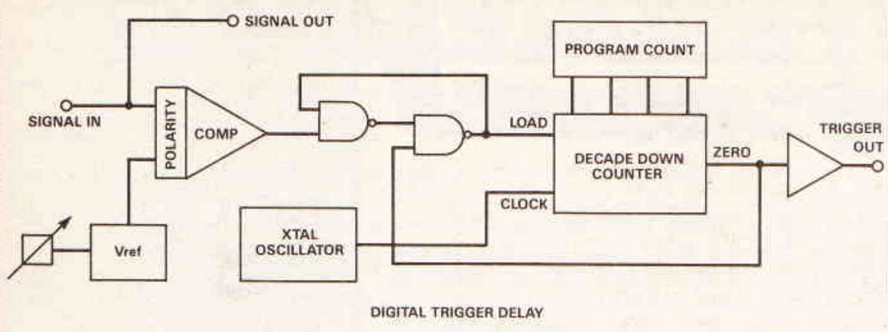


Fig. 3 Digital trigger delay.

of a junction FET allows us an input resistance of up to maybe 100M, while outputs of several tens of mA are possible with ease. The choice of FET in view of our bandwidth requirements limits the field a little, but as there is no voltage gain, devices with a -3dB point around 50MHz are quite acceptable and these are quite common.

The construction of the resulting probe (Figure 1) requires some care, as you must minimise the capacitance of the probe assembly to avoid stray pickup at the very high impedances we are considering. Normal RF practice applies.

Stretching Time

The problem of looking at a small part of the complex signal is solved by delaying the 'scope trigger until the signal area of interest comes along. To do this you need a reliable triggering event in the signal. to start the delay. This event trips some kind of timer which produces a pulse at the end of its period. The output pulse from the timer triggers the actual 'scope (Figure 2).

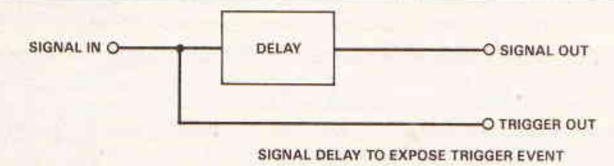


Fig. 4 Signal delay to expose trigger event.

This concept is pretty straightforward, but there is as always, a snag which is not immediately apparent. The time delay between the triggering event and the output pulse to your 'scope trigger must be very repeatable. This means that however long it is, IT MUST BE THE SAME INTERVAL EVERY TIME. If this requirement is not met, the 'scope trace will jitter in the horizontal direction and the resulting display will be practically useless. Let us consider the order of repeatability required. Your 'scope screen has ten major horizontal divisions, each divided into five sub-divisions. Thus the screen markers each represent 2% of the horizontal axis. Is 2% repeatability good enough then? Consider whether you could take a reading from a trace which was moving around by about 1.5mm (the distance between sub-divisions on the average modern 'scope screen). The answer is: probably not. We must improve upon this for ease of use. Let's assume we must go about five times better, which is about the width of the trace on a well tuned 'scope. This equates to 0.4%. Strangely (or maybe not?) this is the same as 8 bit resolution in the digital terms, and is about the minimum resolution/stability/repeatability of any satisfactory instrument used for measuring absolute values.

This 0.4% is the total permissible peak-to-peak jitter, so the specification of the trigger delay timer must be +0.2% that is twice as good in either direction (early or late). This specification pushes to their absolute theoretical limits general RC timers such as the NE555, and comes near the practical limits of TTL and CMOS RC monostables unless special precautions are taken, particularly when long delays are required. The dead easy way to achieve the required stability is to use a digital divider driven from a crystal oscillator, which is normally capable of 100 ppm (parts per million) or 0.01% A basic block diagram is given in Figure 3. The divider is programmable via thumbwheel switches, and the total delay is

$$\frac{n+1}{f}\ \mu s$$

where:
f is the crystal oscillator frequency in MHz
n is the number programmed into the divider

It obviously pays to use the fastest possible oscillator (to increase resolution) and a fairly high module divider. If, you used a four digit decade divider (max. count 9999) and a 10MHz oscillator you could provide trigger delays from 200ns to just less than 1ms (999.9μs) in steps of 100ns. This would serve most purposes.

We have seen how delaying the 'scope trigger while allowing the signal to arrive on time lets you look at the late events in a complex signal. There are times when you are interested in what happened just before the trigger event. This would at first seem an insuperable problem: how does the 'scope display something that hasn't happened yet? Discounting

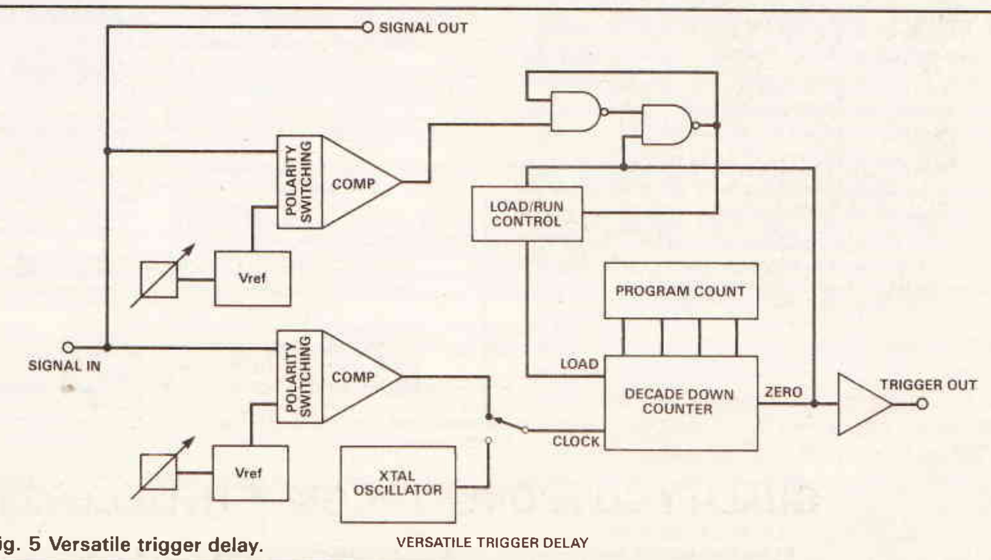


Fig. 5 Versatile trigger delay.

faster-than-light signals (which some people have recently suggested exist!) we simply reverse the trigger delay process: we trigger the 'scope before the significant portion of the signal arrives at the Y amplifier. You obviously can't manipulate the trigger event itself to do this, so you simply delay the signal in its passage from the 'scope probe to the Y amp, and use the incoming signal to trigger the 'scope before it reaches the delay circuit (Figure 4). This facility is built into most 'scopes above basic student quality, but if you don't have it, there are two approaches. The first (old-fashioned version) is to use a Lumped Constant Delay Line this consists of an array of carefully chosen series and parallel inductors and capacitors which form an All Pass Filter. The all pass filter has a flat frequency response across its working range, but introduces a phase shift (a delay) in the signal as it passes through. The lumped constant delay line is rarely adjustable, so it is really restricted in its application to allowing the trigger event to be visible on the 'scope screen at all times. A more useful and flexible solution is to use a bucket brigade delay line which can be an adjustable device, allowing quite long periods of pre-trigger information to be displayed. Some of the audio band bucket brigade chips have featured in recent ETI projects. The limitation of all these chips is their bandwidth. I don't know of a bucket brigade which will pass signals in excess of 100kHz at the moment. Of course, if your signal is a regular complex waveform, there is nothing to stop you using the trigger delay circuit with a delay so long that it shows you the very end of the previous cycle. This display will effectively give you the pre-trigger information if your signal is truly repetitive.

The final problem to solve is one faced by the video engineer. Suppose we want to examine a specific line of the video frame. How do we cause that line and that line only to be displayed. The answer is to use the general circuit of Figure 2, but replace the delay with a device which counts trigger pulses. Instead of waiting a finite time before triggering the 'scope, the system will then wait a specific number of triggers. This means the 'scope will not be triggered until the correct video line is presented. The resulting facility is know as HOLD OFF. In the video context, the frame sync pulse will zero and start the countoff and the line sync pulses will advance the count until the required number has happened. The same circuit can be made to do both jobs by switching the clock source (Figure 5). This circuit will provide either trigger delay or hold-off at the flick of a switch, providing a very versatile control over the display complex signals. Note, the relative complexity of the triggering arrangements. This is unavoidable if you are to allow all possible triggering options. The alternative modes of operation could be:

- Negative pulse clears counter, n positive pulses ignored;
- reversed polarity of above;
- large amplitude pulse clears counter, n small amplitude same polarity pulses ignored;
- 'scope triggered every n pulses, no clear.

The first two are used for the TV frame scenario, the third has only specialised applications (nothing comes immediately to mind!) and the forth could be used to stabilise something like an RS232 data character stream on the 'scope screen.

That about sums up the information on analogue testing. In the next instalment I will begin discussing approaches to digital systems test and measurement.

ETI

FIVE -IN- ONE

Richard Worthington builds this multi-purpose remote sensing switch-alarm

For a circuit which amplifies nothing but 'hum', *Five in One* is surprisingly useful. It works by detecting and monitoring the low-frequency signals from mains power leads, telephone cables and the like and as the name suggest, it provides five different functions in one unit.

The initial idea was for a simple device to keep an eye on electronic equipment operating unsupervised for longish periods. Cassette recorders and music centres are commonly left to copy tapes or record radio programmes. Fault conditions like failure of the mains supply, a tape becoming tangled, or a malfunction which might start an electrical fire, are all detectable. An alarm summons you back to the room to sort things out. This relies on the indirect sensing of any changes in the appliance's mains supply current.

The same principal is used to provide the second application — signalling the completion of a task. Take the first example of the cassette recorder, *Five in One* will also detect the end of a tape — even if the other deck is still running. The idea works with many other appliances, of course, including Ultra Violet Light Boxes and EPROM Erasers (incorporating a timer), automatic 12v chargers, or almost anything used with a timeswitch. You just 'set it and forget it', before going off to do something more interesting instead.

Modern phones often have a relatively quiet ringing tone, compared with the traditional bell. For our third idea, *Five in One* will sense incoming calls and sound a much louder alarm which is handy if you're working outside the house, or when that important call is expected. There's no electrical connection to the phone system.

Finding which fuse or circuit breaker (MCB) connects to which mains circuit can be a slow process. Instead, set *Five in One* to monitor the relevant light switch or power point and then disconnect fuses MCBs at the fusebox while listening out for the alarm. (Being battery operated is a must here). The fifth and final use is in the detection of mains wiring in walls before drilling holes. The last thing you want is to drill through a power cable.

Construction

The component overlay is shown in Figure 2. Before starting construction you'll probably need to drill three holes in the board. Two PCB mounting spacers can go either side of C6; the third hole allows adjustment of preset RV1 from both sides of the board. You could also drill two holes to the right of IC2, routing the battery leads through them to reduce strain on the joints.

Twenty-two connections for off-board wiring are provided, though in most cases only nineteen are used. The top ends of the pots, would go to SW1c instead of back to the board. The completed PCB can be mounted on top of the switch and pots, C6 occupying the space between RV2 and RV3.

Testing And Setting-up

The specified piezo-electric buzzer is extremely loud, so temporarily cover the hole with some tape. Plug in the pick-up coil and switch SW1 to position 2 or 3 (see table opposite), then insert the battery. Rotating RV2 and 3 should turn LED1 and 2 on and off. The buzzer will sound when either is lit. A crystal earpiece should produce a gentle hiss from IC1b output, depending on the setting of RV1.

A music centre of twin cassette recorder would be helpful for the next stage. Firstly, you'll need the pick-up coil close to the cable being monitored; a battery charger clip is suitable for this (see Figure 3), but its teeth must be bent out of the way. Don't have the coil too near the appliance. Next, listen to IC1b

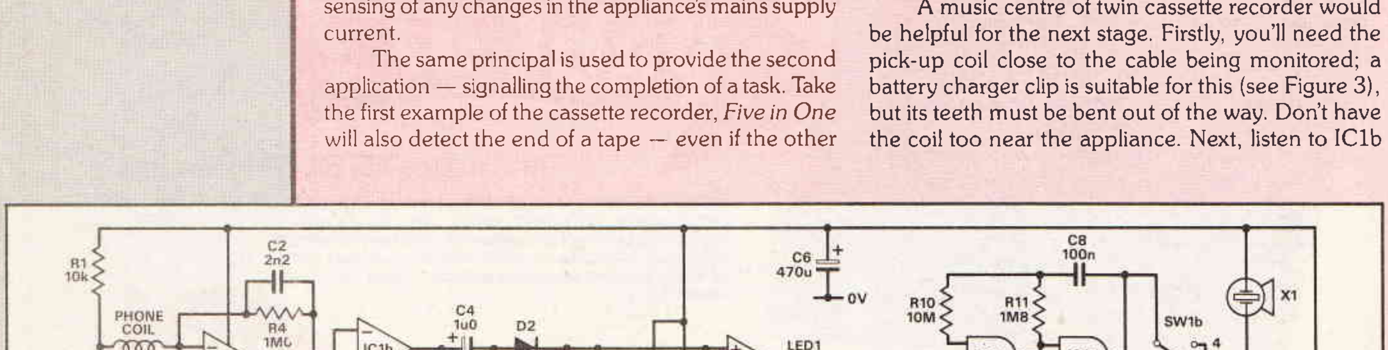


Fig.1 Circuit diagram of 5-in-1

output as described earlier and adjust preset RV1 for a moderate hum. Turn RV2 and 3 so their associated LEDs are just off. Insert two tapes, press Play on either tape deck and LED1 should light. Set both decks to Play, re-adjust RV2 and 3 and stop one deck. LED2 should now light, and in both cases the alarm will sound.

In Use

The first two applications employ a phone pickup coil as sensor which is an inductive method, so try to position the coil away from loudspeakers, transformers, other mains cables.

Uses three and four employ a length of wire to provide a capacitive coupling, so the wire should be close and roughly parallel to the source cable. The sixth and final application of tracing cables in walls can use either method. The first accurately pinpoints mains cable, but only if a load is connected and a current is flowing. The second, like in many commercial units, no current flow is required.

	ALARM VOLUME	SPEED OF RESPONSE	USE
1	OFF		
2	LOW	FAST	SETTING UP, TRACING CABLES
3	HIGH	FAST	OTHER APPLICATIONS
4	HIGH	SLOW	DELAYED REACTION

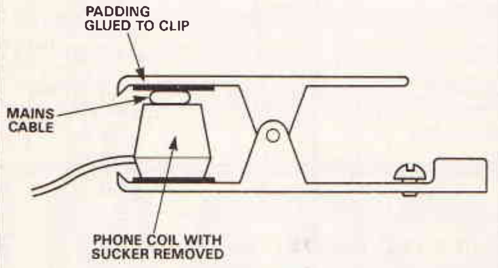


Fig.3 Pick-up detail

HOW IT WORKS

Using the phone coil method, induced current in the coil depends on the supply current of the appliance, and therefore on the secondary current drawn from its power supply transformer.

In the second method, the length of wire and the source cable form a low value capacitor, allowing a 25 or 50 Hz signal to reach IC1 Pin 2.

IC1a and IC1b are used to form an inverting and non-inverting amplifier respectively. C2 cutting the high frequency response. The output is rectified and passed to IC1c-d which, together with RV2-3, are used as a window comparator. The two thresholds are independently variable, LED1-2 indicating "Over" and "Under".

Without C7 in circuit, the alarm section is triggered the instant either LED lights. With C7, a short delay is introduced which smooths out any intermittent triggering. Two NAND gates (IC2a-b) act as a non-inverting buffer, the output of which, gates the slow oscillator IC2c-d. This switches the alarm at a frequency of 2-3 Hz, the volume depending on the base current limiting resistors R12-13.

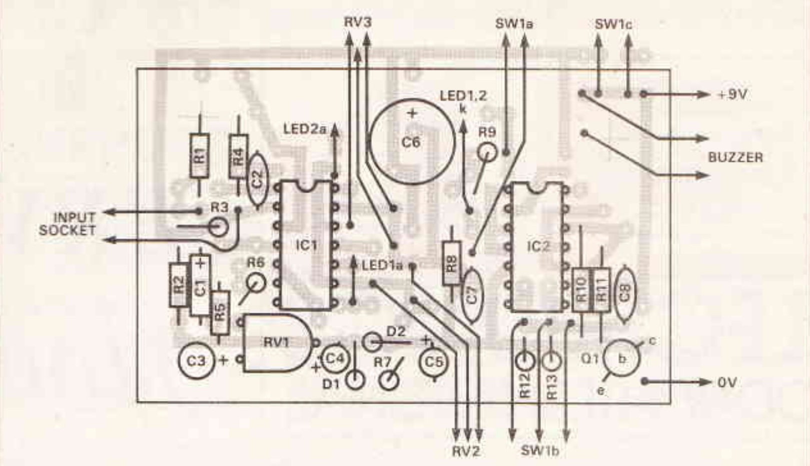


Fig.2 Component overlay of 5-in-1

PARTS LIST

RESISTORS (all ¼W 5%)

R1,2,13	10k
R3,8	4k7
R4	1M
R5,6	1k
R7	200k
R9	4M7
R10	10M
R11	1M8
R12	2M7
RV1	100k horiz, preset
RV2,3	470k lin.

CAPACITORS

C1,3	10µ 16V elect
C2	2n2 polyester
C4	1µ 63V elect
C5	4.7µ 63V elect
C6	470µ 16V elect
C7,8	100n polyester

SEMICONDUCTORS

IC1	LM324
IC2	4011BE
Q1	BC107
D1,2	1N4148
LED 1,2	red LEDs

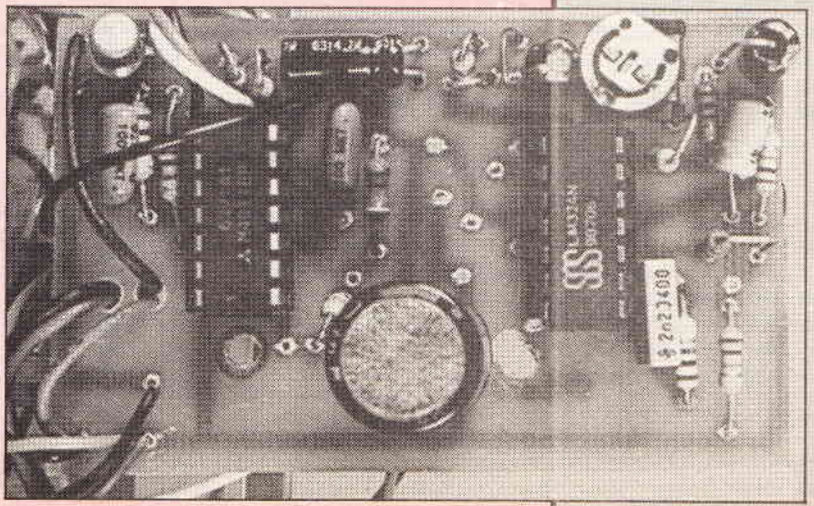
MISCELLANEOUS

B1	9V battery
X1	High power piezo, buzzer
SW1	3p4way rotary switch

PCB, case, phone coil, wire, 3.5mm mono plug and socket, DIL sockets, PP3 clip, LED clip, knobs, nuts and bolts, PCB mounting spacers, battery charger clip

BUYLINES

All the components are commonly available apart from the piezo buzzer (Maplin FK84F).



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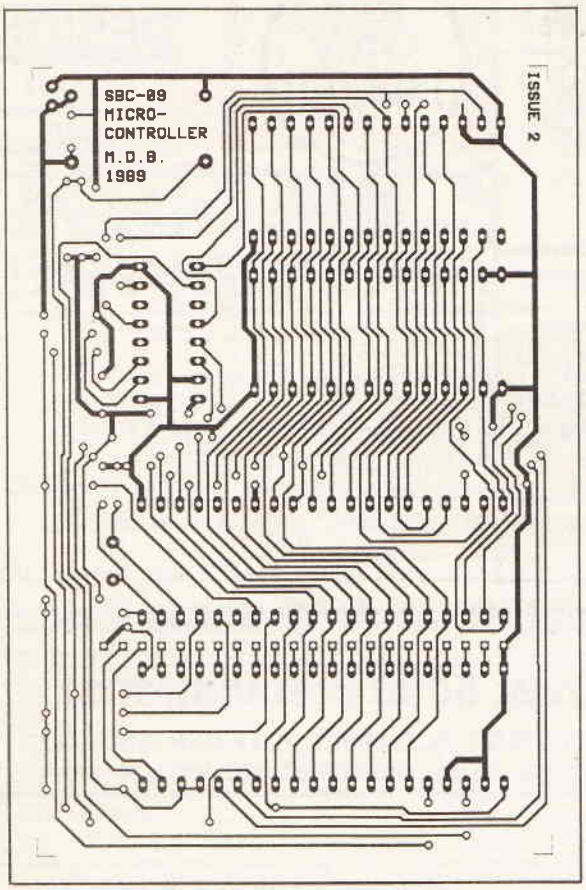
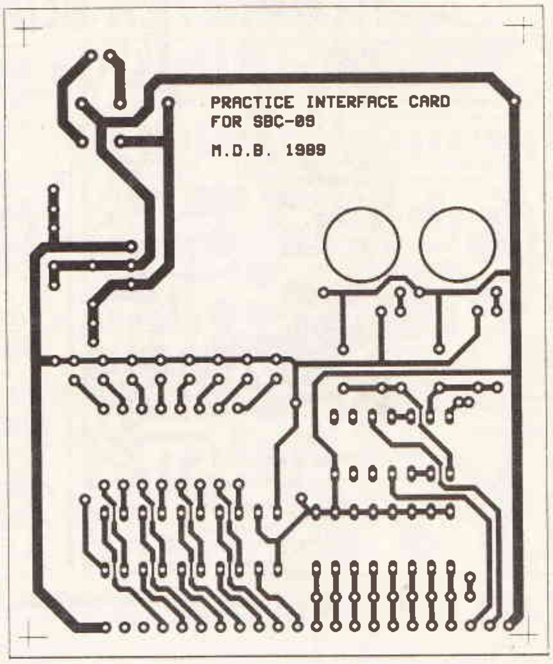


The SBC09 Main Board

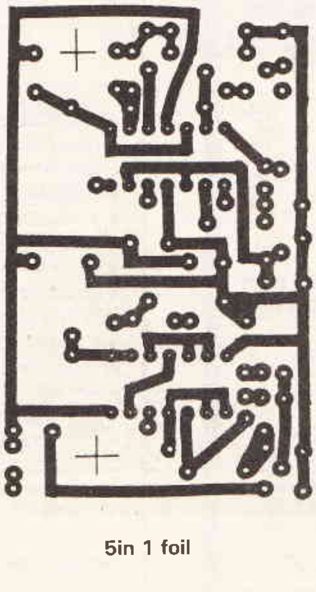


SBC09 Practice Interface Board

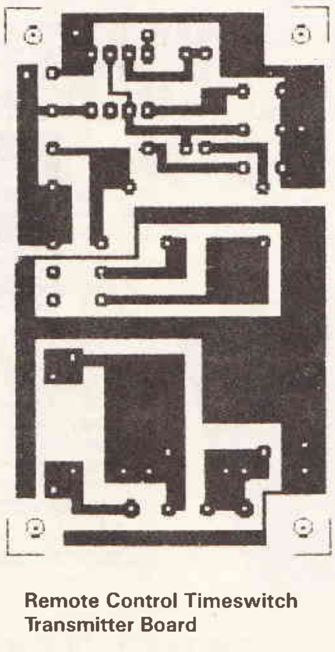
Four Track Cassette Recorder (November 1990)
In Fig. 2, D1 should be shown the other way round.

Digital Frequency Meter (July 90)
On Fig. 4 C6 at the top left of the diagram should be labelled C5 and R8 above IC2 should be labelled R3. The foil on Fig. 5 is shown displaced downwards by 10mm.

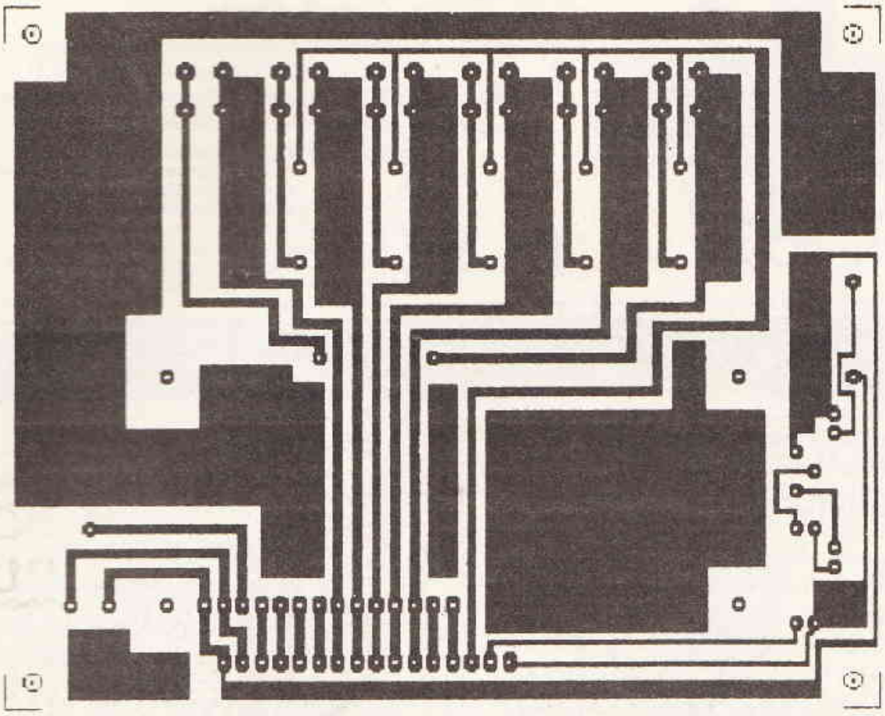
Infra-lock (November 90)
Fig. 4 Symbol D1 the infra red diode should be rotated 180 as correctly shown in the similar diagram for the Infra-switch (December 90). In Fig. 5 IC4 is shown the wrong way round and should be rotated 180 along with D1. After connecting the hearder plug, connect an LED between Pin 7 IC4 and ground (cathode to ground). This should come on after power-up and be toggled on entry of the correct code.



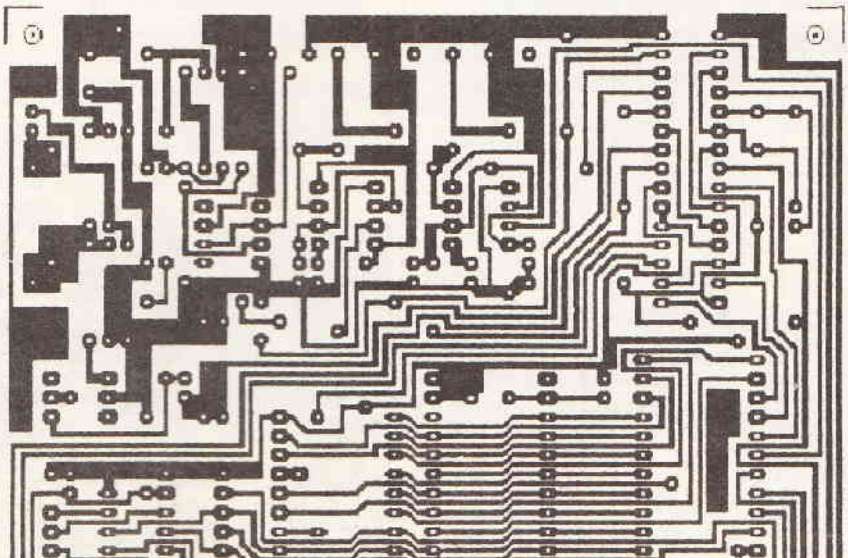
5in 1 foil



Remote Control Timeswitch Transmitter Board



Remote Control Timeswitch — Display Board



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Congratulations

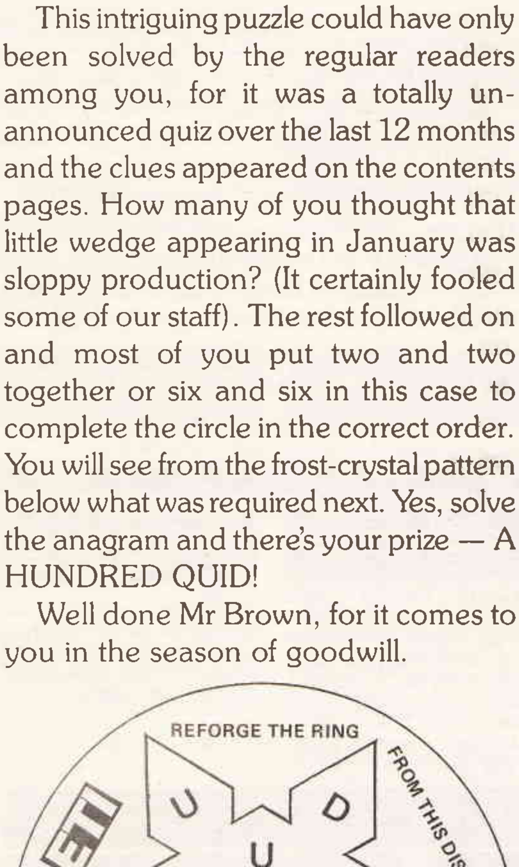
MR D J BROWN of COVENTRY

You were the first to send us a correct reply to our hidden competition. And quick off the mark you were too with the December magazine out on Friday 2nd November, yours was the first reply to be opened Monday.

So what was this cryptic competition if indeed it was ever one in the first place?

This intriguing puzzle could have only been solved by the regular readers among you, for it was a totally unannounced quiz over the last 12 months and the clues appeared on the contents pages. How many of you thought that little wedge appearing in January was sloppy production? (It certainly fooled some of our staff). The rest followed on and most of you put two and two together or six and six in this case to complete the circle in the correct order. You will see from the frost-crystal pattern below what was required next. Yes, solve the anagram and there's your prize — A HUNDRED QUID!

Well done Mr Brown, for it comes to you in the season of goodwill.



You clever things, and if you find that easy we promise you it will not be so easy next time, things will not appear in obvious places. Cryptology will never be the same.

NEXT MONTH

If you are an established hand at electronics and you have a friend that is eager to understand the business, then you might get them to borrow the February edition of the mag or better still buy one. For next month we start a beginners series on the basics of electricity. It can be a daunting task to digest the ins and outs of so many branches to the subject and so it is with this article that we give a chance to those new to the area to make a start.

Projects for February include a multifunction burglar proof alarm system to keep your electrical appliances in their rightful places, the final part of our remote controlled timer to automate your electrical functions and more on the SBC09 microcontroller.

For audio fanatics or any level headed listeners for that matter, we have an article/project on a design for a twin driver loudspeaker system and cabinet. All this, along with all the usual items you have come to expect from the number one technology mag. So why not order it today and pick up your copy on January 4th 1991.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

In the December issue, ETI published articles on HDTV, the European solution to the problem, the second part in Recording Studio design and the problems of unwanted acoustics and the first of an article on Repairing Oscilloscopes.

Our projects listing for December included the first part of the Remote Control Timeswitch, the Infra-switch to operate in-room electrics by remote control and the final part of the four channel cassette recorder. A limited number of back issues are available from Select Subscriptions (address on contents page).

ADVERTISERS' INDEX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