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THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY
NOVEMBER 1990 £1.60

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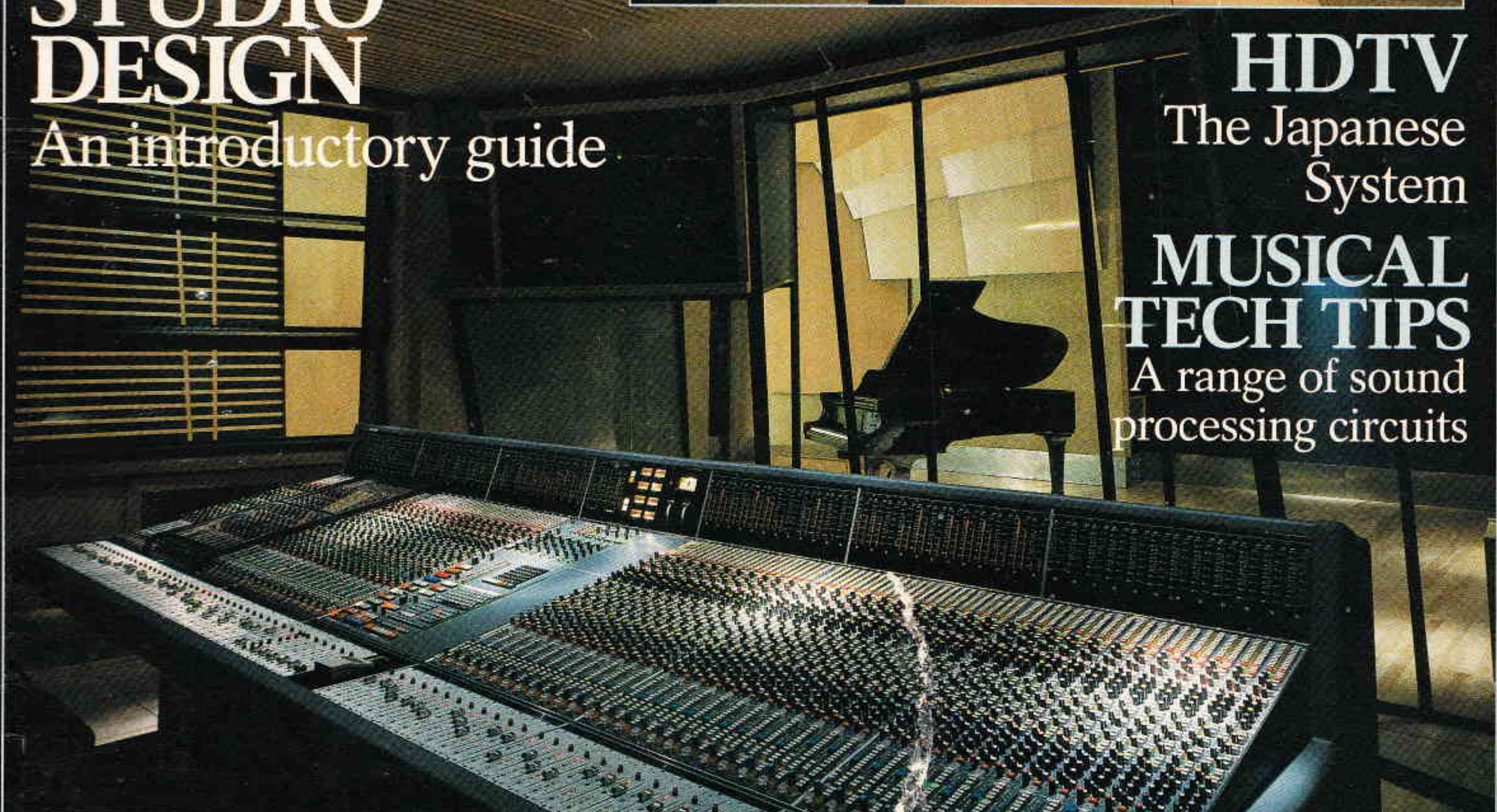
A sound construction



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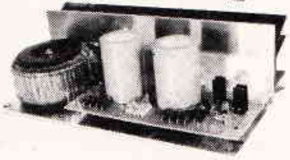

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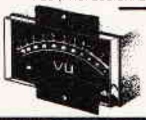

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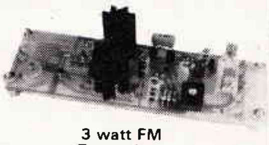

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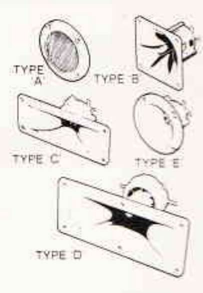


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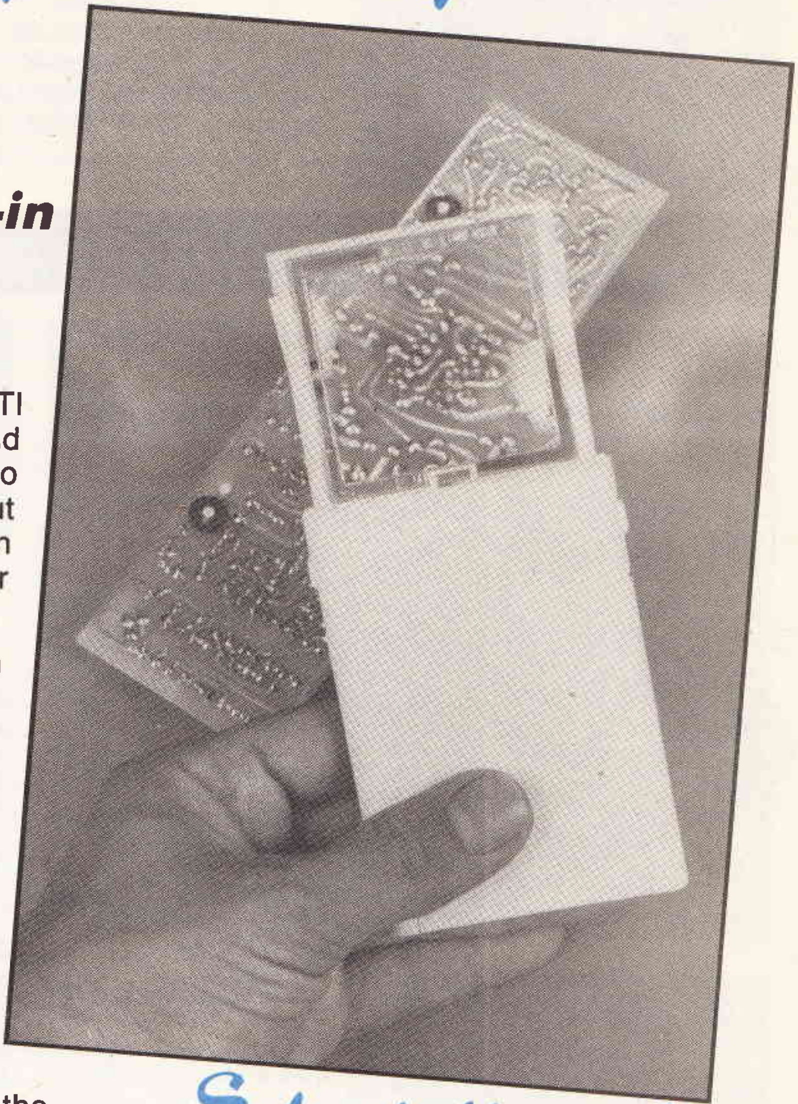

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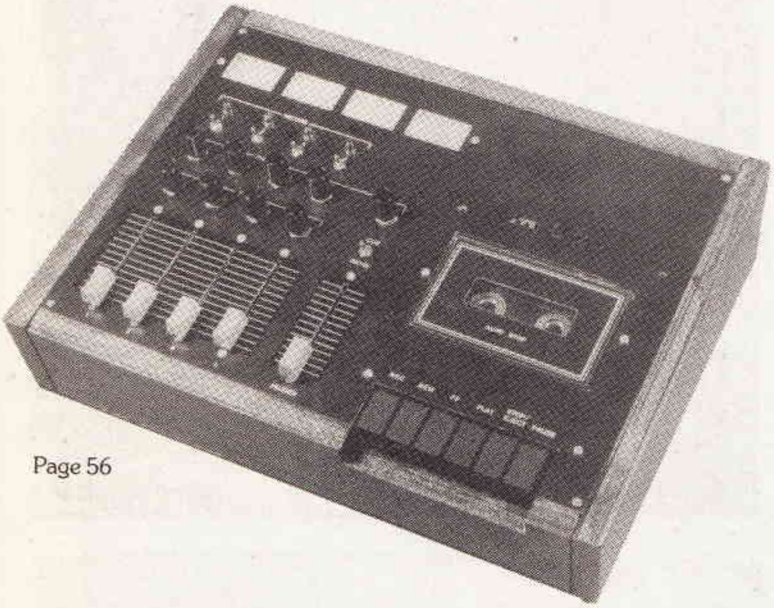

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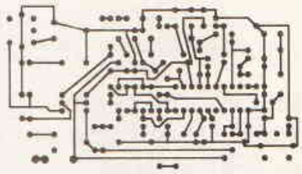


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## FEATURES/PROJECTS

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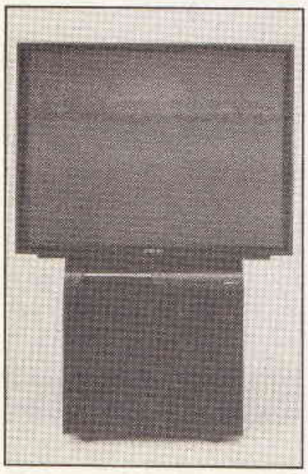



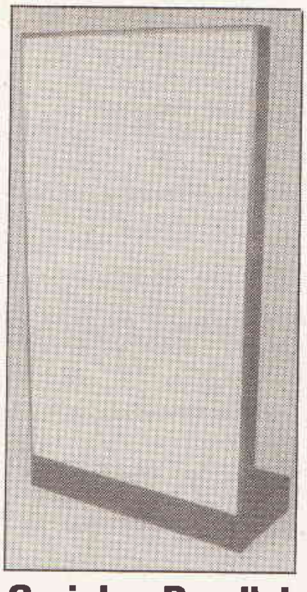



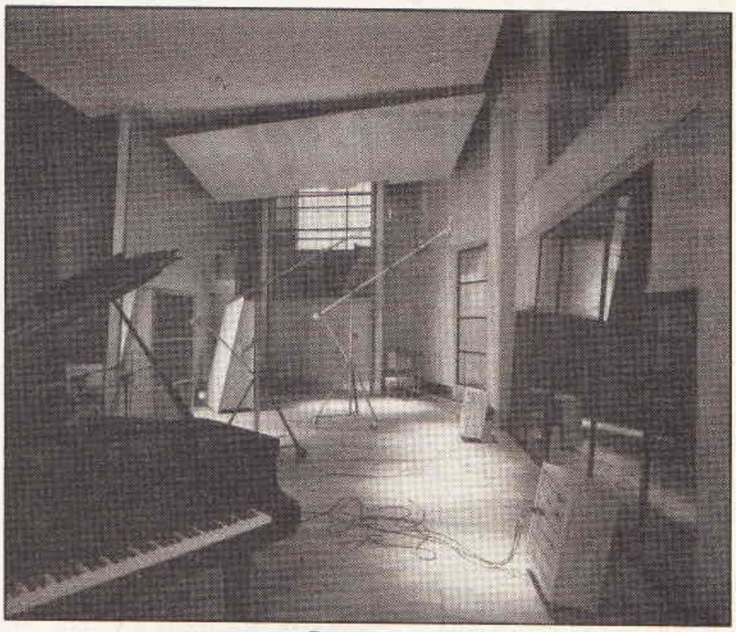

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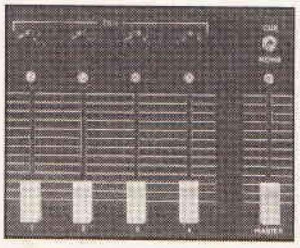



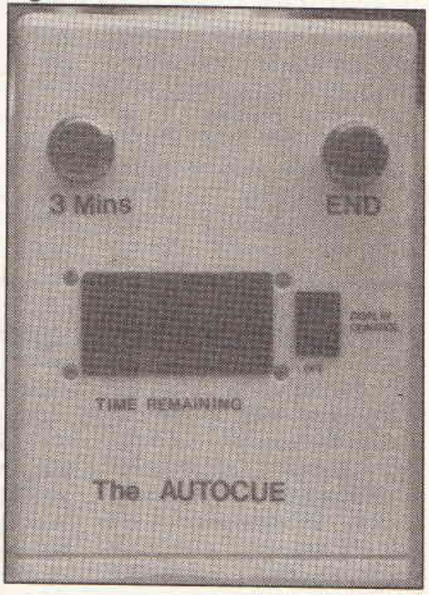


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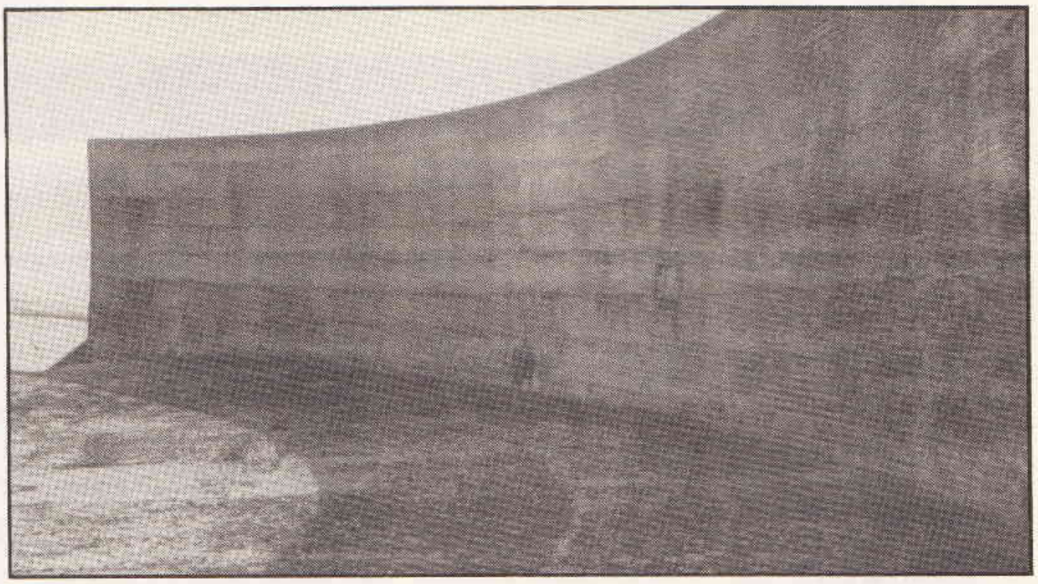
# READ\WRITE

ETI LETTERS

## *Acoustic Radar — The Listening Post*



I realise the title is somewhat nonsensical but it conveys the significance of what follows in the fewest of words.

In the middle 1930s, one of my projects was testing an underground explosive store in South Wales. On one site visit, the research officer attached, over a cup of tea, related a little of a former research exploit. It appeared that a very massive curved wall had been built, concave in shape for the purpose of concentrating the sound of approaching aircraft. This was picked up by a series of microphones placed at the focus area. I was told this had been located at Dungeness, Kent, at an isolated spot well away from noise of any kind and facing the sea. To reduce possible noise from the waves, a short wall was built seawards behind which the microphones were placed. Trials were mainly conducted at night and in daytime the local road and rail traffic was stopped. Clouds affected the results appreciably due to reflection. Various types of listening apparatus was used, some of which could face inland, and an interesting feature was that the roar of London traffic was easily discerned, especially with the help of cloud cover, starting up roughly at 4 am.

It will be remembered that the Radio Direction Finding systems at Bawdsley had proved themselves in 1935. This was fortunate for the result of the trials at Dungeness were rather limited, and they were therefore terminated.

I had forgotten this episode until, some time after retiring to Sussex, I heard that there were some strange constructions at Greatstone, not far from New Romney on the Dungeness peninsula. With a little difficulty, I located the site, for few people knew about this strange activity at the time, and even fewer know about it today. I was then able to view the reality of what I had heard about fifty years earlier in South Wales. In addition to the large wall, there are a few giant 'saucers' still with the remains of the microphones supports rusting away, and the whole is slowly falling into the adjoining gravel pits. The attached photo gives a general idea of the enormous 'strip mirror', the size and shape of which can be judged by the standing figure. Anyone interested can find it half a mile west of the Maddieson Camp Station on the Romney, Hythe & Dymchurch Light Railway. There is a tedious scramble over loose gravel on the last lap. A few, but not many, of the locals know of it as 'The Listening Post'. There were other 'ears' around the south coast of England but none which match the size of the Greatstone edifice.

**W. Harms, Bexhill, East Sussex.**

## *Amplifier Parts Going Critical*

Regarding the letter from Mr Graham Nalty in the September issue of ETI.

What can I say? My name is now talked about on street corners, in Glasgow, and in hushed wispers.

Yes the wire I used *is* PVC covered, being also silver plated and ex-BT equipment wire but the funny thing is my amplifier doesn't sound disastrous to me and that's using Stax-Lambda loudspeakers and as Mr Nalty will no doubt tell you, are pretty nit-picking devices. Some hi-fi nuts prefer stranded cable, opening the door to the argument that one man's meat is another man's poison. Even the golden ears of the Hi-Fi magazine writers differ from each other in their judgement of equipment.

From cartidge to headphones there are no switches in my amplifier, also no source resistors, no output resistors nor output inductances just larger power, but same specification transistors and FETs (heat effects on solid-state devices).

I have also tuned the amplifier to the Stax headphones via my trusty but old wide-band oscilloscope.

As a certain hi-fi manufacturer of high quality amplifier modules will point out, emitter or source resistors, inductances and the like, cause appreciable distortion when under current load, so if I can live with the effects of PVC wiring, silver-plated or not, Mr Nalty can surely live with the effects of resistors and coils heating up and cooling down.

**D Lucas
Glasgow.**

I have read Mr. Graham Nalty's letter in your September issue, in which he offers components which he claims will 'improve the sound quality' of my 'Audio Design' power amplifier.

I appreciate that Mr. Nalty makes his living by selling electronic components, and I welcome the fact that there are people who engage in this activity. However, as the designer of the circuit in question, I am not very happy at his implied suggestion that the sound quality of my amplifier is less good than it could or should be.

As most people who have tried their hands at audio amplifier design would agree, this is not a simple job to do well, since it involves the fairly careful balancing of component types and values, circuit design, and system layout. The nearer one gets to getting this balance right, the better the amplifier will perform.

The 'sound quality' of any audio design is the outcome of the skill of, and choice of parameters made by, the individual designer. The effect of this is that any one designer's products are likely to have a family resemblance to one another — with one hopes, the more recent being just a little nearer to perfection that the earlier ones.

Part of the task of the conscientious amplifier circuit designer is to try to make his design fairly tolerant of LS load impedances and the precision of circuit component types or values, since these will vary anyway. However, complete layout, is impossible to achieve, and one must be careful about some aspects of the design.

In the present case, Hart Electronics have accepted all my recommendations for component types, and have followed my suggestions on layout, in all cases where this is critical. A practical testimonial to the success of this collaboration is the delighted response of so many people who have built the Hart kit.

Unfortunately, there is no way by which the 'sound' of an amplifier, or any other piece of audio gear, can be either measured or specified, and this has opened the door to salesmen who claim wonderful improvements in 'sound quality' for a host of — usually very expensive gadgets and accessories in the 'hi-fi' field.

Since the sellers of these gadgets usually stop short at urging their customers to take a soldering iron to the insides of their gear, the activities of the 'add-on' specialists are usually no less benign than the vendors of 'go-faster' stripes for ones Ford Capri who do at least stop short of claiming an actual increase in speed or MPG, for fear of the Trades Descriptions Act.

However, in the case of audio amplifiers, one can never be quite so sure that component changes will have no effect on the circuit performance, and if they do alter the performance at all, one would need to do a series of fairly careful instrumental measurements to make sure that it was not worsened by the change. Then, if there was no apparent worsening of the performance, one would need to do some further, equally careful, listening trials to confirm that all was still well — since the ear can sometimes pick up small changes which one might have overlooked in ones measurements.

**John Linsley Hood**
**Taunton, Somerset**

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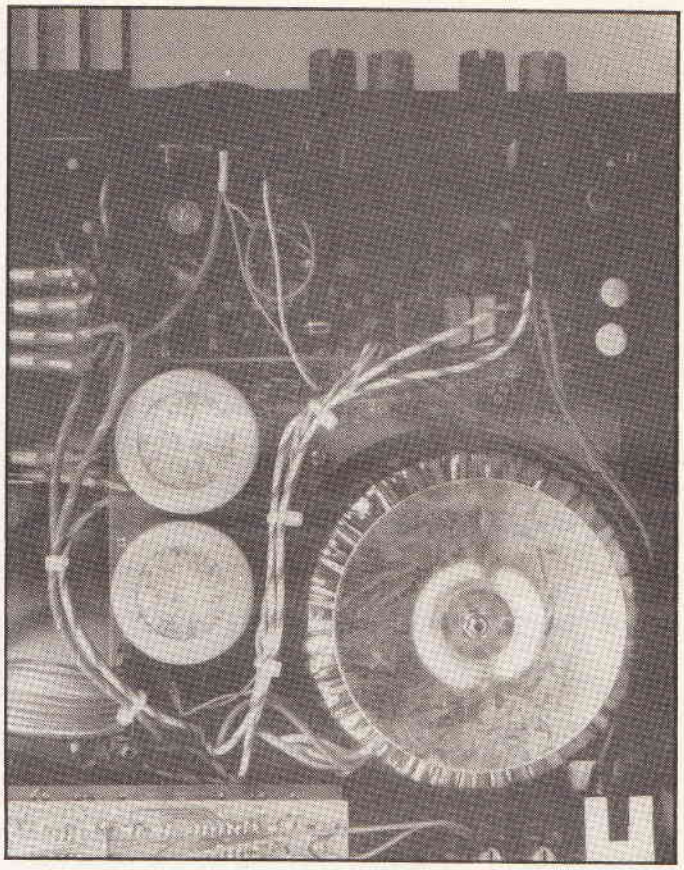
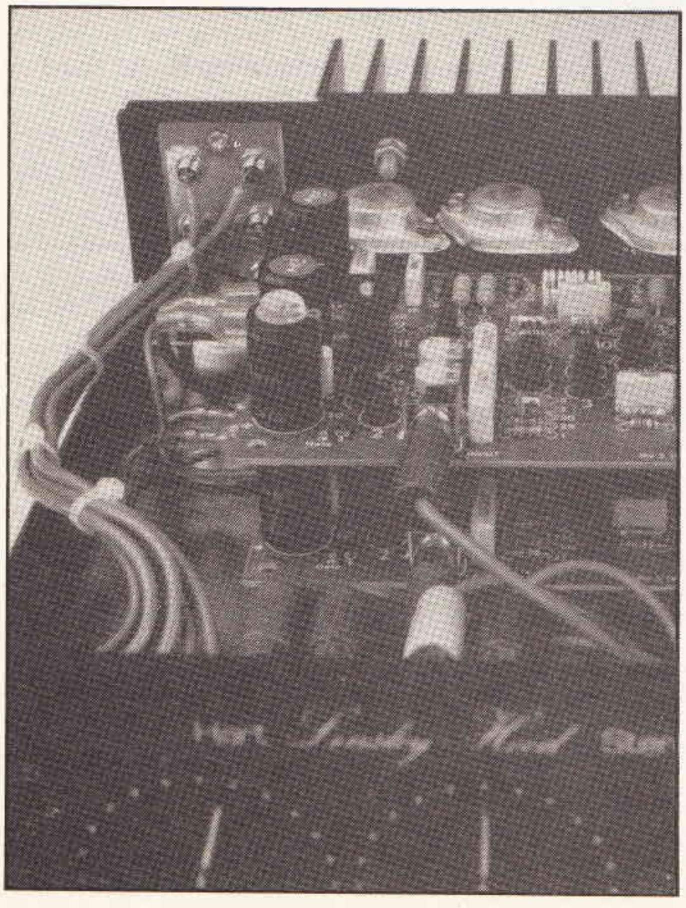
I feel I ought to make a few points concerning Graham Nalty's letter (Power Amplifier Parts) in the September issue of ETI.

If, as it appears, Mr Nalty is writing on behalf of his business is drawing attention to the products and services that this business provides, it is surely more appropriate to do this through the advertisement pages than through Read/Write. I appreciate too that Mr Nalty earns his living by selling the components referred to in the letter, but I have to disagree with his statement that the use of ordinary components, cables etc makes an amplifier sound 'disastrous'. Over the past few years I have designed and built many amplifiers, both for hi-fi and sound reinforcement (PA) purposes. These have all been either built for, or demonstrated to, several friends who appreciate high-quality sound, and whose judgement I am inclined to trust, and have all been claimed to be entirely satisfactory. Yet these same amplifiers all used normal industrial grade components and PVC — insulated cables of varying size and construction. I would suggest that if the insulation IS removed as per recommendation, the resulting language when a short-circuit clobbers about fifty quid's worth of transistors may indeed sound disastrous!! Obviously it is sensible to use good quality components rather than those out of the junk box, and there are one or two places where something a little out of the ordinary is called for. Firstly I would agree with John Linsley Hood about choice of capacitors (due to the problem of dielectric loss and absorption). Secondly, screened cable tends to be very variable in quality and here it pays to use the best you can obtain. Although all components have parasitic impedances associated with them due to their method of construction, in any well-designed circuit these will not have any significant effect except at very high (radio) frequencies, so it should not be necessary to use ultra-expensive exotic components.

**Dom Banham**
**Redbourn, Hertfordshire.**





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I have read both the letter published in your September Issue and the 'component note' from Mr Nalty, regarding the Hart kit for the John Linsley Hood Audio Design Power Amplifier. It is such a pity that we did not have the benefit of these words of wisdom before John or ourselves started any work on the design of this amplifier. Certainly we did not realise that all the careful optimisation of the printed circuit boards, component specifications and chassis layout was all totally unnecessary. All those hundreds of hours work for nothing, why didn't someone tell us?

Too late we learn that all we needed to do was strip the insulation off all the connecting wires, replace all our 1% metal film resistors with Mr Nalty's 1% metal film resistors at 40p each and the amplifier would sound marvellous!.

Or is someone pulling our leg?

**A.H.Milligan**
**Hart Electronic Kits Ltd.**

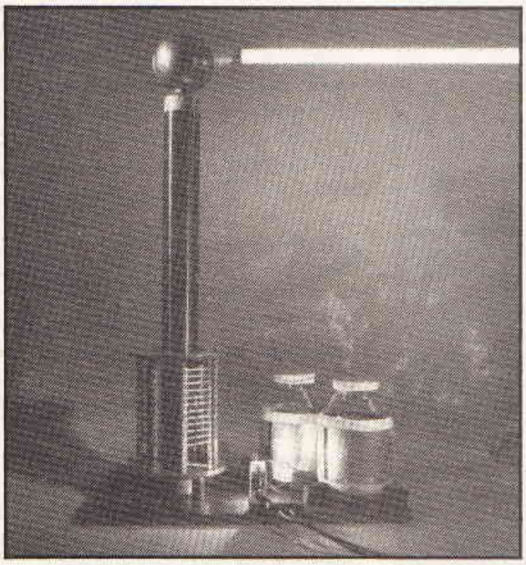
## *The Inventions Researches and Writings of Nikola Tesla* by Thomas Commerford Martin

ISBN 0 917914 90 2 Published by Lindsay Publications Inc. 496 pages, Price £10.95.

This is one of many Lindsay Publications marketed in the UK by Camden Miniature Steam Services. It is a facsimile reprint of material from The Electrical Engineer of New York for 1894.

A great many years ago when I was in short pants, radio was wireless and TV box-watching hadn't been thought of, the Junior section of the local library was in great demand. In addition to the usual Bulldog Drummonds, Sherlock Holmes and the adventure stories of Henty there were many good books on technical subjects; it was here that I first came across Tesla. Faraday, Swan, Edison, Lodge and so on were names well chosen to those customers of the library who had any interest in electrical matters, but the name Tesla was a strange one which appeared only in a book about the Tesla coil, with an account of the seemingly magical things it could do.

Even now, few people seem to know much about Tesla even though the currently fashionable name for the unit of magnetic flux density is the Tesla (one Weber per square metre). Yet it was Tesla who in the 1880s invented the all-important polyphase a.c. systems. He started with two-phase with 90 degree phase shift between two phases and went on to three-phase and to polyphase systems. He produced designs for generators and for motors working on these power systems. He invented the single-phase squirrel-cage motor using a capacitor (then called a condenser) to feed the second winding and also the repulsion or hysteresis motor, all of which are currently in widespread use.



In those days electricity distribution was just beginning and there was a great deal of debate about the relative merits of DC and AC, so it is surprising that Tesla's name is not more widely known since it was he who laid the foundations for the success of alternating current. A clue to this may be found in this book, which covers comprehensively his work on polyphase systems and machines and on high voltage high frequency electrical phenomena. Part 1, running to over 100 pages, is an account by the author of Tesla's work up to 1892 in the field of polyphase currents and it is an eye-opener.

The original diagrams are reproduced and there is a lot that can be learned here. Part 2, running to 277 pages, deals with the high voltage stuff and most of it comprises verbatim the texts of lectures given by Tesla to the American IEE in New York, May 1891, to the British IEE in London, February 1892 and to the Franklin Institute in Philadelphia, March 1893. Again the text is accompanied by the original pictures.

Reading all this material dating from days when the only method of generating high frequency currents (above about 20kHz) was by spark or arc fed by an induction coil, the spark in turn being used to excite the primary of a Tesla coil and looking at from the viewpoint of modern AC theory, high frequency and microwave technology, the depth of his insight is astonishing. But the real surprise is that he should have devoted so much effort to promoting high voltage high frequency power as the ideal source of illumination via electrodes or single-electrode light tubes. It may be that his emphasis on this part of his work overshadowed the significance of polyphase power at the time, even though it was never within sight of becoming a practical proposition.

Part 3, Miscellaneous Inventions and Writings, covers methods of obtaining DC from AC (the rectifier had yet to be invented), oil dielectric capacitors, the self-regulating third-brush DC dynamo, thermo magnetic motors and unipolar generators, all in his own words. Part 4 is a short Appendix covering early polyphase motors exhibited by Tesla at Chicago World's Fair in 1893 and a lecture he gave at the Fair on electrical and mechanical oscillators.

For any student of the history of electrical engineering this is strongly recommended reading. But apart from the solid information and the glimpses of the current thought in the electrical world towards the end of the last century, the manner in which the English language is used is also worthy of a note. It should give many of us cause to pay more attention to our own literary efforts. And when we remember that Tesla was born in Eastern Europe and was already in his twenties when he emigrated to USA the perfection of his English is truly remarkable.

**Herbert Bickley**

## *Tesla Coil Secrets* by R. A. Ford

ISBN 0 917914 31 7 Published by Lindsay Publications Inc. 74 pages, Price £4.70. Available in the U.K. from Camden Miniature Steam Services.

This book is in effect a collection of short articles from various sources on the construction of Tesla coils and ancillary apparatus. Some of the articles are quite old and use the terminology of their day, but there is no difficulty in understanding them.

On a quick inspection one might tend to be put off because of the differing sizes and styles of the type — indeed some of the sections are reproduced directly from transcript. But it is all perfectly readable and what matters is the substance rather than the form.

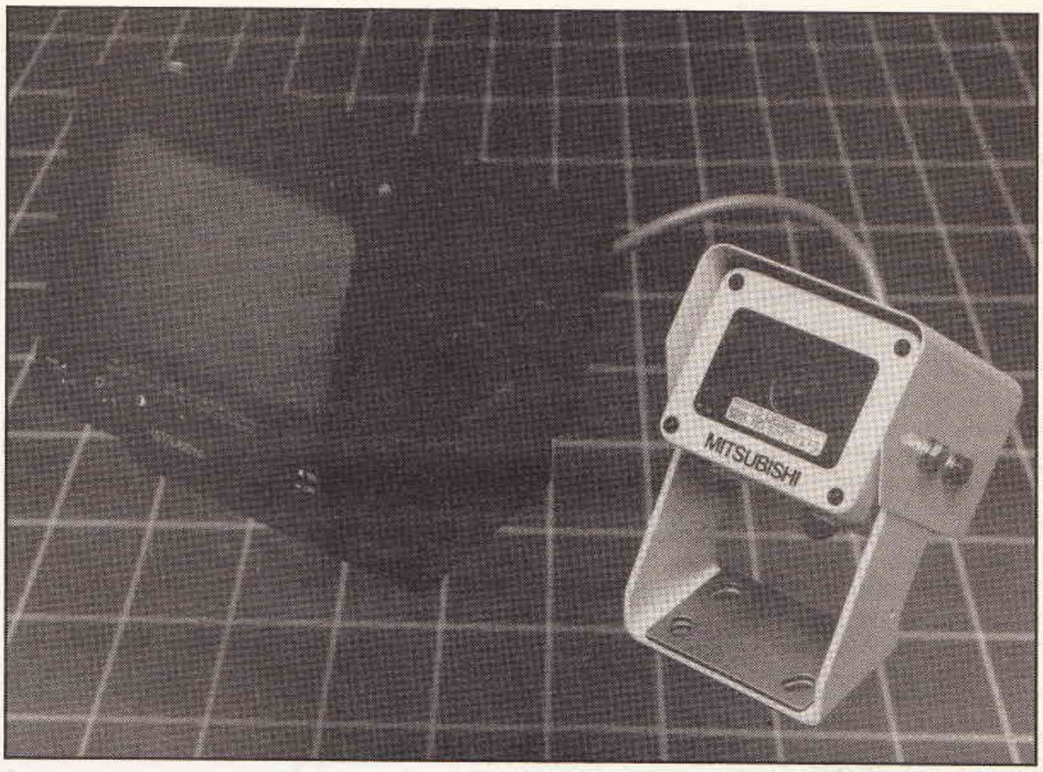
The book gives plenty of practical information, but does not go much into the underlying phenomena though readers who are familiar with radio circuitry will recognise what goes on in a Tesla coil. Not surprisingly, the author and publishers disclaim responsibility for any damage to persons or property which may result from the construction or use of any of the projects described in the book — just as well since one diagram shows a 5,000,000 volt generator.

It should be pointed out that much of the material in the book dates from the days when the most common type of shipborne radio transmitter was a spark set and broadcasting had not begun. Operation of even a small Tesla coil, unless inside an effective screen, would nowadays upset neighbouring radio listeners and TV viewers and could interfere with vital services.

**Herbert Bickley**

ETI

# NEWS




## MOBILE CCTV

Mitsubishi Electric UK Ltd has launched its latest mobile CCTV system, the C-Vision CV-654, giving a wider and deeper field of view. The safety conscious mobile system eliminates the problems caused by blind spots at the rear or side of vehicles and enables drivers to safely and accurately manoeuvre their vehicles.

CV-654 comprises a wide angled CCD camera and 6in monochrome monitor. The camera is positioned on the rear or side of the vehicle, or both, depending on the application, and with its focal length of 2.5mm, it provides an improved and extensive field of view, compared to competitive designs, from directly below the camera to 15m horizontally away. The monitor conveniently sits on the dashboard in the cab and provides a quality picture of 420 lines resolution horizontally and 350 lines resolution vertically.

The C-Vision system operates from 12 or 24V, negative earth, DC supplies and consumes 16W in operation from a 24V supply and 1.5W on standby. It provides an instant picture on switch-on and operates over a temperature range of −15° to 50°C as standard. A cold region option is also available enabling operation in temperatures down to −30°C.

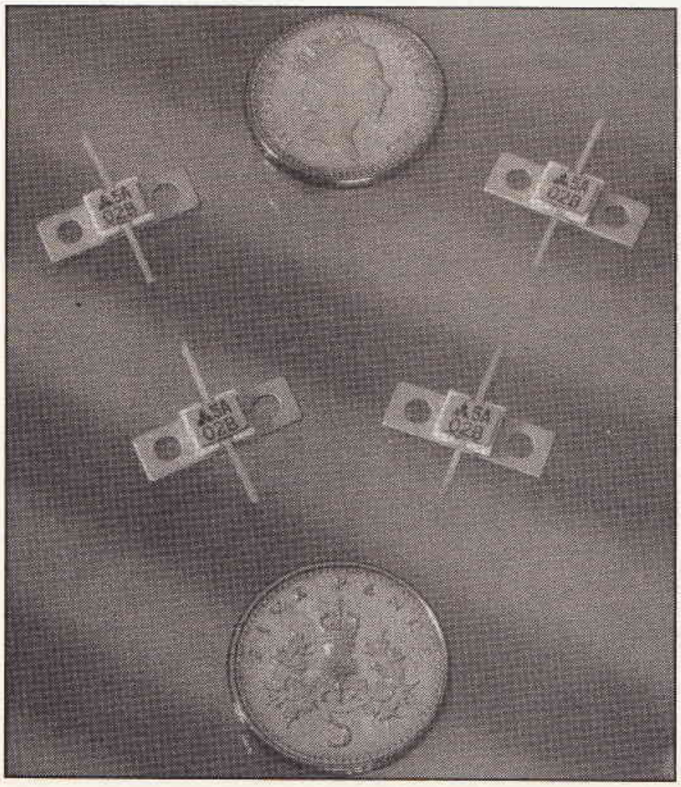
The system provides an effective field of view of 110° horizontally and 85° vertically, inlight levels ranging from 5 to 100,000 lux. The scanning system is 2:1 interlaced.

The compact camera measures 158 × 109 × 117mm fully assembled and mounted, and it weighs 1.5kg.

The system is operated by the driver from the cab, and applications range from single operator refuse collection vehicles, to quarrying and construction vehicles.

Optional equipment includes a washing system to clean the camera lens and a bullet-proof, polycarbonate cover which is said to be ideal for quarrying and mining applications. The CV-654 camera can also be supplied with a motorised, protective shutter which is activated at switch-on.

For further information, please contact either David Selman or Christine Warren at Mitsubishi Electric UK Ltd, Telephone: 0707-276100.



## GAAS FETS AND MMICS

The latest series of power FETs and GaAs military microwave ICs are now available from Mitsubishi Electric UK Ltd.

The MGF0900A series comprises five power FETs with outputs ranging from 30mW to 10W. The high gain, high efficiency devices are primarily for use in the 500MHz to 3GHz band and they are available for commercial as well as screened for military applications.

The power FETs incorporates an N channel Schottky gate design and are intended primarily for UHF to L band amplifier applications. Operation of all devices in the series is rated at Class A, providing high output power and gain, together with high power added efficiency. The devices are hermetically sealed in metal ceramic packages and measure 17.5 by 6.35mm main body width, and stand 4.5mm high.

Within the range, MGF0906A and MGF0907A, provide typical high output power ratings of 37dBm and 40dBm respectively at 2.3GHz. Respective high output gains are typically 11 and 10dB, and quoted high power added efficiency ratings are typically 40% and 37% respectively.

The MGF70XX series of GaAs military microwave ICs are for surface mounted applications. These ICs are ideal for UHF band, low noise amplifier applications.

Between 0.2 to 1.8GHz, the MGF7011 exhibits a typical gain of 15dB and noise figure of 3.5dB. The device is biased from a 4V DC supply with a drain operating current of 20mA. The total power dissipation is quoted at 300mW.

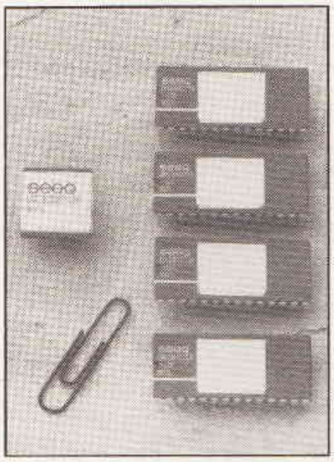
Contact Paul Springate. Tel: 0707-276100.

# WORLD'S FASTEST 1MBIT EEPROM

The world's fastest 1Mbit EEPROM is being launched by Seeq Technology. The 120ns maximum access time, 28C010 is in volume production, and is available for military and extended temperature range applications. The electrically erasable programmable read only memory has an active and standby current of 1Mbit EEPROM of 80mA and 350uA respectively.

The devices have applications in program memory and data storage, including flight data recorders, radar and military control systems. Designers can replace SRAMs on their designs with the 28C010 from SEEQ, cutting out cost and space requirements, as well as the reliability problems of battery backed systems.

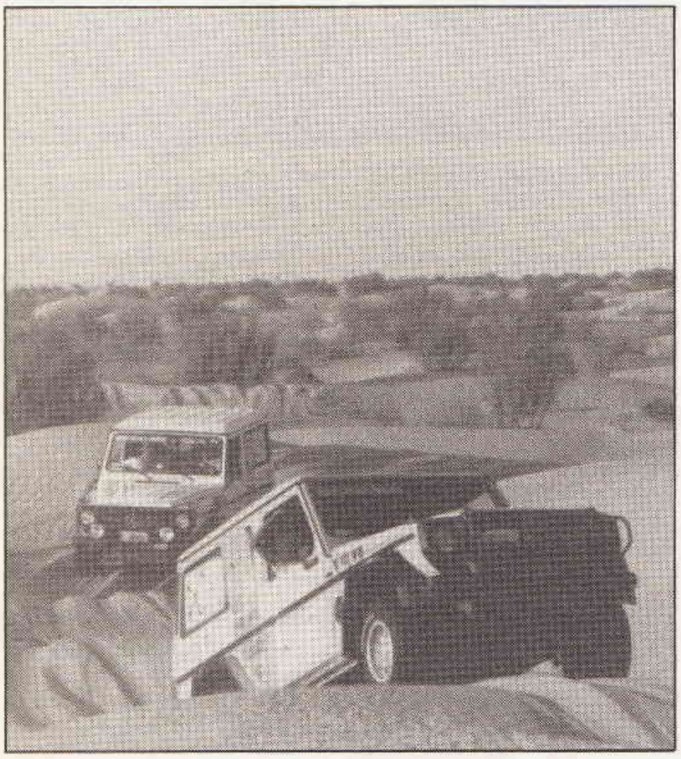
Features of the EEPROM include an extended chip select facility which eliminates the ×4 decoder required for multi-part system applications. A reverse bias generator provides improved latch-up protection as well as protection from voltage drops and surges. Software write protection, incorporating a disable option is also provided, together with false write and erase protection.



Differential sensing on the 28C010 is similar to that of SRAM devices to improve read access time and noise immunity, speeding up memory data signals improving reliability. Double layer metallisation reduces word line delays and access times. The 1μm channel length reduces internal gate delays.

The 1Mbit, 120ns 28C020 EEPROMS are available now and cost around £380 and £600 each in quantities of 100 for the commercial temperature range and MIL-STD-883C devices respectively.

Further information from Debbie Foot. Tel: 0793 694999.



# SAHARA TEST

An important study of the physiological effects of stress has been undertaken through a series of clinical trials recently performed in the Sahara Desert, using a V-Store instrumentation recorder manufactured by Racal Recorders Limited.

The tests, which took place using off-road vehicles in the south of Tunisia, were carried out by a team from the University of Pavia Neuropathological Clinic in Italy. The objective was to monitor the effects of the grueling conditions to which the cross-country drivers and navigators were subjected.

Medical transducers were used to continuously measure heartbeat and blood pressure for eight hours a day. Every two hours during rest periods, these measurements were recorded, together with tests taken to assess brain alertness and muscular tension in the jaw. All of the data collected was logged on a V-Store recorder, mounted in the back of the four-wheel-drive vehicle throughout the trials, for subsequent laboratory analysis.

The V-Store is already in worldwide use in a wide range of portable and laboratory applications, from medical and automotive to military and industrial research. Lightweight and rugged, the V-Store is a compact recorder and provides up to 24 channels in one unit.

Using an AC/DC power supply and standard VHS tapes, the V-Store is able to record signals from all types of sensors with electrical output from DC to 100kHz.

# POWER BEHIND THE BUTTON

Fieldtech, has recently introduced the PS300 series of high voltage power supplies.

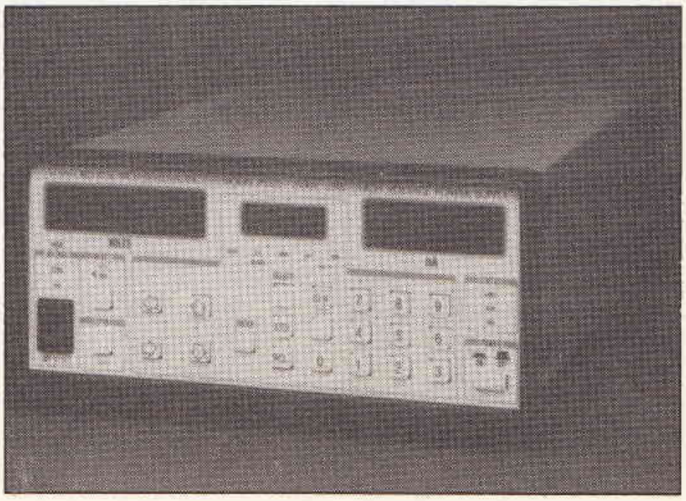
Manufactured by Stanford Research Systems Inc the PS300 series provides GPIB programmable high voltage for laboratory and ATE applications. The three 25watt models cover a range of output voltages to 5kV and currents to 40mA.

These power supplies will provide more than their rated current at reduced output voltages. For example the PS325 has a maximum output current of 10mA at full voltage (2500V), but can supply 20mA at ½ full voltage (1250).

Microprocessor control has made it possible to incorporate a wide range of protection features. In addition to being arc and short circuit protected, these supplies have separate programmable hard and soft current limits, Allowing the supply to act as a constant current source or as a circuit breaker.

Two displays show output voltage and current. A third display shows the parameter being adjusted. For manual use there are both numeric and cursor entry. The GPIB interface allows program access and control of all instrument functions.

Reader enquiries to Mr Graham Holden, Fieldtech Heathrow Limited, Huntavia House, 420 Bath Road, Longford, West Drayton, Middlesex UB7 0LL.




## DIGITAL COMPASS

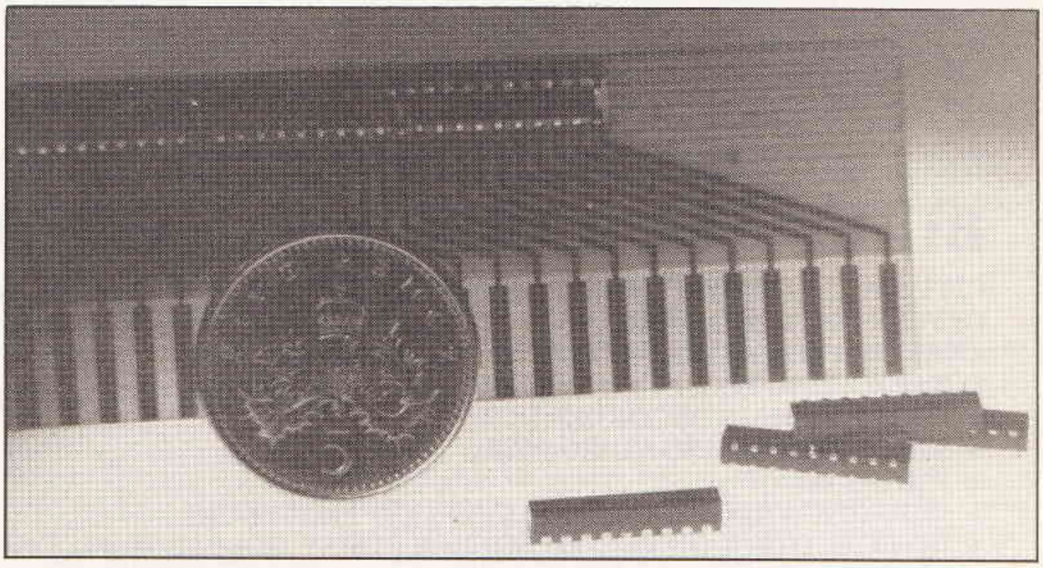
The newest addition to the Navico range of instruments for sail or power vessels is the DC200/DC200P fluxgate compass. The weatherproof display head shows digital and analogue steering information and doubles as an on-deck repeater for Decca, Loran or GPS readings.

The heart of the unit is the weatherproof heading sender, a fluxgate so light and small in its gimbles that accurate average readings can be obtained in less than a second. Different averaging periods can be selected and the readings are updated every second.

The display meter powerboat version is designed for recessed, flush panel mounting; the sailing version stands proud of a bulkhead and contains an extra 'tack' function. There are 4 display modes. If a repeater is used, different modes can be displayed simultaneously.

- In compass mode, the display can be changed to a Trim function showing intended course and a bargraph analogue indication of angle off-course. The DC200 compass for sail also offers a tack function allowing the optimum port and starboard tack courses to be memorised; arrows will indicate whether to head closer into the wind, or ease off to maintain the memorised tack angle.
- Nav Repeater and Nav Cal mode. When a radio navigation receiver is connected, a display mode can be instantly selected showing cross-track error and range to waypoint.
- Lastly the Rate-of-Turn mode resolves the turning rate to 0.1 degree per second. This is useful is judging tack rate and for large vessels manoeuvring in confined waters.

## SMALLER RESISTOR NETWORKS

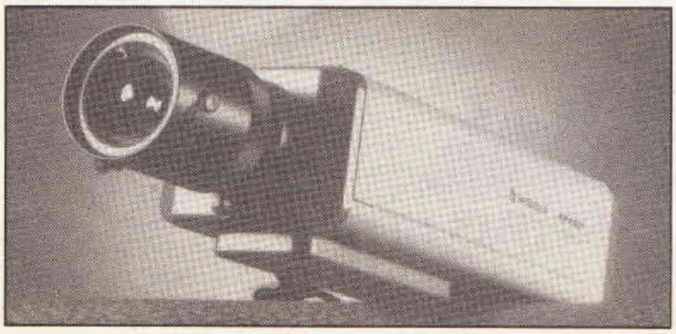


Panasonic Industrial are introducing what is believed to be the first molded SMT SIP resistor network in the world. The miniature EXB H Series surface mounted resistor networks will greatly improve production times since multiple networks can be placed in a single operation.

The EXB H Series resistor networks offer a compact, high density, low profile package 2.54mm high when mounted, with a 1.27mm pin pitch, this gives a 70% space saving when compared to SO package resistors and a 30% space saving compared with discrete chip resistors. Designed for easy handling, the new resistor networks are available in 16 or 24mm embossed tape for use with automated high speed chip placers.

The networks offer a choice of 5, 6, 7, 8, 9 or 10 pin SIP configuration and are available in a bussed circuit, isolated circuit or line terminator format with +/-5% (J) resistance tolerance. The resistance range on E-6 Series is 22R to 1M with a rated power of 1/16 W in a bussed circuit and 1/10 W in an isolated circuit.

## S-VHS CAMERA



Hitachi Denshi has announced two further developments to its KP-C500 range of single CCD colour cameras.

The KP-C506 and KP-C507 incorporate 'S/VHS', the new evolution of signal processing, which produces a significant improvement in picture resolution. By obtaining separate Y/C (luminance/chrominance) output signals and recombing them, the sub-carrier component of the chrominance signal cannot interfere with the response characteristic of the luminance signal. Since there is no deterioration of the fine picture pattern higher resolution is obtained.

When the cameras are used with a 'Super VHS VTR, which also has Y/C separation input channels, a very high quality picture can be recorded and played back. The new 506 and 507 cameras are expected to find a range of uses in inspection, training, and in optical or microscope-orientated applications in the medical field.

## SWITCHING ON REFLECTION

SDS/Matsushita has introduced a range of long-distance, surface reflection photoelectric switches which are suitable both for positioning and detection of static or moving objects.

Using optical triangulation characteristics of the triple beam detection principle, the new MR3 range will detect medium to large objects, at distances of up to 2m.

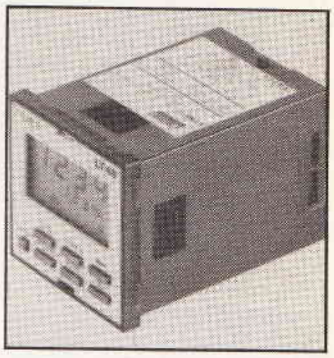
These switches can be used in personnel detection, automatic warehousing, conveyor systems, door controls, large product assembly lines, packaging equipment and woodworking machinery.

Both AC and/or DC power types are available, the self-contained AC/DC range operating on 24 to 240 VAC nominal or 240 to 12 VDC nominal, whilst the DC range operates on 24 to 12 Vdc. The MR3 'T' type has a built-in timer function to prevent detection errors and to make it easier to send a high speed signal — for instance through a PC.

All the switches in the MR3 range will accurately detect objects across a wide range of colours, materials and shapes including object with mixed colours. The M100 group has a distance sensing range of 0.2 to 1.0m, and the M200 group a range of 0.5 to 2.0m. These reflective type sensors are not susceptible to 'false detection', caused by movements beyond the set detection range.

## UNIVERSAL TIMER

As timers accumulate more and more functions, they can become unneccessarily complicated to use. This problem has been addressed by SDS/Matsushita with the development of a universal timer with an easy-to-understand programming mechanism.



Suitable for many timing applications the 'LT48' is capable of accepting a wide control voltage, from 24V to 240V DC or AC, 50 or 60Hz, and can even be used on applications which experience widely fluctuating voltage.

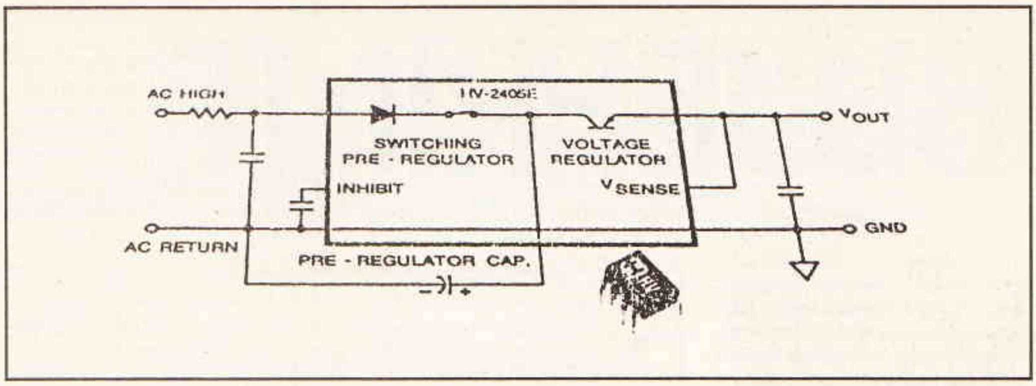
Regulated by an accurate microcomputerised quartz oscillator which provides 11 timing ranges extending from 0.001sec to 9999h, in either decimal or sexadecimal modes, and a timing accuracy of +/-0.05 sec, the unit is available with either a relay output (5A, 250VAC resistive, 1NO + 1NC contact), or with a transistor output for up to 10 million switching operations.

It also has an inbuilt battery to ensure against power failure for up to 7 years. Even during a power cut the unit remains fully operational, and allows its set value and operation to be changed.

The front panel controls input, output, operating function and timing range on a standard 48 x 48mm housing sealed to IP65, and suitable for plant and factory floors.

The LT48 universal timer typically costs below £60 for small quantity orders.

# ETI NEWS stateside




## New power supply chip

A new power-supply chip converts 240-VAC line voltage to a 5-24VDC output. The new device, called the HV-2405E, provides double the capacity of the HV-1205, a 120-V power-supply chip previously introduced. The HV-2405E, like the HV-1205, functions as a transformer, rectifier, and three-terminal voltage regulator.

Key to the HV-2405E's higher capacity is a "tail-killer" circuit that can interrupt, or switch off, current at levels higher than could be acheived before, The circuit does so by eliminating minority carriers, or tail current, while charging a capacitor.

Current interruption is critical to the chip's operation, which is based on electronic switching. The new chip uses a common switch to draw current in short bursts whenever the incoming AC line voltage reaches a given level. The current is stored in a capacitor that delivers a DC voltage to the load.

The eight-pin plastic integrated circuit is available in 1,000-piece quantities for $2.93. The price is approximately 15% more than the HV-1205. The manufacturer is Harris Semiconductor Inc. of Melbourne, Florida.

## Detecting movements of miniature electronic devices

Detecting the motion of microscopic objects is now one step closer with the fabrication of a tunnelling probe at the University of Rochester, Rochester, New York, and IBM Thomas J. Watson Research Centre, Yorktown Heights, New York. The probe, which can sense the motion of molecules or atoms, may be used to monitor the movements of miniature electronic and mechanical devices such as tiny tweezers, motors, and levers.

The probe operates similarly to a scanning tunnelling microscope. It consists of a sharpened piece of wire connected to a battery. When the probe tip is placed a few angstroms away from the object being monitored, a weak current flows from the tip of the wire. The number of electrons per second that tunnel from the tip to the surface of the object are monitored and the distance based on the tunnelling rate calculated.

The current flow is a sensitive indication of the distance between the object and tip of the wire. If the tip is moved just one angstrom, the current might double. So by monitoring the current, the motion can be inferred.

The probe also allows measurements to be made of how molecules react to a very weak force.

Because electrons are extremely small and of low mass, the electrical signal from the probe does not disturb the object being monitored. This is crucial when monitoring very small objects, such as atoms, because the force of the probe itself can easily affect the object and distort measurements.

## Providing stable signal operation

Silicon pressure sensors in high-precision instruments can provide unstable signal output during the first hours of operation. However, a pressure-sensing chip developed by NovaSensor could overcome this problem.

The custom chip gives a stable signal immediately after power is applied and more precise pressure measurements can be made in the first hours of instrument operation.

The chip, incorporated in the company's NPH and NPI pressure sensors, consist of a diaphragm bonded to a silicon wafer with resistors diffused in the diaphragm. The integrated device converts resistance changes, caused by applied pressure, into electric signals.

Short-term instability in most sensors results from ion migration near the resistors when power is applied. The moving charges create an electrostatic attraction that changes resistor geometry and causes signal drift.

NovaSensor sidestepped the ion-migration problem using a manufacturing process called SenStable. The proprietary process stabilizes drift by reducing ion migration, and ensures that resistance does not change with pressure, temperature, or time.

## Thin film batteries

The University of California at Berkeley is negotiating with several firms to transfer its technology for solid-state, thin-film batteries, which hold promise for use in electric vehicles, satellites and other applications where weight or volume is important.

The key is a class of materials, discovered at Lawrence Berkeley Laboratory, called solid redox polymerization electrodes which can be made from a variety of inexpensive, readily available and easy-to-fabricate materials. They have excellent electrochemical reversibility and cyclability, which implies a long service life.

The batteries are constructed by sandwiching a solid-state polymeric electrolyte — typically polyethylene oxide complexed with salts, between a thin-film cathode and thin foil of alkali metal, such as lithium or sodium. They consist of long-chain polymers (S-R-S) with linkage between the sulphur atoms. The electrons transferred break the S-S bonds, releasing energy and forming alkali-metal thio salts that repolymerize under charging conditions.

At 80°C, the battery has about twice the capacity per unit volume of lead-acid and nickel-cadmium cells, at about half the weight. At ambient temperatures, it exhibits about 30 per cent more capacity.

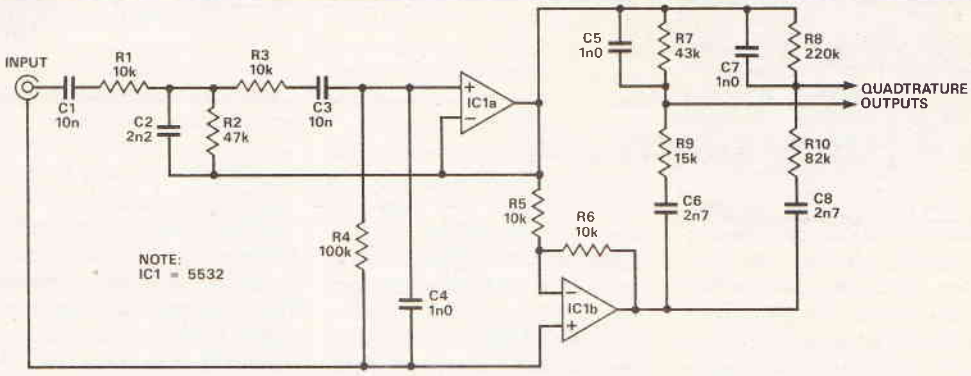
# BLUEPRINT

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.

This month's Blueprint continues the tale of the howling microphone, with circuitry to put inside the blocks of the frequency shifter design shown last month.

The most difficult part of the circuitry to design is the wide bandwidth audio phase shift network. To make the design practical, it is probably best to precede it with a bandpass filter, so that the 90° relative phase shift only has to be maintained over a limited range of frequencies.

Figure 1 shows the circuit of a suitable bandpass filter and phasing networks. The filter is a standard VCVS (voltage controlled voltage source) type, but with highpass and lowpass circuitry combined. There will be some interaction between the high and low pass characteristics, but not enough to matter for most uses. The phase shift networks have resonant frequencies of 720Hz and 4kHz respectively, and Q values of 0.21 (from M. Hartley Jones, Wireless World July 1973).



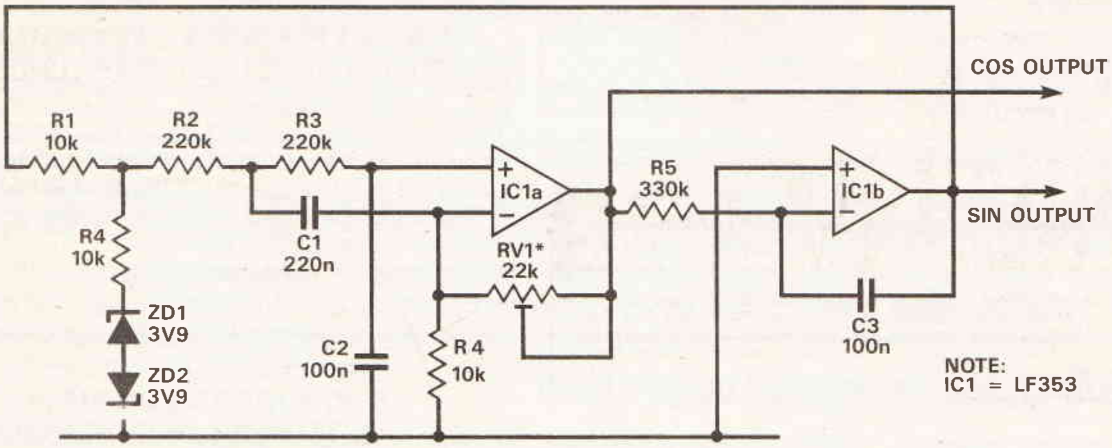

BANDPASS FILTER FROM f1 TO f2 WHERE:

$$f1 = \frac{1}{2\pi\sqrt{C1xC3xR2xR4}} = 232\text{Hz AND}$$

$$f2 = \frac{1}{2\pi\sqrt{R1xR3xC2xC4}} = 1070\text{Hz}$$

AND, FOR MAXIMALLY FLAT RESPONSE:
R1 = R3, C1 = C3, C2 = 2xC4, R2 = ½R4

Fig 1.




*SEE TEXT

Fig 2.

A standard quadrature oscillator circuit is shown in Figure 2. This design uses a VCVS lowpass filter as a phase shifter, giving 90° phase shift at the -3dB point. The integrator gives a 90° phase shift at all frequencies, but with a gain which depends on frequency. The inversion of the integrator ensures that the correct phase relationship (input in phase with output) for oscillation to occur. The phase shift of the VCVS filter depends on frequency, so this part of the circuit sets the frequency.

## Gain

When stable oscillation is taking place, the loop gain of the oscillator will be unity. If the circuit actually has a lot of gain, the circuit will overload and clip to make the average loop gain exactly 1. To minimise distortion to the sinewave outputs, the loop gain of the

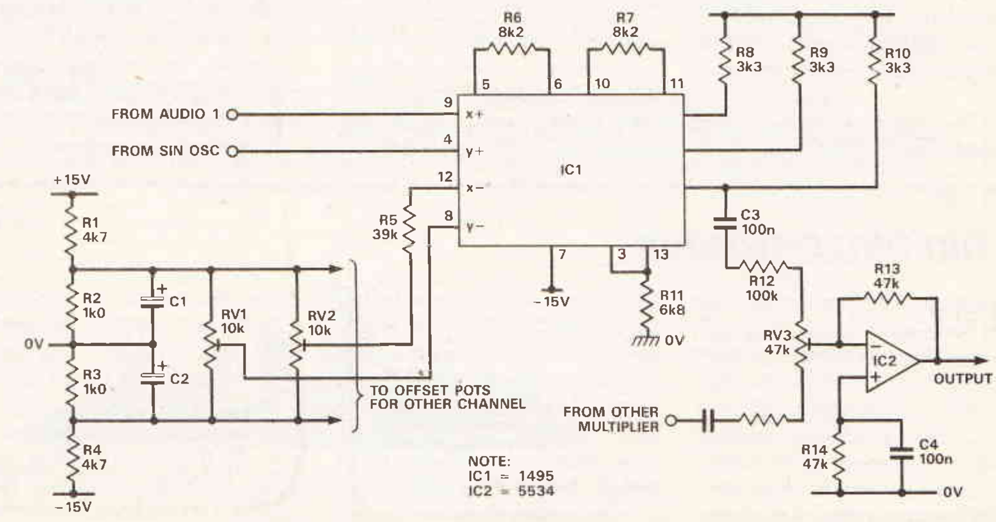



Fig 3.

circuit is designed to be adequate for oscillation to occur, but not excessive. Controlled clipping before the lowpass filter is carried out by R1, R4, ZD1, and ZD2. The signal is not clipped hard — the gain is simply reduced to 50% of its pre-clipping value.

The voltage gain of the integrator is just less than unity at the 90° phase shift frequency of the filter (4.9Hz), and the gain of the filter itself is -3dB, so extra gain in the op-amp buffering the filter is provided by R4 and RV1. When this part of the circuit is being tested, RV1 should be set so that oscillation just occurs, and then turned a small amount further in the direction of stronger oscillation. This should guarantee that the oscillator always starts.

## Multiplication

The circuits use 1495 multipliers, (as did the Wireless World design) but as DC coupling is not necessary, a circuit employing the CA 3080 could turn out to be effective and economical.

The linearity of the multipliers is quoted as 2% on x inputs and 4% on y inputs. Audible distortion to voice by this will be minimal, but the accuracy of the multiplication can be slightly degraded by non-linearity. To minimise this, two offset potentiometers are used to centre the signal and oscillator on the most linear portion of the transfer characteristic.

The design of the multiplier section is shown in Fig. 3 Two such circuits are required, feeding to the common output stage.

No power supply circuit is shown. A conventional ±15V supply, perhaps using 7815 and 7915 regulators, will be suitable. Readers are left to design their own circuit for this.

## Testing And Calibration

Using an oscilloscope, check that the oscillator produces waveforms of approximately 5Hz sinewave, at approximately 9V peak to peak. Observe that the waveforms appear in phase quadrature.

With no input signal, adjust the x offset controls for the minimum 5Hz output. An oscilloscope is best to use to check the output, but an AC millivoltmeter would be adequate.

With an input sinewave signal of approximately 1kHz, adjust the y offset controls and the adder balance pot for minimum amplitude modulation of the output. Again, it is best to monitor using an oscilloscope, but simply listening to the output will give good results.

If an oscilloscope is not available, then all tests can be carried out successfully *assuming that the oscilloscope works as planned*. Don't forget, although this design is likely to work, it has not been built, so minor alterations may be necessary. Carrying out such design changes without proper test equipment would be a daunting task. If enough interest is expressed in readers letters, I may design a project and produce a kit.

2

# HIGH DEFINITION TELEVISION

## Japan's Hi-Vision — The world's first HDTV system

*James Archer examines the present Japanese HDTV system*

Surprising as it may seem to those who still see HDTV as something for the distant future, it was some twenty years ago, in 1970, that the Japanese broadcaster NHK began research into the possibilities of developing a High Definition Television System, and they gave it the name HDTV.

The standards which their system was to use were decided upon after much basic research, not only into television engineering, but also into basic characteristics of the human eye/brain combination and into the effects which viewing conditions would have on the total viewing experience. Since, the acceptability of a picture depends to some extent upon its content, the Japanese researchers were careful to use a wide range of pictures in their tests, many of them computer generated images of carefully controlled characteristics.

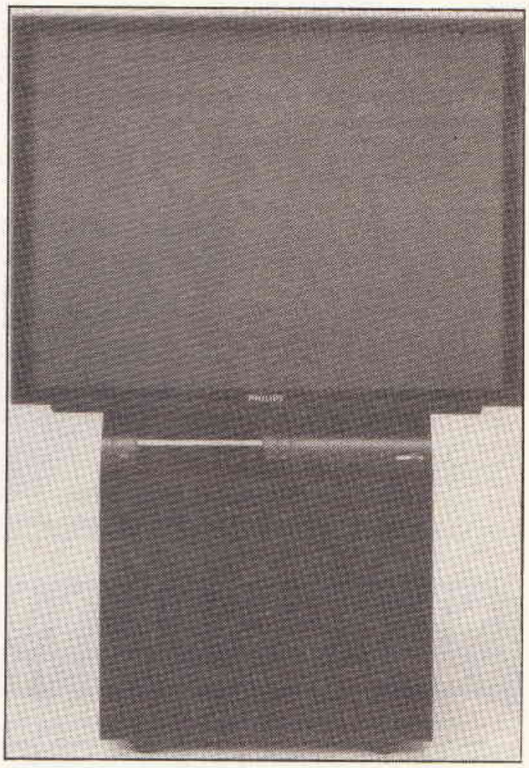
Ten years after the project began, in 1980, the first HDTV tests via satellite were carried on 'Yuri', the somewhat curiously named Japanese experimental satellite. By 1982 the system, which had 1125 lines, 60 fields per second, and an aspect ratio of 5:3, which was later to change to 16:9, was being demonstrated on large screen, and much of the equipment necessary to equip a studio had been built by NHK and the Japanese manufacturers. NHK was able to show HDTV cameras, telecines, videotape recorders, and both cathode ray tube and projection displays, and some of the pictures were comparable in quality with those from 35 mm film.

### A range of 1125/60 systems

It is important for readers to note that in the 1990s it is an oversimplification to talk about 'the Japanese HDTV system', because the basic system that will be described in the next few paragraphs has been subject to considerable changes over the two decades of its existence, and there have really been three main phases in the life of 1125/60Hz HDTV television systems.

Originally the system put forward as a standard to be used both for studio production and for transmission over the air and via cable. Criticism of the enormous bandwidth requirements for transmission led to the development of the MUSE system, described below, which allows for 1124-line/60Hz pictures to be transmitted over standard bandwidth satellite or cable channels at the cost of a small reduction in the quality of some pictures. It has now become generally accepted that any transmitted 1125/60 HDTV signals will use one of the variants of MUSE.

The third phase has really come about as a result of the so-far unsuccessful struggles to achieve a world standard for HDTV, the politics of which were described in the previous article. Realising that it would




not be possible to achieve their original goal, which was to get the whole world to adopt the 1125/60 HDTV system for both production and transmission, and seeing that they were many years ahead of competing systems when it came to the availability of HDTV studio equipment, the Japanese have adopted another approach. They have began to make a complete range of HDTV studio equipment available to programme makers around the world, and are attempting to make the full-bandwidth highest quality 1125/60Hz system the de-facto world *studio* standard for HDTV. Already facilities houses in the United States and in Europe have bought HDTV production equipment, and even the BBC, which is nominally committed to the development of the competing European 1250/50 HDTV system, has utilised the Japanese equipment to gain experience of HDTV production, although the resulting programme, 'The Ginger Tree', has to be standards-converted to 625/50 before its transmission in 1989.

### The parameters of the Japanese system

The basic standard adopted for the Japanese HDTV system had the following characteristics, although it is important to note that some characteristics were changed as the system developed, and some para-

HDTV

meters have been changed to suit particular applications:

| | |
|---|---|
| Scanning lines per frame | 1125 |
| Number of active (picture) lines per frame | 1035 |
| Aspect Ratio (later changed to 16:9) | 5:3 |
| Interlace ratio | 2:1 |
| Field frequency | 60Hz |
| Line frequency | 33750 Hz |
| Luminance (Y) bandwidth | 20 MHz |
| Chrominance (colour difference signal) bandwidths | |
| (i) wideband signal ($C_w$) | 7.00MHz |
| (ii) narrowband signal ($C_w$) | 5.5MHz |

Note that the field frequency is precisely 60Hz, not the 59.94Hz which is used in the American and Japanese NTSC terrestrial systems in order to improve compatibility for black and white television viewers.

The original RGB signals from the HDTV source are passed through a resistive matrix to provide a luminance signal Y and two colour difference signals of different bandwidths, $C_w$ and $C_n$.

These first HDTV signals were intended for transmission over satellite radio-frequency channels, and numerous transmissions were made using both composite colour signals, the luminance and chrominance signals being frequency multiplexed, and using time compressed analogue component signals. This form of transmission was known not as MAC, but as TCI, Time Compressed Integration, and in this system the compressed luminance and chrominance signals are time-division multiplexed on a line-sequential basis. In a further series of tests the Yuri satellite was also used to transmit luminance and chrominance signals on completely separate satellite channels, but although this was an interesting experiment, it is unlikely to have practical applications.

The composite form of this HDTV system, using a form of wide-band PAL known as HLO-Pal (Half-Line Offset PAL) with a colour subcarrier at 24.3 MHz and a baseband spectrum occupancy shown in Figure 1, was tried over FM satellite broadcast channels, but

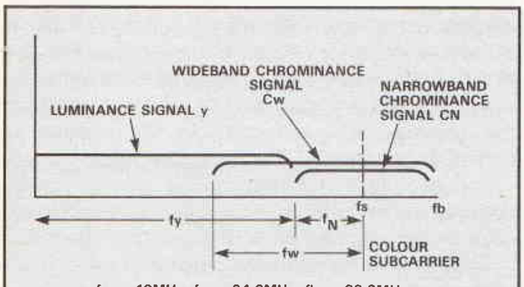


**Fig. 1 Frequency spectrum of HLO-PAL system**

had poor noise performance, especially noticeable in the coloured parts of the picture, as might have been expected. This composite system was, however, found to perform well over SHF terrestrial transmitter paths using both AM-VSB and FM, and over wide-bandwidth optical fibre cable systems.

The TCI component system was, however, found to give much better results over low-power FM satellite paths, and it has the same advantages as other multiplexed analogue component transmission systems.

In the MAC system, using time-compression increases the signal bandwidth, and to take account of this, care was taken in the NHK TCI system to ensure that the bandwidth of the compressed chrominance signals did not exceed the 20MHz of the uncompressed luminance signal.

The original TCI system used no processing of

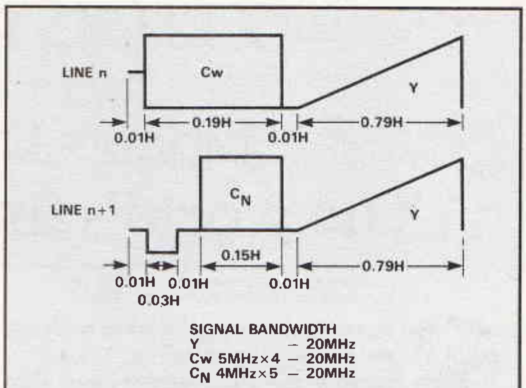


**Fig. 2 Basic details of the TCI line waveform**

the luminance signal, which took up about 79% of the normal line time. Another 19% of the line time was used to carry the chrominance components, either both together, or line sequentially.

The expressions TCI-LI (time compressed integration of line colour signals) and TCI-LSI (time compressed integration of luminance and line-sequential colour signals) are used to denote the two different systems.

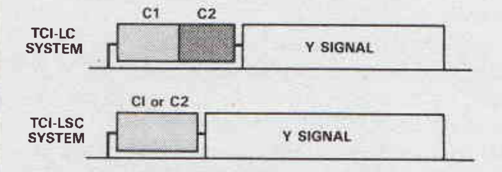


**Fig. 3 Distinguishing between TCI-LC and TCI-LSC systems**

The bandwidth of the two chrominance signals is altered from that originally specified in order that the compressed $C_W$ and $C_N$ signals can be fitted into the 20 MHz bandwidth required for the luminance signal. For the TCI-LSC signal we thus have:
Bandwidth of the Y signal = 20 MHz
Bandwidth of the compressed $C_W$ signal = 20 MHz
Compression ratio applied to $C_W$ signal = 4:1
Thus maximum bandwidth of uncompressed $C_W$ signal = 20/4 = 5MHz.
Similarly:
Bandwidth of the compressed $C_N$ signal = 20 MHz
Compression ratio applied to $C_N$ signal = 5:1
Thus maximum bandwidth of uncompressed $C_N$ signal = 20/5 = 4MHz

As the $C_N$ signal takes up less line time than the $C_W$ signal, there is time for a horizontal synchronising pulse to be fitted in at the beginning of each alternate line.

Figure 4 shows a simplified version of the circuitry by which such a TCI signal can be achieved. The RGB signals are matrixed to produce the luminance signal Y and the two colour-difference signals $C_W$ and $C_N$ and then these signals are low-pass filtered to prevent aliasing and then digitised. The time compression is achieved by reading the signals into a line store at one frequency, and then reading them out at a higher frequency; the actual combinations of frequencies for the $C_W$ and $C_N$ signals are shown on the diagram. The time-multiplexed colour signals are then combined with the luminance signal, and the completely

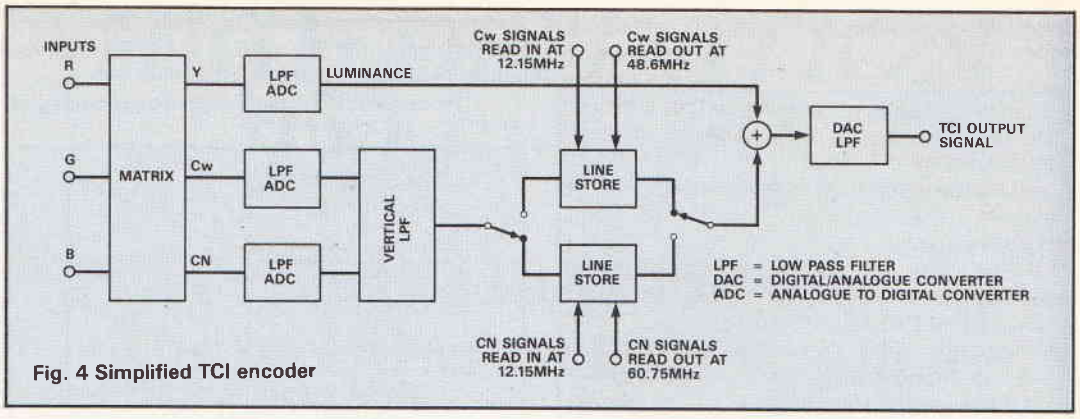



Fig. 4 Simplified TCI encoder

multiplexed signal is then changed back to analogue form in a digital to analogue convertor.

More complex TCI-LSC systems were then developed, in which the luminance signal was subjected to processing, being divided into high and low frequency components, $Y_H$ and $Y_L$. The low-frequency component is transmitted on every line, whereas the high frequency component is only transmitted on alternate lines, as indicated in Figure 5.

The main advantage of the modified system is

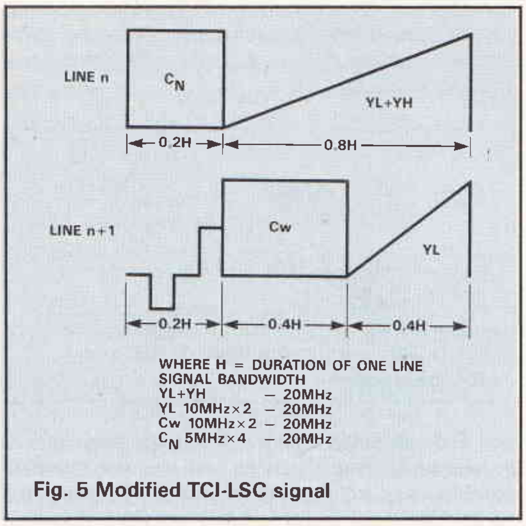



Fig. 5 Modified TCI-LSC signal

to allow the chrominance bandwidth to be higher, so that when different compression ratios are used we achieve a bandwidth for $C_W$ of about 10MHz and about 5MHz for the $C_N$ signal.

Various other modifications of the basic HDTV signal have been worked on, and the aim seems to have been to provide systems for all possible situations.

## The HDTV studio production standard

When HDTV signals are being used in production studios, in closed circuit areas such as the televising of medical operations, or as source material for the printing of high quality still pictures there is no need to worry about bandwidth constraints, since the signals are only being passed over short distances around the studio. To take advantage of the large available bandwidths in these situations there is a version of the HDTV system which has been designed to provide for a studio production standard. This has nominal bandwidths of 30MHz for each of three parallel, time – coincident component video signals, which may be based upon Red, Green and Blue components or upon luminance and colour difference components. Each component signal carries its own sychronising pulse waveform. The basic characteristics of the 1125/60 studio standard are shown, below, and it is instructive to compare these with the characteristics of the 1250/50 HD-MAC system which will be described in a later article.

| | |
|---|---|
| Total number of lines per frame | 1125 |
| Number of active (picture) lines per frame | 1035 |
| Interlace ratio | 2:1 |
| Aspect ratio (Horizontal:vertical) | 16:9 |
| Field frequency | 60 fps |
| Line frequency | 33750 Hz |

## Bandwidth Considerations

We can see from the wide bandwidths required for the baseband luminance and chrominance signals, something of the order of 30MHz, that the ratio frequency bandwidth requirements will be even greater, and it is generally assumed that to transmit such an HDTV signal will require perhaps four or five times as much RF bandwidth as a normal PAL or NTSC television signal.

Although it is possible to imagine future transmission systems where enough bandwidth could be made available for an HDTV system of this type, perhaps using fibre-optic based cable systems or satellites radiating on frequency bands above 40GHz, at the present time it would seem totally impracticable to devote such bandwidths to television transmission, since any HDTV signal could only be transmitted at the expense of a reduction in the number of conventional channels that could be carried.

Even in such a futuristic world it will undoubtedly be important to continue to make the best possible use of the necessarily finite amount of spectrum space that will be available for television purposes, and in these conservation-minded times it surely makes sense to use no more bandwidths than that absolutely necessary for the satisfactory transmission of HDTV signals. With this object in mind the Japanese have developed techniques and equipment whereby wide-bandwidth 1125-line 60 fps HDTV signals may be converted into baseband signals which take up no more than about 8.1 MHz at baseband, so that what are ostensibly 1125/60 HDTV pictures may be transmitted over standard satellite channels. This bandwidth reduction system, of which there are several variants, has been given the name MUSE — Multiple Sub – Nyquist Sampling Encoding.

## Sampling and sub-sampling principles as applied to television

In the explanations of the workings of the MUSE system which follow, and in our consideration of other HDTV systems, we shall be discussing how the system makes extensive use of sampling and subsampling techniques, so before embarking on this, it may be useful to look at some of the basic principles of sampling television images.

A television picture can be considered as a two-dimensional representation of an original image, which varies with time. It is easy to see that the television picture is already sampled vertically, because of the way in which the picture is made up from horizontal lines, but perhaps it is less obvious that there is also a time-based (temporal) sampling taking place because the image is made up from successive fields, repeated at regular intervals. If we now also take samples of the television signal at regular intervals along the length (i.e. during the period) of each line, we are can effectively represent our image in the form of a three-dimensional pattern of samples.

An HDTV picture is likely to give rise to a great many samples per second, which will require a wide bandwidth signal to carry it. The aim of MUSE, and of other HDTV systems such as HD-MAC, which will be considered in a following article, is to reduce the bandwidth required by HDTV picture signals, and this is done by throwing away, in a carefully controlled manner, some of the samples from which the original image is built. The process of discarding these samples is known as sub-sampling.

If a radio frequency signal is sampled at a frequency, known as the sampling frequency, f, then the sampling process will unavoidably generate a theoretically infinite number of repeats of the original signal at multiples of f throughout the spectrum. In that case of a television signal, as shown in Figure 6(a), this means that the first of the repeated spectra will be at f MHz above the centre frequency of the original spectrum, as shown in Figure 6(b).

Looking at Figure 6(c) it can be seen that if the sampling frequency chosen is less than twice the frequency of the original signal, then the original spectrum and the repeated one will overlap, causing aliasing, interference between the two signals, which shows up as some form of patterning on the sampled picture. In order to prevent this happening when we sample a television picture, we must first of all filter the picture signal so that it does not contain any components above half the sampling frequency; this will ensure that no aliasing occurs, as shown in Figure 6(d).

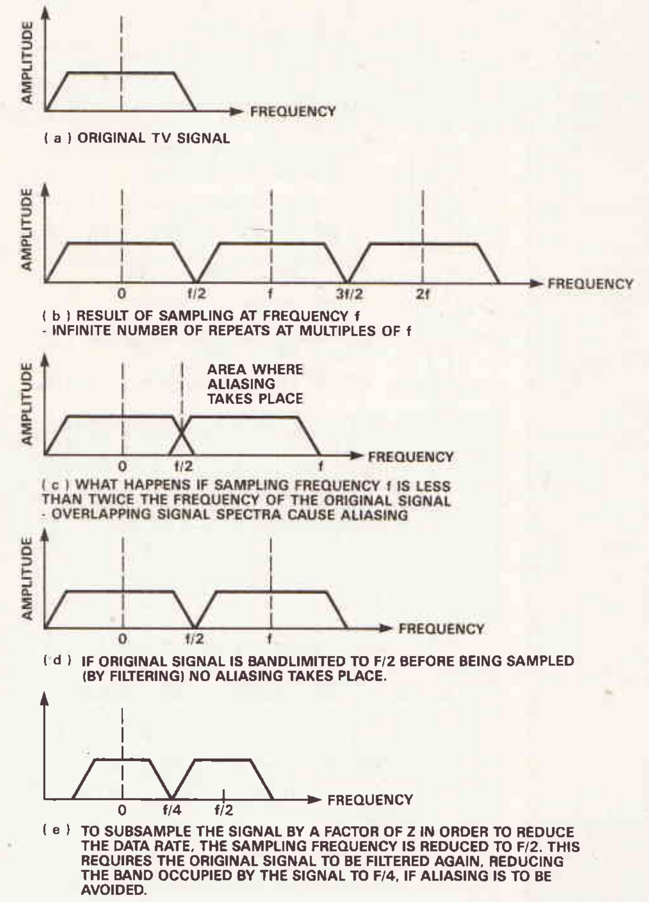



**Fig. 6 Sampling, subsampling, and the need for filtering**

## Subsampling

The process of subsampling, re-sampling an already sampled signal in order to reduce its data rate, will require the sampling frequency to be reduced, and this will therefore create a whole new set of repeat spectra. In Figure 6(e) it can be seen that if the signal is to be subsampled by a factor of two the sampling frequency will need to be reduced to f/2. If we are to avoid aliasing, therefore, the original sampled signal must be filtered again, reducing its bandwidth to f/4.

Thus wherever we wish to sample a television picture signal we will first need to appropriately filter that signal, in order to avoid aliasing; the large number of low-pass filters that can be seen in the block diagram of a MUSE coder shown in Figure 7.

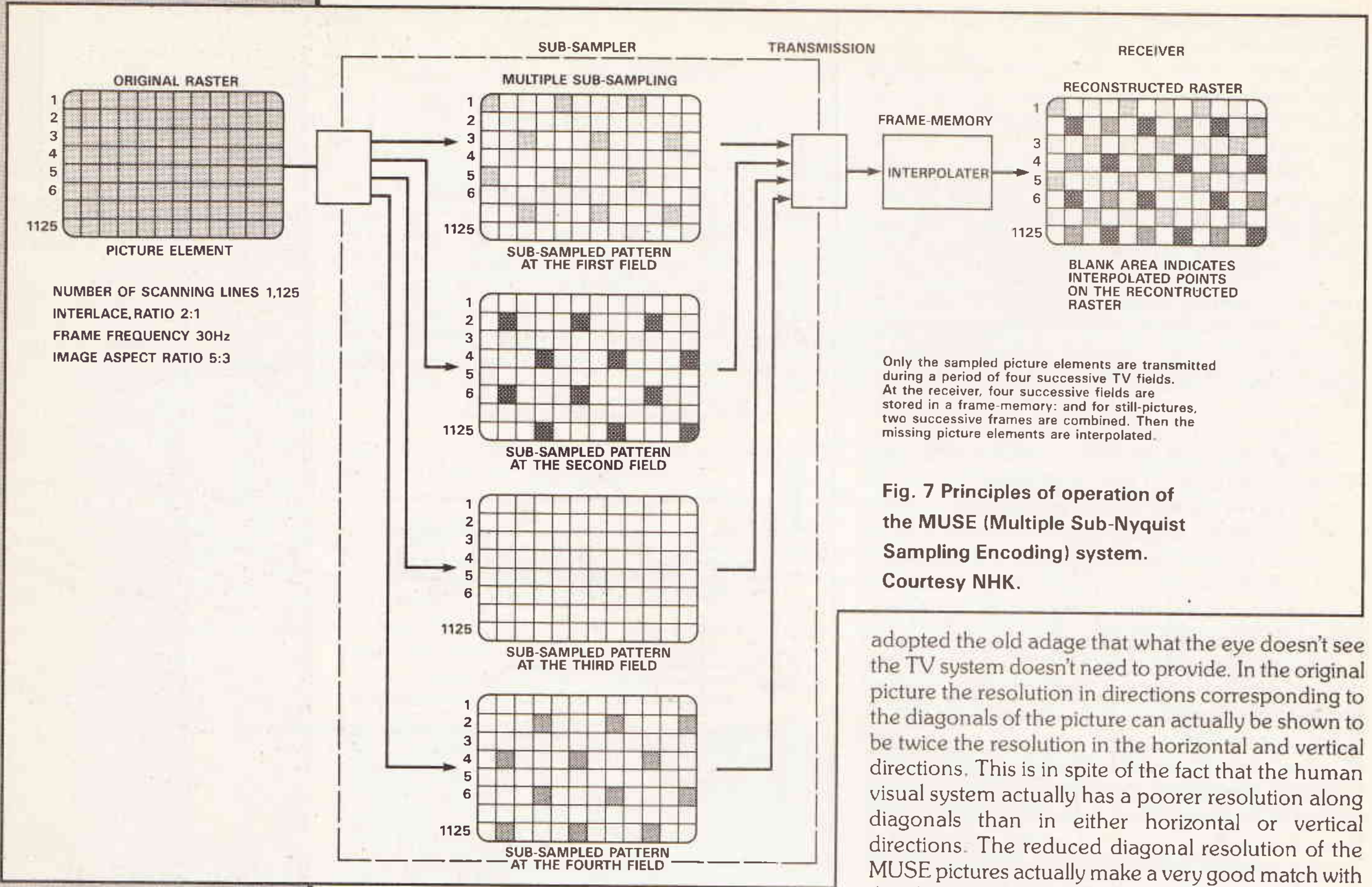
## The MUSE System

The MUSE system is an essentially analogue television transmission system that uses a clever technique of sampling all the individual elements of an interlaced picture, and then selecting a fraction of these to form the actual signal that is transmitted. Stationary parts of the picture are sampled using a frame and field offset sampling technique, whereas moving parts of the picture use line offset sampling. Figure 7, provided by NHK in an early explanatory paper on their plans for satellite broadcasting, provides a useful illustration of how the MUSE system works in principle, but as we shall see later, there have been many developments in this system, and there are some significant differences between the system shown in Figure 7 and the current system. The main difference is that with the current system the pictures are subsampled by a factor of three, as shown in Figure 8, rather than by the factor of four shown in the explanatory sketches of Figure 7.

In Figure 7 we can see that the original raster that is produced by scanning the picture with 1125 lines, at a frame frequency of 30Hz and with a 2:1 interlace, is first of all sampled at 48:6 MHz and then the various sub-sampling patterns for each of the fields are generated as shown. During each of four successive television fields only the sampled picture elements which are indicated on the diagram are transmitted, and in the receiver it is therefore necessary to store four successive fields.

## Still picture areas

For still pictures, two successive frames, (four fields) are combined, and then any missing picture elements are obtained by interpolation in the receiver; the interpolated points are shown as the white squares on the diagram.




Only the sampled picture elements are transmitted during a period of four successive TV fields. At the receiver, four successive fields are stored in a frame-memory: and for still-pictures, two successive frames are combined. Then the missing picture elements are interpolated.

**Fig. 7 Principles of operation of the MUSE (Multiple Sub-Nyquist Sampling Encoding) system. Courtesy NHK.**

## Moving parts

For moving parts of the image, advantage is taken of the fact that the resolution of the human visual system is much less for moving objects than for stationary ones, In practice, the human eye/brain combination does not try to keep all parts of a moving image in sharp focus, so if the eye is looking at the pattern on a man's suit, for example, all the fine detail will be seen whilst the suit is stationary, but if the suit moves, the eye is quite happy to endure the situation where the detail in the pattern just disappears; this type of motion blur is quite acceptable.

In the MUSE system the moving parts of the picture are subsampled at a fraction of the main sampling rate, giving a poorer resolution, but the effect is generally quite satisfactory as far as the eye is concerned. There is, however, one particular type of television picture which seems to catch out the MUSE system, leaving the visual system feeling that something is not quite right. This occurs when a fast moving object, perhaps a racing car, suddenly comes to a halt. Whilst the car is moving the eye is quite happy with the slight motion blur, but as soon as the car stops the whole image appears to instantly come into sharp focus, giving a rather unnatural effect. Some people feel that this problem is sufficiently troublesome to say that the MUSE system does not provide a good enough basis for an HDTV system which is to last for at least a generation, but most people accept that this effect will be rare in normal viewing, and it is generally felt that the disadvantages of MUSE are more than compensated for by the massive reduction in bandwidth requirements.

There is no doubt that the resolution of the MUSE picture is less than that of the original sampled picture, for both moving and stationary parts of the image, but once again television engineers have adopted the old adage that what the eye doesn't see the TV system doesn't need to provide. In the original picture the resolution in directions corresponding to the diagonals of the picture can actually be shown to be twice the resolution in the horizontal and vertical directions. This is in spite of the fact that the human visual system actually has a poorer resolution along diagonals than in either horizontal or vertical directions. The reduced diagonal resolution of the MUSE pictures actually make a very good match with the characteristics of the human visual system.

## Panned and tilted pictures

A third type of image is actually the most complex for MUSE to deal with, and that is when the whole picture needs to move, as when the scene is panned or tilted. In these cases a motion compensation vector is calculated for each field, indicating the speed and direction of the panning motion, and this extra information is transmitted during the frame flyback period so that the receiver can make use of it to accurately reconstruct the image.

Figure 8 shows diagrammatically what effectively happens in the current versions of the MUSE system. Starting with a full-definition HDTV signal of the 'Hi-Vision' type, we subsample the picture elements by three, so that the resulting signal can be transmitted over a satellite channel that can handle baseband signals of about 8MHz. At the same time, information about the movement of the picture is sent from transmitter to receiver in the vertical blanking period of the picture. This 'motion vector' information is then used to enable the sophisticated receiver to reconstruct an HDTV image.

Figure 9 shows much simplified block diagram of a MUSE coding system. The RGB input signals from the camera are digitised at a sampling frequency of 48.6 MHz and then turned into linear form by removing the gamma correction. They are then converted into luminance (Y) and colour difference (C) signals in a matrix, and the Y and C signals are combined into a Time Compressed Integration (TCI) format. The colour channel signals are time – compressed by a factor of four to one compared with the luminance, so as to provide the most acceptable noise performance. The TCI signal is then processed in different ways for the static and moving parts of the picture. For moving parts line offset subsampling at 24.3 MHz (48.6 MHz / 2) is used, and for stationary parts frame and field offset subsampling is used. The three stage sampling of the stationary parts of the image is carried out as follows:

Original sampling — 48.6 MHz (orthogonal sampling pattern)

First subsampling — 24.3 MHz (field offset)

Second subsampling — 16.2 MHz (frame and line offset)

The static and moving parts are then combined pixel by pixel, according to the amount of motion that has taken place, and the signal is subsampled at 16.2 MHz, the MUSE sampling frequency. Notice that the 16.2 MHz sampling frequency will allow the final MUSE signal to fit into a bandwidth of about 16.2/2 = 8.1 MHz. The original sampling frequency of 48.6 MHz was in fact chosen so that the 16.2 MHz figure would be achieved after the subsampling processes.

The signal then undergoes gamma correction and non-linear pre-emphasis to improve the noise performance, and the control signal (motion vector information) and synchronisation signals are then multiplexed together, as well as the digital audio signals, which are carried in the vertical blanking period.

In addition to the digital sound and the motion vector signals that are carried in the vertical blanking interval, special vertical interval test signals are included to give automatic equalisation of the transmission channel, allowing the receiver to compensate for any transmission deficiencies.

MUSE has been carefully developed to provide a very practical means of transmitting HDTV signals over relatively narrow bandwidth channels, and it includes other desirable features such as a very rugged synchronisation system, and a quasi constant luminance system which is very desirable for an HDTV system.

The hardware for the coding and decoding of MUSE signals is fairly complex, and has up to now been expensive. During 1989 the first large-scale integrated circuits for MUSE were produced, and it is expected that these will soon be available in quantity, which should make it possible to market MUSE equipment at prices which will appeal to the consumer market. The Japanese satellite BS3 began the transmission of regular MUSE transmissions in 1990, and will be interesting to see if the availability of MUSE equipment at reasonable prices will lead to the Japanese public being the first to buy HDTV equipment in quantity. It is important to remember, though, that research suggests that the price of an HDTV receiver is more likely to depend upon the cost of the large screen display than upon the cost of the complex electronics, so it may well be that these receivers will still remain too expensive for the mass market.

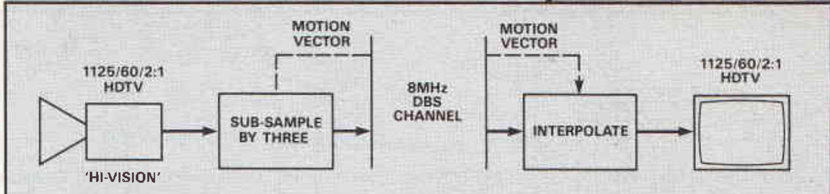



**Fig. 8 The essentials of the MUSE system**

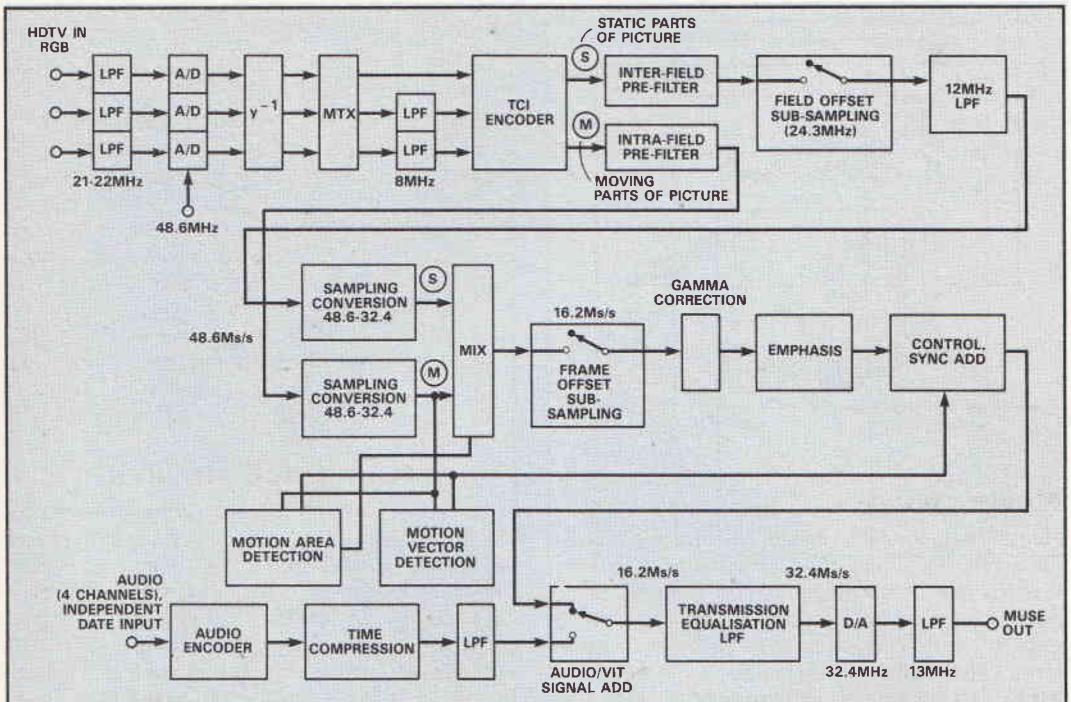



**Fig. 9 Simplified MUSE coding system**

Although the Japanese HDTV production system and the transmission of its pictures via MUSE is currently far in advance of other systems in terms of the development and availability of equipment, there are still big question-marks as to whether such a completely different system, which is totally incompatible with any existing television transmissions, can possibly achieve market acceptance. The problems of this incompatibility and of having only a very small initial audience for programmes transmitted on such a different system have led other countries in Europe and America to adopt a different approach. They see the ideal HDTV system as being downwards compatible with existing television systems, so that the same transmitted signals would provide HDTV pictures for those viewers equipped with HDTV equipment, whilst viewers with existing receivers could receive normal definition pictures on their existing equipment. This different approach is discussed in subsequent articles.

The MUSE technique for obtaining significant reductions in bandwidth whilst still being able to regenerate acceptable HDTV pictures is being utilised in other ways, and we shall see when we come to discuss the various proposals for ATV systems in the USA that various different forms of MUSE are being developed to allow ATV signals to be carried on fairly narrow-bandwidth terrestrial transmitters.

1

# INFRA LOCK

*Protect consumer electrics with a security code and unlock them with an infra-red remote transmitter. Dominic Banham reveals all.*

There are many situations in which it would be beneficial, for reasons of security, safety or economy, to have a means of preventing the unauthorised use of certain pieces of equipment. For example, it could be useful to make sure that data stored in a computer is not altered or deleted, to prevent accidents caused by mis-operation of potentially dangerous equipment (eg. in a lab or workshop), or to make sure that misguided adjustment of a heating system does not result in a serious waste of energy and money. This can obviously be achieved by fitting each device to be protected with a key-operated switch, but the requisite

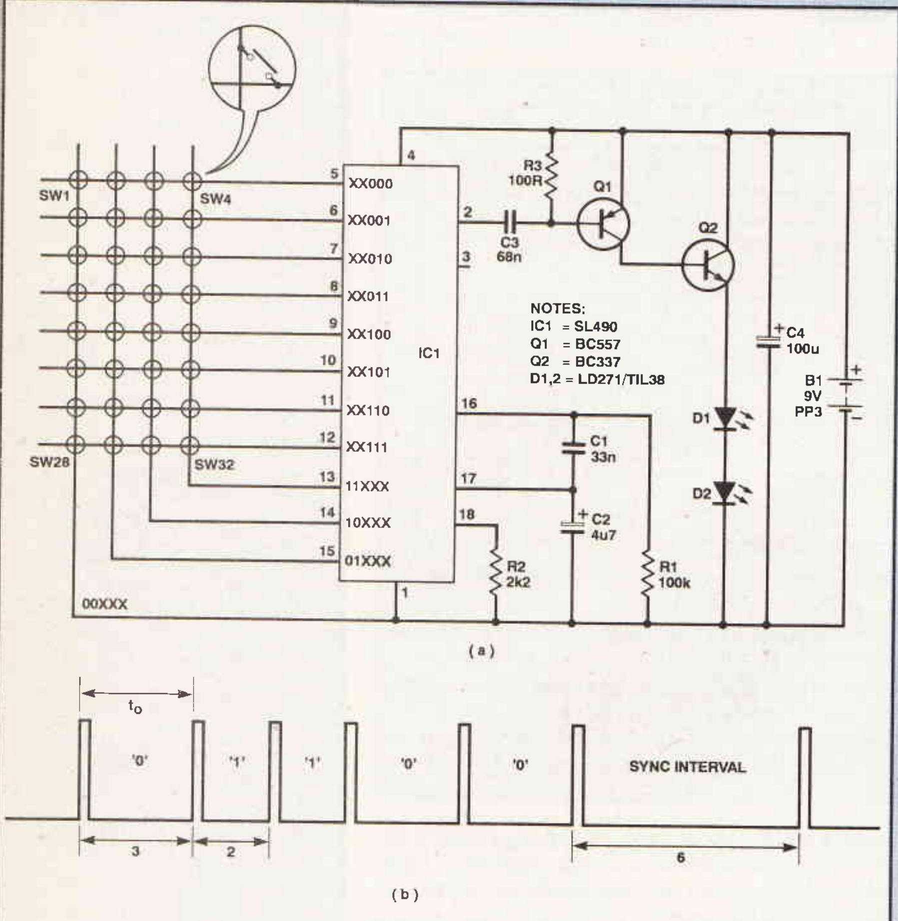
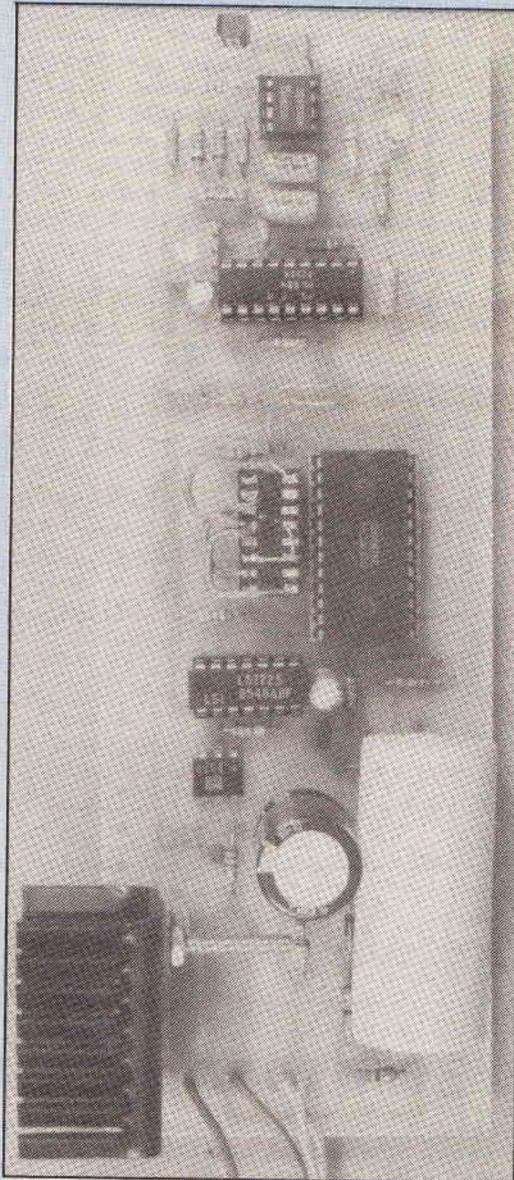
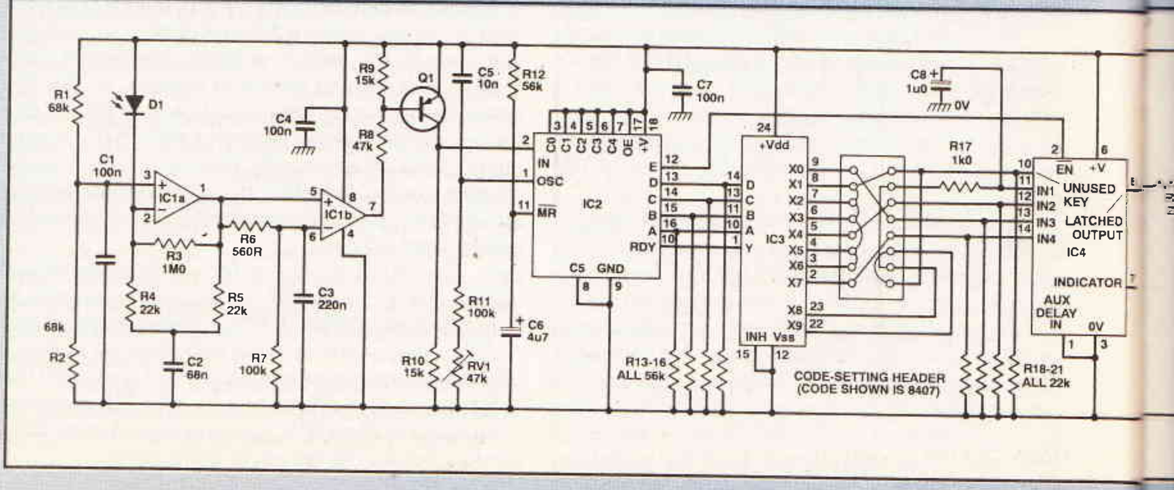



Fig. 1 a) Circuit diagram of transmitter
b) Transmission format used by SL490/ML924






PROJECT

number of keys becomes a problem if several pieces of equipment are to be controlled by more than one person. The use of some sort of electronic combination lock seems more appropriate. However, most keypads are too large to fit conveniently on the front panels of many items of equipment, and those adequately rugged to be used in a workshop or lab tend to be expensive.

The solution described here is to use a combination lock system on each controlled device, but to have the keypad as a separate unit operating over an infra-red link. This way the only externally mounted element on each controlled device is the infra-red sensor, which is small, cheap and fairly waterproof. It can also be made quite discreet if it is desired not to give away the presence of the system. The single remote keypad can of course be used to control a very large number of such devices.

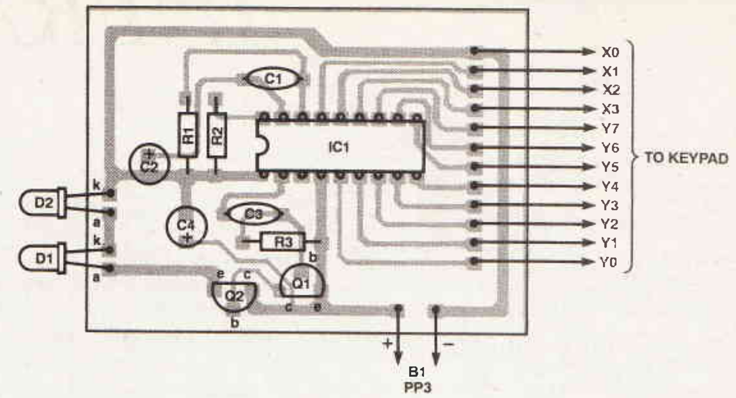


Fig. 2 Component overlay for transmitter

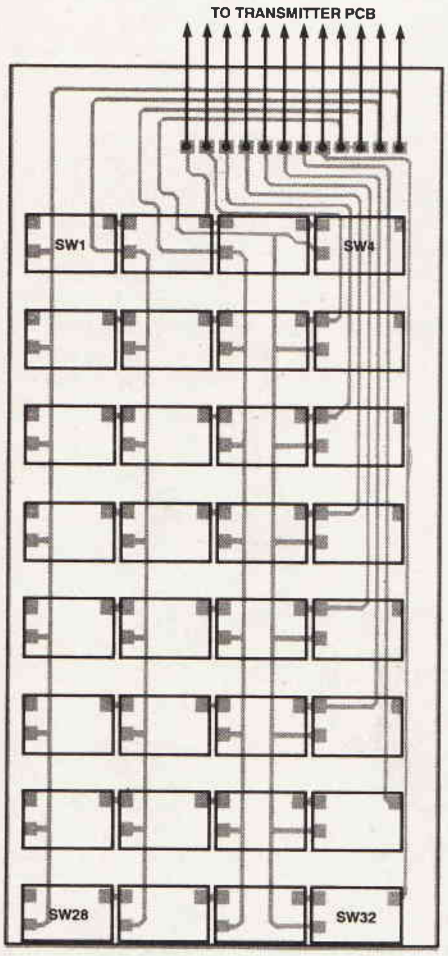
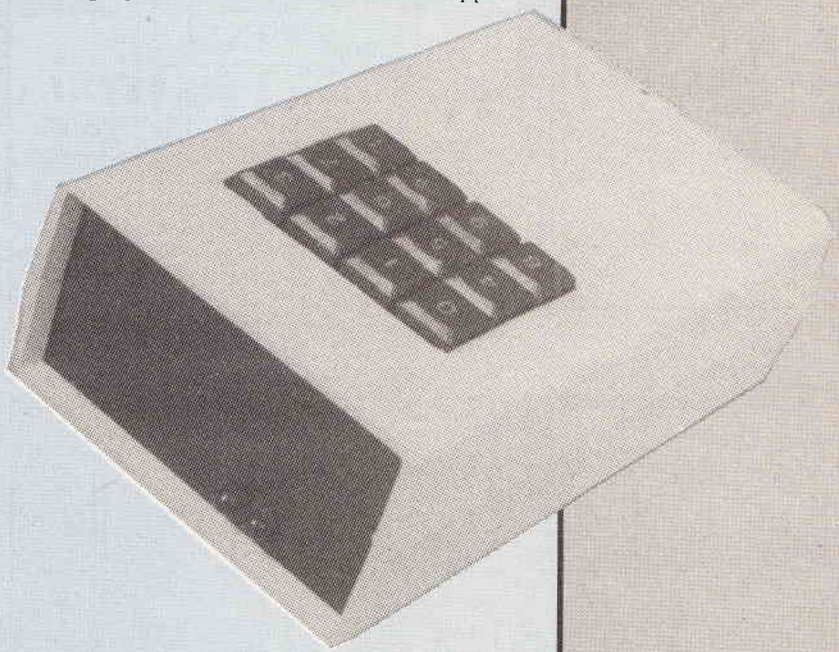


Fig. 3 Keypad overlay

An infra-red link such as this has many applications, and forthcoming articles will describe several alternative uses. This should go some way towards avoiding a proliferation of remote control 'zappers'.



## Transmitter Construction

The assembly of the transmitter PCB is very straightforward and the component overlay is shown in Fig.2. The SL490 is not particularly cheap, so it is advisable to mount this IC in a socket.

A possible layout for a keypad PCB is shown in Fig.3. This has space for up to 32 low cost Maplin keyswitches. However, it is appreciated that taste in switches, preferred layout and available space will influence the design of the keypad, so this layout is only given as a guide. Only switches 1-10 need be fitted for the present application.

The choice of case is also up to the individual, and there are several styles available which are specifically intended for this application. In the prototype, the case used is slightly larger than necessary and was simply used because it happened to be available.

The transmitter can be tested by connecting an infra-red photodiode to the input of a scope. If the transmitter is pointed at this diode and operated (at close range), it should be easy to detect the PPM signal on the scope.

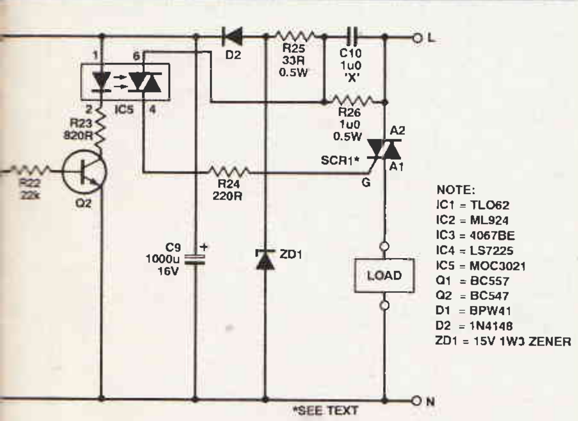


Fig. 4 Infra-red anti-tamper system receiver

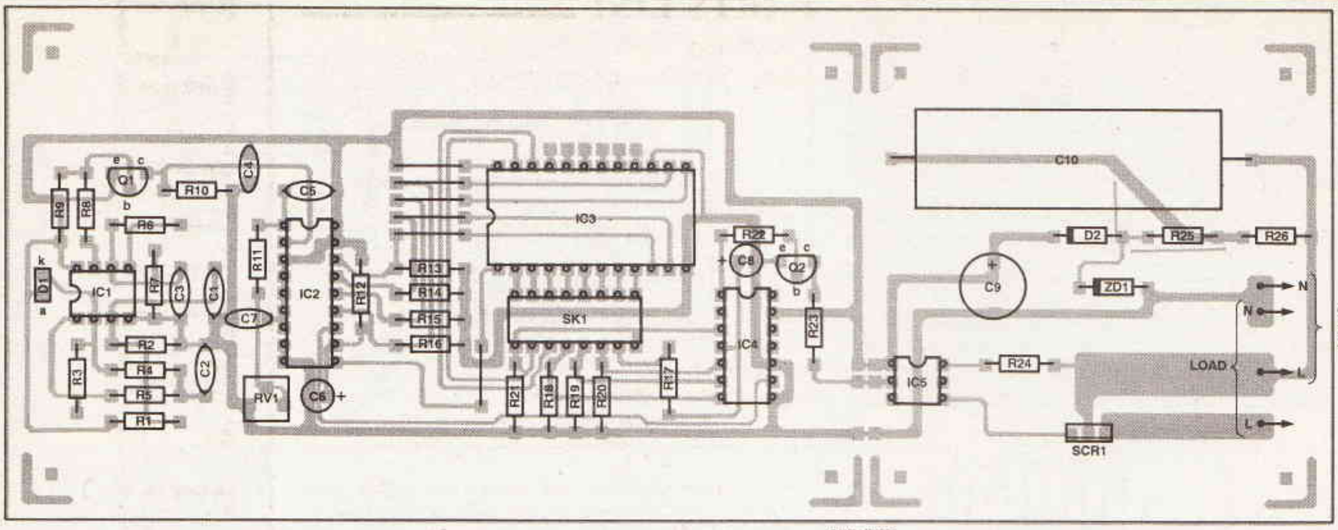



Fig. 5 Receiver board overlay

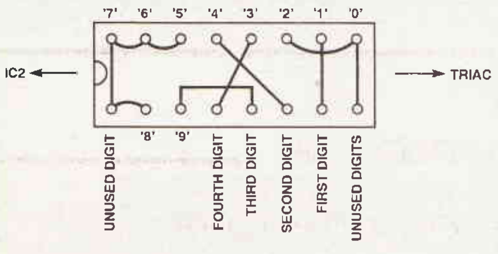
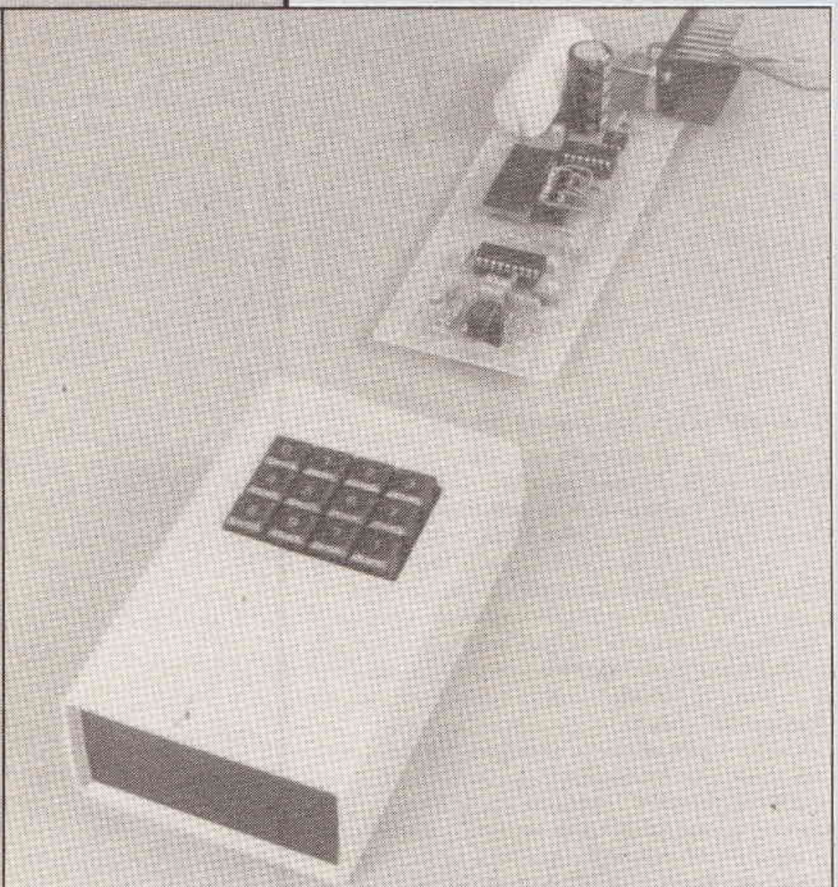



Fig. 6 Wiring of code-setting header plug: code shown is 1493



## Receiver

The overlay for the receiver PCB is shown in Fig 5. Provision has been made to separate the PCB into two parts, if this makes fitting to the intended equipment easier, and it is obviously best to decide whether the board is to be cut before proceeding. Apart from this, construction is straightforward, if somewhat fiddly. Start with the wire links and IC sockets, and pay very careful attention to the orientation of the semiconductor devices and polarised capacitors. The dropper capacitor C10 has mains voltage across it and that faintly gooey waxed paper one out of Granny's old valve radio will NOT do!! A good quality class X or Y type, which are designed for direct connection to the mains, is essential here.

Setting up is fairly simple, especially if an oscilloscope is available. WARNING: THE RECEIVER MUST NOT BE CONNECTED TO THE MAINS DURING TESTING. THE USE OF A LOW-VOLTAGE POWER SUPPLY IS FAR SAFER. Connect a 12-15v power supply to the +14v and 0v rails of the receiver unit and switch on. Current consumption should be about 5-8mA. With the 'scope connected to pin 2 of IC2, transmit the code '00000' on the transmitter. The PPM signal should appear on the scope at about 12v peak level. If not, switch off and check the circuitry around ICI and the orientation of DI. Assuming you have success, measure the '0' interval ($t_O$) Using a x10 probe, observe the operation of the oscillator at pin 1 of IC2. Adjust RV1 until the period of this oscillator is equal to 1/40 of $t_O$. Transmission of any code should now result in pin 10 of IC2 rising to +12v, returning to 0v when transmission ceases. If a scope is not available RV1 can be adjusted by trial and error to give correct result. A 16-pin DIL header should be wired for the desired code and plugged in, and an LED on and off. If so, the LED can be disconnected and the receiver tested by connecting it to the mains and 100w light bulb as a test load. Do not attempt to adjust the receiver in this condition!! When first connected to the mains the light should be off and should only come on when the correct code is entered. The system is now ready to be fitted to the controlled equipment, taking care to ensure adequate heatsinking of the triac if heavy loads are to be controlled.

## HOW IT WORKS

**Transmitter:**

The transmitter circuit, Figure 1, is very simple and is taken straight from the SL490 data sheet. Nearly all the work is done by the encoder, IC1. When one of the switches SW1-32 is operated, this IC generates the appropriate PPM signal in active-low form at pin 2. This is amplified by Q1 and Q2 and used to drive the infra-red emitters D1 and D2. R1 and C1 determine the timing of the output signal, C2 decouples an internal supply rail of IC1, and R2 disables the IC's internal carrier oscillator which is not needed in this application. R3 and C3 ensure that the infra-red emitters are fed with very short pulses so they do not overheat. C4 decouples the supply. No on-off switch is needed, since the IC consumes only about 1 microamp when not transmitting.

**Receiver**

The receiver can be divided into three sections: the infra-red receiver proper, PPM demodulator and sequence detector system.

Signals incident on D1 cause corresponding variations in the leakage current of this device, and these variations are amplified by IC1a. R1, R2 and C1 bias the operating point of this op-amp to half supply voltage. R3 sets the gain of this stage, which operates as a current-to-voltage converter. The network R4-C2-R5 provides DC bias compensation to allow for variations in leakage current due to ambient lighting conditions. The output of IC1a is coupled to both inputs of IC1b. Normally the potential divider formed by R6 and R7 holds IC1b's inverting input at a slightly lower voltage than its non-inverting input. As a result, the output will be high, and this condition will hold during any slow variations in level caused by, for instance, mains lighting at 50Hz. However, if a short pulse such as those produced by the transmitter is received, IC1a's output will swing rapidly negative. Pin 6, the inverting input of IC1b, is decoupled by C3 and will remain at its original level, thus causing pin 7 to be pulled low. This arrangement thus has good resistance to interference, but is sensitive to the wanted signal.

The output pulses from IC1 are re-inverted by Q1; this is necessary because the output of IC1 cannot be relied upon to swing close enough to the positive supply to correctly operate the input of IC2, which has a very high input threshold.

IC2, an ML294, is the PPM decoder. Correct decoding obviously depends on measurements of timing, so the IC has a reference oscillator whose frequency is set by C5, R11 and RV1. R12 and C6 provide a power – on reset pulse. The ML294 can operate in various decoding modes set by the logic levels on pins C0-C5. Here, it is set to its simplest mode, where a PPM input gives a corresponding binary output on open-drain pins A-E. Pin 10, (RDY) goes high while valid data is being received. This output, together with outputs A-D, is decoded by IC3, a 16-way analogue switch. This is used rather than a normal decoder IC because it can have its outputs wire-ORed together without damage. The first ten outputs are made available at the code-setting socket SK1. These outputs are high when the corresponding codes are received, and open circuit otherwise.

Four of these outputs, corresponding to the desired access code, are connected to the inputs of IC4, a combination-lock-on-a-chip. The unused outputs are connected to the reset input (pin 10) of IC4. The first input is connected via R17 and C8. The correct sequence must be received within a time period set by C8 and the internal pull-down resistance of IC4; the value shown gives a time of about 4 seconds. If the correct code is received within the required time interval, the output at pin 8 of IC4 is toggled; internal circuitry in IC4 ensures that this output is off when power is first applied. The output drives opto-triac IC5 via Q2, and this in turn triggers the main triac SCR1 via R24. Although this output drive circuit may at first sight seem over-complicated, the power supply of the receiver cannot supply enough current to trigger the triac directly (most triacs need about 50mA of trigger current). It is also worth noting that IC5 is a simple opto-triac and not the sort with an integral zero – crossing detector. This ensures that the triac is hard fired, ie. continuously supplied with trigger current. This ensures that it will switch reliably with small and/or reactive loads.

Power for the circuit is derived from the mains by a reactive power supply consisting of C10, R25, ZD1, D2 and C9, and this can provide about 30mA at 14v. The principal function of R25 is to reduce any switch-on surge caused by the charging of C10, but it also acts as a fuse in case of failure of this capacitor and should therefore not be changed from the value and power rating specified.

## PARTS LIST

| | |
|---|---|
| **TRANSMITTER** | |
| **RESISTORS** (all ¼W carbon film) | |
| R1 | 100k |
| R2 | 2k2 |
| R3 | 100R |
| **CAPACITORS** | |
| C1 | 33n polyester |
| C2 | 4µ7 10v radial electrolytic |
| C3 | 68n polyester |
| C4 | 100µ 10v radial elelctrolytic |
| **SEMICONDUCTORS** | |
| D1,2 | LD271 or TIL38 infra-red emitters |
| Q1 | BC557 |
| Q2 | BC337 |
| IC1 | SL490 |
| **MISCELLANEOUS** | |
| BATT1 | PP3 9v battery and connector |
| SW1-32 | Keyswitches (eg. Maplin type FT16S – see text) Case, PCB(s), connecting wire etc. |

## PARTS LIST

| | |
|---|---|
| **RECEIVER:** | |
| **RESISTORS** (all ¼W carbon unless stated) | |
| R1,2 | 68k |
| R3 | 1M |
| R4,5,18-22 | 22k |
| R6 | 560R |
| R7,11 | 100k |
| R8 | 47k |
| R9,10 | 15k |
| R12-16 | 56k |
| R17 | 1k |
| R23 | 820R |
| R24 | 220R ½w |
| R25 | 33R ½w |
| R26 | 1M ½w |
| **CAPACITORS** | |
| C1 | 100n polyester |
| C2 | 68n polyester |
| C3 | 220n |
| C4,7 | 100n min. ceramic |
| C5 | 10n polystyrene |
| C6 | 4µ7 16V radial electrolytic |
| C8 | 1µ 16V radial electrolytic |
| C9 | 100µ 16V radial electrolytic |
| C10 | 1µ 25V AC class 'X' mixed dielectric |
| **SEMICONDUCTORS** | |
| D1 | BPW41 or TIL100 or SFH205 |
| D2 | 1N4148 |
| ZD1 | 15v 1w3 zener |
| Q1 | BC557 |
| Q2 | BC547 |
| IC1 | TL062 or NE5532 |
| IC2 | ML924 |
| IC3 | 4067BE |
| IC4 | LS7225 |
| IC5 | MOC3020 |
| SCR1 | Triac, 400v or greater, current rating to suit load. |
| **MISCELLANEOUS** | |
| PCB, wire, heatsink for triac, mounting hardware etc | |

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| E9011-2 | Infra-lock transmitter (2 boards) | K |
| E9011-3 | Infra-lock receiver | H |
| E9011-4 | Four-track cassette recorder (record/playback one channel) | F |
| E9011-5 | Four-track cassette recorder (Bias/erase oscillator board | K |

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| E9002-4 | Superscope Timebase Board | K |
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| E9003-2 | Superscope Y2 input board | J |
| E9003-3 | Superscope switch generator | E |
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Capacitance.................0-100p-20μF ± 6%
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**Position Ref:** Probe tip grounded via 9MΩ resistor, oscilloscope input grounded.
**Position X10:** Bandwidth; D.C. to 100MHz: Risetime; 3.5 nanoseconds: Input Resistance; 10MΩ ± 1% when used with oscilloscope with a 1MΩ input: Input Capacitance; 11.5pF when used with oscilloscopes which have a 30pF input capacitance: Compensation Range; 10-60pF: Working Voltage; 500V D.C. (including peak A.C.) **£13.80**

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Another parcel of panels from Dowty. These are all believed to have come from discontinued units and as far as is known are not faulty. However, please note some have missing chips or boards cut to prevent re-use. They are therefore being sold for their component value only, not as working units.

**Z4320. KILOSTREAM MULTIPLEXER.** Panel 300 x 210mm with 4 x 25-way 'D' sockets, 15W'D' skt Z84C42 x 3, Z84C30 x 2, CMOS Z80 CPU, 6264 RAM, 30 assorted CMOS/TTL/Linear chips and nice power supply comprising a potted transformer with mains input and 0-9V, 0-9V outputs both at 1A, 7812, 7915 and 7805 regs. Also Xtal, 64-way connector, switches etc. Great Value at **£6.50**

**Z4321 EXPANDER** Panel for above 230 x 170mm with 4 x 25-way 'D' sockets, 2 x Z84C42, Z84C30, 8 x 45406 plus 7 74 chips. Also short length of 64-way ribbon cable with IDC skt. This panel is complete. **£3.50.**

**Z4322** Panel 310 x 205mm with 2 x 25-way 'D' Sockets, 5 other sockets. Over 40 chips on board including Z85C3010 and TLC32040 (both in sockets), TL074 x 2, MOC3021 x 2, ULN2803, and lots of logic, 3 DIL relays, R's, C's, etc. etc. **£3.00**

**Z4323** Minimo Plus 4 Panel 180 x 158mm secondary panel 90 x 85mm and front panel 165 x 43mm on which is mounted a 25-way 'D' type socket and a BT socket. On the large board is a mains transformer with (presumably) 2 outputs feeding LM317 and LM327 variable voltage regs, and a 7805 on a small heatsink. Also 80C32 (in socket), 8256 UART 6264 RAM and several other chips. There are 3 switches, 5 LED's, 2 relays, a speaker and the usual T's, R's and C's. The smaller panel has M6951 and M85C154 'piggy back' chip and 4 HCT chips, 18.432 xtal module etc. An excellent selection of components for just **£5.90.**

**Z4319** Display panel 294 x 49mm with an alphanumeric Dot matrix LCD, 20 characters x 2 lines, size 118 x 36mm; 4 push button switches,; 40mm dia speaker; short length of 26-way ribbon cable with IDC connector. Information on LCD supplied – these are in distributors catalogue at around **£30.00** each **£10.00**

**Z8886** From the above parcel, there's a quantity of partly populated panels. There are not enough of any one type to list separately, so we're selling these in parcels of 5kg – many high quality components including Memory/LS/HC/TTL/CMOS/LINEAR chips, LED's, passives, Xtals etc. etc. An excellent selection giving superb value for money – many hundreds of components for just **£10.00.**

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# THE AUTOCUE

*M. Lawson builds this device for timing speeches.*


This device was devised for lectures, meetings and other occasions where speeches are to be made. It provides the speaker with a way of seeing how much time he or she has left and a 'near end of speech', and 'end of speech' warning is given. This has been used successfully at a recent conference. The unit is designed for battery operation to provide portability.

The unit allows the user to load a down-counter with the number of minutes the speech is allowed to last (from 0 to 99 minutes). This instantly displays the count and starts counting upon pressing the 'START' button. The counter has a compare register on-chip which can be loaded with a count and compared with the present count after every clock pulse — if they are the same, a pin on the chip is flagged high. This register is loaded with 3 to provide a '3 minutes left' warning near the end of the speech. When the counter reaches zero another pin is flagged high, used to provide the 'end-of speech' warning. The register is loaded with 3 upon power up, along with a reset to ensure the counter displays zero and stops there. The counter can be reset to zero or restarted at any time.

To save power, a 'display control' switch is provided, which holds the load register input low, causing the counter to go into power-down mode. This turns off the display and multiplexer oscillator but the count continues and the flag outputs still operate. (That switch should only be used once the counter has been started and after that the start switch will not reload the counter).

## Construction

In constructing the PCB, follow the usual rules, linking pins first, then diodes, resistors, IC sockets, Veropins, small capacitors, transistors, large capacitors, voltage regulator and PCB headers.

Because CMOS devices are being used, IC sockets should be used and be careful when handling

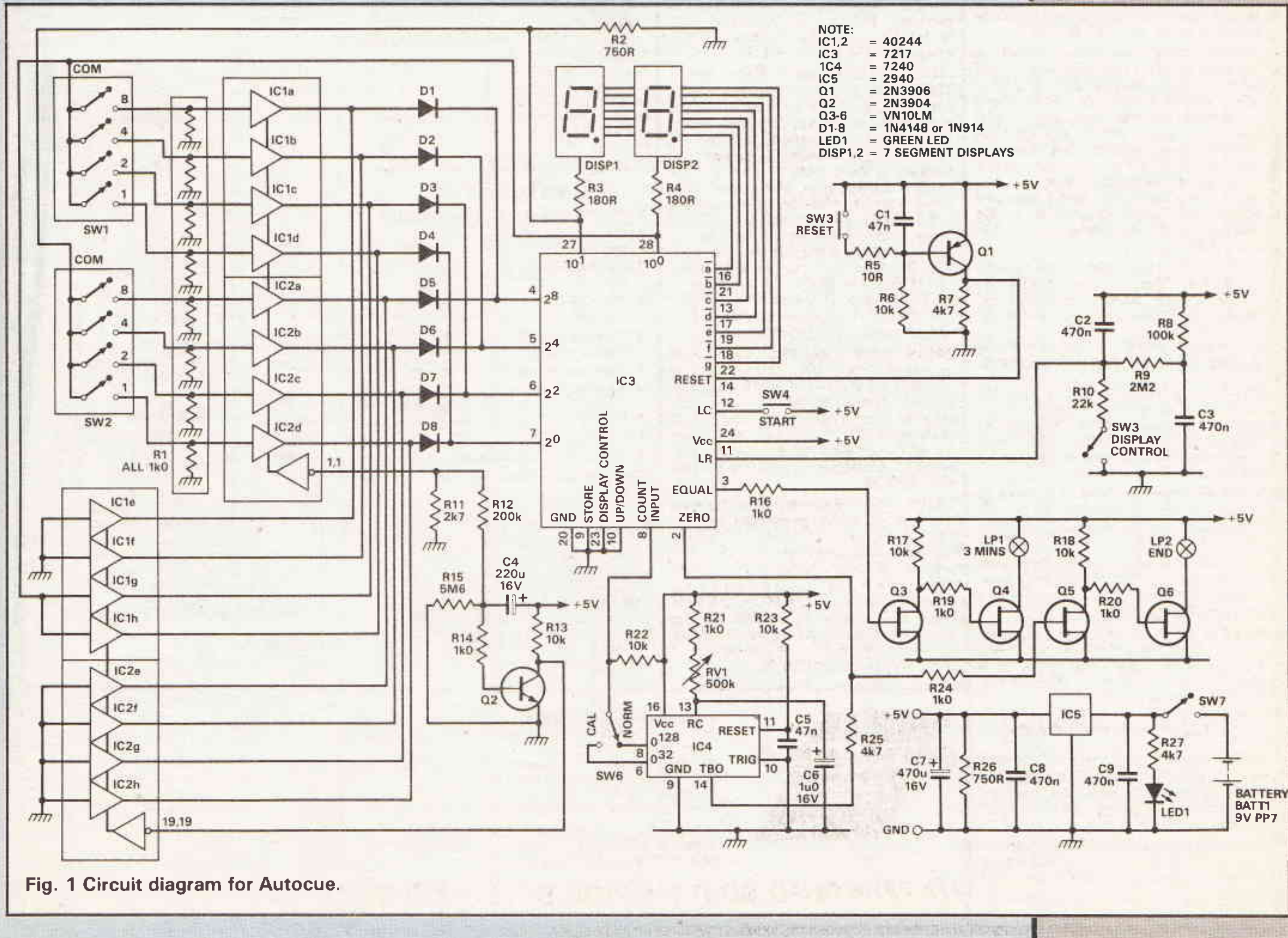


Fig. 1 Circuit diagram for Autocue.

the devices — never touch the pins, and earth yourself first by touching pipework in the house or anything metal going to ground. Avoid wearing nylon or acrylic clothing which builds up static charge. For the displays on the display board use cut-up 28-pin ROM sockets.

Use a right angled PCB header for connecting the ribbon cable. Do not insert any ICs yet. Make up the PCB connectors: one 9-way ribbon to 10-way sockets; the other, 10-way to 10-way cable, wired directly to the thumbwheel switches.

The box is made by Vero which incorporates an aluminium front panel and battery compartment. The battery compartment is designed to hold 4 × A4 size batteries, so this must be removed to leave only the lid, allowing a PP7 battery to fit through the hole. The top of the case has two lamp holders, display bezel and display control switch mounted on it. Mount the display PCB beneath the bezel using four M3 bolts, and 15 mm standoffs. Place two foam strips beneath the lid beside the display, for the battery to rest on with the terminal clips wedged between the strips.

The front panel houses the START and RESET switches, the thumbwheel switches, power switch and LED. The holes should be cut first, then fix labels or transfer and spray with a protective coating. The push button switches used for Start and Reset have removable caps which allow legends to be placed on the push button behind the cap.

Once all parts are in position, wire them up to the main circuit board Veropins, mount the board in the box with self tapping screws and plug all connectors in. You are now ready for testing.

## Testing

1. Connect the battery and check the voltage at the output of the regulator. This should be 5V. Check that +5V is present at the Vcc connection to the ICs.
2. Socket the ICs, noting the handling procedures described earlier.
3. Connect the battery and turn on. The power LED should light and the display should come on displaying two zeros. If the display does not come on, check the 'display control' switch is off. If the display starts up on another count and not zero, press the reset switch.
4. Set the thumbwheel switches to 3. Press the START button and the '3 Mins' lamp should light. Press the RESET button and the '3 Mins' light should go out and the 'END' light should come on.
5. Try turning off display using the 'Display Control' switch.
6. Set SW6 to the calibrate position (up), set the count to 20 on the switches and press start. Time the length of time it takes to count down *after* the first count. It should be 15 seconds — adjust VR1 until this is the case, as accurately as possible. When this is accomplished, push SW6 to normal position (down).
   Note that the first count after the start button has been pressed varies between 0 and 15 or 0 and 60 seconds (depending where the switch is).
7. Time the next count for 60 seconds.
8. Set switches to 10 and press 'START'. Check that '3 Mins' lamp comes on at 3 minutes and the 'END'

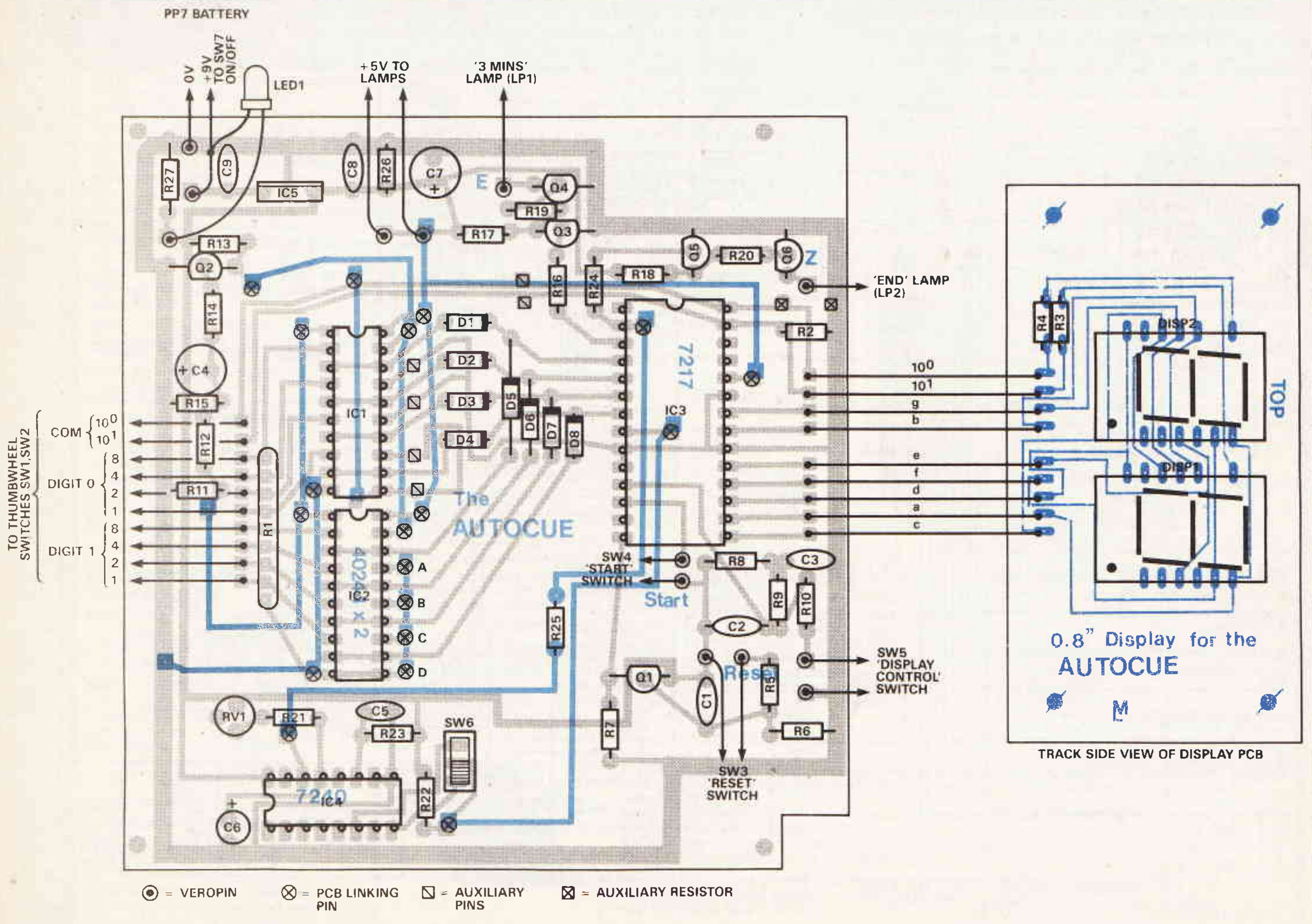

Fig. 2 Component overlay for Autocue.

lamp comes on at zero. The '3 Mins' lamp should go out at 2 minutes.

## Modifications

If you would like the "3 Mins" lamp to come on at a different time, work out the BCD equivalent of the time you want it to come on at and alter the PCB to suit. Remember that anything that needs to go high has to be connected to the corresponding common line.

For example for the lamp to come on at 15 minutes:

| DIGIT 1 | DIGIT 0 |
|---|---|
| 0 0 0 1 | 0 1 0 1 |

This means that IC1b has the 4 and 1 inputs connected to the $10^0$ common line and IC2b has the 1 input connected to the $10^1$ common line. The other inputs are grounded. Do not forget to cut the connections between 1,2 and $10^0$ on IC1b.

Alternatively, if you wish the warning time to be variable, another thumbwheel switch could be used. If you refer to the PCB overlay, the auxilliary pins and pins A,B, C and D can be soldered in to connect to the new thumbwheel switches. 1k resistors must be soldered from the BCD inputs to ground and diodes must be inserted in the commons of the present *and* new thumbwheel switches. You may find problems with the auto-loading circuit after this. If this is the case, solder a 750R resistor where the auxilliary resistor pads are.

*Note*: Cut between A,B,C and D as required, on the component side and cut the common track on the track side. The diodes are inserted with their cathodes connected to the commons. ($10^0$ or $10^1$)
The unit works accurately and reliably but it should be noted again that the first count is likely to be inaccurate — this is due to connecting the 7240 as an astable multivibrator. Various methods of resetting the timer were tried but its recovery from the reset was random and uncontrollable.

The unit could theoretically last for at least 24 hours used continuously, as long as the 'END' lamp is not left on too long between speeches. If battery power does get low (the display becomes fainter) turn off the display after starting the counter, and turn off the unit between speeches.

The original box contained a battery compartment designed for 4 AA cells. These would give 2.2AH at 6V if Gold Seal batteries were used. This could be suitable until the battery voltage dropped below 5.45V. For this reason a PP7 was chosen as it allows for a larger voltage drop and is cheaper than 4 AA cells, the only problem being that the battery compartment has to be cut out.

The recommended box can be stood upright with the front panel downwards. This allows the displays to be seen better.

## HOW IT WORKS

The heart of the circuit is the 7217 counter/driver which can drive up to 4 LED seven-segment displays directly. The 7217 can count up or down, multiplex up to 4 LED displays and load preset counts either directly into the counter or into a comparing register. The Autocue only needs to count in minutes so only two displays are used to save on battery power. The clock input to the counter needs a pulse every minute, so a 7240 CMOS precision timer is used for this purpose.

Thumbwheel switches are used to provide the speech time input to the counter, these are commoned together using diodes to the counters 4-bit, BCD, bus.

Upon power-up, a reset is forced from the circuit built around Q1, and a "load register" is performed by the circuit built around Q2 and the CR network that includes C2 and C3. To enable a separate count of 3 to be loaded into the register, a count of 3 would have to be set up on the thumb wheel switches and a high – going pulse applied to pin 11 (LR). Then the speech time is set up and a high-going pulse applied to pin 12 (LC), to start the counter. This is obviously a long-winded operation with the possibility of errors creeping in, so a method of loading the counter with 3 without the thumbwheel switches was devised. Two octal tri-state buffers were used so that the BCD bus could access the switches and the 3 minute count. The 3 minute count was hard-wired by connecting only the inputs corresponding to 1 and 2 to the multiplexed common line $10^0$. All the others are grounded to give logic 0. When the enables on IC1b and IC2b are taken low, the binary equivalent of 3 is multiplexed onto the BCD bus. At the same time the enables for IC1a and IC2a are taken high to prevent bus contention.

To achieve this on power-up, C4 and R15 hold the base of Q2 high for a few seconds, causing the collector output at the bottom of R13 to go low – enabling the buffers for the 3 minute count. At the same time the other enables are held high through R12. While the 3 minute count is set up the RC network of C2, R9 and C3 provides a positive pulse to the load counter input. After a few seconds have elapsed Q2 turns off, disabling the 3 minute count and enabling the thumbwheel switches.

To stop counting when zero is reached, a resistor (R25) is connected between the time base output (TBO) on the timer and the zero output on the counter. When the output goes low the TBO pin is pulled low, preventing the internal oscillator from working correctly, the frequency of which is set by RV1, R21 and C6. RV1 is adjusted to accurately set the 60 second clock rate. Switch SW6 selects either 15 second calibrate or normal 60 second operation.

As mentioned earlier, the counter provides two outputs to indicate that the counter has reached zero and the counters register is equal to the present count. These are active low. A pair of VN10LM VMOS FETS are used to invert the signal and drive the corresponding lamp. The current drawn by the circuit is less than 40mA with the display on, and less than 30 mA with the display off. Current rises to around 130mA with one lamp on. The regulator used is the 2940, which is a 5V, low dropout device, which will regulate right down to 5.45V, thus giving longer battery life. The seven-segment displays used are 0.8" low – current high-intensity types. The buffers and timer are CMOS to reduce power consumption.

## BUYLINES

| Description | Supplier | Catalogue No. | Price |
|---|---|---|---|
| Plastic Box | Verospeed | 65-2073K | £10.15 |
| | Electromail (RS) | 508-532 | £11.09 |
| 7-Segment, Low-Current High Intensity Displays (0.8"D) | Farnell Electronic Components Ltd | HDSP-NIC, | £2.72 |

*Note* if these cannot be obtained then use a low-current or high intensity display and change R3 and R4 to give the minimum brightness required.

| Description | Supplier | Catalogue No. | Price |
|---|---|---|---|
| Display Bezel | Farnell Electronic Components Ltd | 175-707 | £1.64 |

*Note* any bezel that will accommodate 2, 0.8", displays, will do. If you have difficulty in obtaining one, then don't use one at all. Just glue a red filter plastic in the bezel cutout – this is nearly as good.

| Description | Supplier | Catalogue No. | Price |
|---|---|---|---|
| Min Thumbwheel Switches | Maplin | FF84F | £4.35 |
| | Electromail (RS) | 338-339 | £4.27 |
| | Switch | | |
| | 2 Endplates | 338-406 | £1.63 |

## PARTS LIST

**RESISTORS** (all ¼W 5%)

| | |
|---|---|
| R1 | 1k SIL, 8 Commoned resistors |
| R2,28 | 750R |
| R3,4 | 180R |
| R5 | 10R |
| R6,13,17,18,22, 23 | 10k |
| R7,25,27 | 4k7 |
| R8 | 100k |
| R9 | 2M2 |
| R10 | 22k |
| R11 | 2k7 |
| R12 | 200R |
| R14,16,19, R20,21,24 | 1k |
| R15 | .5M6 |
| RV1 | 500k, min Cermet, Preset |

**CAPACITORS**

| | |
|---|---|
| C1 | 47n, Min Layer, Polyester |
| C2,C3,C8 | 470n, Min Layer, Polyester |
| C4 | 220u, Radial Electrolytic (16V) |
| C5 | 47n Ceramic |
| C6 | 1M, Tantalum (35V) |
| C7 | 470u, Radial Electrolytic (16V) |
| C9 | 220n, Min Layer, Polyester |

**SEMICONDUCTORS**

| | |
|---|---|
| IC1,IC2 | 40244 Octal Buffer |
| IC3 | 7217 Counter/Driver |
| IC4 | 7240 Precision CMOS Timer |
| IC5 | 2940 5V, Low Dropout Red |
| Q1 | 2N3906 (PNP) |
| Q2 | 2N3904 (NPN) |
| Q3,Q6 | VN10LM |
| D1,8 | 1N4148 or 1N 914 |
| D9 | Green Rectangular LED |
| DISP2 | 0.8" Common Anode Seven-Segment Low Current, High Intensity |

**MISCELLANEOUS**

| | |
|---|---|
| SW1,2 | BCD, Thumbwheel |
| SW3,4 | SPST Pushbutton |
| SW5,7 | Min Rocker (SPDT) Switches |
| SW6 | Min PCB Slide |

VEROBOX Type 65-2073k
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ETI

# Tech-Tips

## Logic Analyser for Home Computer

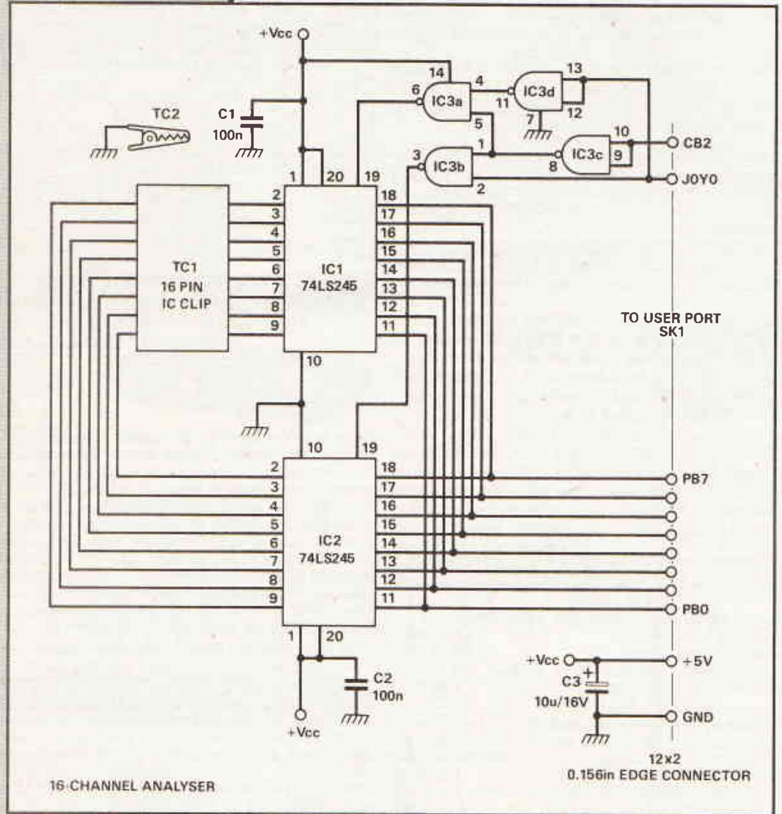
While developing TTL sequential logic circuits it soon became evident that some means of continuously and simultaneously monitoring several logic signals would be very helpful. There are ready-built devices that perform this function, but since they cost several hundred to several thousand pounds, a cheaper alternative was required. One method would be to use a row of LEDs, but it was felt it would be more useful to have some means of storage and computational capabilities available, hence the use of a Home Computer; in my case a VIC-20.

The circuit is based on two Octal Bus Transceivers, IC1 and IC2, permanently wired for one direction only. These have tri-state outputs which are enabled by taking pin 19 low. This is controlled by two lines from the user port and a gating circuit based around IC2, a quad two-input NAND gate. The transceiver inputs come from a 16-pin test clip that is clipped on to an IC in the circuit under test. The crocodile clip is connected to the ground rail of the circuit before attaching the test clip.

The computer program control has two main tasks to perform : select which transceiver to enable, and input data from the user port to be displayed on the screen. The selection is controlled by the JOY0 line — HI for IC2, LO for IC1 — and is toggled by the software. Inputting data is performed by taking CB2 low, reading the user port and returning CB2 to a high state. The sampling process continues, repeatedly switching between IC1 and IC2, taking in more data and displaying it.

The hardware for this project can also be connected to a Commodore 64 and a BBC since they both use the same I/O chips (the 6522) as the VIC-20. The software however, will have to be changed due to differences in addresses and languages.

**Neil Johnson, Northiam, East Sussex**



16-CHANNEL ANALYSER

**Example Control Program for VIC-20**

```
10 REM ANALYSER CONTROL PROGRAM
20 POKE 37148,224
30 POKE 37139,255
40 POKE 37138,0
50 POKE 37151,0
60 GOSUB 100
70 POKE 37151,4
80 GOSUB 100
90 PRINT CHR$ (147)
95 GOTO 50
100 POKE 37148,192
110 V=PEEK (37136)
120 POKE 37148,224
130 V$=" "
140 FOR P=7 TO 0 STEP-1
150 V$=V$+CHR$ (30+ABS (V AND
(2^ P)))
160 NEXT P
170 PRINT V$
180 RETURN
```

## RIAA Characteristic

During my hi-fi period some years ago, I had cause to look into the business of RIAA characteristics. My objective was to achieve the least amount of error in reproduction. I use the word error as distinct from distortion as distortion usually refers to the waveform, for example harmonic distortion and cross-over distortion. Whereas I imply error to mean amplitude distortion as well as waveform distortion.

The RIAA characteristics specifies the play-back characteristic from disc, assuming a perfect cartridge/tone arm combination. Such a combination would give an output proportional to frequency. The cartridge after all is a simple alternator with limited movement. If you turn it twice as fast you get twice the voltage! In this case you can't turn it very far but the principle is just the same.

The RIAA characteristic is in four bands recorded from 20Hz-50Hz flat, from 50Hz-500Hz falling 6dB/octave, 500Hz-2KHz flat, and 2kHz-20kHz falling 6dB/oct. This is shown at A in Figure 1. Combining this with the rising characteristic of the replay mechanism gives a requirement for the shape in B Figure 1.

However its not easy to produce a filter network where there are sharp corners as in Figure 1. The best that can be produced without too much difficulty is

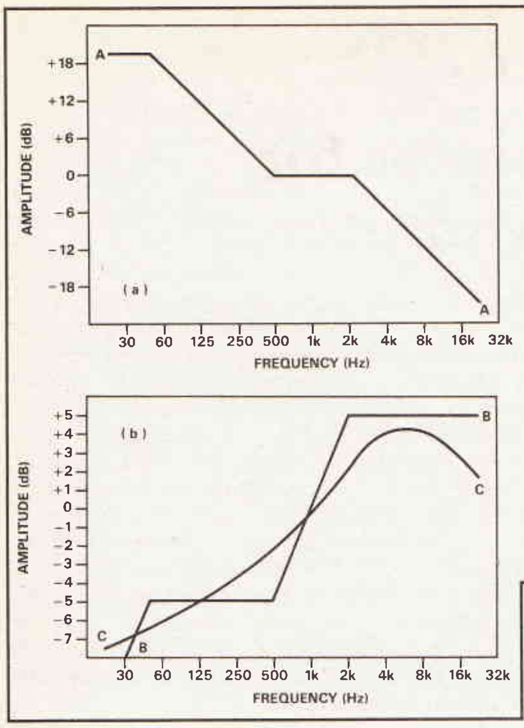
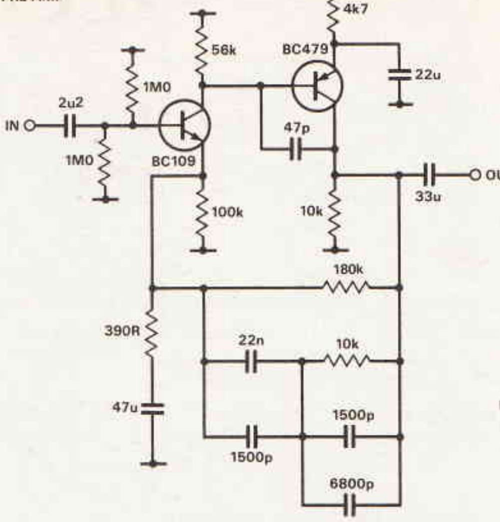



Fig 2.
PRE-AMP



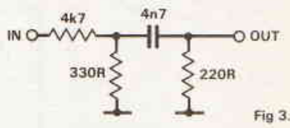




Fig 3.

a filter which is within ±3dB. Such a design is shown in Figure 2. With its curve C plotted against the required curve in Figure 1.

The circuit is a high stability low noise design requiring not less than a 12V supply (not more than 25V). The transistors are not critical but they must be of the low noise variety! The feedback network appears between the emitter of the first stage (BC109) and the collector of the second stage (BC479).

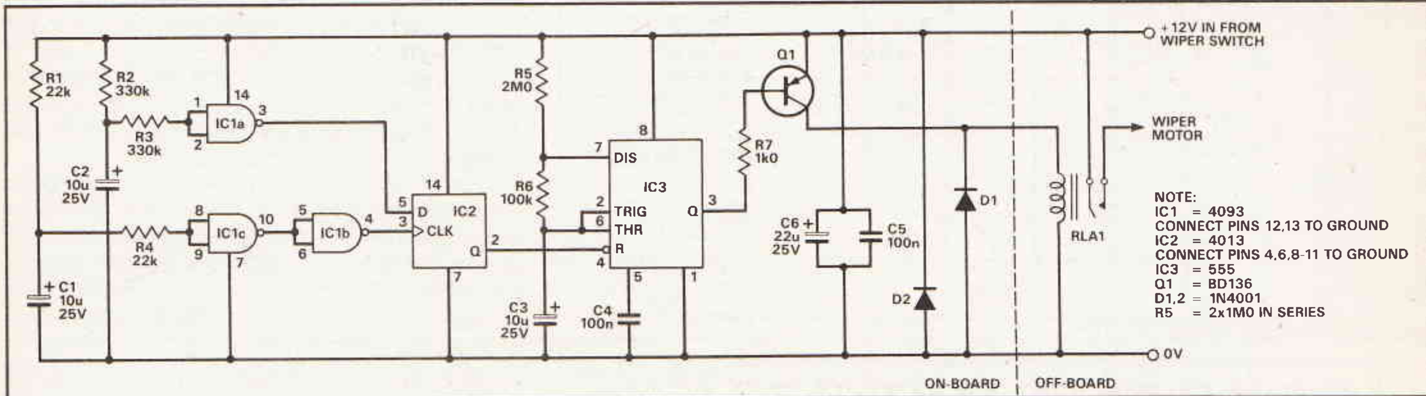
The effectiveness of the circuit is realised using a tone generator followed by an RC network giving the required 6dB/oct rise. The curve C was obtained in this way. See Figure 3.

The circuit of Figure 2 does not include any correction specified by the cartridge manufacturer. For many moving iron (variable reluctance) cartridges this correction is of the order of 47k in parallel with 220p in parallel with the input of Figure 2.

The design in Figure 2 is not my design, however I cannot recall where it came from and so cannot acknowledge someone elses ingenuity. To that person I apologise.

**K Garwell, Stoke on Trent**

# Improved One-switch Delayed Wiper




Further to Steve Roberts' Design in Tech-Tips July 1990, I might suggest the following additions/ improvements.

To recap, intermittent action is obtained when pin 4 of IC3 is held high by the $\overline{Q}$ output of IC2. On first switch on, a logic 1 is clocked to the Q output of IC2, using the clock pulse generated by R1, C1 and IC1b/c. The $\overline{Q}$ output is therefore low, resetting IC3 and ensuring continuous wipe by energising RLA1.

A brief off/on after 3 seconds will clock a logic 0 to the $\overline{Q}$ output of IC2 as C2 will now have charged, forcing pin 3 of IC1a low. The $\overline{Q}$ output is now high, enabling the 555 astable.

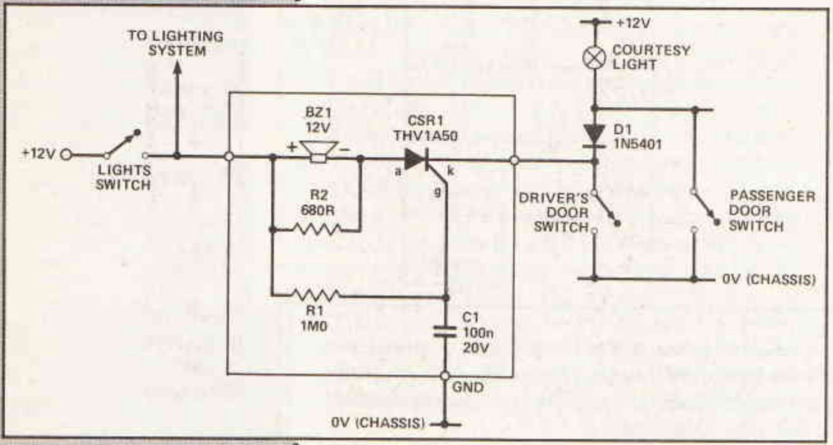
I found R4 unnecessary, and also that the 555 got rather hot driving the relay directly. Q1 prevents this, and also allows one side of the relay coil to be grounded. This means the three connections to the board can be made via the relay terminals, allowing easier connection with the larger incoming cables to the unit. D2 shunts back any voltage generated by other Electromechanical devices on the car. The increased values of R5 and R6 give a more suitable delay of around 20 seconds.

The relay used was a '30A Accessory Relay' purchased from a local DIY store for around £2. The unit was installed in an Escort Diesel Saloon in a couple of minutes, and cost less than £9 including ABS box.

**David Geary, Romford, Essex**

# Car headlights reminder

Although circuits which perform this function appear in the electronic press with monotonous regularity, all the circuits I have come across seem to be very over-complicated, often using a couple of ICs and several discrete components. The circuit which I have developed is very simple and robust, using only five components including the sounder.



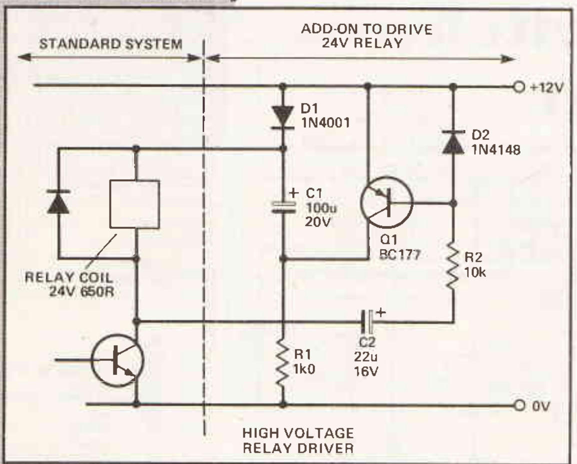

Operation is as follows: if the headlights are on, point 'A' will be at +12V and C1 will change through R1. Point 'B' is also at +12V, so thyristor SCR1 is not triggered. If the car door is opened, point B will drop to 0V, and C1 will discharge into SCR1's gate, thus turning the thyristor on and sounding buzzer BZ1 until the door is closed or the headlights switched off. R2 is simply to ensure that there is enough current through SCR1 at all times to keep it in the 'on' state. If it is wished to leave the lights on, the door should be opened first, before the lights are switched on. When the door is opened, C1 will discharge as before, but because point 'A' is at 0v (lights off), the buzzer will not sound and SCR1 will not latch on. If the lights are now switched on, point 'A' will rise to +12v but C1 is effectively short-circuited by the gate-cathode junction of SCR1. The current through R1 is far too small to trigger SCR1 in this state, so the buzzer remains off.

If it is thought necessary, diode D1 can be fitted to prevent the circuit from operating when the passenger door is opened.

**D Banham**
**Redbourn, Herts.**

# High voltage relay driver

This circuit was developed to allow me to make use of some 24V relays in a system which was powered from a 12V supply. It relies on the fact that a relay needs a much higher voltage to pull in than it does to stay in once operated. This circuits exploits this fact by supplying a high voltage at the moment of switch-on. This also has the advantage that the relay consumes less power than it would if it was continuously powered from its rated voltage.




When the relay is off, C1 changes to +12V via D1 and R1. When the relay is energised by grounding point 'A', R2 and C2 supply a brief pulse of base current to Q1, which turns on and pulls the negative terminal of C1 up to +12V. The junction of D1, C1 and the relay coil therefore rises to +24V, which is sufficient to fully operate the relay contacts. C1 discharges through the relay coil, which is then supplied with a 'holding' current via D1 from the +12V rail. Once C2 has charged Q1 will switch off, allowing C1 to recharge and preventing a continuous current drain through R1. D2 allows C2 to discharge safely when the relay is switched off.

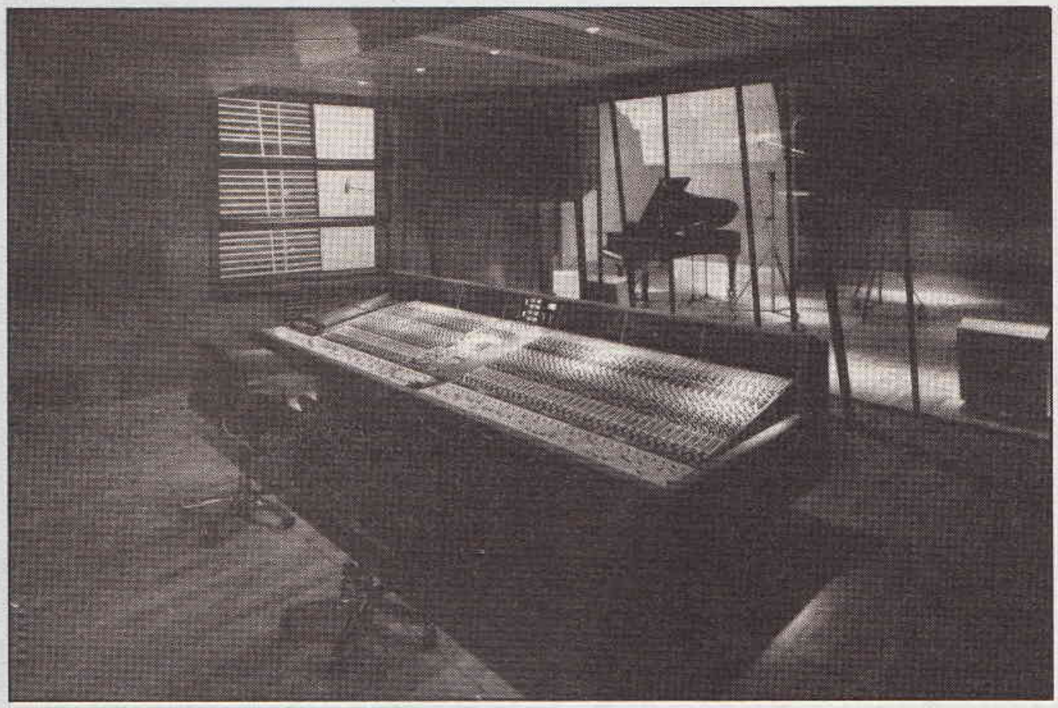
The component values given are not critical, but here are some guidelines:

D1 and Q1 should be chosen to handle the relay's rated current.

C1 should be sufficiently large to pull the relay in fully when the circuit is operated.

R1 should be chosen to allow C1 to recharge in between operations of the relay. If it is only to be operated infrequently then R1 can be made large. C2 and D2 can then be omitted unless power consumption is absolutely crucial.

**D. Banham**
**Redbourn, Herts.**



DESIGN 1

# AN INTRODUCTION TO RECORDING STUDIO DESIGN

*James Roberts reports*

This article takes a look at Sound Recording design. We will briefly examine all facets of the process, as the technical considerations have rather a special relationship with the rest of the design process, being crucial but secondary, meaning the technical performance of the studio must be entirely adequate for the intended function. This comes a long way down the list of priorities, though. Before we can talk about the design process, it would be rather helpful to have a more exact idea of what we mean by 'Recording Studio'.

What is a Recording Studio? Here is a ponderous definition — A recording studio is an assemblage of equipment, spaces and persons such that a performance in sound may be created and recorded onto a medium for later reproduction. The word studio has two distinct uses: firstly in the approximate sense of somewhere where study and work is done, hence 'recording studio' and secondly in the sense of 'the studio room', where traditionally the instruments are played. The other essential space in the traditional studio is the 'control room', where the controls are operated (Figure 1). Nothing is as clear cut as this any more so I will describe some of the varying types of facilities and what they are intended to do. First though, a quick glance at multitracks.

## Multitrack Recording And Stereo

Multitrack recording is currently the predominant method of musical assembly work. For those who are not familiar with this, the general idea is to have a recorder with many separate audio channels or 'tracks' — up to 32 is common, but more can be made available by slaving two machines together to give up to 62 tracks (one track on each machine is commonly used for synchronisation code, usually SMPTE code (Society of Motion Picture and Television Engineers). Each track is used for a single musical part, or for an assemblage of parts, having strings on two tracks in stereo for example. This can be achieved either by recording in sections or by 'reduction' or 'bouncing' several previously recorded tracks onto one or more other tracks. This is eventually mixed down to stereo via the mixer, which will have a minimum of one control channel for each tape track. This process does not produce true stereo. Original Blumlein-derived stereo recording is comparable to the process of making a hologram, where a sample is made of the whole sound at that position, the resulting soundfield being reproducible to a surprising degree by two speakers. Ambisonics (as against quadrophony) continues this principle to add most of the characteristics of the original space (Figure 2). Multitrack stereo does not contain the phase differences preserved from the original performance that enable true stereo to be produced. All that can be done is to adjust volume levels between the channels to give an impression of the lateral positioning according to the Haas effect, though attempts have been made to add variable phase delay. This is not particularly important with popular music, the bulk of which is now sourced from assorted computerised instruments which don't have any acoustic output at all to preserve, but makes a mockery of some of the excesses of the hi-fi brigade with regard to perfectly-reproducing something that didn't ever exist. With classical material, the story is different, as true Blumlein techniques are often combined and balance each other with multiple miking to control and balance each section. This is tricky to implement effectively.

## Studio Types

Various Sound Studio types exist. These are:

### Home studio

A studio built in someone's home!. It is not in any way a pejorative description. A lot of material is now being made available to create quality in home studios.The traditional down-market 'demo' studio, originally used for low cost recording of demonstration material, is rapidly disappearing, but we can make a distinction, based on the general quality of output thus:

### Semi-pro

A semi-pro studio will have the facilities to make demonstration material and experiment with production ideas without incurring the high cost of using a professional studio.

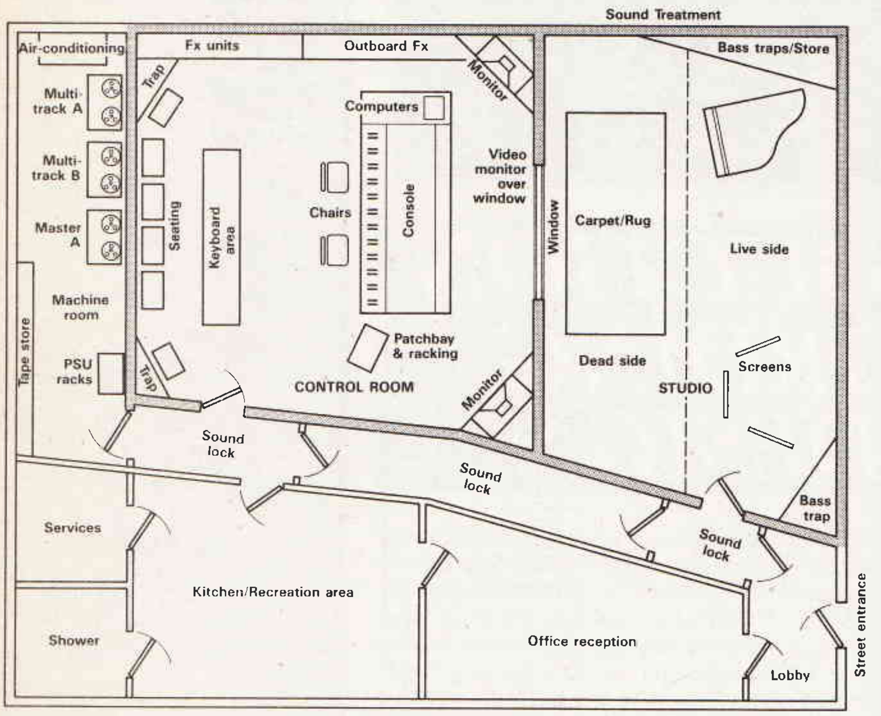



**Fig. 1 A typical small recording studio layout**

### Pro

A 'pro' home studio is essentially a private professional recording studio, with all the same design criteria applying. Release material can be recorded.

## Professional Studios

### Sound to picture

These studios primarily deal with the addition of final soundtrack material to the finished edited visuals for movies and commercials. They will often have facilities for recording large scale orchestral performances, while simultaneously projecting the film that is being worked on. Equipment will include that necessary for synchronisation of audio to film, and processing films for Dolby Stereo or multi-channel formats.

### Radio, Speech and drama

Radio studios have to deal with a broad range of material. Small studios are used for voice material such as interviews and drama, slightly larger ones can also deal with small scale music recording. Speech and drama studios are optimised in terms of acoustics and equipment for speech recording. There are very few studios of this type outside radio.

### Cutting

Cutting studios specifically deal with transfer of material from tape source to master discs, with appropriate 'final tuning' for best results. The number in this category will drop as more direct digital material is released on CD.

### Pre-production

There are two main categories of pre-production studio — MIDI based and 'track-laying' studios, though they often merge indistinguishably. A MIDI (Musical Instrument Digital Interface) studio is primarily computer based, with a dedicated or software-based sequencer controlling various sound sources, keyboards, drum units and effects units. The advent of low-cost fully digital mixers has meant that a high level of automation can be applied, though this can take more time than it saves. The whole lot will be locked to a timing mechanism recorded on one track of a multi-track recorder, which is then used for synchronised vocal, guitar and other 'real' sound sources that are at present not equipped with digital I/O. A track laying studio concentrates more on providing excellent quality acoustic recording, usually offering limited space and mix-down facilities, so that the bulk of recording hours can be done at relatively low cost. The output will normally be taken to another (expensive) studio for final polishing and mix-down. Track laying studios now will offer MIDI facilities.

### Mix-down

Mix-down or Remix studios specifically deal with the reduction of multi-track material to finished masters, usually stereo. A remix studio will concentrate more on making new versions from existing multitrack masters. They will have heavy investment in sound processors and modifiers, and often the ability to synchronise several multi-track recorders to allow new material to be added to the original but on a separate tape, to maintain the original recording.

All of these can be constructed on a small or large scale, depending on the intended market and budget. It is common for a particular studio to be able to cover more than one of these applications, and large complexes may offer all these facilities in-house.

## Commercial Considerations

First we must consider the difference between budget and cost. The budget is the amount you are willing to pay to get the studio going, the cost is the amount you end up paying. Happy is the man or organisation where these two actually coincide.

Examining the market, there has to be sound commercial reasons for setting up a studio, as against bodies like the BBC, who do not have to consider the market, as most material relates to internal consumption.

The usual aspects of market research are taken into account. These are typically — what do the customers want, what do they like that is already available, what don't they like, how far are they prepared to go, how much are they prepared to pay, what special features can be offered that will be exclusive to this studio, and so on.

### Location

Location can be a very important issue. The desired location will depend, in the first instance, on the intended market for the studio. For example, many studios are located for easy access by local clients. Alternatively, some studios are located in the country for a quieter working ambience. Such a studio would

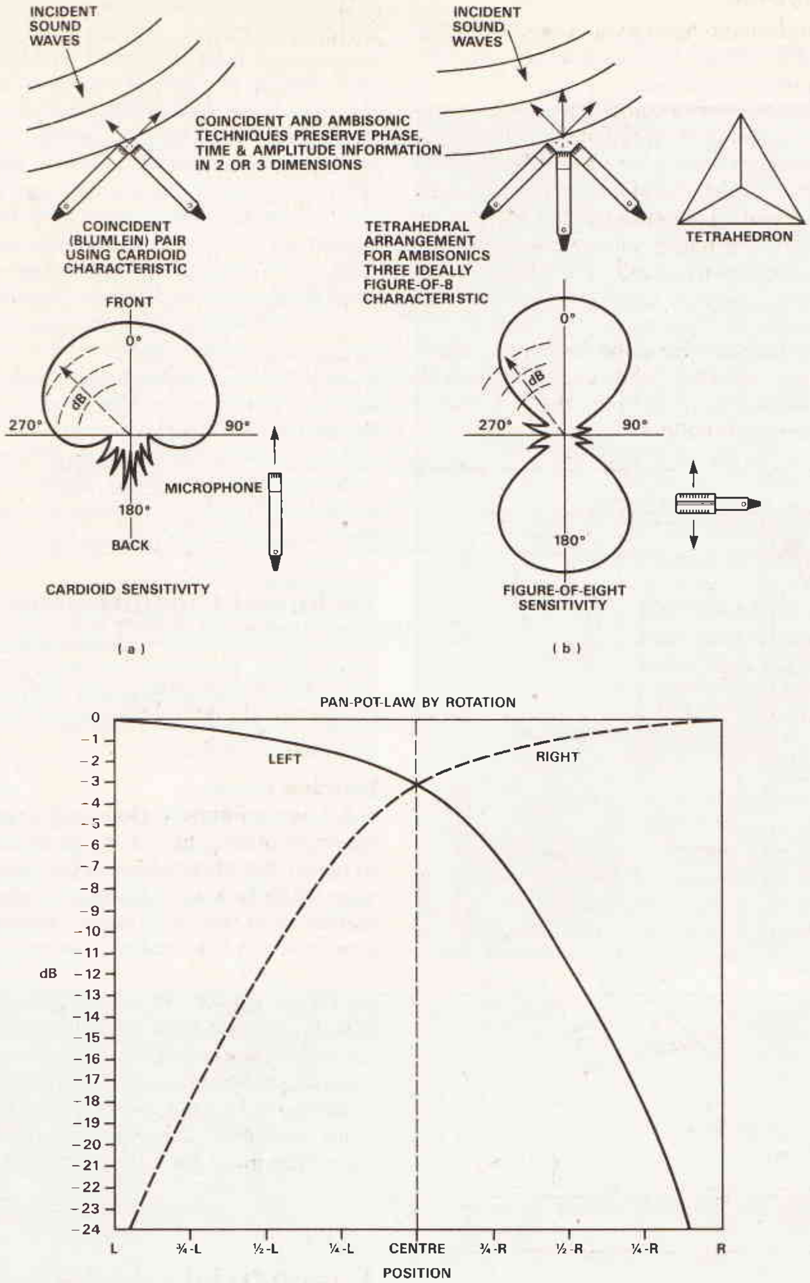



Fig. 2 Blumlein and Ambisonic recording techniques

normally be residential.

Size is another strategic decision. If it is intended to record orchestras, a very large studio will be required. Many facilities have several studios within them, offering overlapping spaces for difference types of work.

Normally, studios require twenty-four hour access for arriving and departing clients. In some special circumstances this might not be required. A studio dealing with large-scale recording will have good access for the transport of large-scale equipment — stairs and narrow alleyways are inappropriate.

## Noise

There are two aspects to this. Various people wanting to build a studio in a residential neighbourhood have discovered that neighbours will be most alarmed at the prospect of having a studio near them, both because they expect loud music (not the case) and the coming and going of lots of people (usually the case). Secondly, it is generally not a good idea to build a studio under the flightpath to Heathrow, under a railway siding or next to an elevated motorway, though if funds are unlimited it can indeed be done.

Parking is another significant issue. Not so very long ago, a large and well funded studio complex in Central London closed down after six months trading, largely because it was situated in Piccadilly and there was nowhere for anyone to park.

## Planning permission

Studios usually require planning permission, and specific permission may be granted only on various conditions. These must be anticipated before a commitment to a specific locale is made. Fire and sanitary regulations will also have to be complied with, dependent on the size of the intended studio and the numbers of people usually there.

## Format

Choice of recording format is now becoming something of a problem. Some formats currently available are shown in Table 1.

**Table 1.**
**Tape Formats**

**Analogue**

Stereo on 0.125 inch cassette
Stereo on 0.25 inch tape
Stereo on 0.5 inch tape
2 track on 0.25 inch tape
3 track on 0.25 inch tape
4 track on 0.125 inch tape
4 track on 0.25 inch tape
4 track on 0.5 inch tape
6 track on 0.125 inch cassette
8 track on 0.125 inch cassette
8 track on 0.25 inch tape
8 track on 0.5 inch tape
8 track on 1 inch tape
12 track on 0.5 inch cartridge
16 track on 0.5 inch tape
16 track on 1 inch tape
16 track on 2 inch tape
24 track on 2 inch tape
32 track on 2 inch tape

**Digital**

Stereo PCM to Betamax
Stereo DAT
8 track on approx 8mm cartridge
12 track on approx 0.5 inch
24 track on 1 inch
32 track on 1 inch
24 track on ½ inch tape (DASH)
48 track on ½ inch tape (DASH)

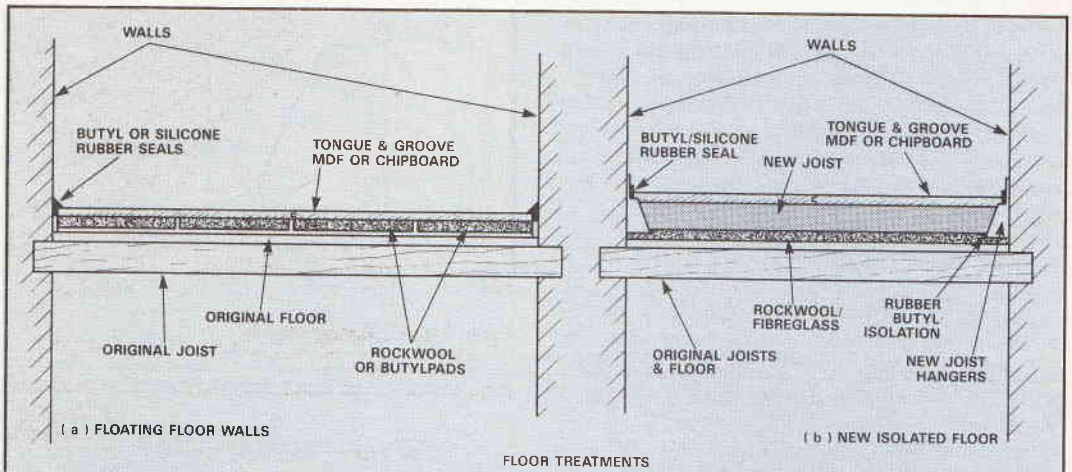



**Fig. 3 Floor treatments**

The analogue formats have variations in tape speed from 1⅞ inches per second to 30 inches per second, equalisation from NAB or IEC, and Noise Reduction, either Dolby A,B,C or SR, or DBX type 1 or 2. The digital formats are all slightly incompatible with regard to the details of the digital encoding. Small wonder that dealing with tapes from another studio can at times be somewhat problematic! Fortunately there are only a few current real standards. The baseline for professional recording is 24 tracks on 2 inch tape at 15 ips with NAB equalisation, and this format is offered by more studios than any other. For smaller studios, 16 track on ½ inch tape at 15 ips with Dolby C has become a subsidiary standard. Stereo masters on quarter inch tape at 15 ips with NAB or IEC equalisation can be dealt with just about anywhere, so most studios will be able to make these. The DAT machine has also made major inroads in smaller professional studios, offering good results, though many people have unresolved doubts about the long term stability of material recorded to this format. However, at the top end of the market, when ultimate quality and control are being sought, the decision as to what format to choose is difficult, especially as the price of top quality digital equipment is very high, if not outrageous. The market for multitrack digital equipment is, by consumer market standard, miniscule, so the development costs are spread over a very small number of sales. This may well change with the introduction of the next generation of computer equipment, whose speed and power, plus the expanding size of digital storage media such as hard discs, may lead to the final demise of tape based storage media, except for long term archive purposes, and even here optical discs show great promise, as the price comes down. Direct digital recording onto erasable optical disc is now available at a reasonable price, though only in four-track format.

## Technical Considerations

Usually commercial considerations will dominate the choice of site. Thereafter the difficulty is achieving the desired technical specification within the available budget. Having chosen a suitable location the next set of problems appear!.

### External noise

In the last decade quiet has largely ceased to exist, so wherever you decide to put a studio there is likely to be noise. The site will have to be surveyed to determine what the base noise level is, what peak noise level is, what frequency band it occupies and what sources are. It is advisable to sample over at least a week and all round the clock — in some locations noises only appear at strange times of day, or when the wind is blowing from a particular direction (aircraft noise). Usually the main problems are traffic, trains and planes. The combination of the data regarding noise levels measured and the noise level required inside will give the specification for the sound proofing work.

### Building construction

If building from scratch, the actual work will need to be designed by an architect familiar with studio requirements. For example, the practice of putting 'butterflies' between rows of bricks in a cavity wall is a definite no-no in studio construction, as it destroys isolation. With an existing building, it will generally be necessary to construct some form of independent

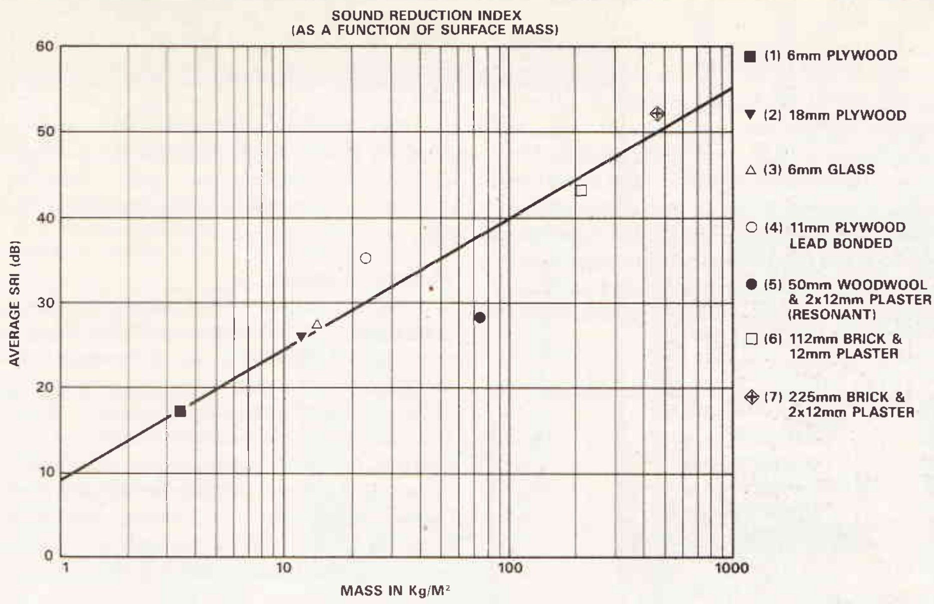


Fig. 4 Sound Reduction Index as a function of surface mass

structure within the existing walls, and the building' structure will need to be suitable for this, or modified accordingly.

### Internal noise

The likely noise sources within the finished studio need to be evaluated and provision made to isolate them acoustically. The noise from a soil pipe can be picked up by a condenser microphone at remarkable distances . . .

### Floor loadings

Studio floors have to take a considerable weight. A lot depends, as usual, on the exact use of the studio. With an existing building, allowance has to be made for sound treatment being laid on top of the existing floor, as well as the loading to go on top of that. Often the answer is a new floor, 'floating ' on top of the existing floor or independently supported from the walls (Figure 3).

### External Noise Control

There is a very simple way of reducing noise transmission, and that is to use 'non-resonant mass', lots of it, in the way of the noise source. Really there isn't any other way to do it. The problem is that massive construction is heavy, putting stress on existing structures. It is costly and takes up space, so the absolute minimum will be used commensurate with the required noise reduction. As long as a wall is non-resonant, it will absorb sound known as its Sound Reduction Index — (SRI) which is proportional to its mass and the frequency of the impinging energy. The theoretical SRI will increase by 6dB at a fixed frequency for the doubling of mass, and for a fixed mass by 6dB per octave increase in frequency (Figure 4). In this diagram the 'mass law' is shown as the solid line.

The amount of noise will have been established from the site survey, and the required internal levels will normally be established by reference to Noise rating (NR) curves (Figure 5). In general, levels between NRO and NR 35 will be needed, depending on the application. For comparison, the levels in typical living rooms are also shown (Figure 6). To attain these levels requires some effort. The addition of massive structures is fairly straightforward, but keeping them non-resonant is harder. Getting light and air to the work space is important which means

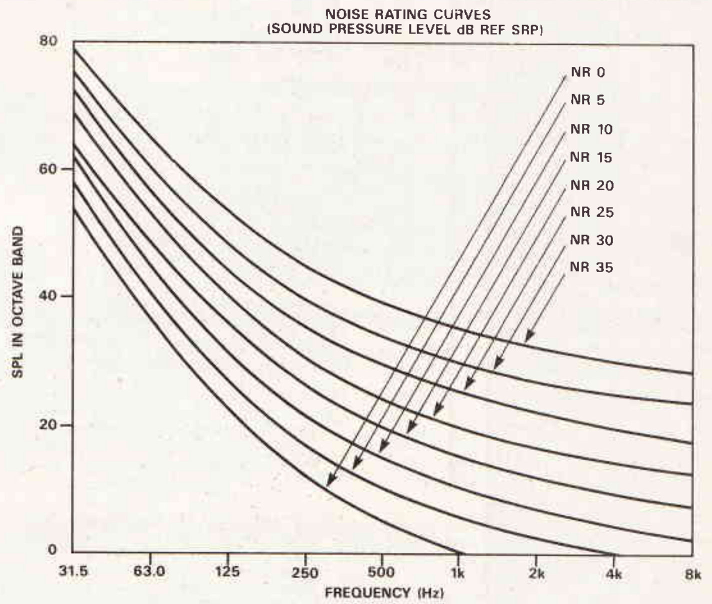


Fig. 5 Noise Rating Curves

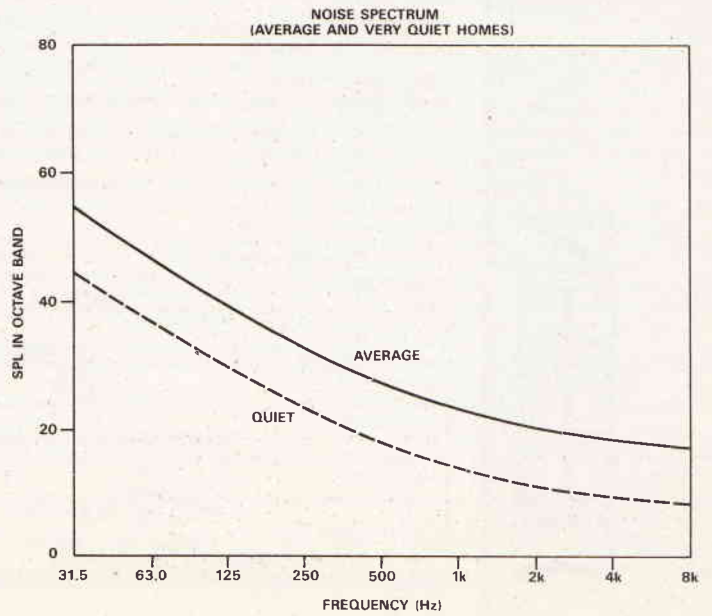


Fig. 6 Noise Spectrum (Average and very quiet homes)

DESIGN

removing the stale air, usually by ducting. Any gap at all in the massive structure will completely negate the purpose of the exercise, to keep the noise out, so doors must have a good seal. There is usually two of them in a sound-lock, so that noise does not enter the studio area as people enter and leave. There are specialist suppliers of doors, and having tried building custom ones, I would go for the specialist every time! Windows are another issue. People quite naturally prefer to work with daylight. Most studios have given up at this point, just imagine the window construction needed to give the same sound loss as two double brick thicknesses plastered walls. This is shown in Figure 7.

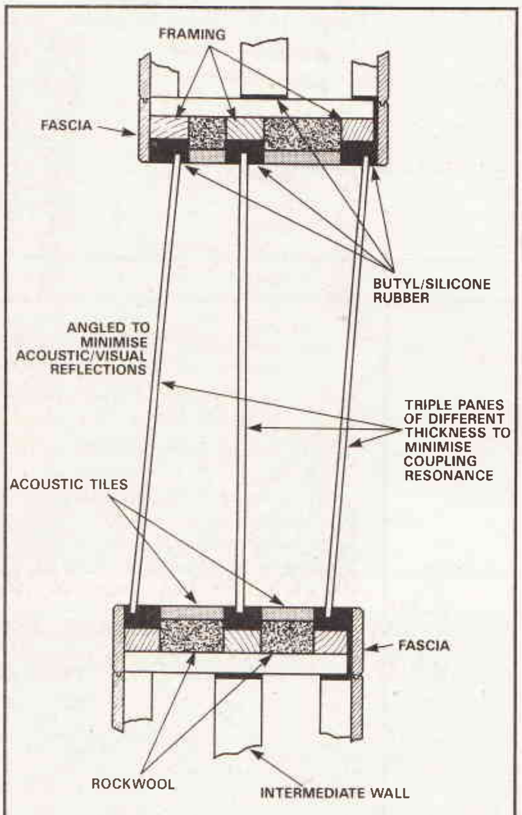


Fig. 7 Window construction (Triple-glazed)

## Electric Connection

### Electrical Noise

It is normal to provide a 'clean feed' of electricity to power all the control room equipment, and this supply will often be taken from a different phase from that used to supply power and lighting for general use within the building. The studio itself also requires a clean feed and caution must be exercised here, as it is not unknown for musicians to mix phases when using their own equipment from control room to studio and embarrassing results can transpire. So it is better to keep control room and studio on the same phase. The cable runs have to be carefully planned, usually with dirty power and lighting runs placed up high, and clean power down low. Audio cable run in the middle of the wall at convenient height for connections. It gets complex when there are two or three studios all needing clean feeds. Standard triac dimmers are generally doubtful assets in a studio, as they broadcast radio and line noise.

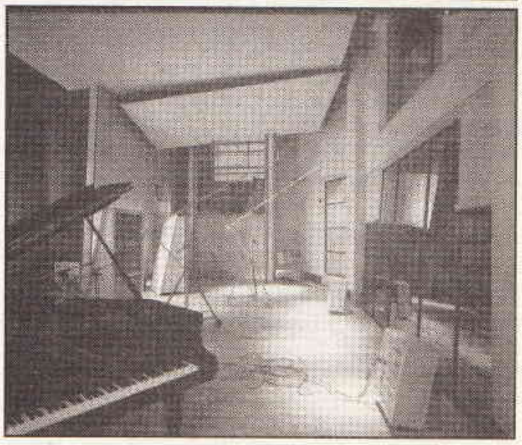
### Electrical safety

In a studio there are a lot of people handling a lot of mains powered equipment, so RCBs (Residual Current contact Breakers) are a necessity. Earthing problems can be a nightmare, with loops being set up at the interface of professional and semi – professional equipment. Double insulation has helped somewhat with this (Figure 8). These are now unfashionable due to the alleged effect on the sound fidelity. Personally, I still use transformer . . . if, however, they are avoided then lots of time will be required to get the system quiet, and much care needed to keep it so.

### Electrical load

Studio recording equipment doesn't itself use a great deal of power, but the associated lighting, heating and air conditioning have to be considered within a large complex, and so there can be a pretty heavy consumption. This in itself is unlikely to be a problem, but the voltage drop on the main feeder from the Electricity Board supply when 50kW of air conditioning cuts in and out at can be. It may be necessary to arrange special feeds. Larger studios will need at the very least back-up lighting to conform with safety regulations, and almost all will have a backup generator capable of supplying the full base load of the complex. The necessity of this is obvious, if you consider the scenario of a studio-full of orchestral musicians, say one hundred, all quite rightly on Musician's Union rates, waiting for eight hours for power to be re-established.

TO BE CONTINUED



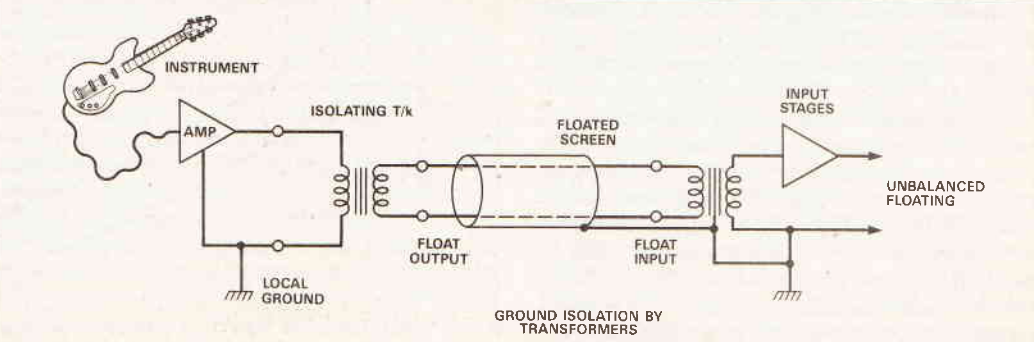


Fig. 8 Ground isolation by transformers

DESIGN

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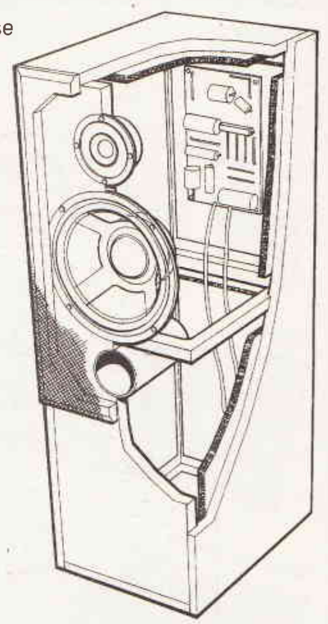

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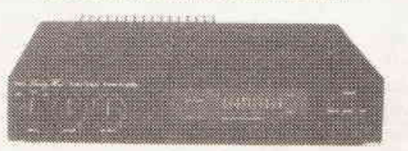

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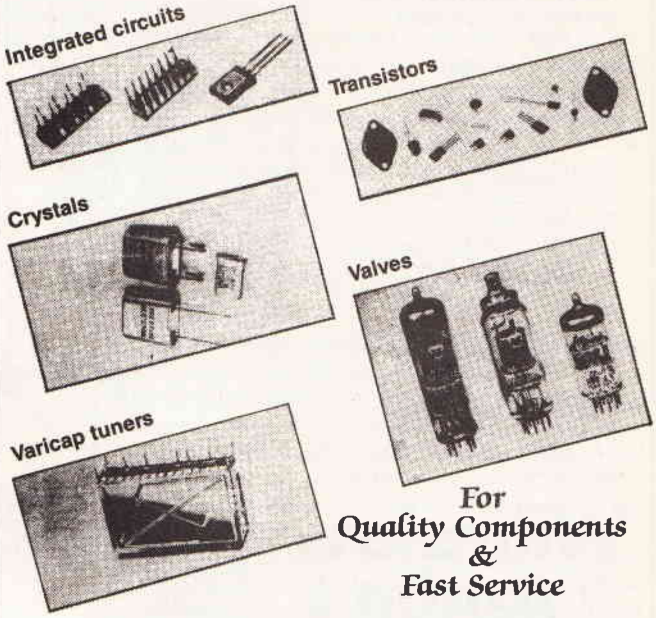


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# SERIAL OR PARALLEL LOUDSPEAKERS

*From the US, Ronald Wagner continues with the theory of Electrostatic Loudspeakers and shows the advantages of serial types*

**2**

## Electrical Interface

One of the most critical items in an electrostatic speaker is the audio transformer that is connected between the plates and the source of the audio voltage.

This device provides two inter-related functions. First, it increases the amplifier's output voltage to a value that can produce the required diaphragm movement. Second, it reflects the speaker capacity, and its associated impedance, back to the output of the amplifier. The following material will show what factors are important and how they affect the speakers response.

## Turns Ratio

One of the key factors in the performance of a transformer is its turns ratio. In effect this number relates how many turns there are in one winding to the number of turns in another winding. Although it is not specifically stated in the transformer data sheets, it is usually provided in some other form. For an existing transformer the number can be determined by measuring the voltage on each winding and then computing their ratio. That is:

$$N = V2/V1$$

where N is the turns ratio between the two windings, V2 is the AC voltage across one transformer winding and V1 is the AC voltage across another winding.

Besides increasing the primary voltages, the turns ratio also increases the speaker capacity that is reflected back to the audio amplifier. As an example, suppose a speaker is to be driven by a 100 watt amplifier. If the amplifier rating is produced across a 4R load, then its peak to peak output is 56.56 volts. When this amplifier is connected to the 24 inch speaker, this voltage must be increased until the plate to plate voltage is 6250 volts. The ratio of these two voltages will establish the tranformer turns ratio, and in this example it is equal to 110.5

Once this value is defined it can also be used to calculate the speakers reflected capacity.

$$C_{pri} = C_{spkr} \times (N)^2$$

where $C_{pri}$ is the speaker's capacity reflected to the primary winding of the transformer, and $C_{spkr}$ is the plate-to-plate capacity of the speaker.

For the indicated speaker the reflected capacity is equal to:

$$C_{pri} = (1.037 \times 10^{-9}) \times (110.5)^2$$
$$= 12.7 \times 10^{-6} \text{ farads}$$

A $12.7\mu$ capacitor will have an associated impedance, at 100Hz, of 125R. Power amplifiers used to drive loudspeakers are usually designed for a load impedance between 4R and 16R. Because this calculated impedance value is very large, it will affect the speaker's ability to produce the required amount of acoustic power. In addition to this a capacitor's impedance is not constant. At 10kHz, for instance, the value will have decreased to 1.25R. Not only can this cause the amplifier to limit its output power, but the capacitive load can also produce an oscillation in the amplifier.

One way to overcome these difficulties is to use several speakers. If each speaker is operated over a reduced frequency range and connected to the amplifier by a suitable crossover network the impedance variation at the amplifier's output will be less. Another solution is to break up a large diaphragm area into smaller sections. Using this technique each section is also connected to the amplifier by a crossover network. As the frequency increases, the area of the speaker will become smaller. More information on this method will be presented in the section on Segmentation.

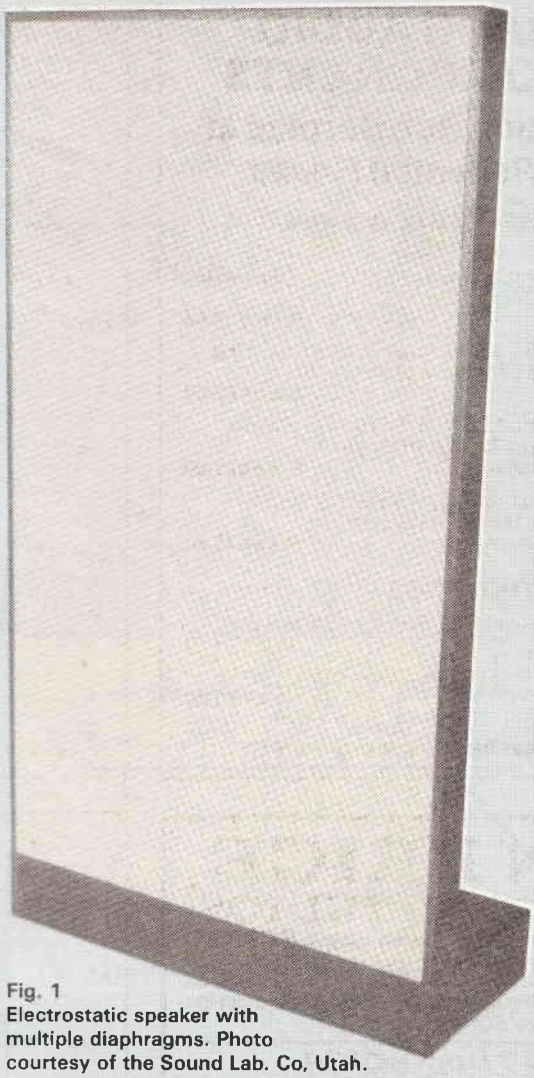

**Fig. 1**
**Electrostatic speaker with multiple diaphragms. Photo courtesy of the Sound Lab. Co, Utah.**

## Transformer Frequency Response

All transformers have frequency limits. Some, such as power transformers, have very narrow bandwidths that only occupy a few hundred Hertz. Others, used in communication systems, can have a frequency response that spans many MHz.

A transformer for a single diaphragm ESL should have its limits located at 20Hz and 20kHz. For any transformer the exact location can be determined by dividing its frequency response into three regions. Each region is then analyzed by using an equivalent model that predicts how the transformer and its associated load will perform.

## Mid Frequency Range

The best place to start analyzing a transformer's response is in its mid frequency range. Within this region the transformer is considered ideal and its performance is determined by the turns ratio. To establish an equivalent model the output winding resistance as well as the load must be reflected back to the input terminals.

Consider, for example, the circuit shown in Figure 7a. The resistance rg is the internal resistance of the voltage source (es). The resistance of the input or primary winding is shown as rp. On the speaker or output side of the transformer, the winding resistance is designated as rs. The speaker capacity is shown as $C_{spkr}$.

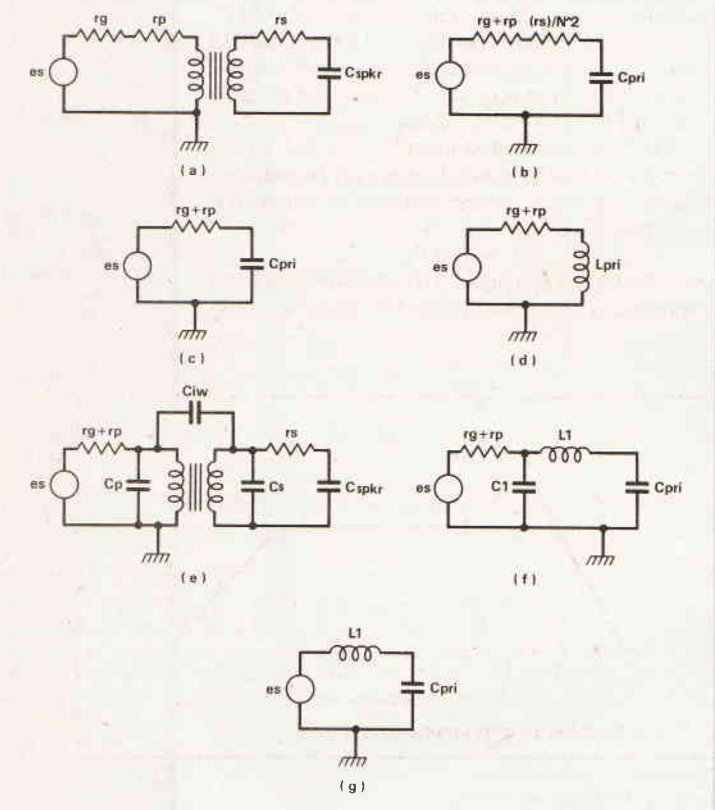


**Fig. 7 Transformer circuit and electrical models.**

An equivalent model is shown in Figure 7b. In this diagram the two resistances (rg and rp) are unchanged. As indicated, the secondary resistance (rs) is referred to the input or primary winding by dividing its value by the square of the turns ratio (N). The speaker capacity is also reflected to the input, but its value is multiplied by the square of the turns ratio.

Although this circuit does not look very complicated, it can be simplified. For instance, most solid state amplifiers have an rg that is less than one ohm. The primary winding resistance is about the same value and the two resistances can be combined. The output or secondary winding resistance is dependent on the wire size and the number of turns. For a transformer used in an electrostatic speaker, this value can vary from 50 to 100R. When it is referred to the input it becomes so small that it can be dropped from the circuit. After making the above modifications the new circuit is shown in Figure 7c.

Electrically this circuit is called a low pass filter. The output voltage, across the speaker capacity, will decrease to −3dB when the reflected impedance of the capacitor is equal to the combined value of rg and rp. If for instance, the winding resistance rp plus the source resistance rs is equal to 1R, then the speakers upper frequency response would be limited to 12.5 kHz. On the other hand, if this resistance was only 0.5R the upper limit would be extended to 25 kHz. Unfortunately transformers are not ideal, and the high end will be determined by a number of other factors. The following section on High Frequency Limits will describe some of the more important factors that control the transformers performance in this region.

## Low Frequency Range

A transformer's low frequency response is determined by the inductance ($L_{pri}$) of the primary winding. When the impedance of this winding is equal to rg plus rp, the voltage across the speaker will decrease by 3dB. Although $C_{spkr}$ is in parallel with $L_{pri}$, impedance is much greater and does not become a factor in the low frequency unit. The low frequency transformer model is shown in Figure 7d, and the location of the −3dB point can be calculated by the following equation.

$$f = X_L/(6.28 \times L_{pri})$$

where f is the −3dB frequency in Hertz, $X_L$ is the impedance value that is equal to the sum or rp + rg (in Ohms) $L_{pri}$ is the inductance of the primary winding in Henries.

As an example, suppose a transformer has a primary inductance of 1.5 mH (0.0055). If the circuit shown in Figure 7d has an rg plus rp that is equal to 1R, the low frequency limit would be equal to:

$$f = 1/6(6.28 \times 1.5 \times 10^{-3})$$
$$= 106\text{Hz}$$

## High Frequency Range

As already stated, there are a number of other factors that must be considered in establishing the transformer's upper frequency limit. The circuit shown in Figure 7e indicates the majority of these elements. In this type of circuit the unknown components are the leakage inductance ($L_1$) the interwinding capacity ($C_{iw}$), the value of the secondary winding capacity ($C_s$) and the primary winding capacity ($C_p$).

The model, shown in Figure 7f, is an equivalent circuit, with all of the secondary elements reflected to the primary winding. This circuit can also be reduced in complexity. For instance, the ESL's secondary winding capacitance ($C_s$) is very small, when compared to the speaker's capacity, and it can be removed from the circuit. The value of the interwinding capacity ($C_{iw}$) is the capacity between the two windings. This value is not multiplied by the turns ratio, but it can be moved to the input side of the transformer, and added to $C_p$. The combination is shown as C1. As long as the source and the primary winding resistance are very low C1 will not seriously affect the transformer's upper frequency limit, and it can be removed from the circuit.

In the transformer's mid-frequency range, the analysis assumed that all of the magnetic lines from the primary winding were linked to the secondary. In actual practice this is not always true. The difference between the number of magnetic lines, produced in the primary, and the number that is coupled to the secondary produces an additional parameter called the leakage inductance. This inductance can be calculated by:

$$L_1 = 2(1\text{-}k)L_p$$

where $L_p$ is the inductance of the primary winding, k is the coefficient of coupling between the two windings, and $L_1$ is the leakage inductance referred to the primary winding.

In the mid-frequency range the value of k is equal to unity, and this makes $L_1$ equal to zero. As the frequency is increased the value of k decreases. If the coefficient of coupling (k) is reduced to 95%, the leakage inductance is equal to:

$$L_1 = 2(1 - 0.95) \times 1.5 \times 10^{-3}$$
$$= 2(0.05) \times 1.5 \times 10^{-3}$$
$$= 1.5 \times 10^{-4} \text{ henries}$$

As shown in Figure 7f, this leakage inductance is in series with the reflected load impedance. The voltage across the speaker will be down 3dB point when the impedance of $C_{pri}$ is equal to the impedance of the leakage inductance. The modified circuit, shown in Figure 7g, is also a low pass filter. The 3dB point can be calculated by:

$$= 1/6.28(L_1 \times C_{spkr})^{1/2}$$
$$= 1/6.28(1.5 \times 10^{-4} \times 12.7 \times 10^{-6})$$
$$= 3.648 \times 10^{3}\text{Hz}$$

Because the previous calculations have indicated that this transformer has a very poor bandwidth, for high fidelity reproduction it can only be used for mid range speakers. To reproduce the bass and high frequency portion will require a different transformer. If the full audio spectrum is to be reproduced by a single transformer then its primary inductance must be greater than the previous value.

Similarly the high frequency response can be extended by selecting a transformer with a lower leakage inductance. In some instances this can be achieved by careful transformer design. On the other hand, if the transformer has a high step up ratio this may be very difficult. One alternative is to use a separate transformer with a lower turns ratio to cover the high frequency range. Although there are a number of other factors that are inter-related, this would decrease the leakage inductance and extended high frequency limit.

## Acoustic Performance

The major acoustical parameters of a loudspeaker are its volume velocity, radiation resistance, power output, frequency response, directivity and distortion. This last parameter is not usually a significant factor in the performance of an ESL. The following section will discuss the remaining parameters.

### • Volume Velocity

This parameter indicates how much air the speaker is moving. The volume velocity is obtained by multiplying the diaphragm movement by the area and dividing the result by the required time. That is:

$$U = A[(6.28 \times d_{rms})/t]$$

where U is the volume velocity, A is the diaphragm area and $d_{rms}$ is the RMS value of the diaphragm movement.

$$U = (0.372) \times [6.28 \times (1.59 \times 10^{-3}) \times 0.707]/0.01$$
$$= 0.263 \text{ metres}^3/\text{sec}$$

### • Radiation Resistance

The acoustic power from a speaker is dissipated in the radiation resistance of the air load. Beranek's book on Acoustics defines the radiation resistance (on both sides of the diaphragm without a baffle) as being equal to:

$$Ra = (1.9 \times 10^{-2} \times a^2 \times p_o \times \omega^4)/c^3$$

where Ra is the radiation resistance in acoustic ohms, a is the diaphragm radius in metres, $p_o$ is the density of air (1.19kg/m$^3$) ω is 6.28f and c is the velocity of sound in metres.

In the above equation, the value of a is for a conventional round speaker. The equivalent area for our square speaker would be 0.344m$^2$. The value of Ra, for a 24 inch speaker, at 100Hz is:

$$Ra = [1.9 \times 10^{-2} \times (.344)^2 \times (1.19) \times (628)^4]/=345)^3$$
$$= 10.13 \text{ acoustic ohms}$$

### • Acoustic Power

The acoustic power produced by the speaker is equal to the radiation resistance multiplied by the square of the volume velocity.

That is:

$$P = Ra \times U^2$$
$$= (10.13) \times (0.263)^2$$
$$= 0.699 \text{ watts}$$

If this number seems high, it's because it is. The previous calculation for the volume velocity assumed that the entire diaphragm moved the total distance that separated the two plates. Due to the mounting system this is far from true. As an estimate, the average displacement is about five to ten per cent of this distance. To keep things simple a value of 0.0125 inches or $317.5 \times 10^{-6}$ metres will be the assumed value. The corresponding volume velocity will be: $U = 74.2 \times 10^{-3}$ metres$^3$/sec. The radiated acoustic power is: $Pa = 55.8 \times 10^{-3}$ watts.

The total power that must be supplied by the source is equal to the power dissipated in the radiation resistance and the power needed to move the diaphragm. That is:

$$P_{in} = P_m + P_a$$

where Pin is the input power to the speaker, Pm is the power required to move the diaphragm and Pa is the

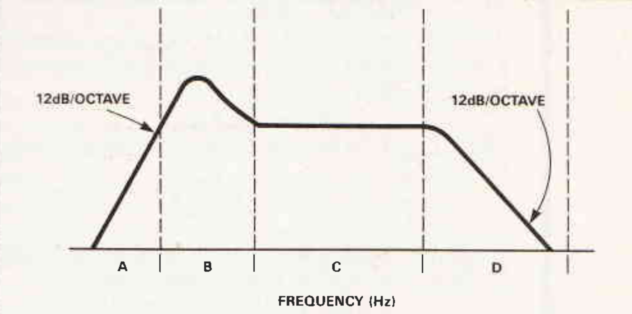


**Fig. 8 Speaker output against frequency.**

power expended in the acoustic resistance.

$$P_{in} = 0.486 + 55.8 \times 10^{-3}$$
$$= 541.8 \times 10^{-3} \text{ watts}$$

### • Efficiency

When the input and output power are known, they can be used to determine the speaker's efficiency. The ratio of these two values indicates that the 24 inch speaker has an efficiency at 100Hz, that is equal to:

$$eff = P_{out}/P_{in} \times 100$$
$$= (55.8 \times 10^{-3})/(541.8 \times 10^{-3}) \times 100$$
$$= 10.3\%$$

where eff is the per cent efficiency.

At first this figure may also seem high. It has been stated that the efficiency of a conventional speaker is between one and ten per cent. Some articles on ESLs have also indicated that an electrostatic speaker's efficiency is about the same value. The reason for this discrepancy is a matter of definition.

In his 1955 article, P.J. Walker stated that:

> "The true efficiency of an electrostatic speaker is very high indeed, but it is difficult to realize because of the large wattless current which has to be provided due to the electrical capacity of the loudspeaker."

To illustrate this point, the 24 inch speaker has a reflected capacity of 12.7μ. The AC current flowing through this capacity is equal to:

$$i = (v \times C_{pri})/t$$

where i is the peak AC current flowing through the speakers plate-to-plate capacity, v is the peak AC voltage across the two plates and t is the time required for the voltage to reach its peak value.

$$ka = 1.83 \times 10^{-2} \times f \times a$$
$$f = 1/(1.83 \times 10^{-2} \times a)$$
$$= 180\text{Hz}$$

This frequency is a long way from the upper limits of the audio spectrum, and some method must be found for extending its value.

In a conventional speaker system the solution is to use a number of speakers, with different sizes, to cover the entire audio range. While this same technique has been used in some ESLs there is an alternative method.

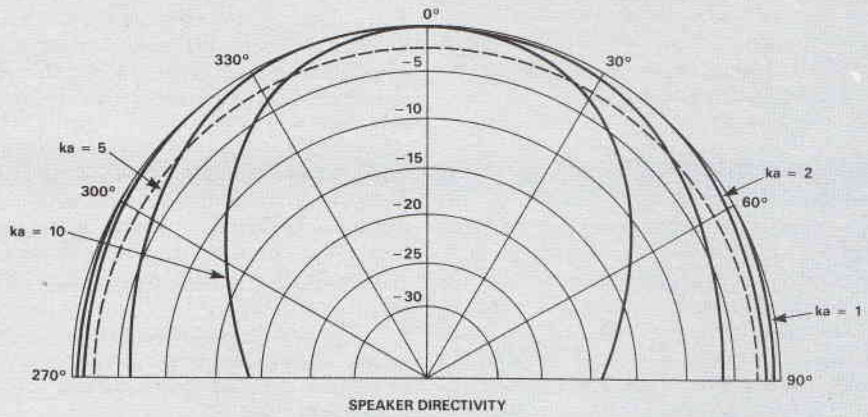


**Fig. 9 Speaker directivity against wavelength and diameter.**

For an amplifier with peak-to-peak output voltage of 56.56 volts, the peak current flow is:

$$i = [28.3 \times (1.27 \times 10^{-5})]/(2.5 \times 10^{-3})$$
$$= 144 \times 10^{-3} \text{ amps}$$

If the RMS value of the input voltage is multiplied by a similar value for the current, the result is the apparent power. In other words,

$$P_{app} = V_{rms} \times I_{rms}$$

where $P_{app}$ is the apparent power being supplied by the source.

$$P_{app} = (28.3 \times 0.707) \times (144 \times \times 10^{-3} \times 0.707)$$
$$= 2.04 \text{ watts}$$

When this value is used to calculate the speaker's efficiency the result is a very small value.

$$eff = (55.8 \times 10^{-3})/2.04 \times 100$$
$$= 2.73\%$$

Not only does this calculation reinforce Mr Walker's statement about the speaker's efficiency, but the results are frequency dependent.

## • Speaker Frequency Response

The frequency spectrum that a loudspeaker must cover can be divided into four areas. The cone or diaphragm movement is controlled, in each of these areas, by one or more speaker parameters. In Figure 8 the peak in section b is the speaker's resonant frequency. This point is a function of the diaphragms mass and the compliance of the mounting system. The height of the peak is controlled by both the electrical resistance (such as rg, rp and rs) and the opposition produced by the diaphragm's air load (Ra).

Below the resonant frequency, in section a the diaphragm motion in controlled by the compliance of the mounting system. In this region the acoustic output falls at 12dB/octave, and the speaker's output is generally not useable.

In the c region the output is determined by the mass of the air load. Most text books indicate that its performance is related to a factor called ka. The k number is frequency dependent and is equal to $1.83 \times 10^{-2} \times f$. The a term is the speaker's radius in metres.

Over most of the c region, the reactance of the air mass (Xm) rises in direct proportion to the increasing frequency. It reaches a maximum value when the ka factor is equal to one.

Instead of using separate speakers the plate or diaphragm area can be divided into a number of smaller sections. Because the speaker's width determines where ka will be equal to one, only this factor needs to be made smaller. In the section on the Dynamic Speaker it was stated that the power output is a function of the volume velocity and the radiation resistance. If the width is made smaller the length should be increased, so that the area remains about the same.

## • Segmentation

Segmentation is the division of the plate or diaphragm area into smaller sections. As an example of this technique, suppose the speakers 24 inch width is divided into six sections. The widest part is 12 inches. The rest of the speaker is divided into sections of 4, 2, 1, 0.5 and 0.25 inches. The total of these will not equal 24 inches. Some space is used to isolate each of the sections. The remainder is needed for the spacers that separate the diaphragm from the plates. For the above sizes the corresponding upper frequency limits are: 360, 930, 2.15k, 4.3k, 8.6k and 17.2kHz.

If each of these sections is combined through a suitable crossover network, then below 360Hz the entire diaphragm will radiate as one piece. Above this value the output from the 12 inch section will decrease and the remaining part of the diaphragm will continue to supply the speaker's acoustic output. When the frequency exceeds the 930Hz the speakers size will again decrease and the four remaining sections will continue to supply the acoustic output. As the frequency continues to rise the output from each of these sections will decrease, and at 17.2kHz only the 0.25 inch section will be acting as a speaker. This concept of segmentation is very useful in maintaining the speaker's frequency response and in providing the broadest directivity pattern.

## • Directivity

In sound reproduction there is also a direct relationship between the width of a speaker and the highest frequency it must reproduce. While some electrostatic speakers use a curved diaphragm, to increase the radiation angle, a flat or planer speaker must change its width to eliminate the beaming effect. The polar plot, of figure 9, indicates a speaker's radiation pattern as a function of ka. Because a hemispherical pattern only occurs when ka is less than one, the diameter of a speaker must be reduced as the frequency is increased.

For instance suppose that it is desired to radiate a 20kHz signal over an angle of ±90 degrees. The wavelength is equal to:

Wavelength = (speed of sound)/frequency
= 13440 inches/20000
= 0.672 inches

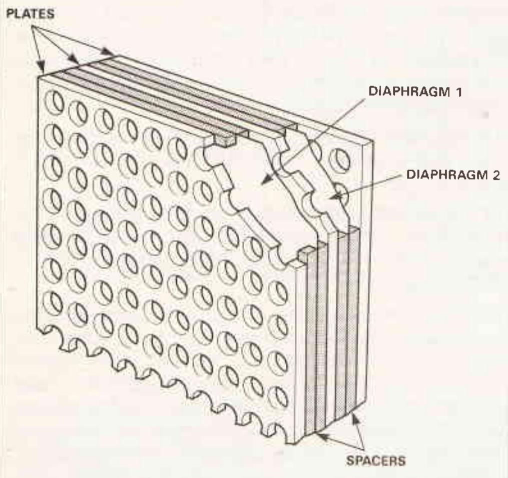

**Fig. 10 Multiple diaphragm electrostatic speaker.**

To obtain the required radiation angle the speakers radius must not exceed 1/3 of the wavelength. Although this would make the speaker's dimensions equal to 0.224 inches, the 0.250 value only produces a slight modification to the frequency response and the directivity pattern.

## Improving The ESL's Performance

Some audiophiles have decided that an ESL does not produce enough bass, and they have tried to modify the low end by adding a conventional speaker. This type of modification can produce a number of undesirable effects. First, the bass will often be over-emphasized. A conventional speaker can also destroy the sonic balance that is an inherent in the design of wide range electrostatic speakers.

Another problem with adding a conventional speaker is the increase in the distortion content. Most ESLs have a distortion value that is less than 0.1%. A conventional speaker has a value that is ten to 100 times greater.

## More Power

From a manufacturing standpoint, the acoustic output of a speaker can be increased by altering its diameter, cone or diaphragm displacement, the number of speakers, or all three.

In an ESL speaker system some of the above factors are difficult to change. For instance, when the plates are moved farther apart, to obtain a greater diaphragm movement, the reflected capacity will decrease and the speakers impedance will rise. To compensate for this, the transformer's turns ratio must be increased. Although this will restore both the impedance and the AC field strength it will also increase the transformer's leakage inductance. In addition to this, the charging voltage for the diaphragm must be increased so that the same field strength is maintained.

If the diameter is made larger, some other design changes must be made. One critical factor is to keep the diaphragm stable. In addition to this, the increased size will require additional segmentation.

## Multiple Diaphragms

The simplest way to produce more output is to add additional panels. When two or more panels are placed next to each other, and each is radiating the same frequency, it increases the amount of air that is being moved.

Volume velocity, which is the movement of this air, is similar to the current in an electrical circuit. If the current is doubled, by connecting two current generators in parallel, then the voltage across the load will also double.

Placing two or more speakers next to each other is in effect creating a parallel configuration. The volume velocity will increase, and this will develop a greater acoustic pressure across the radiation resistance. The result will be an increase in the acoustic power.

The biggest problem with increasing the number of parallel diaphragms is their effect on the speaker's size. Two or three diaphragms, like the one shown in Fig. 3, are reasonable. If the number is doubled above this value, the speaker would be four feet wide. For stereo this means that both speakers would occupy a space of eight feet. Proper placement can only be obtained by having a listening area that is very large.

An alternative solution, which will also increase the bass response, but does not significantly change the size is to place one speaker behind the other. See Figure 10. The two speakers are now acoustically in series with each other. The pressure produced by diaphragm one is again increased by diaphragm two. In an electrical circuit, this is similar to connecting two voltage generators in series. The output voltage is increased, and this produces a corresponding increase in the current. Acoustically the increased pressure will also increase in the volume velocity. The radiated power for either configuration will go up by a factor of four.

While it may seem relative easy to add a second panel or speaker behind the first, commercial implementation actually uses two diaphragms. If the two diaphragms are very close, less than 0.1 inches, then the speaker will work as indicated. Should the design prevent such a close spacing, then the rear diaphragm must operate over a reduced frequency range. The reason for this requirement is sound cancellation.

When the two diaphragms are in series the outputs will add as long as they both have the same phase. Because of the physical separation it is possible to have the sound from the second diaphragm arrive at the first in exactly the opposite phase. When this happens the speaker will not produce any output.

While the Beveridge patent describes a speaker that uses the technique of minimum separation, it is not known if any were ever produced. The Sound Lab Company makes the product shown in Figure 1 and its frequency response is limited to values below 350Hz.

The use of multiple diaphragms, in an electrostatic speaker, should overcome any listener's objection to their lack of bass. In addition to this the speaker now maintains the correct tonal balance and extremely low distortion. The result is a speaker whose sound quality can only be duplicated by a live source.

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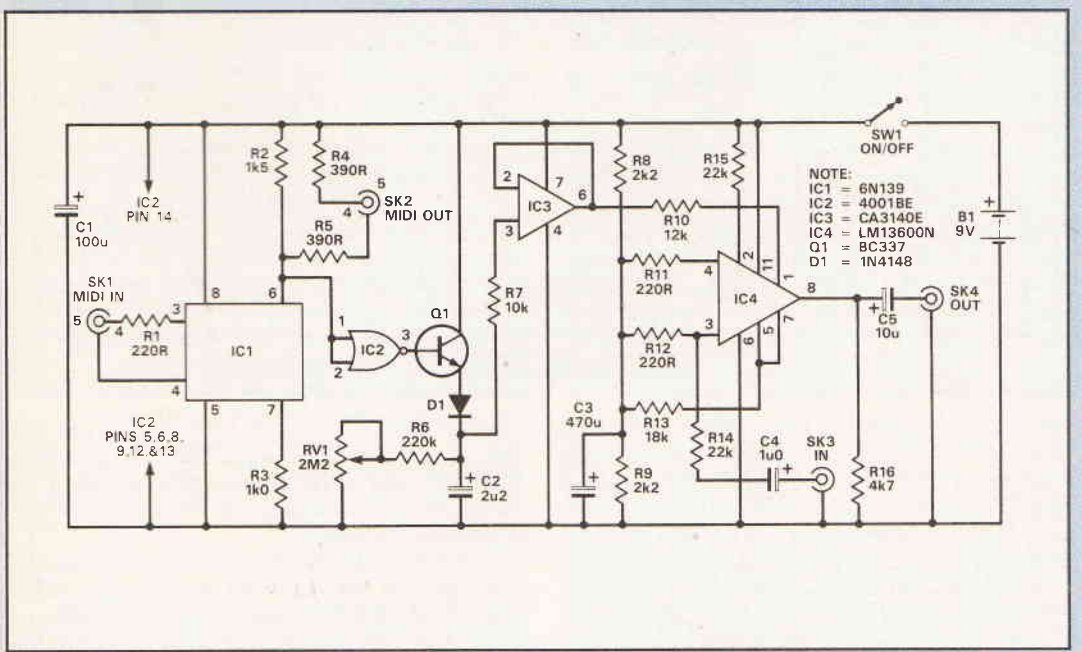
# MUSIC TECH TIPS

## Midi Activated Noise Gate




A normal noise gate is an electronic switch that cuts the audio path unless an input signal above a certain level is present. This gives a simple but effective method of noise reduction, with the signal (and the background noise) being cut off during periods when there is no significant input level, and the noise would be very noticeable. Most noise gates are not actually true gates, in that they do not provide a simple on/off switching action. In order to make the gating action less obvious they normally have a rapid attack and a slow decay, with the signal being faded out rather than simply being switched off. In order to minimise any switching click during the attack period of the gate, either delayline or zero-crossing techniques are often used.

This noise gate takes a slightly different approach. It is only intended for operation with musical instruments which are equipped with a MIDI interface. It is much like a simple conventional noise gate, but with the important difference that it responds to the presence (or lack) or a MIDI signal, rather than being triggered by the audio input signal. This has a potential flaw in that it is possible for a system to reduce MIDI messages at times when there is no audio signal. For example, timing messages are sometimes sent when there is no audio activity. In practice this is not a major problem, and may well be something that can be totally avoided with no difficulty.

An advantage of this method is that the start of the MIDI signal seems to precede the start of the audio signal. It would be impractical to check this unit with dozens of pieces of MIDI equipment in a variety of setups, but on trying the unit with several MIDI instruments in a few different arrangements, the MIDI signal always seemed to slightly lead the audio signal. The importance of this is that it gives minimal clicking each time the unit is activated, without the need to resort to zero-crossing or delayline techniques. It combines the simplicity of a very basic noise gate with the click-free operation of a more sophisticated type.

My original circuits included some MIDI decoding to sort out the note-on and note-off messages from the other types, but even the very short time taken to decode a MIDI byte seemed to degrade performance, with strong switching clicks often being produced. The final design therefore responds to all MIDI messages, but operates very rapidly. In fact the gate probably switches on before the start bit of the first byte has been completed.

IC1 is the opto-isolator at the input of the unit. Some of the output signal from IC1 drives a MIDI output socket, or a 'THRU' socket as this should be called in strict MIDI jargon. This enables the unit to be easily connected into a system using the 'chain' method of connection. IC2 inverts the output from IC1, giving an output that is low under standby conditions. When a MIDI signal is received a few brief positive pulses are produced by IC2. These are used to charge C2, and due to the low output impedance provided by Q1, the change rate is extremely rapid. The discharge time is very much slower, and is controlled using RV1. The optimum decay time depends on the type of music being played, and RV1 is adjusted for the shortest time that will not result in the unit cutting off notes prematurely.

IC3 acts as a buffer amplifier having a very high input resistance, so that the high impedance signal from C2 can successfully drive the relatively low input resistance at the control input of the voltage controlled amplifier (VCA). The latter is connected in the audio signal path, and is based on one of the transconductance amplifiers in IC4. This is an LM13600N, or the virtually identical LM13700N. This is used in the standard non-inverting mode. For a stereo noise gate the unused section of IC4 can be used in a second and identical VCA, also controlled from IC3.

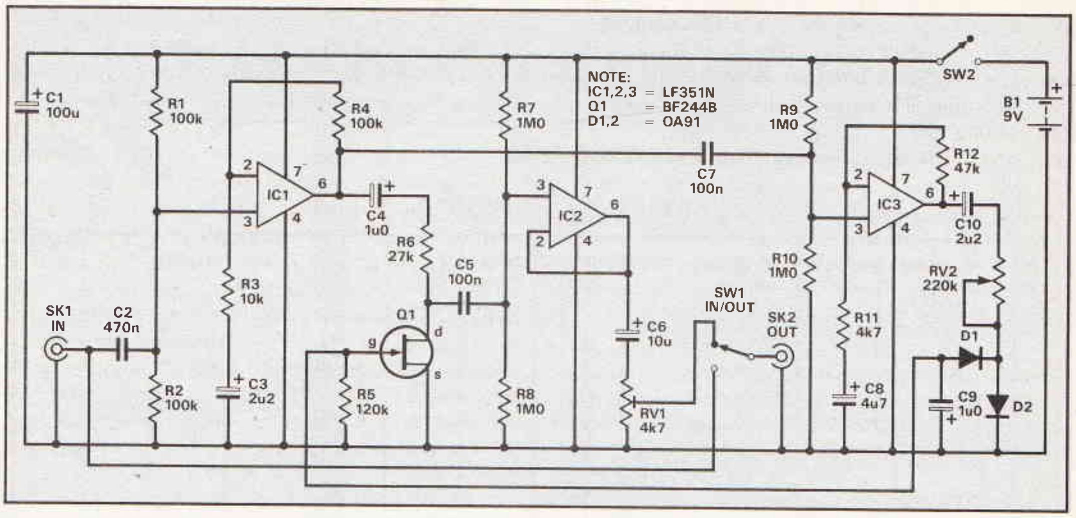
The current consumption of the circuit is about 12 to 13mA. This necessitates the use of a reasonably large 9 volt battery, such as six HP7 size cells in a plastic holder. Construction of the unit should not be difficult, but remember that IC2 and IC3 are both static sensitive devices. Try to keep the MIDI circuitry well separated from the audio circuitry so that there is no significant stray coupling from one to the other.

ETI Audio

CIRCUITS

*Robert Penfold presents a variety of circuits to manipulate your music*

# Envelope Modifier




There are a number of factors which control the nature of sounds, not the least of which is the envelope. In other words, the way in which the sound varies in volume over its full duration. This has a more radical effect on sounds than you might expect, and modifying the envelope of a sound can totally change its character. This envelope modifier is primarily intended for use with an electric guitar, and its main purpose is to slow down the attack phase of the guitar's envelope. This normally has a very fast attack time and a high initial volume level, giving the characteristic 'twang' sound. Slowing down the attack phase, together with the slightly reduced initial peak volume level that results from this, gives a milder sound. It gives what in many ways sounds more like some kind organ than a guitar. With a very long attack time the sound is quite weird, and is not really like any normal acoustic instrument, apart from one where the player has full control over the dynamics and can obtain any envelope shape (within reason). Woodwind instruments are sometimes played to give a slow build-up in volume on each note, so as to obtain what might be termed a 'haunting' effect, and this is probably the nearest equivalent to this unit used with maximum attack time.

The circuit is based on a voltage controlled attenuator (VCA) based on Q1. This transistor is a junction gate field effect (JFET) type, and it operates here as a voltage controlled resistor. Under quiescent conditions its gate and source terminals are both at earth potential, and with zero gate bias Q1 is turned hard on. It therefore has a drain to source resistance of only a few hundred ohms, and there are large losses through R6, which is the passive arm of the VCA. The main signal path is through the input amplifier based on IC1, the VCA, and the output buffer stage based on IC2. IC1 provides about 20dB of voltage gain, but this is only required with low output guitar pick-ups. With high output types R4 can be made lower in value (say about 10k). It is probably worth experimenting a little with various values for R4 in order to find one that gives really good results. RV1 is an output attenuator, and this is adjusted so that there is no obvious change in volume when the effect is switched in and out using SW1.

As described so far, the unit simply attenuates the input signal. In order to obtain the desired envelope shaping a suitable DC control signal must be applied to the VCA. This signal is obtained by amplifying the output from IC1 and feeding it to a rectifier and smoothing circuit. This is the function of IC3, D1, D2, etc. The result is a negative bias across R5 and C9 which is roughly proportional to the volume of the input signal. With a high input level the bias is large enough to switch off Q1, and enable the signal to pass with minimal losses. As the input level decreases, the losses through the VCA increase.

On the face of it, this lets the signal through with no change in its envelope shape, except perhaps a slight exaggeration of the shape. The elongated attack phase is obtained by including RV2 at the output of IC3, so that the charge rate of C9 is increased. The higher the value of RV2, the longer the attack period. In practice it might be found that RV2 can not be used at or close to its maximum value, due to it introducing excessive losses. However, quite long attack periods can be obtained with RV2 set comfortably below the point at which this occurs.

Construction of the unit present few problems, and none of the semiconductors are static sensitive types. However, bear in mind that D1 and D2 are germanium types, and are less tolerant of heat than silicon diodes. The current consumption of the circuit is about 6mA, and a PP3 size 9 volt battery is suitable as the power source. SW1 should be a heavy duty push-button type mounted on the top panel of the case so that it can be operated by foot. The case should obviously be a fairly tough type, and a diecast aluminium type is ideal.

# Springline Reverberation Unit

For the ultimate in artificial reverberation effects there can be little doubt that a modern digital reverberation unit is required. Alternative methods of generating this effect do not seem to be able to compete in terms of quality. On the other hand, effects units that use high quality digital delay lines have remained relatively expensive, and are well beyond the budget of many. Due to the digital origins or their sounds, some modern electronic instruments now have built-in digital effects that are implemented at minimal extra cost. These represent what is probably the best low cost approach to the problem, but there can be difficulties if you are using several instruments, not all of which have built-in digital effects. A mixture of some sounds with reverberation and some without is not likely to give very convincing results, and few instruments with built-in digital effects have any provision for processing external audio sources.

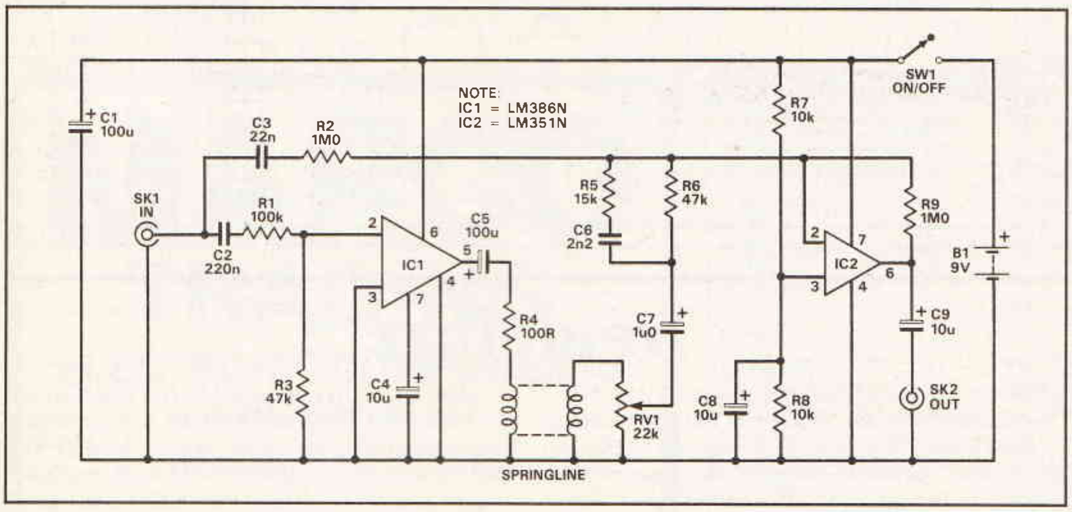
For the electronics enthusiast there is an inexpensive approach to the problem in the form of springline units. These are available at quite low cost, and require only a small amount of inexpensive electronics in order to produce a practical reverberation unit. The audio quality of a springline reverberation unit does not match that of a good digital unit, or even come close to it. The quality is good enough for most purposes though, and despite what some might say, these units actually provide quite a convincing reverberation effect.

A springline unit consists basically of two electromagnetic transducers, with two springs providing a mechanical coupling between them. The audio signal fed to the input transducer is converted into vibrations which travel down the springs to the output transducer. Here they are converted back into electrical signals again. The point of using springs to provide the coupling is that they significantly delay the vibrations, and using two springs provides two different delay times. Combined with the vibrations being reflected backwards and forwards along the springs until they gradually die away, this gives an output signal which provides a good reverberation effect.

In this circuit IC1 acts as a small power amplifier which drives the input transducer. There is a conflicting interest here in that a high drive level minimises problems with microphone, noise, and feedback, but a low input level seems to give noticeably better audio quality from most springline units. In this case a small power amplifier is used to drive the input transducer, but R4 is used to reduce the drive level somewhat.

IC2 is used as a summing mode mixer at the output of the unit. One input of the mixer is fed with the unprocessed input signal. The other input is fed with a controlled amount of the reverberation signal. RV1 is the reverberation level control. Due to the substantial losses through the springline unit, R6 has been given a value that provides about 26dB of boost to the reverberation signal. This permits a very strong effect to be obtained with RV1 fully advanced. A common problem with springline reverberation units is that of a rather dull sounding output. This is caused by the higher losses through the springline at high audio frequencies. This can be counteracted by some equalisation, which is the purpose of C5 and R5. It is worth experimenting with different values for these components, since the optimum values depend to some extent on the particular springline unit used, and this is also, to some extent, a matter of personal preference.

The current consumption is about 8mA under quiescent conditions, but it rises somewhat with high input levels. A medium capacity battery, such as six HP7 size cells in a holder, is suitable as the power source. Construction of the unit is straightforward as far as the electronics is concerned, but the size of the springline (even if it is one of the smaller type) complicates the mechanical side of things. A 19 inch rack-mount case is ideal, but likely to be quite costly. A simple DIY case is likely to be more cost effective. In use, try to keep the unit away from loudspeakers, mains transformers, or any sources of electro-magnetic signals or loud sounds.




# Guitar Tuner

This guitar tuner is relatively simple, but it achieves good reliability with virtually any electric guitar. The unit is easy to use, and has a centre-zero meter as the tuning indicator. It is basically a matter of setting the unit to the right note, twanging the appropriate string, and then adjusting the guitar for zero reading on the tuning meter.

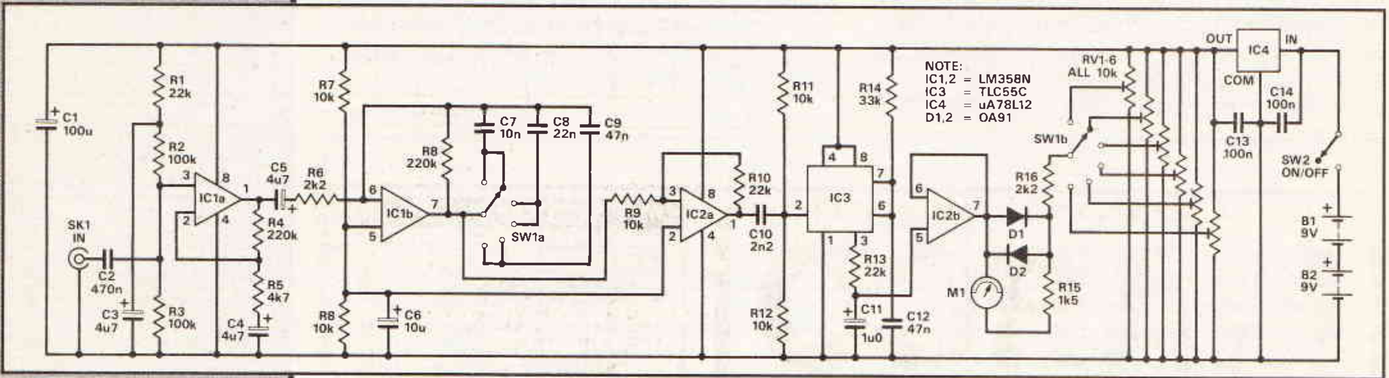
Although, on the fact of it, a guitar tuner can be very simple (basically just a frequency to voltage converter), in reality there is a slight complication. The output waveform from a guitar changes considerably during the course of each note, and is usually something less than straightforward. The harmonic content is quite high, and at times one of the harmonics seems to dominate the fundamental frequency. This slightly complicates matters, as frequency measuring circuits fed with such a signal can tend to measure one of the harmonics at times, giving erratic results. Fortunately, the problem can be easily overcome, and it is basically just a matter of using some lowpass filtering in order to attenuate the harmonics so that they are always significantly lower in level than the fundamental signal.

IC1a and IC1b provide two stages of amplification at the input of the unit. IC1 is a non-inverting mode circuit which has a voltage gain of just under fifty times and gives an input impedance of about 50k. This is intended for use with a low output guitar pick-up. For a high output type R4 should be reduced to about 15k, which will give a voltage gain of about four times. IC1b is an inverting mode circuit which has a voltage gain of about one hundred times, and which clips the output signal. The lowpass filtering is provided by C7, C8, or C9, depending on the setting of note selector switch SW1. A compromise filter capacitor value for all six notes failed to give good results, which led to the use of three switched capacitors. C7 provides filtering on the two highest notes, C8 is the filter capacitor for the middle two notes, and C9 provides the filtering on the lowest two notes.

The output from IC1b drives a trigger circuit based on IC2a, and having a large amount of hysteresis provided by R10. This circuit in turn drives a simple frequency to voltage converter. The latter is just a simple low power 555 monostable circuit based on IC3, followed by a smoothing circuit (R13 — C11). IC2b acts as a buffer stage between the smoothing circuit and the meter circuit. RV1 to RV6 provide a series of voltages that are equal to the voltages from the frequency to voltage converter when each of the six correctly tuned guitar strings are played. With a note selected using SW1, and the appropriate string plucked, there should be zero volts across the meter circuit. If the note from the guitar is too high there will be a positive deflection of the pointer — if the note is too low there will be a negative deflection. Adjusting the guitar for zero deflection of the meter is a very simple task, and should ensure accurate tuning. R15, R16, D1 and D2 protect the meter against strong overloads.

The frequency to voltage converter requires a well stabilised supply if it is to provide consistent results. A stabilised 12 volt supply is derived from the 18 volt battery supply (2 x 9 volt batteries in series) by a small 12 volt monolithic voltage regulator. The current consumption is only about 7mA, and small (PP3 size) batteries are adequate as the power source.

Construction of the unit should not present any major difficulties. RV1 to RV6 should preferably be multi-turn trimpots, as they need to be adjusted with a fair degree of precision. Note that D1 and D2 are germanium diodes, and are more vulnerable to heat damage than silicon types. Take due care when connecting them. None of the integrated circuits require any anti-static handling precautions. On the prototype ME1 is an inexpensive 125 — 0 — 125mA type (Maplin LB69L), but a 100 — 0 - 100mA meter can be used if preferred and by virtue of its larger scale should provide slightly better accuracy. The easiest way to adjust RV1 to RV6 is to first tune the guitar accurately against a set of pitch pipes (or whatever). The guitar can then be used to provide six accurate notes so that RV1 to RV6 can, in turn, be adjusted for zero deflection of the meter with the appropriate note being played. Do not worry if there is a large negative deflection of the pointer under standby conditions, or when a note has largely decayed. This is due to there being zero output from the frequency to voltage converter with no input signal or a very low input level, and is quite normal. This makes it clear when the input has decayed to an inadequate level, and avoids confusing readings with small input signals.




# Tremofuzz

Coming up with a new guitar effects unit is probably bordering on the impossible, but it is certainly possible to do some useful reworking and combining of old ideas. The 'fuzz' or distortion effect has remained quite popular with guitarists over the years, and it probably represents about the cheapest and easiest means of substantially changing the sound of an electric guitar. Some distortion effects are much more musical than others, and to my ears at least, the 'soft' distortion variety sound substantially better than those that provide hard clipping or simply convert the input signal to a basic pulsed output waveform.

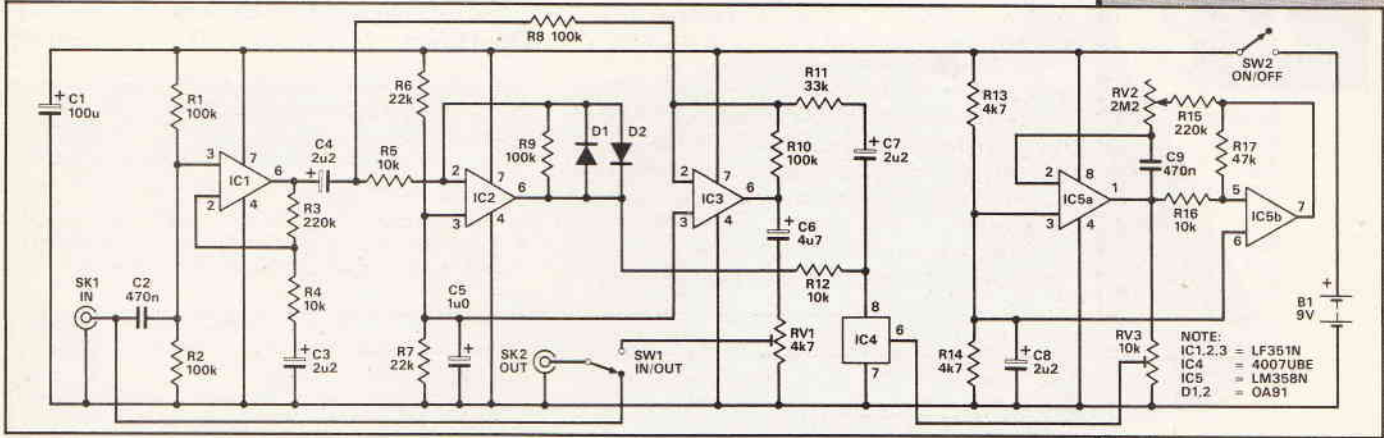
This effects unit is basically a soft distortion type 'fuzz' effects unit, but it has the addition of a tremolo effect on the distortion. The unit consists more or less of a soft distortion unit feeding into a tremolo unit, with the processed and unprocessed signals being mixed. The effect this provides is a rhythmic distortion which comes and goes at a frequency which is controlled via the tremolo rate control. This gives a sound that is in some ways more interesting than straightforward 'fuzz', or plain tremolo come to that. This effect is not well suited to all types of music and playing, but it can give good results if used in the right context, and is certainly worth giving a try.

The distortion is provided by IC1 and IC2. IC1 acts as an input stage which provides an input impedance of about 50k and a voltage gain of about 23. This is for use with a low output guitar pick-up, and lower voltage gain will be needed if the unit is used with a high output type. The closed loop voltage gain of IC1 can be reduced by making R3 lower in value. A value of 10k (giving a voltage gain of two times) is suitable for most high output pick-ups. IC2 operates as an inverting amplifier having a voltage gain of about ten times, but the inclusion of D1 and D2 in the feedback network results in clipping on output signals of more than a few hundred millivolts peak to peak. In practice this means any input signal, except where a note is allowed to decay for a few seconds. This gives the required distortion, and by using germanium diodes for D1 and D2 it is soft clipping that is obtained. Soft clipping is obtained simply because the forward threshold voltage of a germanium diode, unlike a silicon type, is not sharply defined. This gives reduced high frequency harmonics, and a less harsh distortion effect.

IC3 is a simple summing mode mixer. It combines the unclipped signal from IC1 with the clipped signal from IC2, after the clipped signal has been fed through the tremolo section of the unit. RV1 is an output attenuator, and is adjusted for an output level that is comparable to the output signal from the guitar. This avoids any obvious change in signal level when the effect is switched in and out using SW1. This switch simply connects the output socket to either RV1 or the direct signal from the guitar.

In the tremolo section of the unit IC4 acts as a voltage controlled resistor, which forms a voltage controlled attenuator (VCA) in conjunction with R12. Note that only one N channel FET of IC4 is used, and the other sections of the device are ignored. The triangular control signal for the VCA is generated by IC5, which operates in a standard configuration which has one amplifier acting as a Miller integrator and the other functioning as a Schmitt trigger. RV2 is the tremolo rate control, and it gives a frequency range of about 5Hz to 0.5Hz. RV3 must be adjusted to give the best effect. This is likely to be with the wiper set just far enough up the track to give a reasonably deep tremolo effect on the distortion signal. Power is provided by a 9 volt battery, and as the current consumption is only about 7mA a small (PP3 size) battery should suffice.

Construction presents few difficulties, but bear in mind that D1 and D2 are germanium diodes, and as such are more vulnerable to heat damage than are modern silicon types. IC4 is a CMOS device and requires the usual anti-static handling precautions. Units of this type are normally housed in diecast aluminium boxes, which are very tough and provide good screening from mains hum. SW1 should be a heavy duty, successive operation, push button switch, mounted on the top panel of the case so that it can be operated by foot.



ETI Audio

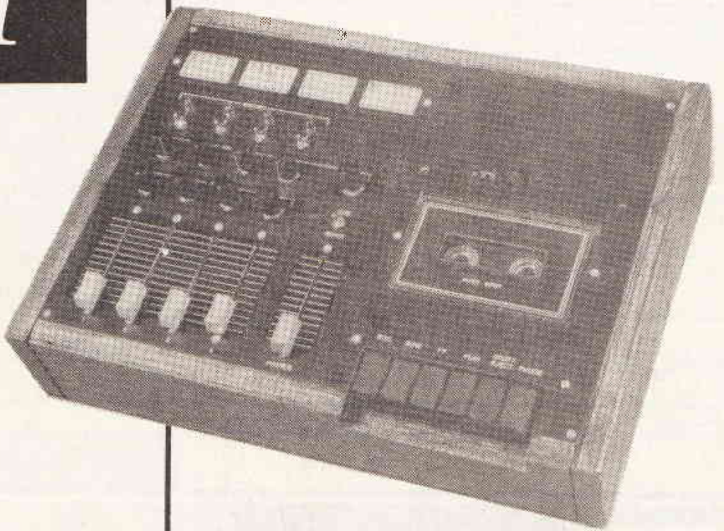
*Tom Scarff builds a four channel recording system*

1

# FOUR TRACK CASETTE RECORDER

Having an interest in music and electronics over the years I have as a 'one-man band' been using various recorders to create songs by transferring tracks from machine to machine.

Recently I decided to move to a four track cassette system to enable me to record individual tracks and have complete control of the mix-down process.



However since the price of these machines is in the hundreds of pounds range I decided to design my own system.

Any standard mono or stereo two-head cassette deck (except Sony, whose head mountings are non-standard) can be used and the erase and record/playback heads easily replaced. These decks are available cheaply from many sources.

## Features

The main features of the unit are as follows :

- A standard cassette recorder deck running at 1⅞ips enabling playback of standard cassettes.
- Four microphone inputs and four line level inputs, with each channel having independent level and pan controls and overall stereo master fader control.
- Headphone monitoring of main stereo outputs or of each separate track via four adjustable tape cue mix levels.
- Recording on any individual channel or in specific stereo pairs with automatic VU metering of all record and playback channels.
- Remote control recording switch and safety record interlock switch.
- Battery operation for portable use. Also provision of an automatically switchable 12V DC adaptor socket.

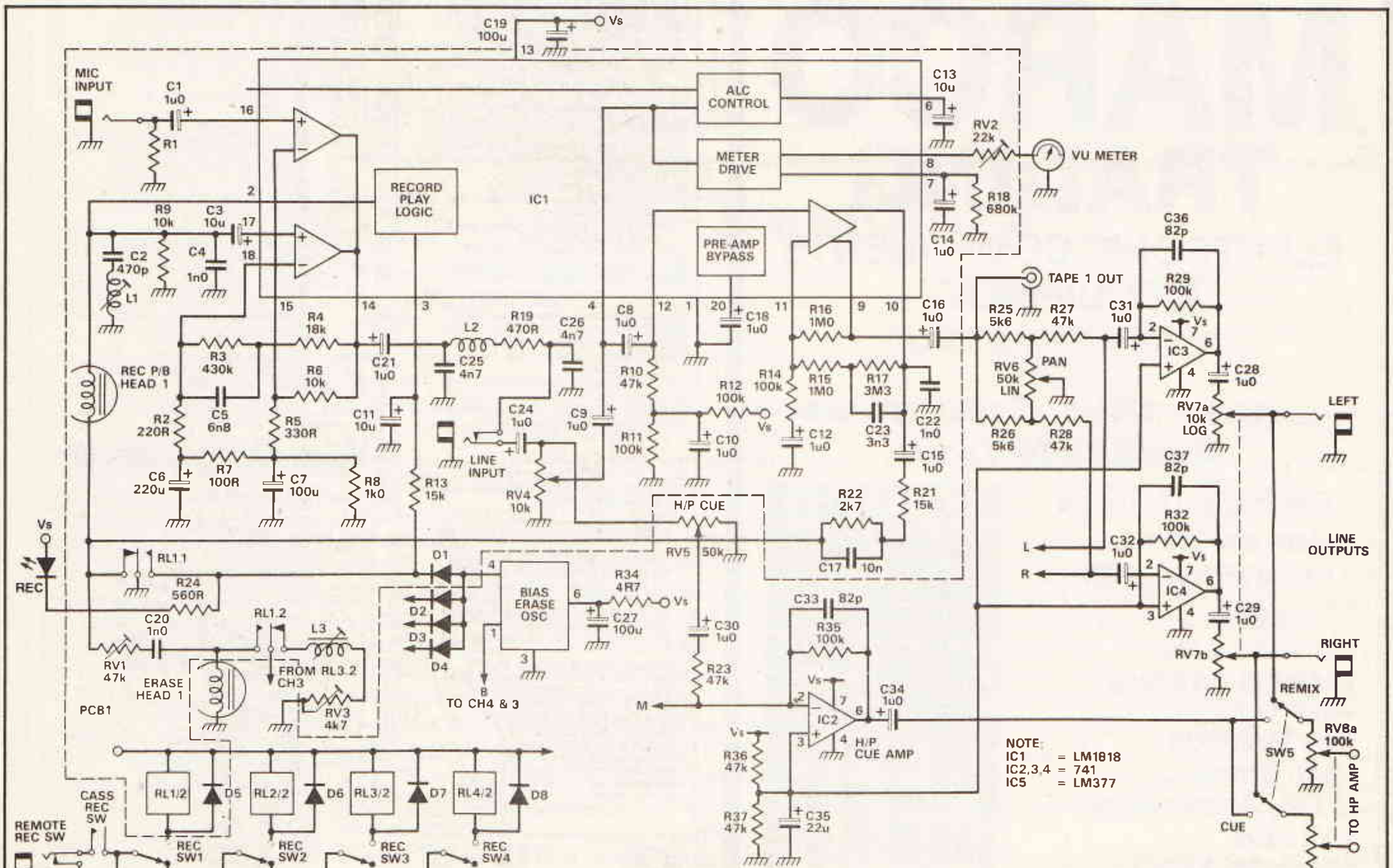



**Fig. 1 Circuit diagram of Record/Playback amplifier (one channel only) and associated circuitry**

● Four independent tape out sockets allowing transfer of discrete tracks to another tape recorder or via a separate mixer for equalisation before mixdown.

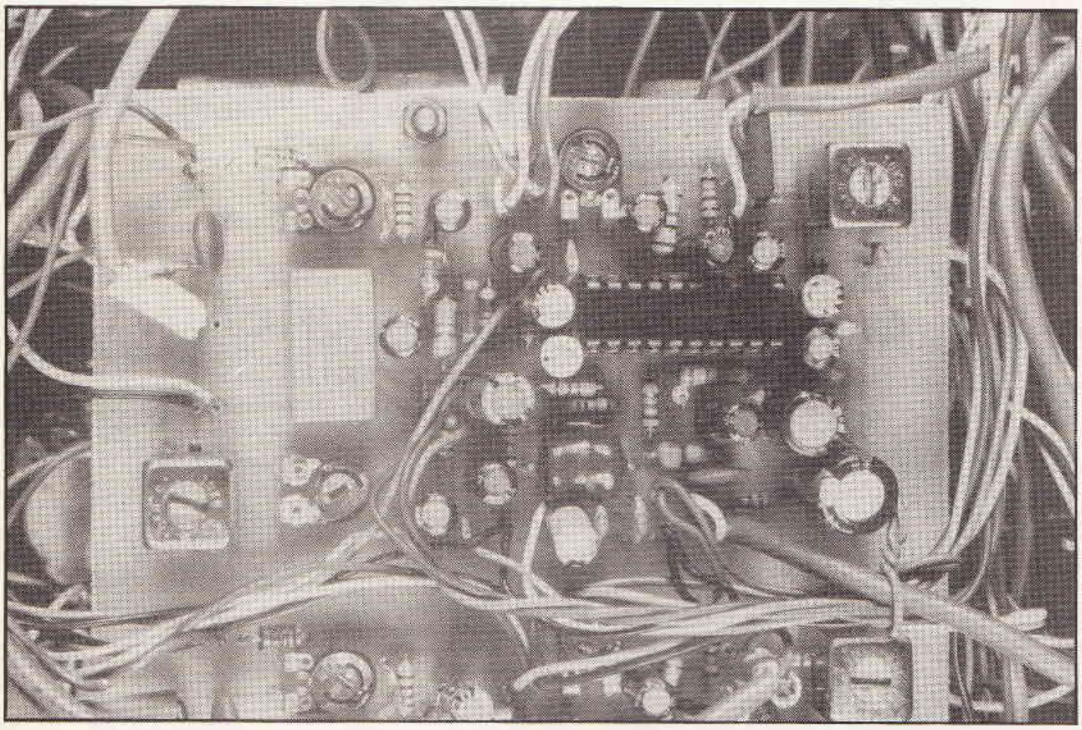
## Circuit Description

### RECORD

The record/playback relay RL1 is operated by the series combination of a toggle switch, a cassette record micro-switch and an optional external footswitch. When operated the normally open contact of the relay closes and provides a path to ground to switch on the bias/erase oscillator and to switch the LM1818 IC record/play logic into the record mode. The record/playback head is grounded internally via pin 2 of IC1.

The components C11, C13 and R13 provide a time delay system which is used to suppress clicks when switching between record and playback.

A low level recording signal can be fed to the microphone input socket where it is amplified with a midband gain of (1 + R6/R5).



A line level signal can be fed to the line input socket, thus overpluging the mic. feed, so avoiding the extra noise contributed from the microphone preamplifier.

Both microphone or line signals are fed directly to the headphone cue amplifier IC2, and via the slider fader to the internal record output amplifier and meter circuits.

For ferric-oxide cassette tapes the DIN record equalization standard requires a flat response above 50 Hz (3180 µs) with a 6 dB/octave boost below 50 Hz and this is provided by the components R15,C23. However to compensate for head losses at higher frequencies the output record signal is AC coupled via C15 to the record head through the parallel combination of R22 C17 which gives a high frequency boost starting at 6.3 kHz.

The low output impedance of the record amplifier in combination with C22 eliminates the bias voltage without the need for any additional bias-trap circuit.

## Bias/Erase Oscillator

Each channel has a DPDT relay which switches the amplifier between playback and record, it also switches on the oscillator whose output (pin 1) is fed to the heads of channel 1 or 3 ; and 2 or 4. This allows recording on any individual channel or on specific stereo pairs.

In record mode the oscillator output is fed to the erase head and via the series combination of C20, RV1 to the record head.

The dummy erase heads, consisting of the series combination of L3 and RV3, on channels 1 and 2 provide a constant load across the oscillator no matter which channel or channels are in the record mode. This maintains a constant output voltage from the oscillator allowing the bias level, once set, to remain constant.

## Playback

The DIN standard for ferric-oxide coated tapes specifies 3dB corner frequencies of 50 Hz (3180 µs) and 1.326 kHz (120 µs).

In the playback mode the normally closed (NC)

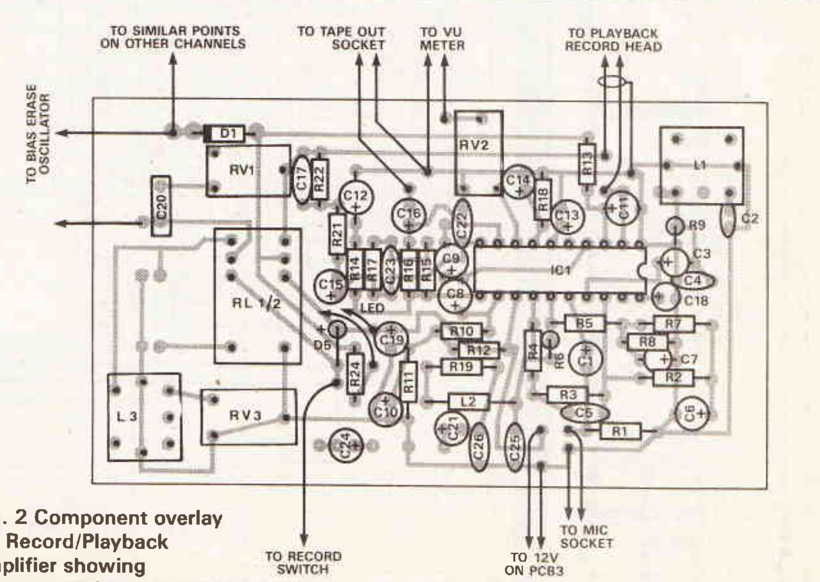



**Fig. 2 Component overlay for Record/Playback amplifier showing interconnections**

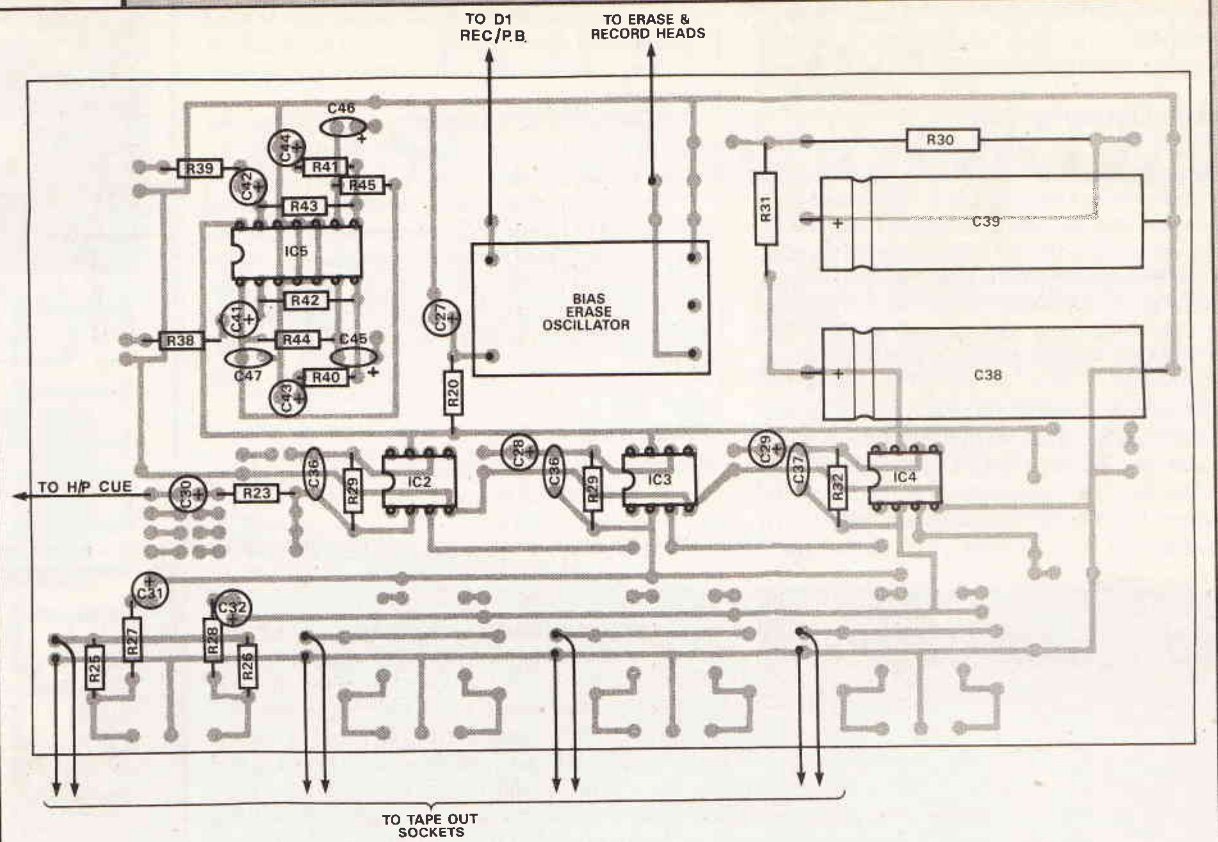



**Fig. 3 Component overlay for Bias/Erase oscillator, PSU and Headphone Amp (some components shown for one channel only)**

contact of relay RL1.1 grounds one side of the record/playback head. The other side of the head is connected via C3 to a preamplifier in IC1.

The bias trap L1, C2 removes crosstalk bias breakthrough; R9 is a damping resistor for this network. C4 reduces further HF or RF.

The midband gain for the preamplifier is (1+R4/R2) which is set to a voltage gain of 83.

A pole in the preamplifier is provided at $F=1/(2\pi\ C5\ R3)$ which occurs at 50 Hz. A zero in the frequency response occurs at $F1 = 1/(2\pi\ C5\ R4)$ which occurs at 1.3 kHz. The combination of R2,C6,R7,C7 provide a two-pole technique for the low frequency response, improving turn-on settling time.

Internally both inverting inputs of the pre-amplifiers are referenced at 0.5V DC. The output quiescent point, pin 14, is set by negative feedback through the external divider (R6+R5)/R8. For bias stability the current through R8 is made ten times the current from the inverting inputs, pins 15 or 18.

Output of the playback preamplifier is AC coupled by C21 to the bias-trap network of L2,R19,C25 and C26. These remove bias crosstalk from adjacent channels if they are in the record mode.

The output of the bias-trap network is then AC coupled via C24 to the channel fader control through a normally closed contact on the line input jack-socket.

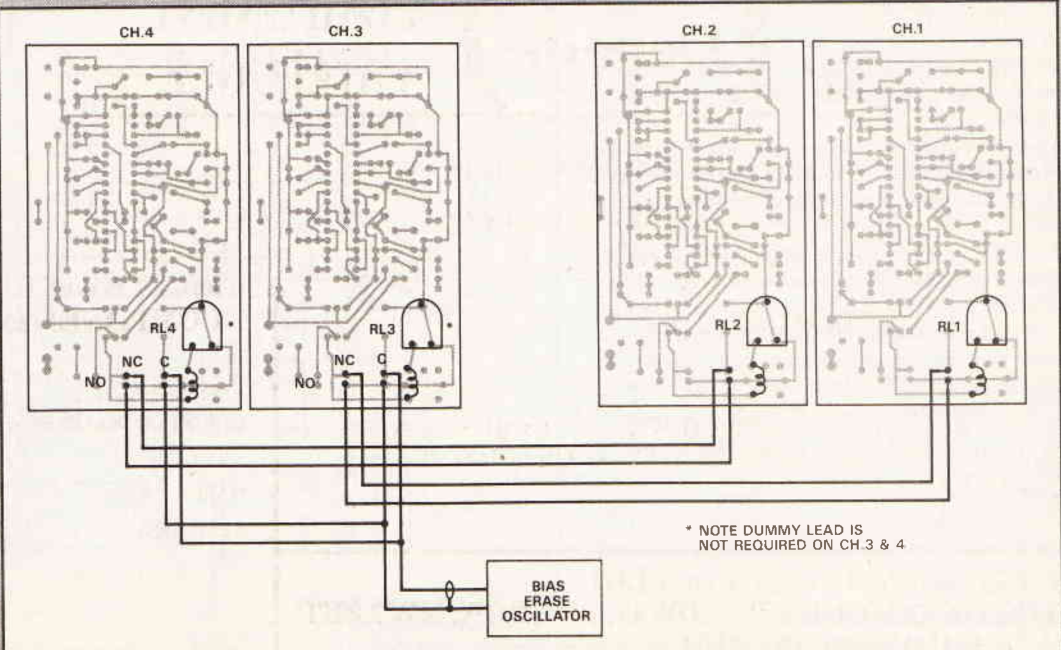
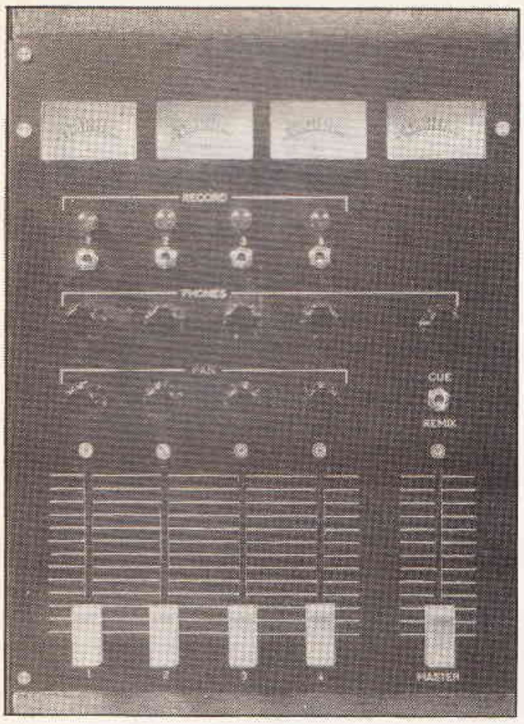



**Fig. 4a Interwiring of channels with Bias/Erase oscillator (boards shown component side)**




The signal across the fader is fed directly to the Headphone Cue volume control, allowing pre-fader monitoring of the channel.

Slide fader output is connected to the meter drive circuit and the internal output amplifier, has a mid-band gain set to (1 + R16/R14). The low frequency cut-off corner is set by $F = 1/(2\pi\ C12\ R14)$.

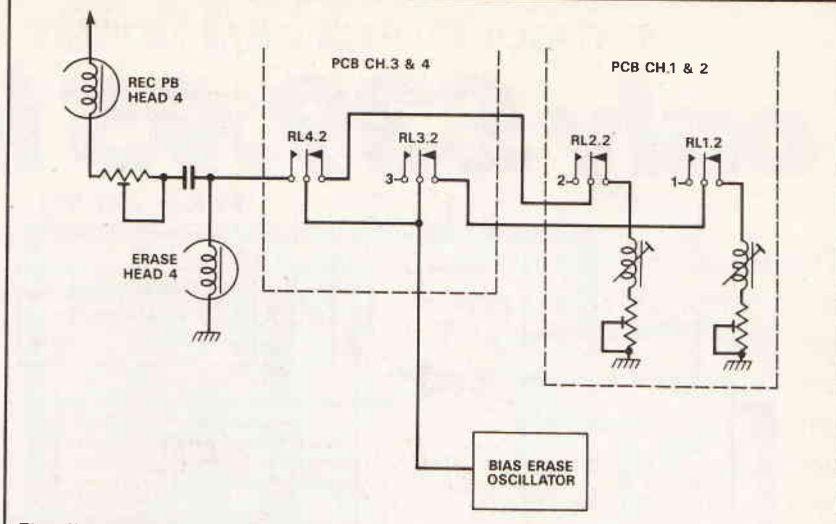



**Fig. 4b Wiring circuit for Bias/Erase Oscillator and connections to Dummy load**

The internal playback output amplifier is wired to a channel-out phono socket, allowing transfer of individual channels to an external mixer or tape recorder. It is also connected to the pan control and associated components, R25 to R28, allowing the mono output to be panned either left or right to the two line-output amplifiers IC3 and IC4.

The gain of the left and right line output amplifiers is set by R29/R27 and R32/R28 respectively. The amplifiers feed a pair of jack-sockets via a stereo master fader.

A full components list and buylines will be published at the end of the second part next month.

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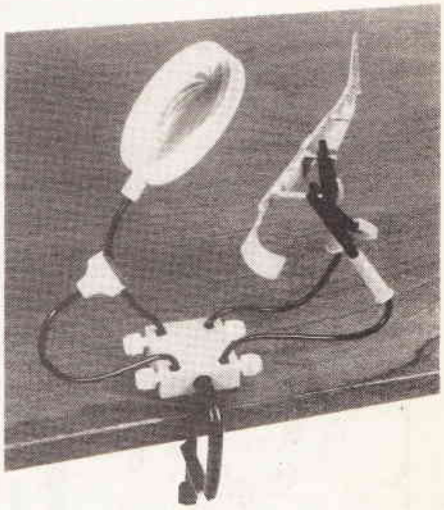

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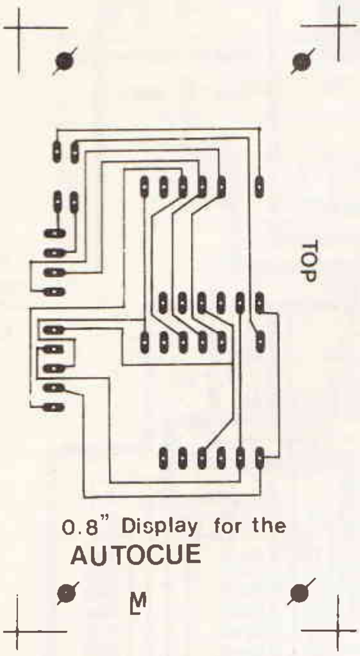
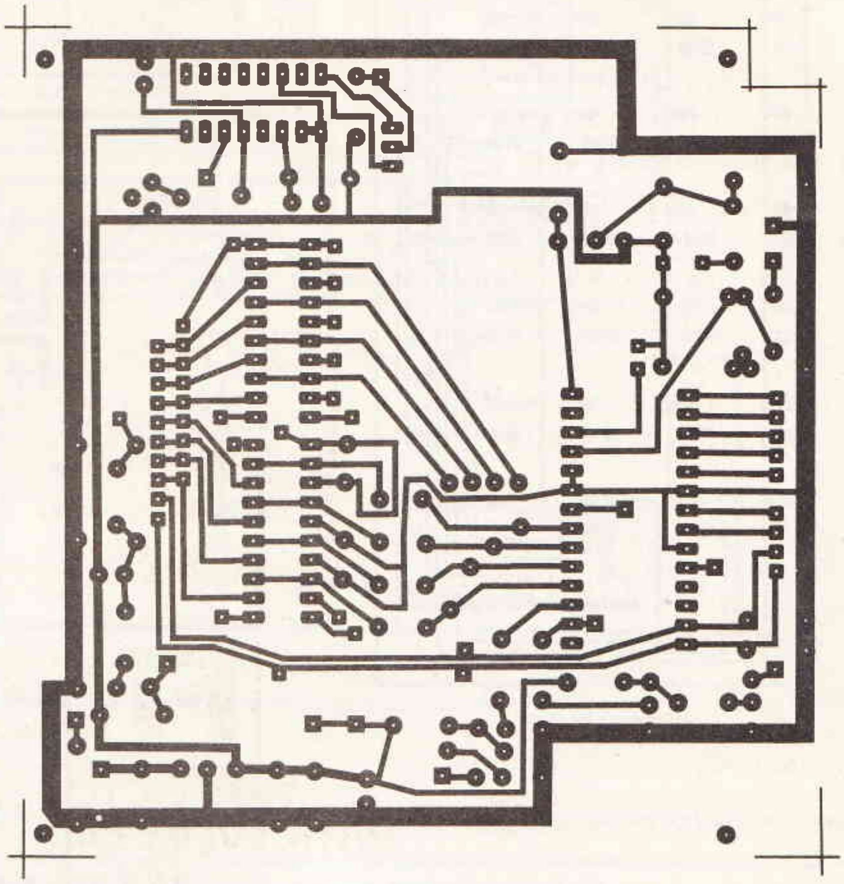



Autocue Display Board



Autocue underside

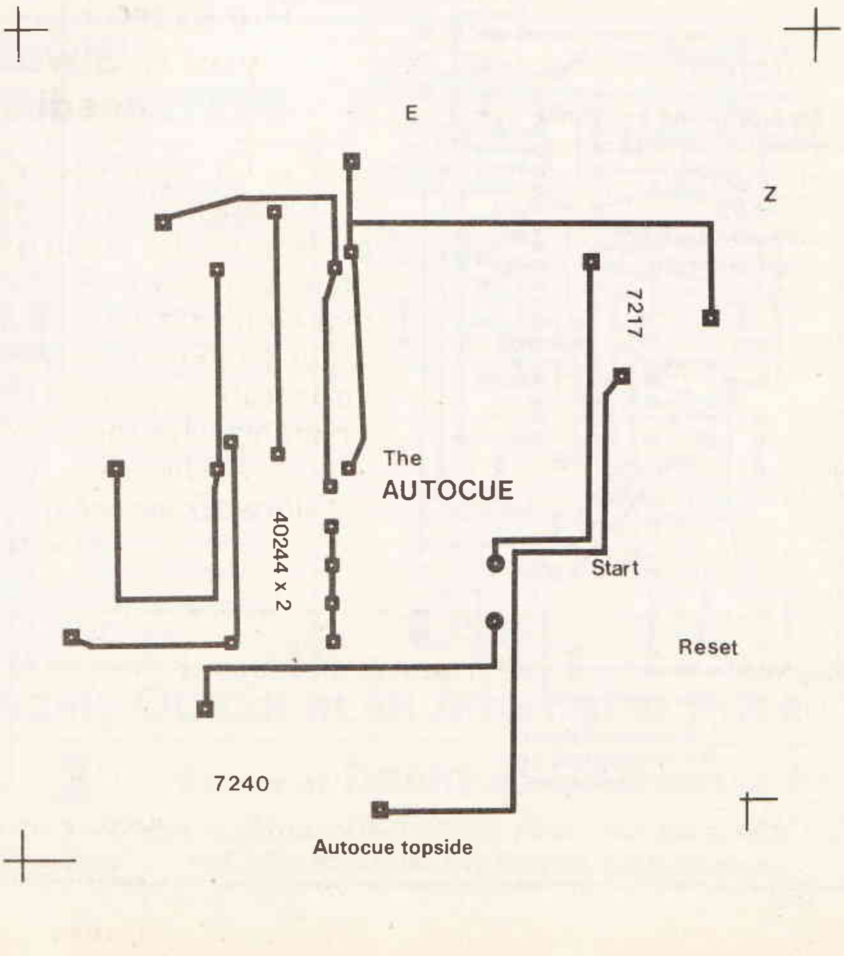

Some new corrections . . .

**20-metre Receiver** (January 1990)
On Figure 4, page 56. The polarity of C24 is not critical in the way it is placed on the board, but it could be turned around to agree with Figure 6. In Figure 6, C23 top end should be shown connected to the ground plane as well as pin 4 of IC3 with a cross.

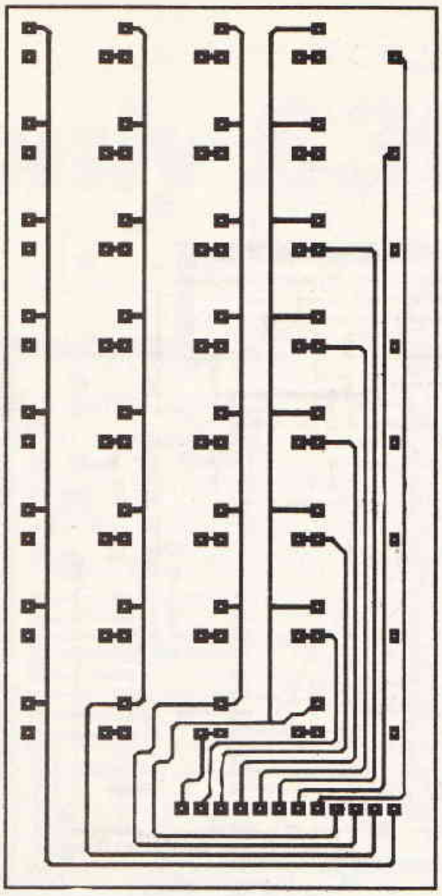
**Tech Tips** (July 1990)
Lighting Control without RFI, Q1 should read TR1.

**The Entertainer** (September 1990)
Text refers to adjusting R7, R10 and R23. These should be RV1, RV2 and RV3 respectively as in Figure 2.

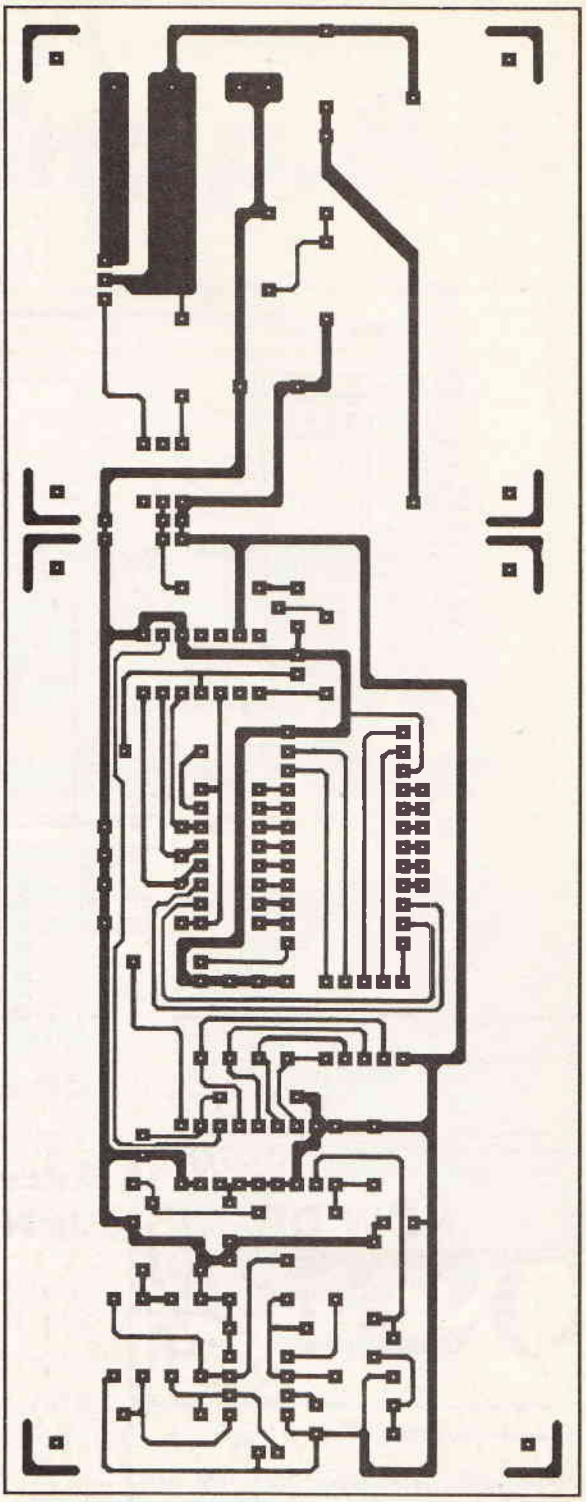
**Temperature Controller** (August 1990)
In Figure 2 RV1 connections should read B.A.C. from left to right. SW3, Relay and Neutral connections should be displaced down by one hole on the board on the right hand side.



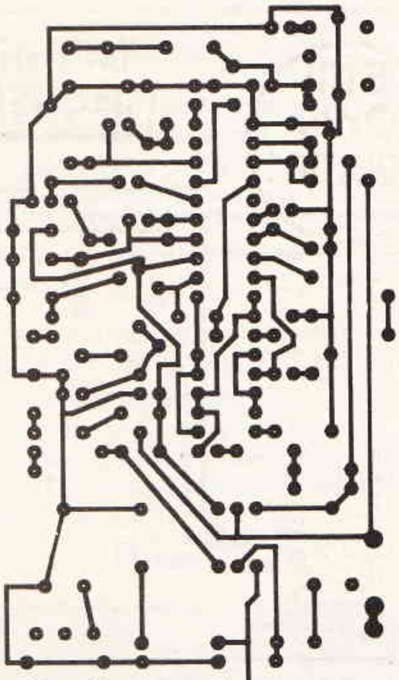

Autocue topside



Infra lock keypad



Infra lock receiver foil



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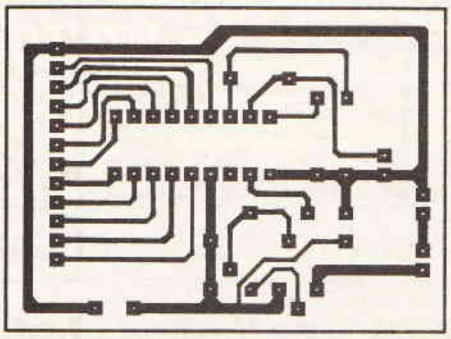
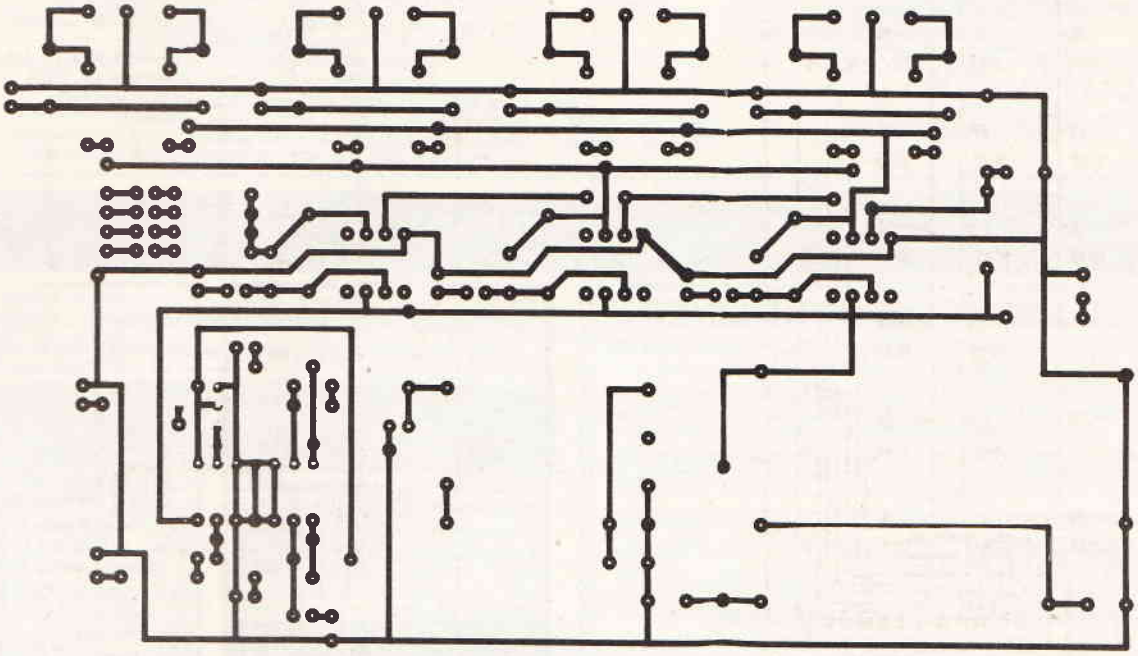
for one channel



Infra lock transmitter



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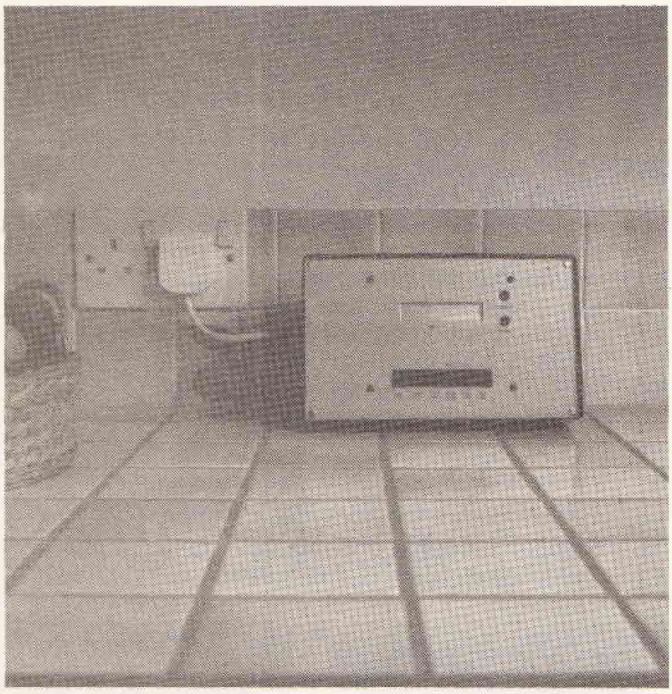
ELECTROMART

# NEXT MONTH



You have proved to us with the soaraway success of 'The Entertainer' in our September issue that this in-house piece of audio electronics is one of the many useful but not commercially available projects you would certainly like to have. So it comes as no surprise that two of our projects in the December issue will we think, be just as useful around the house. Firstly a Home Management system to control any of those useful electrical items that need to be operated with monotonous regularity, or even programmed for advanced operation. Just a few examples are lighting for security, heating and of course, curtain control to prevent prying eyes in your absence. All this from a micro-controlled, digital read-out, mains-borne system. And as if that wasn't enough, the second project develops your Infra-red security lock featured this month, by using the same controller to operate electrical appliances in the same room. Who needs to turn on your electric blanket by an Infra-red 'zapper' downstairs when you have your electronic House Manager to do it for you?

Still on the project front, we present the final part of the Four-track Cassette Recorder and a Five-in-one very useful device to monitor changes in mains current without direct electrical connection.

Plus, the second part in Recording Studio Design, more on High Definition Television and another Testing Testing.

So make it a date with your newsagent to reserve a copy and collect on 2nd November.

*The above articles are in preparation but circumstances may prevent publication*

# LAST MONTH

The October issue of ETI contained features on Solar Power and how our homes can make the best use of available sunlight and heat, the second part of Microwave uses: past, present and future and a design feature on Electrostatic Loudspeakers. High Definition TV started by looking at the real need for an improved technical quality of television and Mike Bedford concluded his article on Data Communications. Projects included, a Surface-mount Radio Receiver, a Guitar Pick-up and a Component Tester. Back numbers are available from Select Subscriptions — address on contents page.

# ADVERTISERS' INDEX