

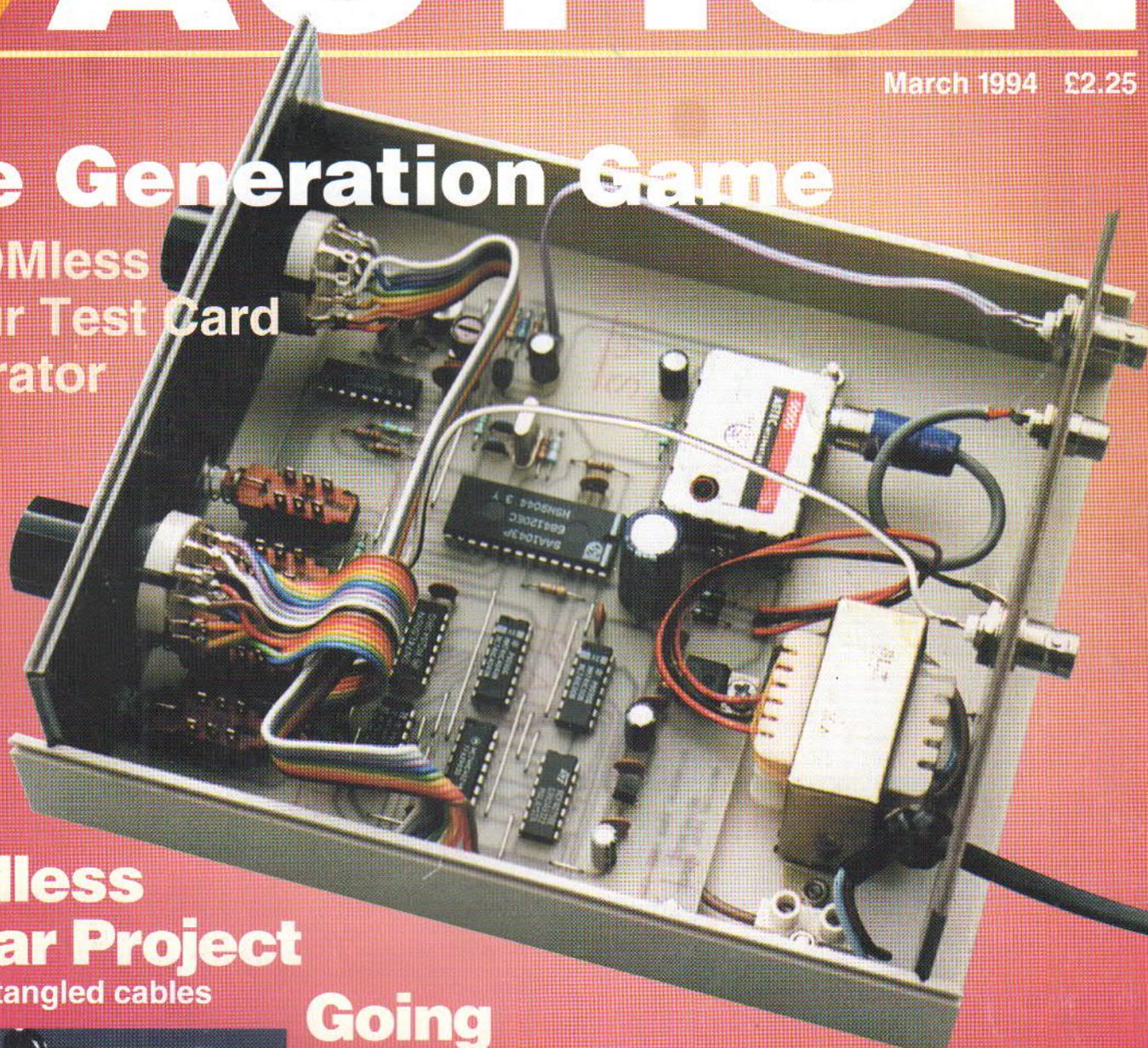
BOARDMAKER 1 - Special Offer Inside

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The Generation Game

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Colour Test Card
Generator**



Cordless Guitar Project

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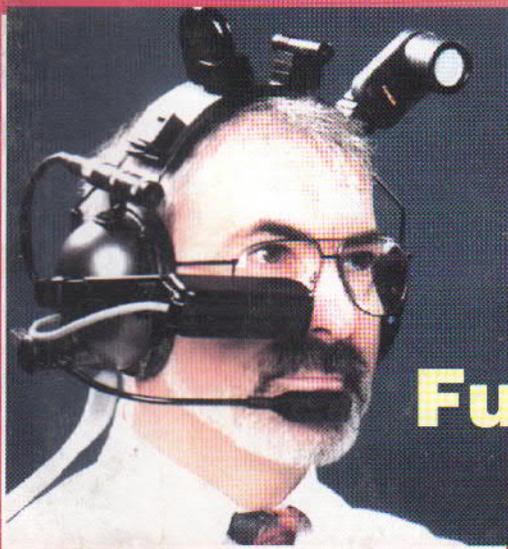
Going Underground

Covered in earth *and* basking in the sun

The Evolution of Audio - Part 2

Future View

BT's Multimedia Architect and
Intelligent Communication Networks

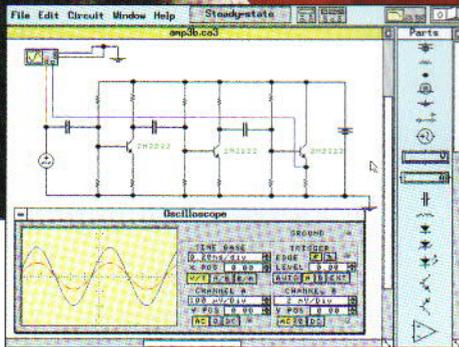
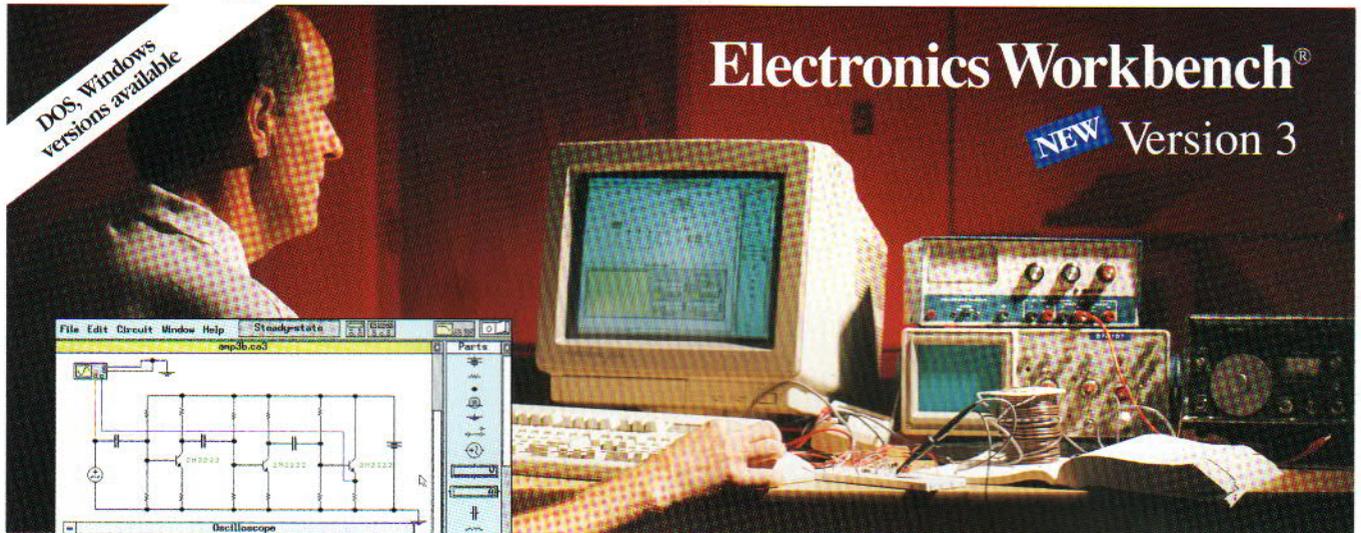


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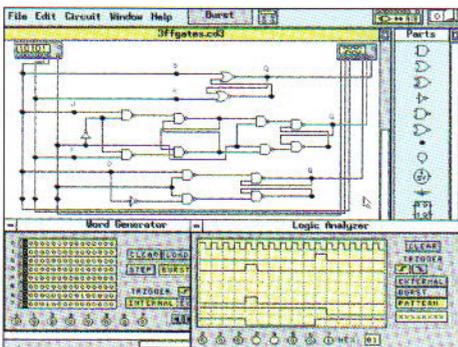
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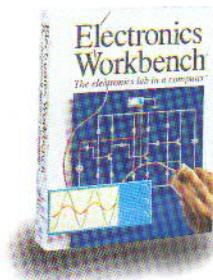
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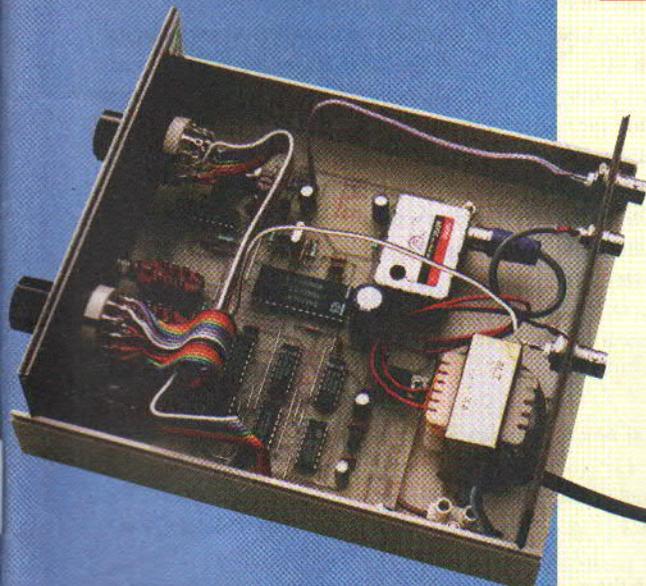
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All change - for what?

Perhaps you have never stopped to consider how well our domestic mains plug and socket used by everyone of us every day is made and to what safety. We use the mains plug and socket so often we take it for granted.

However, the leaders of our European Community, in their great wisdom, are proposing to unify all domestic mains electrical connectors. They think we should all use the same type of plug.

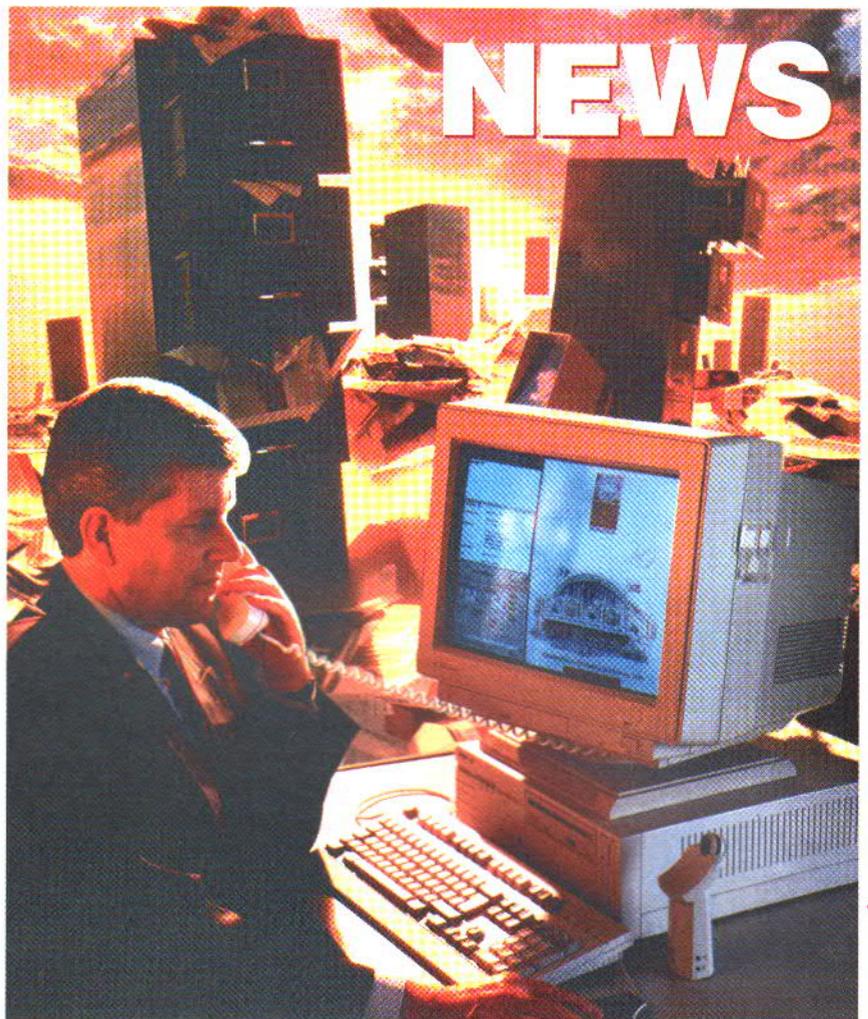
Standardisation may be good for many things but in this case I cannot see the point for island communities.

For some inexplicable reason the bureaucrats think the continental plug and socket should be that standard. So if this proposal went through it would mean us Brits on this 'tiny offshore island' would spend countless millions of pounds and thousands of man hours changing all the outlets - and for what? It is not as if millions of us traverse the water with our worldly electrical goods everyday and groan about the inconsistencies.

The solution for the UK is simple. Do as we have done and use a simple well designed adapter.

We have a safe and well designed electrical connection system that serves us well. Let us keep it that way.

Paul Freeman-Sear



Multimedia goes on-line

On Demand Information Plc is heralding its multimedia single-source on-line information access system as the most significant breakthrough in information communications this century.

While history has yet to award the comms prizes for the 20th Century, and multimedia is struggling to assert itself in the face of recession and information technology overload, it nevertheless seems likely that highly centralised, user-driven on-line information storage and retrieval will become central to communications, especially for businesses and services, before the year 2000.

Most on-line systems are text-based and rely heavily on live phone communication. Call charges and service charges tend to mount up quickly. The system set up by On Demand Information provides users with their own in-house PC-based index, so that only the calling and dumping of information takes place on-line. "Fuzzy" search techniques, as well as index searching is used to help locate relevant data - if no definite reference is known, "clues" can be entered to locate relevant information. Multimedia shows its advantage here as sound and graphics

information can be exchanged, and added, as well as text.

The basic tools of the system are a 386 or 486 IBM PC or compatible with a graphics card, an autoscanning high-res super VGA monitor, and an ISDN card enabling connection to ISDN lines for data transfer. The graphics and ISDN cards are developed by On Demand Information. Up to eight users can share a party line, and all the PCs on the network can pass information to each other.

The central information-holding computers are backed up at various locations for security, and information can be updated daily.

The advantage to both information seekers and information providers is a centralised location, fast updating, and (it is hoped) a massive reduction in postage, paperwork and paper storage.

The most likely markets for centralised information initially will be well-defined industry sectors. On Demand Information is already available to be construction industry - poised for a new take-off soon, according to economic pundits - through BCQ, a joint venture between On Demand Information and the Building Centre Group.

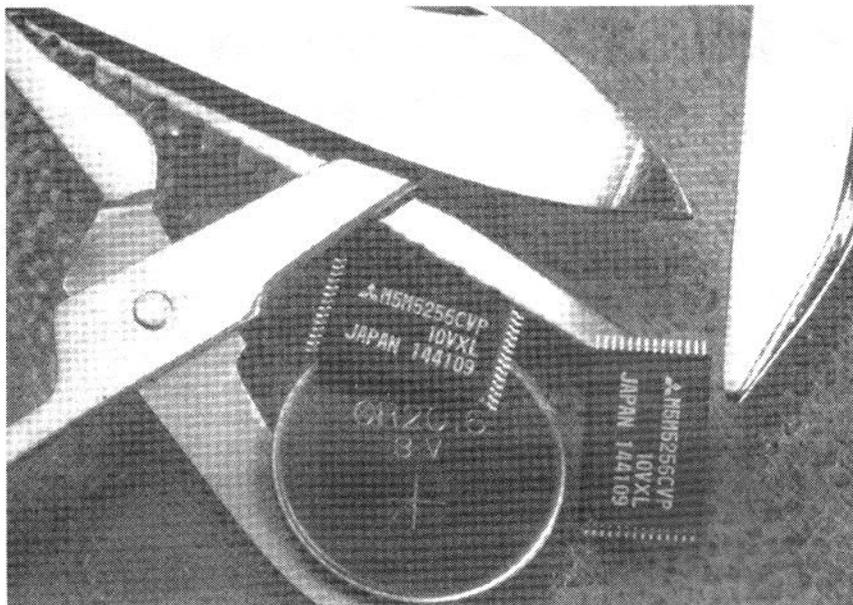
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More low power SRAMs

A new MEMORY from Mitsubishi is the third-generation, super low power 256K SRAMs, including products for 3V and 5V operation. The new devices have a maximum operating current of 20mA at 3.3V and 50 mA at 5.5V, with a maximum standby consumption of 2uA. Access times are 55 or 70 nanoseconds at 5V, or 85, 100 and 120ns at 3V. Package options include 28-pin, 0.6in DIPs, 28-pin 0.45in SOPs, 28-pin 8.13 TSOPs and reverse pinout packages. The SRAMs are organised as 32K x 8-bit CMOS. All inputs and outputs are directly TTL compatible. ●



CD-i takes off

It looks as though the Philips CD-Interactive games and video disk system is going to become an established format, despite the reluctance of consumers to invest in new systems these days. CD-i is reported to have outsold Sega's Mega CD games machine in Dixons stores in the UK. Worldwide sales of CD-i players are now around 350,000.

Good prospects following Christmas sales in Europe and the United States were even considered newsworthy by the national press. Another major film studio, MGM, signed up to release movies on CD-i at the International Consumer Electronics Show in Las Vegas in January, joining Paramount who signed in 1993. Warner Brothers is also expected to sign later in 1994.

Another important prospect is good

sales of CD-i discs, prompted by the release of several new disks just before Christmas, including adult mystery thriller *Voyeur*, and *The Joy of Sex*. Soon to follow is the Full Motion Video (FMV) version of Virgin Games interactive chiller mystery *The 7th Guest*, now scheduled for March/April 1994, and an completely new CD-i version of science fiction "inner space" adventure *Microcosm*, also scheduled for May. ●

Multilayer Flexi Board

Northumbria Circuits have recently produced a multi-layer flexi-rigid circuit board. The 20 x 14-inch boards, which have to control all aspects of Formula One engines as part of the cars' electronic engine management

system, were temperature-tested for racing conditions at Cape Environmental Engineering of Warwick, England.

The thermal and mechanical shock, vibration and stresses that components in a Formula One engine, including the flexi-rigid PCB, endure in a racing car at up to 200 mph are particularly severe. The two-day temperature tests had to simulate the thermal conditions to ensure that the boards would be reliable under these extreme circumstances.

The tests were carried out in 14-hour temperature cycles from -10 degrees centigrade to +85 degrees centigrade, over a 48-hour period, and held at the extremes of temperature for an hour between cycles.

Following the increasing trend towards simulation at various stages in development, the boards completed the tests successfully and are now performing in Formula One championship cars. ●

Multi processor kit

A new microprocessor development kit for ECAL supports assembler language development for more than 170 different processors from the Z80 to the 68000 for under £500, or for a single processor for under £200. The optional emulator, costing £385, connects to its target via an EPROM socket, making it processor-independent.

Facilities include source level debug, unlimited breakpoints, single-step operation, monitoring of all registers or variables, reading and writing to target,

support of 16-bit systems with two pods and 32-bit systems with four, and download of 64 KBytes to emulator in a few seconds.

The system provides most of the facilities of an ICE at about 10% of the cost. An introductory booklet and demo disk covering all processors are available from of charge from OEMA Ltd., 7/7A, Brook Lane, Warsash, Southampton, Hants. SO3 9FH, UK. Tel 0489 571300, fax 0489 885853.



WindowSafe combats window danger to car children

Recently, the danger to young children of electrically-operated car windows has been back in the news again, but it is not new. Children have lost their lives before, trapped by the accidental operation of an electric car window. Casualty departments know that many more children are injured than are killed, though the injuries are not widely reported.

The WindowSafe is designed to increase the safety of electrical windows, allowing the window to detect an obstacle, and wind down to free the trapped person.

If the window encounters resistance, such as a human limb, while the winding switch is being operated, WindowSafe will stop the window. The window then reverses about six inches to free the victim.

The window will then remain stationary for several seconds, so that an accidental winding cannot be quickly repeated by, for instance, a toddler with her foot on the switch.

Advanced design features (patent applied for) distinguish between friction and an obstacle. A window can retain the power to drive past friction, while limiting the peak pressure applied to a limb.

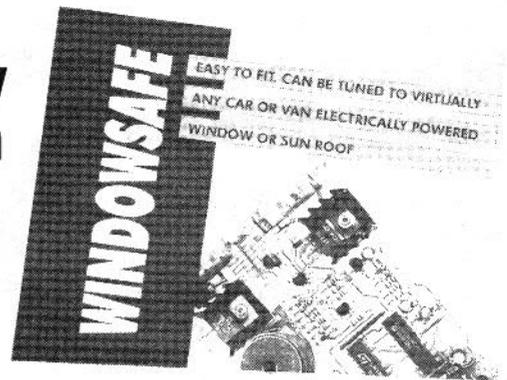
This aspect is central to the usefulness of the product. If the WindowSafe were to operate falsely, winding the window down as it

encounters a sticky patch on the runners it would soon be rejected by the user. At the same time, it is vital to limit the pressure applied to someone's limb. The system works so well that in many cases the peak pressure on a trapped limb before the WindowSafe begins to operate can be less than the force simply required to overcome windowframe friction.

The standard model is installed in the window circuit, where it can protect all the electrically-operated windows (and sunroof) in the vehicle.

The protection may be temporarily overridden, for the safety of drivers in potentially perilous situations, such as a woman drivers alone at night, or in areas where there may be risk of attack. Drivers have had bags or jackets snatched by thieves reaching through open windows while the car waits at a junction. To override the protection, a separate switch, for instance, the window-washer, must be operated at the same time as the window switch is in use. Installers can choose a suitable switch which is convenient for the driver without compromising the normal protection.

The project started in 1992 with the



EASY TO FIT. CAN BE TUNED TO VIRTUALLY ANY CAR OR VAN ELECTRICALLY POWERED WINDOW OR SUN ROOF.

Can be installed quickly without special tools
Only two connections into window/sunroof drive circuit
Incorporates an override circuit to allow normal window closing for protection against intruders
Distinguishes between runner friction and physical obstruction to window
One unit guards up to four powered windows
WindowSafe's case measures 142x80x30mm and fits neatly under dashboard
Can be tuned to compensate for different window closing speeds.

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news story about the child killed by an electric window.

The design went through seven stages of development, starting with a basic overcurrent detector, which could only be set to work with one individual window, to the present microprocessor controlled unit which is tolerant of a wide range of operating conditions, and contains the patented feature. The AA and Halfords, the car accessory people are currently evaluating the product. The Distributor of WindowSafe is:

Sempal Ltd.
Phone 0905 617544
Fax 0905 617545

MT-8 Phone on the street



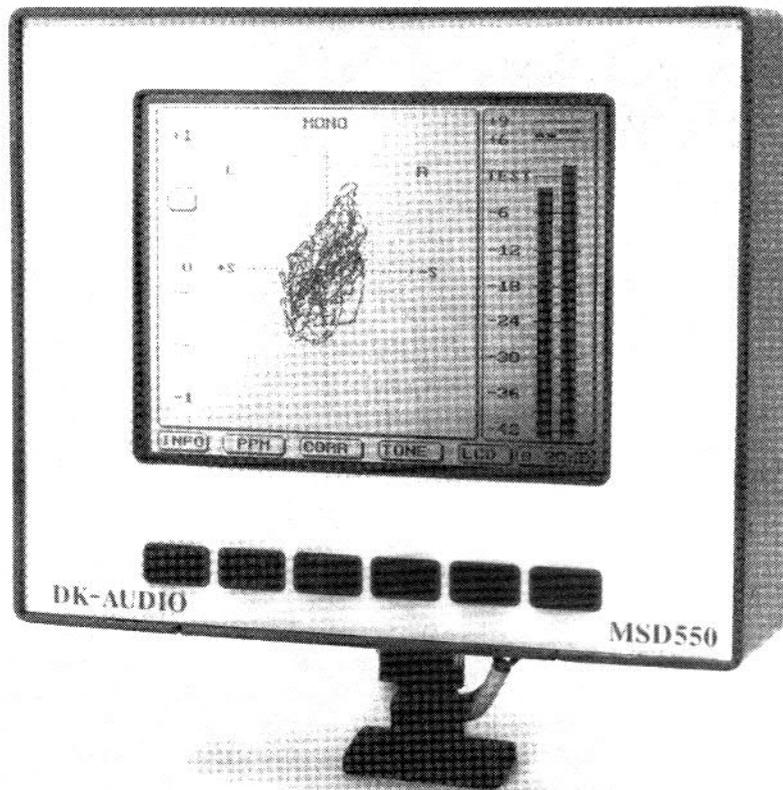
The Mitsubishi TACS-2 analogue ETACS MT-8 handheld cell phone is now out and about and should appear in high street stores at around £149. Based on the award-winning MT-7, and MT-8 weighs only 230g with standard battery, and at 156x56x24mm fits tidily into the hand. It can store up to 20 numbers and auto-redial unanswered numbers. The backlit 10-character LCD screen has a storage capacity of up to 32 digits. Volume control moves through 7 levels, and ringing rises to a maximum volume if a call continues unanswered. The phone can be locked to prevent unauthorised use.

The MT-7 can exploit two types of battery. The standard battery typically

provides 50 minutes of talking time or 8 hours on standby. The extended NiCad option provides around 110 minutes of talking time or 20 hours on standby. An optional desktop charger can fast-charge a standard battery in one hour or the extended battery in 2.5 hours. When connected to the phone, it will also trickle-charge either battery in 8 hours.

Also available is a hands-free car kit for mobile use, and a cigarette-lighter power connection in two versions, one with an external antenna connection. Other options include an in-car cradle and a leather case.

The MT-7 comes complete with NiCad battery, travel charger, AC mains adaptor and manual. ●



Five-way stereo display

Sound engineers may be interested in a workstation monitor for displaying stereo audio signals in terms of several different meter standards.

The MSD550 Master Stereo Display by DK-Audio combines the functions of a level meter, correlation meter, sine generator and audio vector oscilloscope in one workstation. Using digital audio processing and a fast, high-resolution LCD, the workstation provides real-time reading of a stereo signal. It can be connected to any balanced line level output, and removes the need for add-ons like LED, bar-graph or oscilloscope tubes for phase indication or stereo image monitoring.

The five most popular international level meter standards are loaded into the MSD550 and can be selected by a

keypress. Also included are new features like flying peak and true digital peak for sound engineers using hard-disk recording systems.

The MSD550 has transformer-balanced inputs and automatic input sensitivity on the audio vector oscilloscope, and an extended-lifetime LCD. All the features are software-based, and future releases will include headphone output and fast fourier transformation (FFT).

The unit's dimensions are 155x132x45mm. The UK price is £1465 plus VAT, and the UK dealers, Plasmic, can be contacted at 0252 721236. Technical information can be also obtained from Morten Stove, Danish Pro Audio. Tel. +45 4814 2828 (Denmark).

Electron Beam Tests for VLSI

Professional Component Services, part of the UK Ministry of Defence Research Agency's Quality Assurance Arm, has acquired a leading electron-beam probing system to carry out failure analysis on complex ICs.

The IDS 5000HX electron beam prober is made by Schlumberger Technologies, provider of around 90%

of the world's e-beam prober market. Used to carry out non-destructive high-bandwidth measurement on complex ASICs and other VLSI (very large scale integration) devices, e-beam probers are used by semiconductor manufacturers, but are not readily available to smaller chip design companies and in-house teams producing lower volumes of custom semiconductors. Companies like PCS - which formerly specialised in the evaluation of components for defence use - can now make this service available to other designers.

The IDS 5000HX is the most recent of Schlumberger's advanced IC

diagnostic systems. Like the widely-used IDS 5000Plus, it uses an electron-optical column and positioning system to probe chips up to 32mm square. With a probe size of only 80 nanometres, generated by a lanthanum hexaboride electron source, semiconductors with sub-micron fabrication geometries can be probed for faults. Voltage-contrast images can be acquired from passivated or unpassivated devices. Measurement is speeded up by a unique waveform acquisition technology, known as dual-gate acquisition, which works by minimising the averaging needed to obtain the best signal. Dual-gate acquisition removes correlated system noise, so that very small signal levels can be determined. For instance, voltage levels between memory cells and sense amplifiers in modern CMOS static rams are less than 100 millivolts.

Electron beam probing works by reflecting an electron beam from the item under test, and measuring the strength of the reflected beam. See page 54 for a detailed explanation. ●

The Sensaura sound from EMI

The audio engineers in EMI's research laboratories at Hayes have found a way to reproduce dummy head recordings through conventional loudspeakers.

CRL's new Sensaura microphone system imitates the human hearing process, using digital signal processing to encode the signal from a dummy-head "binaural" microphone arrangement and enabling it to be replayed on normal stereo speakers. This new recording presents a three dimensional sound image, containing height information which extends out beyond the speakers.

CRL's engineers have been making Sensaura™ recordings using analogue to digital converters made by Yamaha which supplies a 19-bit digital signal to the Sensaura multi-channel signal processor, and a Yamaha DRU8 eight track 20-bit digital recorder.

The multi-channel signal processor uses conventional multi-microphone techniques, making it suitable for use with both live and overtracking recording methods.

It has already been used on Frank Sinatra's Duets album and on Milla Jovovich's forthcoming album and in many experimental classical recordings at Abbey Road and Symphony Hall, Birmingham. The first complete Sensaura™ classical recordings are due to be issued in the Autumn. ●

Research World

Technical Advances from around the Globe

Software reach business cards

Cognitive Technology Corp. has announced software that reads business cards directly into databases. One pass of any handheld scanner over the business card and card reader performs instant optical character recognition and automatically inserts all key information into database fields. BCR is now working with the Lotus Organizer's Address Book, but other databases will be supported in the future.

BCR uses an adaptive threshold technology to automatically adjust scanned images in real-time for maximum recognition accuracy. The company also claimed its scale-to-gray technology improves legibility of black-and-white images on a computer monitor.

ATM and the cable industry

Asynchronous transfer mode (ATM) switching technology should get a huge boost from the cable industry. ATM is uniquely suited for video-on-demand (VOD) services. The massive switching required to deliver VOD initially seemed to favour the use of massively parallel processors. The technological hurdle most often cited for VOD systems has been the vast amount of storage necessary - a menu of 400 movies would require about a terabyte of storage. However, the more fundamental challenge may lie elsewhere. The problem in building a dedicated hardware VOD device is primarily switching, rather than storage.

An original expectation, among many in the cable industry, was that massively parallel computers acting as video servers would be the only technology currently available to allow thousands of simultaneous digital video streams to be routed. It now appears, however, that much less sophisticated servers can be used if the task of routing is handed over to ATM switches.

Broadband ATM designs

Several large broadband switching companies have given some details of their Asynchronous Transfer Mode (ATM) switch prototypes. Industry leaders such as AT&T Co., Fujitsu Ltd., Siemens A.C., NEC Corp., Hitachi Ltd. and Mitsubishi Electric Corp. share a common view of ATM deployment patterns in wide-area networks, and the similarities in marketing plans are leading to similarities in system design.

Customers will first ask for virtual-path services as extensions to local-area networks which will require lower-level, passive ATM equipment like cross-connect systems, add-drop multiplexers and access multiplexers. Demand for switched virtual channel services by the turn of the century will drive a second-stage deployment of full-featured ATM switches.

In the ATM schemes developed by the International Telecommunications Union, virtual channels are defined as the de facto point-to-point links established between two ATM nodes. Multiple virtual channels of similar services, such as video, data or audio, are clustered into virtual paths. Telephone companies will first allow customers to set up permanent virtual circuits for ATM cell relay. These will offer established bandwidth, but will let customers pay on an as-needed basis, rather than as a

permanent lease cost similar to that for a T1 line.

Unlike the LAN-emulation and campus switch vendors in the local-area environment, who can deploy ATM using a variety of topologies and interface speeds, broadband switch vendors have to plan their hardware deployment of cross-connects and switches carefully, to ensure that technology does not outpace user demand by too large a factor.

Despite the greater complexity of providing ATM cell assembly on top of Sonet payload framing, the advances made in very large-scale integration (VLSI) circuitry in the last few years have allowed NTT to significantly shrink system sizes. The prototype ATM cross-connect platform is one-tenth the size of a Sonet-only prototype developed in the late 1980s, Tokizawa said, and uses multiple CMOS, BiCMOS and CaAs ASICs for cell assembly and switching.

Bell Labs has assembled what it calls a cross-connect "mainframe", consisting of four of the systems described by NTT linked by a junction frame for a total throughput of 80Gbits/s. The card slots in the mainframe will accept line cards operating at the three ATM/Sonet rates of 155Mbits, 622Mbits, and 2.4Gbits. Slower virtual paths are fed into a shared-memory fabric interface multiplexer card, which feeds the heart of the mainframe, an 8 x 8 shared-memory switch with 2 1/2Gbit capacity. Bell Labs is already working on a second-generation 256 x 256 switch design, with a total capacity of 640Gbits/s.

New HTS device

Researchers at Westinghouse Electric Corp.'s Science & Technology Centre are preparing to deliver an upgrade of a prototype device called a filter bank channelizer. The four-channel device is based on microstrip filters created with a high-temperature superconductor (HTS) of yttrium-barium-copper-oxide.

The device was designed as part of the U.S. Navy's high-temperature superconductor space experiment, managed by the Naval Research Laboratory.

In terms of frequency, each channel is 50 MHz wide, and separated from the next channel by 65 MHz. The centre frequency is 4GHz.

Each channel of the unit is made of two microstrip filters with a hybrid coupler connecting them. Parameters such as length and spacing of the strips dictate the frequency to which the channels are tuned. Each filter is about 100 microns wide, and each channel (two filters) is about 1.25 inches wide.

The advantage of HTS filters is their diminutive size and light weight, at least compared with waveguide filters or dielectric resonators, which are important considerations in space-based applications. If used for communications, the filters would almost certainly be deployed in an array to cover a wide spectrum. Even with the cooling unit necessary to refrigerate RTS materials to their transition temperature an HTS channelizer array would be lighter and significantly less bulky than waveguide filters or dielectric resonators.

The new version of the channelizer is about 25 per cent lighter than the prototype and has been re-engineered to be space-qualified.

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The Generation G

An EPROM-less colour test card generator by Paul Stenning

When servicing and repairing televisions and other items of video equipment, it can be helpful to have a stable and recognisable test signal. A colour bar pattern is often used for this, and indeed many television and video recorder service sheets use this type of signal as a reference.

A variety of other patterns are used for specific tests. For example, a crosshatch is useful for checking picture linearity and convergence (colour gun alignment), while a checkerboard pattern is ideal for setting up the focus.

The test pattern generator described here features these patterns as well as horizontal lines, vertical lines, dots, blank raster and white screen. The three primary colours are individually switchable. So for example the white screen can be switched to red, green or

blue for checking colour purity.

There have been several designs for test pattern generators published in the past. Many of these are monochrome only and are often based on the ZNA234E IC. Published designs for colour units are often complicated, and therefore probably too expensive for occasional home use. In addition some of these designs require EPROM programming by the author, which can be an inconvenience.

The aim of this design was to produce a straightforward reliable piece of equipment with no unnecessary frills and features. It should be possible to construct the unit for around fifty pounds including a case, which is cheaper than commercial units having a similar specification. Setting up is straightforward and requires no test equipment.

The instrument is mains powered (see Figure 1). A standard composite

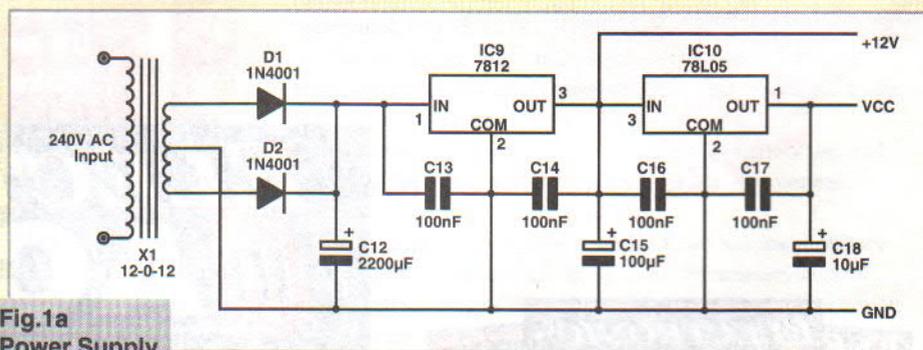


Fig.1a
Power Supply

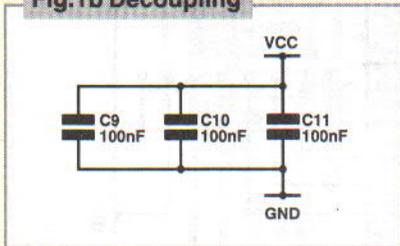
video output is available (1V pk-pk into 75R), as well as UHF modulated (UK channel 36). An oscilloscope trigger output is also available, which is switchable to either line or frame sync.

Many commercial units feature an extended range of patterns including circles and full test cards, which have not been included in this design to keep the cost down. A more comprehensive (and naturally more expensive) unit is under consideration for a future article if there is sufficient interest. Please write to the author, via the magazine address, with your comments and suggestions.

The Works

The circuit diagram is shown in Figure 2. Most of the complicated stuff is handled by IC1 and IC2, which helps to simplify the remainder of the design. IC1 (SAA1043) is a universal sync

Fig.1b Decoupling



ame

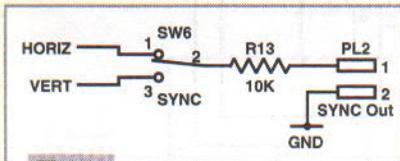


Fig.1c

generator, whose timing is controlled by XT1. In this design IC1 configured for the UK standard 625 line interlaced PAL, and four outputs are used.

A 5MHz clock signal is derived from XT1. This controls the first binary counter (IC3, 74HCT4040), which is reset at the end of each line by the CB (composite blanking) signal. 256 clock pulses are counted by IC3 between each blanking pulse.

A second binary counter (IC4, 74HCT4024) counts the 312 CB pulses within a frame. This counter is reset by the VERT signal at the end of each frame. The fact that the counter has a

capacity of only 128 is irrelevant in this case, since it merely wraps round.

The various patterns are derived from the outputs of these counters with some logic and switching. I will come back to this in a moment, once I've described the inputs required for IC2.

IC2 (TEA2000) is a colour encoder IC. To function it requires composite sync and composite blanking signals that are supplied by IC1. The colour inputs set the output colour. There are six such inputs, two for each primary colour. Taking the red inputs for example, if R0 is high a dark red is obtained, if R1 is high a brighter red is obtained, while if R0 and R1 are high a very bright red results. The device can produce 64 different colours although only nine are used in this design.

For the colour bars the R0, G0 and B0 lines remain low, and the R1, G1 and B1 lines are controlled in the appropriate sequence. For the black to white pattern, this is the binary output from three lines on IC3, while for the white to black pattern these three lines are inverted by gates in IC8. Three sections of SW2 select either of these or connects the three lines to the monochrome pattern logic. The fourth section of SW2 connects R0, B0 and G0 to ground when colour bars are selected or to the monochrome pattern

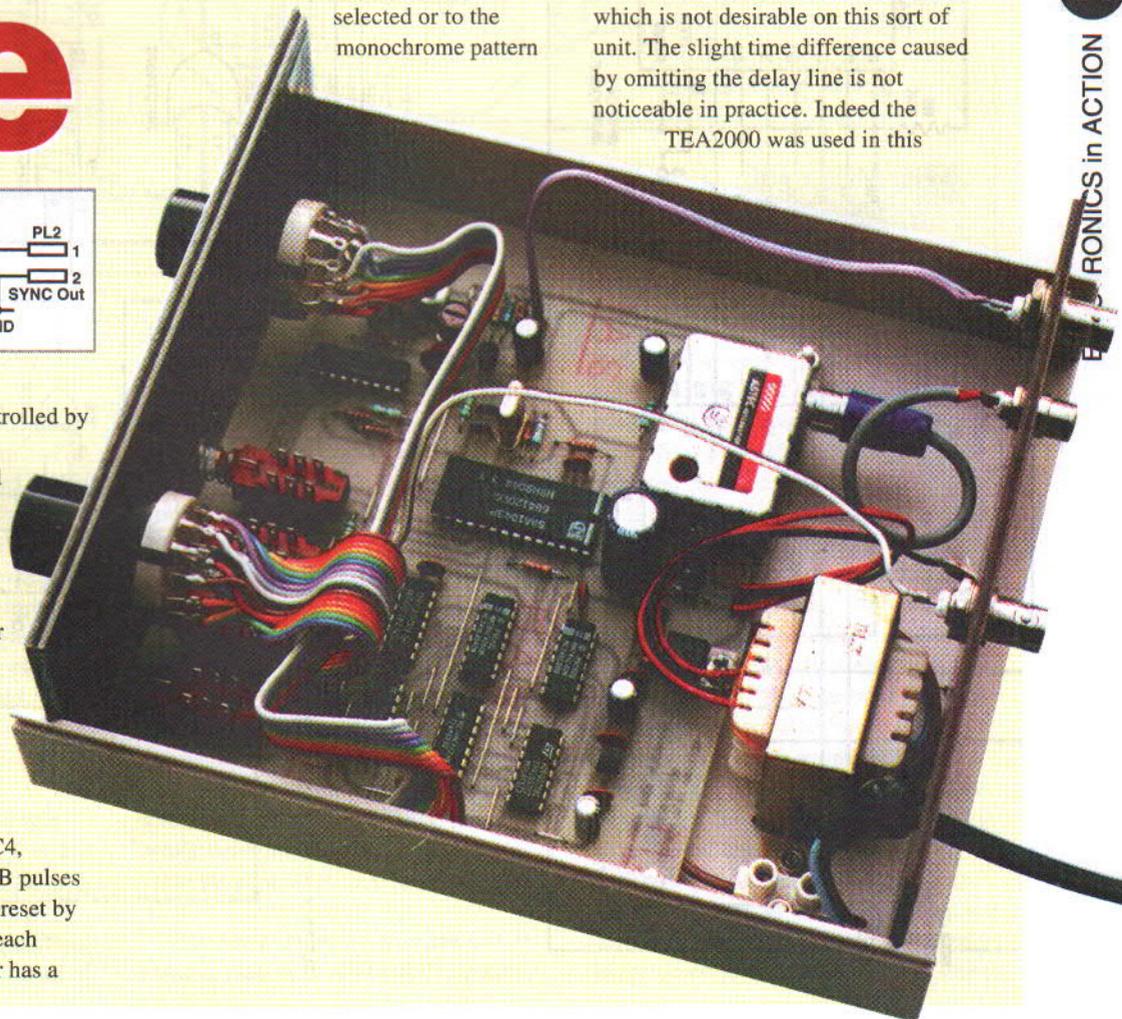
logic.

For the monochrome patterns, all six lines are taken high or low together, giving bright white or black. SW1 selects which pattern is displayed. The vertical bars are obtained from an OR gate on three outputs of IC3. The output of this OR gate is low when the three lines are low, this is inverted by the gate of IC6 after SW1. The horizontal lines are obtained by a similar arrangement on the outputs of IC4.

The crosshatch is obtained by an AND gate on the horizontal and vertical line signals, while the dot pattern is derived from an OR gate on these signals. The two checkerboard patterns are due to exclusive-OR gates on an output from each counter.

Two switches (SW1 and SW2) were used for pattern selection, since the logic required to do the job with one switch would complicate the unit significantly. The three primary colours are individually switched by SW3, SW4 and SW5.

According to the data sheet for the TEA2000, a 270ns luminance delay line should be connected between pins 7 and 8, to compensate for the slight delay in the chrominance signal caused by the chrominance filter L1/C20. However in practice this delay line causes ringing, which is not desirable on this sort of unit. The slight time difference caused by omitting the delay line is not noticeable in practice. Indeed the TEA2000 was used in this



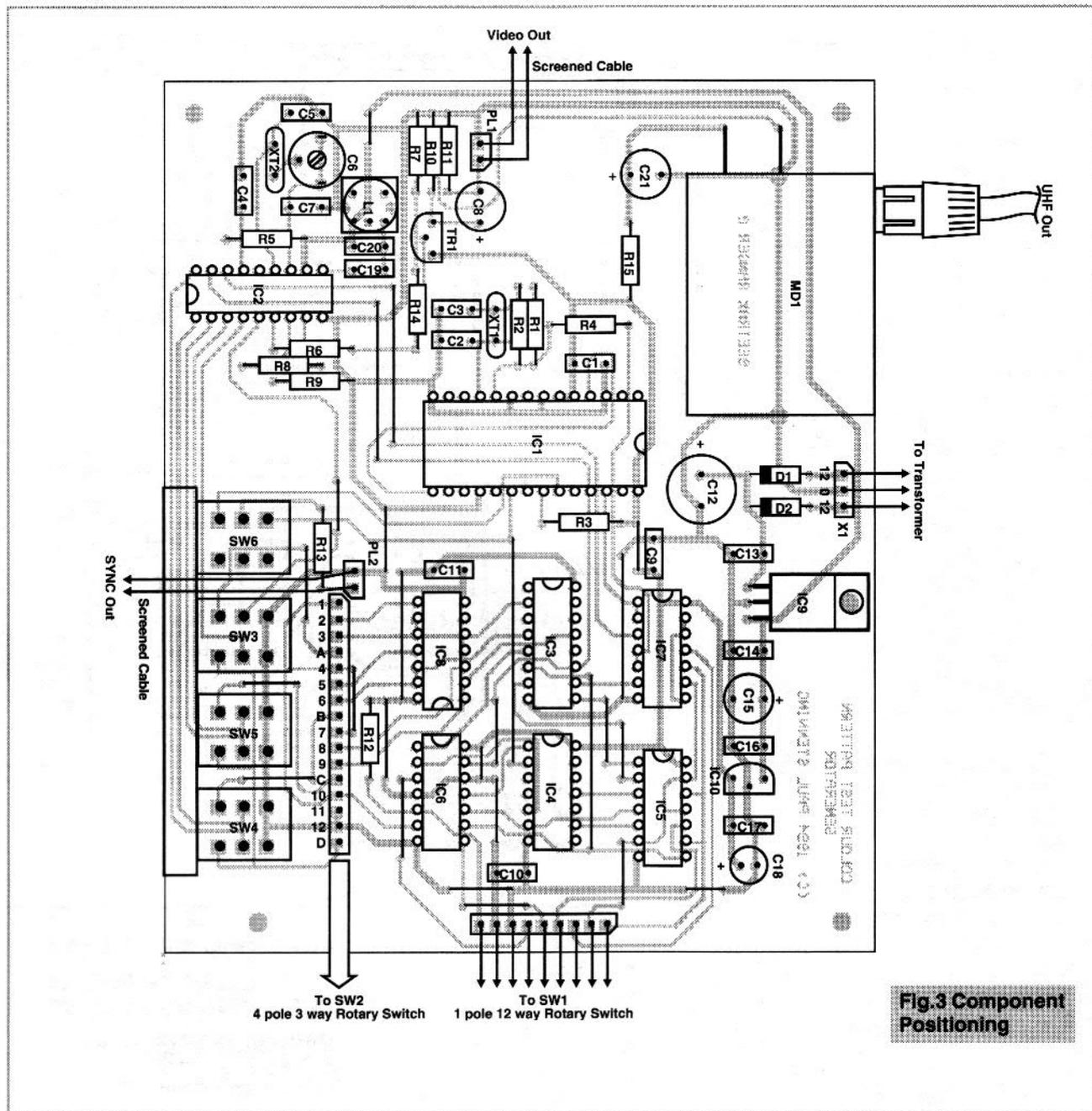


Fig.3 Component Positioning

configuration in the Sinclair Spectrum +2 computers.

TR1 buffers the output from pin 6 of IC2 for the composite video output. The UHF modulator is also connected to this point, the correct signal levels for both outputs being obtained by R6, R14 and R7. The modulator was found to be affected by noise on its power supply rail, this is therefore locally decoupled by R15 and C21. The power supply circuit is completely standard and requires no explanation!

Construction

The circuit is assembled on a single sided PCB, 130mm x 110mm. This has been redesigned slightly since the prototype, so the buttons on the push switches now sit next to each other properly. If a mounting bracket is used

on these switches the latch mechanism should be removed and the individual switch latches retained.

The component overlay is shown in Figure 3. PCB construction is completely standard, so I won't bore you with the details! IC9 should be screwed to the PCB, but does not need a heatsink.

The prototype was constructed in a plastic case, 190mm x 165mm x 68mm, see parts list for details. A suitable overlay for the front panel is shown in Figure 5. Two photocopies may be taken (162mm x 64mm), one can then be used as a drilling template while the other may be fixed to the front panel with clear self-adhesive vinyl.

The rectangular hole for the switch buttons may be made by drilling a

6mm hole at each end and cutting out the remainder with a junior hacksaw blade. This can then be finished with a small file. Two, 10mm holes are also required for the rotary switches.

If the PCB is fitted in the case with 6mm long spacers, it should be the correct height for the switches to line up with the front panel. Set the end stop of SW1 to 8 positions and SW2 to three positions, and fit the switches to the front panel. The rear panel should be drilled for two BNC sockets, one phono socket and a grommet for the mains flex. The transformer should be mounted at the rear of the case away from the modulator.

The PCB can now be wired using the connections as shown in Figure 3. Multicoloured ribbon cable was used in the prototype for the switches, video

Fig.4 Foil Pattern

Resistors (0.25W 5% or better)

R1	3M3
R2,4,8,11	1K0
R3	4K7
R5	36K (2% preferred)
R6	390R
R7	470R
R9	820R
R10,14	150R
R12,13	10K
R15	10R

Capacitors

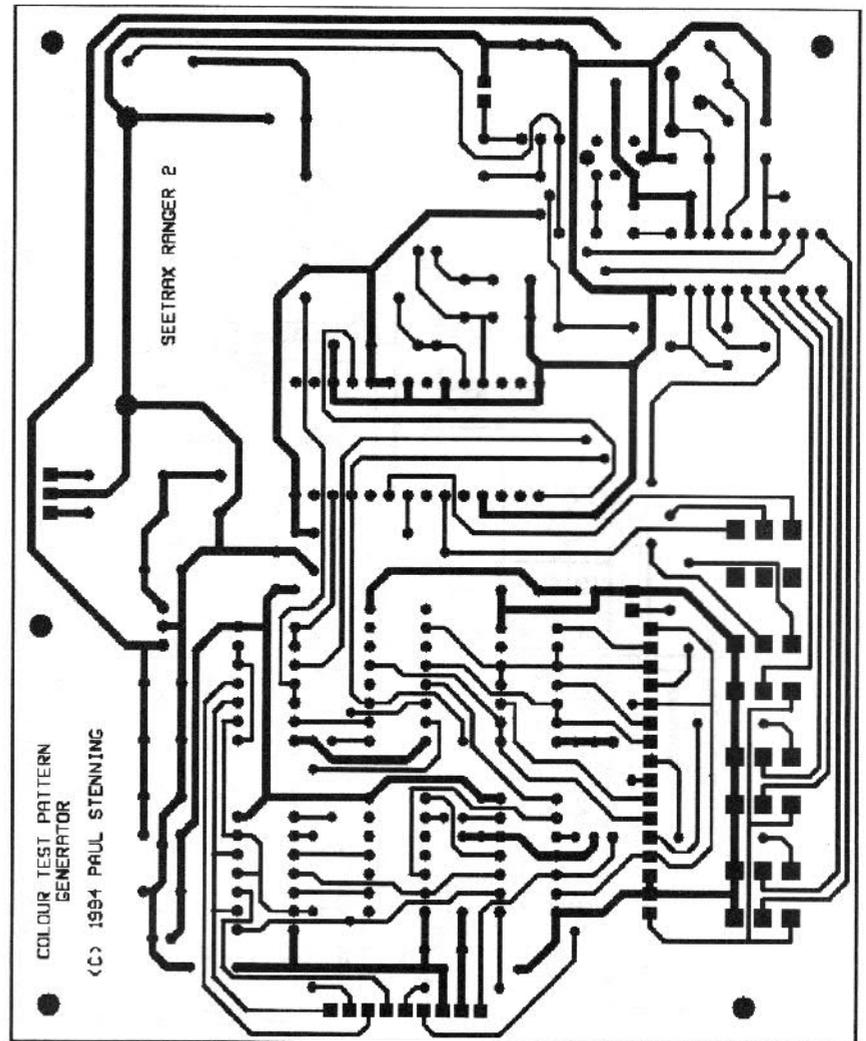
C1,9,10	
C11,13,14	
C16,17	100nF
C2,3	47pF
C4	330pF (5% or better)
C5,7	5p6
C6	22pF Trimmer (Maplin)
C8,15	100uF/16V
C12	2200uF/25V
C18	10uF/16V
C19	10nF
C20	82pF
C21	47uF/16V

Semiconductors

IC1	SAA1043 (Maplin)
IC2	TEA2000-V1 (Maplin)
IC3	74HCT4040
IC4	74HCT4024
IC5	74HCT4075
IC6	74HCT86
IC7,8	74HCT00
IC9	7812
IC10	78L05
TR1	BC548
D1,2	1N4001

Miscellaneous

XT1	5.000MHz
XT2	8.867 MHz
L1	15uH Adjustable (Maplin)
PL1,2	75R BNC Panel Socket
SW1	1 Pole 12 Way Rotary Switch
SW2	4 Pole 3 Way Rotary Switch
SW3,4,5,6	DPDT PCB Push Switch (Maplin)
MD1	UM1233 (Maplin)
X1	12-0-12V 250mA Transformer



Phono Socket
Phono Plug
PCB
Case
Knobs for Switches
Ribbon Cable
Co-ax Cable
2 Core Mains Flex
Choc-block
13A Plug with 3A Fuse
Sockets for IC's if Required.

The plastic case used for the prototype is made by Bafbox, and is available from RS/Electromail, stock no 506-788.

The PCB is available from Electronics in Action.

Parts

output socket and sync output socket. A short length of co-ax fitted with a phono plug extends the UHF output from the modulator to the rear panel phono socket. The mains input flex is connected to the transformer leads with a choc-block connector.

Testing and Setting Up

Providing the unit has been carefully constructed there is no reason why it should not work first time. Connect the

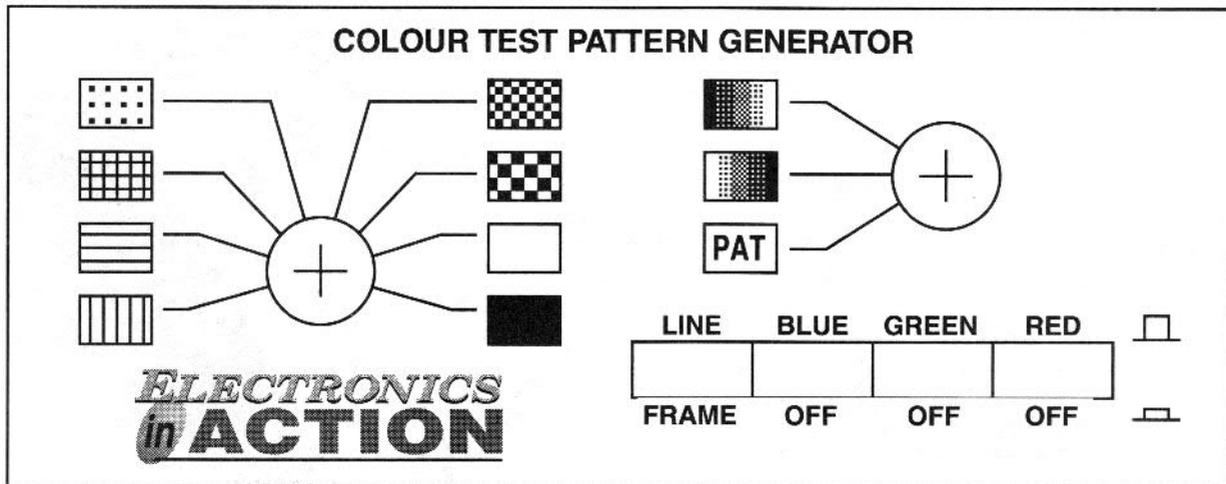
unit to the mains. If a test meter is available, check the +12V and +5V (Vcc) rails are correct. Connect the UHF output to a television and tune in to UHF channel 36 (often used for video recorders and video games). Ensure the four push switches are out. Set SW2 fully clockwise and a set of colour bars should appear.

Adjust C6 with a suitable trim-tool until the colour locks on, and then trim for brightest colour. Now adjust L1 for

the clearest colours and a well defined edge where the colours change. This will probably be about a third of a turn up from the bottom. If an oscilloscope is available this can be connected to the video output and L1 adjusted to peak the amplitude of the colour information on the signal.

If SW2 is turned to the centre position, the direction of the colour bar pattern should reverse. If the switch is now set fully anti-clockwise, the pattern

Fig.5 Front Panel details



displayed is controlled by SW1. Check SW1 works as expected, then set it to the white screen position and check SW3, SW4 and SW5.

In Use

Operating the unit has already been detailed adequately above. One final important comment - if you are working inside a television set or other piece of equipment with the power on, please be very careful.

Footnote

Several examples of my electronic design work have appeared within the pages of Electronics in Action. I would be interested in considering any offers of electronic design work (except defence) on either a contract or full time basis. Please contact me initially in writing at the following address:

Paul Stenning, 1 Chisel Close, Hereford, HR4 9XF

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The Mains Attraction



Be safe and test your mains sockets with this very simple gadget.
A mini project by Mark Price

You know the situation - you've spent all day knocking channels and holes in the plaster, and burying the cables. It's now nearly midnight, and you're just fitted the socket plates and turned the power back on. You could get the multimeter out and check it's all wired correctly, but you really can't be bothered. After all you joined the three wires to the right terminals didn't you? And the earth wire didn't come away when you screwed the plate in place, did it? Can you be certain it's correct?

Wouldn't it be useful to have a little whatsit that you can plug into the socket, and that'll tell you instantly if it's wired OK or not. A professional electrician would have a test plug with three neon lights to do just this. However these items are not readily

available in DIY stores.

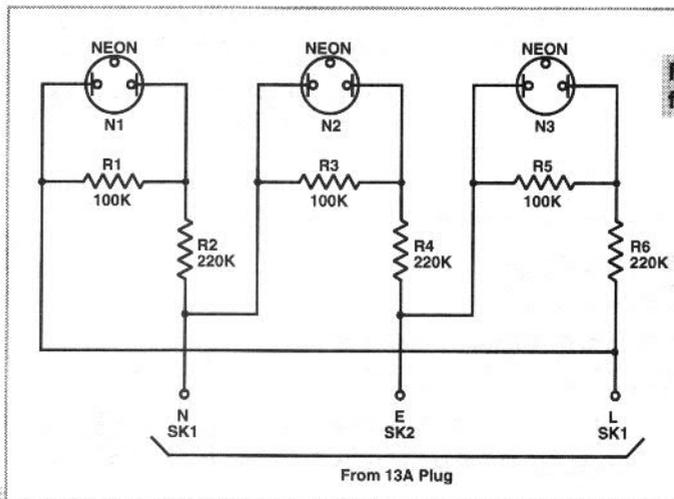
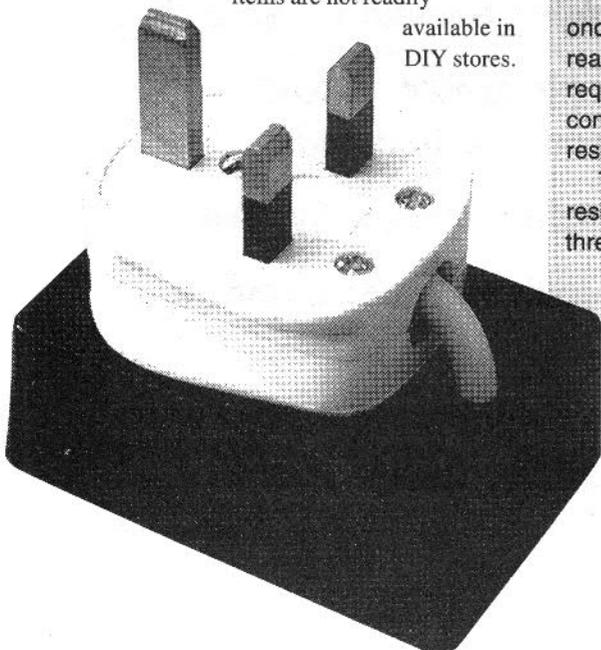


Fig.1 Circuit for tester

The Works

The complete circuit diagram is shown in Figure 1.

The neon lamps will illuminate once the voltage across them reaches about 70V. The current required is less than 1mA, which is controlled by the series 220K resistor.

Three sets of neon and series resistor is connected between the three pins on a 13A plug. With a correctly wired socket, the Live to Neutral and Live to Earth

neons only, will light.

The additional 100K resistors in parallel with each neon prevent the neons lighting if there are two in series. This would happen if the Earth or Neutral wire was not connected.

This unit can reveal all common socket wiring errors, except Neutral and Earth reversed. Since these two lines are at almost the same potential this is impossible to detect with a simple testplug.

You can get them from electrical trade counters and wholesalers, but they cost around £40, which is rather expensive for the occasional DIY job.

The testplug described here does

exactly the same job as the professional ones - and works the same way. However this one uses about six pounds worth of readily obtainable bits.

The testplug is also useful for checking multiway adaptors and

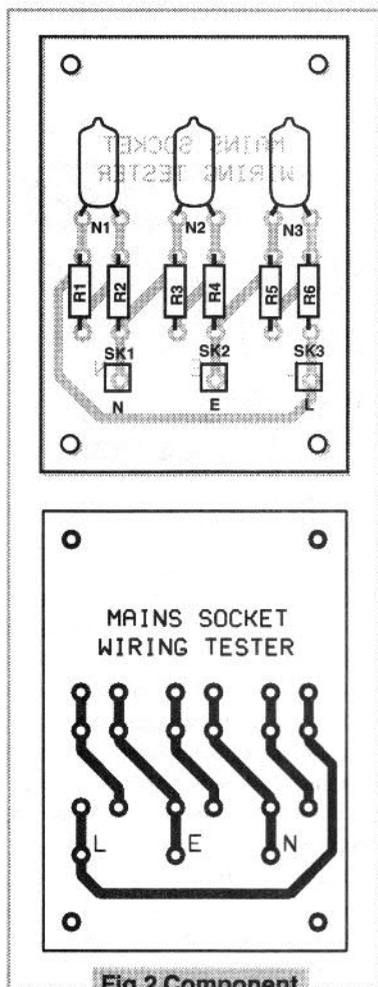


Fig.2 Component positioning and foil pattern

extension leads. Earth faults are surprisingly common with these, and will normally pass unnoticed until the worst happens.

Construction

The neons and resistors are mounted on a small PCB, which is available from the EIA PCB service. The component positioning is shown in Figure 2.

Before fitting the neons, attach a white self adhesive label to the PCB, with the bottom edge 5mm above the neon holes. This is to reflect the light from the neons. Bend the neon leads 5mm from the body before fitting into the PCB. Although the PCB assembly is straightforward, please take care to avoid errors.

The PCB is fitted into a small plastic box (type T3), which is mounted on the back of a normal 13A plug. The original plan was to use one of the small cases fitted with plug pins, intended for small power supplies. However these are not readily available with a metal earth pin.

Select a 13A plug with a flat back (many are slightly curved). Ideally this should be made of the softer unbreakable plastic, since this is easier

to drill. The plug used on the prototype originated from the far east and was branded PMS.

Remove the back from the plug, and drill two 3mm holes in convenient positions. On the prototype, one hole was above the cord grip and the other was in the void between the Neutral and Earth pins.

Position the plug back on the base of the box, about 5mm down from the top, and mark the positions of the holes. Drill the holes and fix the plug back in place with two 6mm long M3 screws and suitable nuts. Drill a hole in the back of the box, below the plug cable entry position, to suit the three core being used.

Take a 100mm length of this flex and connect one end correctly to the plug base. Fit a 3 Amp or lower fuse in the plug. Feed the other end of the wire through the hole in the box, and screw the plug together. Fit a cable tie around the cable on the inside of the box. Strip the outer insulation back, inside the box.

Position the PCB centrally inside the box lid. Mark and drill the four 3mm fixing holes and three 6mm holes for the neons to show through. If a piece of clear or red filter material is available this should be glued inside the case over the holes.

If the unit is correctly assembled there is no reason why it should not work first time

Cut the wires to length and solder to the PCB as shown on the component overlay. Mount the PCB with M3 nylon screws or insulated spacers. Ensure that any metal parts outside the box are not connected to any metal parts inside the box.

When fitting the lid onto the box, ensure the wires do not lay underneath the PCB. A suitable front panel overlay is shown in Figure 3. This may be photocopied and fixed to the case with clear self adhesive vinyl.

Testing

NEVER OPERATE THIS UNIT UNLESS IT IS FULLY ASSEMBLED. MAINS VOLTAGE CAN KILL - PLEASE BE VERY CAREFUL!

If the unit is correctly assembled there is no reason why it should not work first time. If a residual current (earth leakage) circuit breaker is available, it would be

sensible to plug the testplug into this for initial testing. Assuming your socket is wired correctly, the outer two neons should light and the centre one should remain off.

If you wish to try the various fault conditions, this can be achieved by altering the wiring in one end of an extension lead. Switch the mains off and unplug before touching any connections, and replace all covers before switching back on. Be sure to rewire the extension lead correctly when finished.

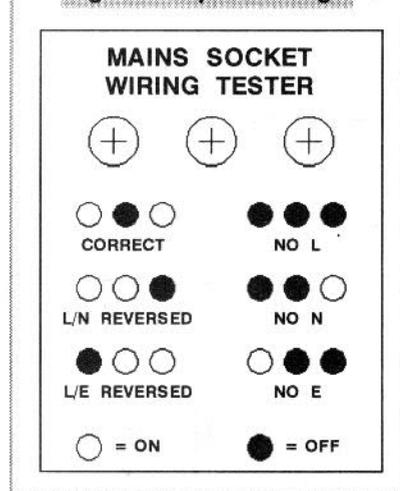
In Use

Using the testplug is extremely straightforward. Simply plug it into the socket, if the outer neons light the socket is wired correctly. If any other combination of neons illuminate, there is a fault with the socket which must be investigated. A faulty socket must not be used under any circumstances.

When testing extension leads and multiway adaptors, wiggle the test plug around and check that the neons do not flicker. Many multiway adaptors have poor earth contacts which can give intermittent operation.

Never take any chances with mains electricity. If you are in any doubt, please seek expert advice.

Fig.3 Front panel design



Resistors

R1,3,5 100K 0.25W

R2,4,6 220K 0.25W

Additional Components

N1,2,3 Wire Ended Neon Lamp

PCB

13A Plug (see text)

3A Fuse

Box Type T3

3A Three Core Mains Flex

M3 Screws Nuts and Spacers

Cable Tie

Parts

We mentioned back in Part 1 that the introduction of extraneous semiconductor devices (the Analog Devices SSM 2412 solid state switch IC's) into the audio pathway might be perceived by the subjectivist brigade of the hifi purists as ruinous of overall quality. This is very much a subjective description, since I was unable to measure any distortion whatsoever (better than 0.01%) using the test equipment which was to hand. Furthermore, this was with an input level of some +16dBu (about 7V RMS), so with the much lower signal

magnitudes normal in domestic hifi equipment, distortion SHOULD be better by an order of magnitude.

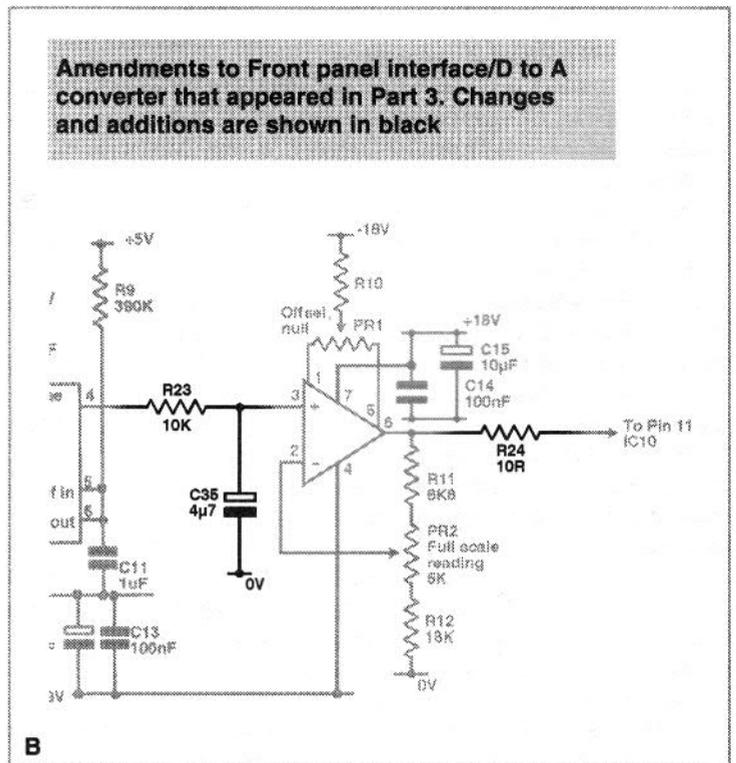
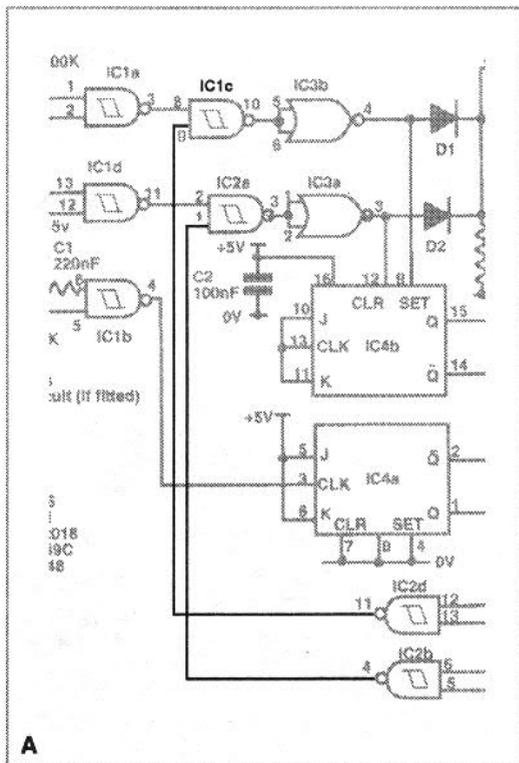
Noise was also below measurable limits, except on a Hewlett Packard Dynamic Signal Analyser, which showed it to be around the -105dBu mark. From these two measurements, most audio engineers would surmise that both distortion and noise performance of the system are up to good pro-audio standards ie better by an order of magnitude than most of the mid-priced domestic hi-fi equipment.

However, in order to appease the diehards who believe ALL of the specifications given with domestic equipment (as regards noise and distortion performance), I've designed a version which uses relays, rather than solid-state devices, to implement the switching function. In this way, those

who wish the output to sound as clean and unimpaired as the original (the input), might just be satisfied. Rather coincidentally (and sadly, if you've already built the solid-state version), the relay version is much less expensive to build (about £30 at present day prices).

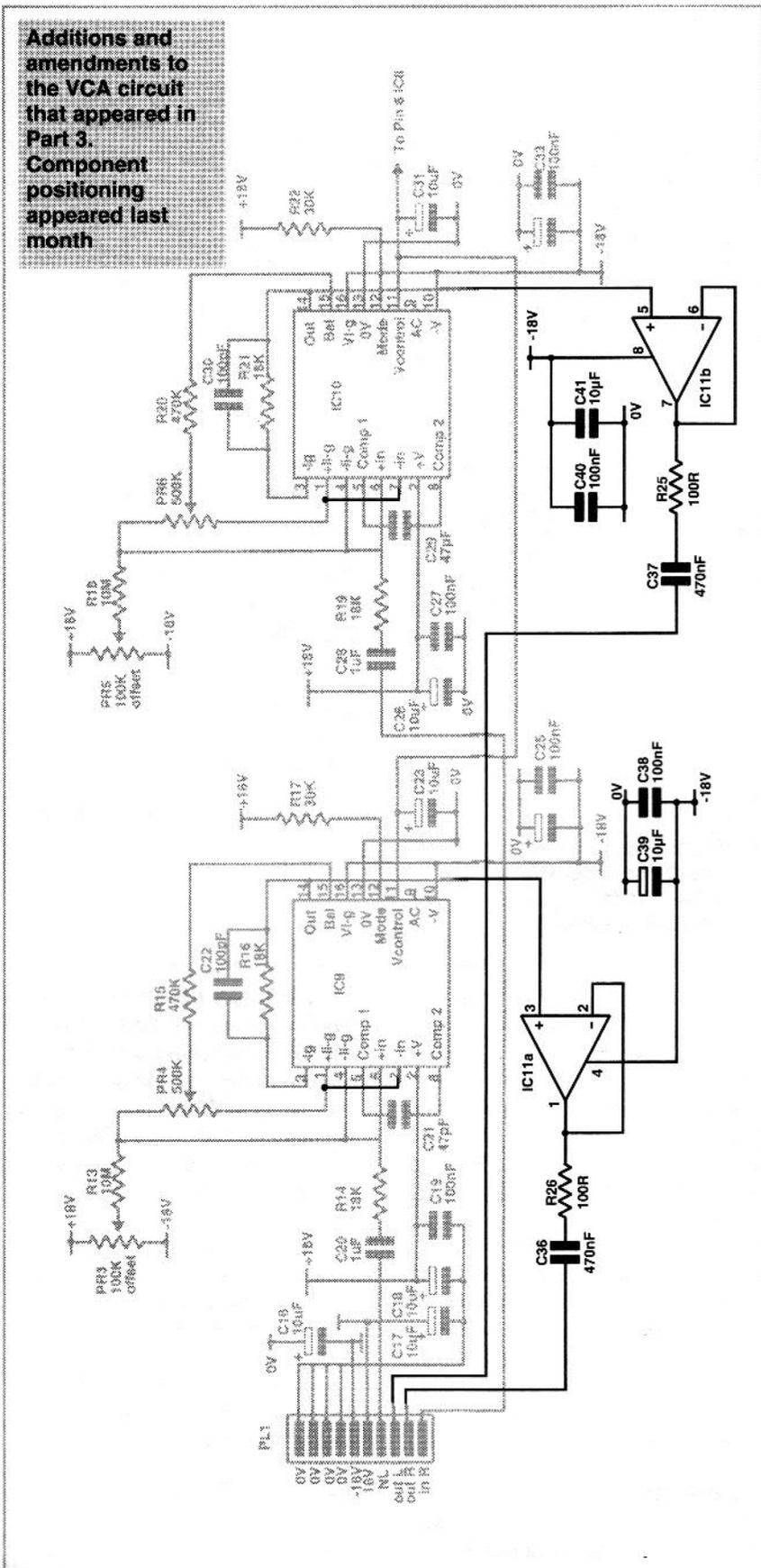
Unfortunately, my enthusiasm probably doesn't extend quite as readily as it might. Where solid state devices are used in an application such as this, adherence to the manufacturer's guidelines detailed in the application notes, a bit of breadboarding and tweaking of component values, and finally, common-sense implementation of track-routing and ground-planes at the PCB design stage should realise a problem-free and successful layout.

Systems using relays aren't quite so forthcoming. The step from what SHOULD be an error-free theoretical or breadboard design, to PCB layout, is



Amendments to Front panel interface/D to A converter that appeared in Part 3. Changes and additions are shown in black

Additions and amendments to the VCA circuit that appeared in Part 3. Component positioning appeared last month



filled with more traps and pitfalls than a typical Indiana Jones movie. It is difficult to predict what circuit pathways ground currents will take, and just what signals the induced voltages will affect as the relays contacts open and close, and the actuating coils source and sink what can be fairly hefty currents. In many ways, it is akin to the creation of a

hum and noise-free earthing or grounding system in any medium or large audio electronics. Someone much wiser than I once said, "Rules are for the blind obedience of fools and the guidance of wise men." A wise fool often compromises in situations like this, breaking with accepted convention, or theoretical dictates, in a effort to

eliminate hum or noise or relay-induced splats.

And so it is here. Relay circuitry and audio circuitry earthing conductors have been separated except at one point, where all earth points converge in the system star earth. Copious decoupling of supply rails, hefty earth and supply trackwork, isolation and shielding of audio signals with earth tracks, and soft-start relay drive circuitry all help to eliminate some of the many problem which plague systems using relays or similar devices, either where these are used to route the audio, or other signals, but are in very close physical and electrical proximity to low level audio signals.

Operation Relay

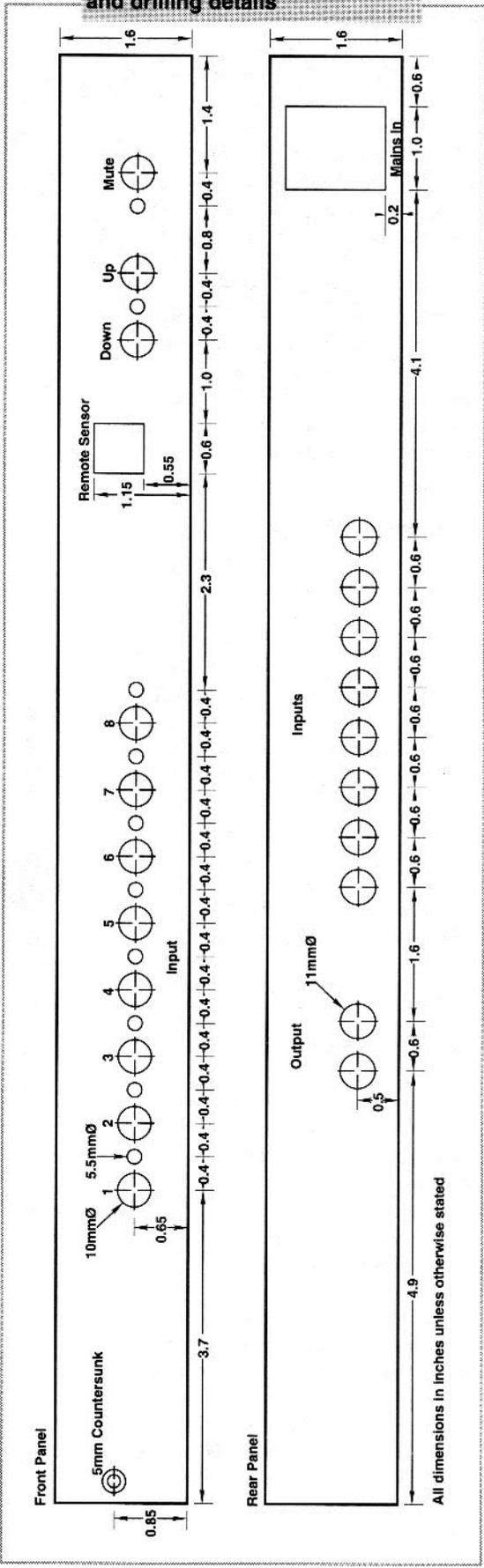
High quality, sub-miniature DIL-size DPDTreed relays are used to route one of four (or eight) audio sources onto the main left and right audio busses. Blocking capacitors remove any DC offsets from the audio inputs - which would cause splats as the relays changed state - while pull-down resistors provide a good ground reference/load impedance for the audio sources. Explanation of the workings of the logic and source selection circuitry was made in Part 1 and reference is made to this. The output stages of the CMOS IC's employed aren't hefty enough to drive very much at all, so a transistor driver is interspersed between relay and logic output to provide the necessary drive current. (I've found this to be good practise no matter what the load - even an LED - since there is no absolute guarantee that connecting such devices directly to the output, while not causing immediate death, may in fact be responsible for premature and unexplained expiry. However, I do SOMETIMES break this rule where the application demands).

A CR circuit on the transistor base provides a small time constant, and means that the relay pulls in (or releases) after a short delay. This helps to soften any transients that might be produced as the coils energise and de-energise, since the control voltage is no longer a step waveform with a theoretically infinite rise time.

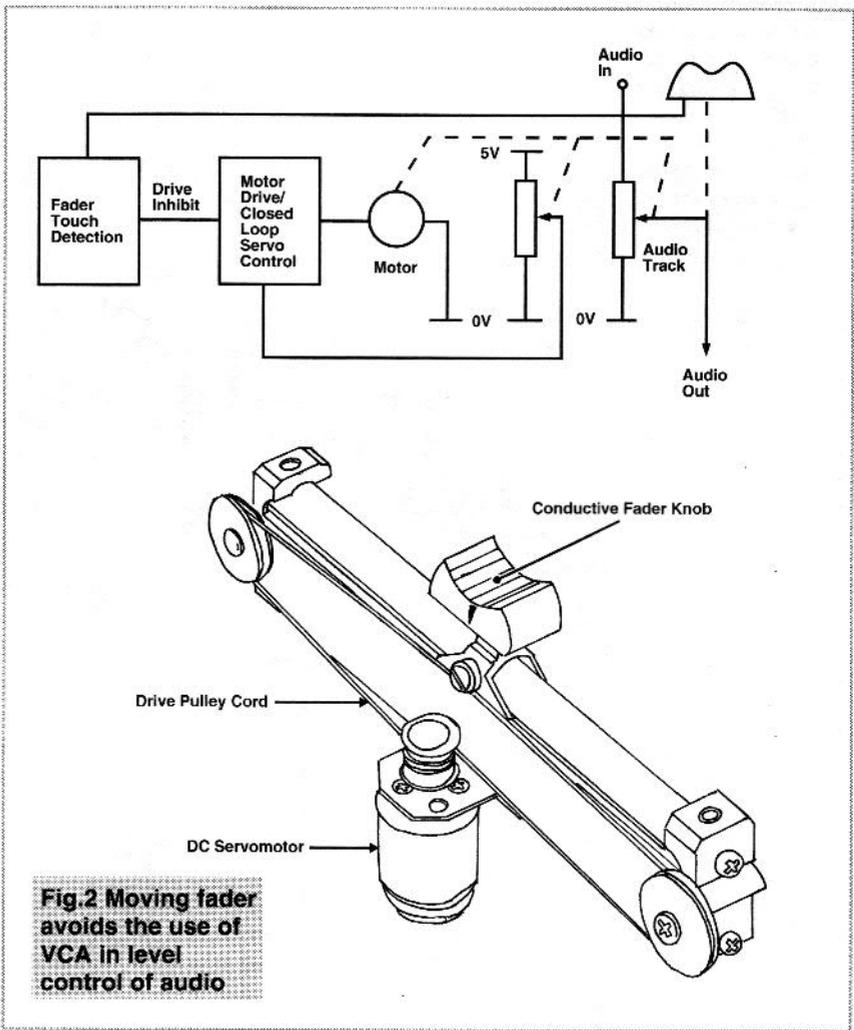
Construction

General construction procedures follow those outlined in Part 2, with components mounted in the order specified at that time (basically in order of ascending size). The relays are soldered directly to the PCB trackwork.

Fig.1 Front panel dimensions and drilling details



Where parts of the component overlay are NOT shown in Figure 2, these can be assumed to be identical to those shown for the solid-state version. Please note that all components necessary for the relay version are shown with a suffix of



1 (eg R101, C123), and are the parts required in addition to (or in some cases, instead of) those given for the solid-state version. As some of the parts used in the solid state version are superfluous (eg the SSM2412's), this system shows more readily what parts are different and the ones to look for on the component overlay.

Procedures for the verification of functionality, and for testing, are identical to those of the solid state version and again, reference is made to those. Finally, the amendments to the VCA circuit diagram is shown on page 19 and changes to The Switcher analogue board are shown on page 18.

The Future

For those dedicated audiophiles building the relay version for purist reasons (rather than for reasons of out and out economy, or downright meanness), the VCA board is unlikely to hold much attraction. VCA's and their inclusion in the pathway of high quality audio has been the subject of much heated debate and argument for as many years as the devices have been in existence. They are most likely to cause disparaging remarks and rude comments when fitted

to mixing desks, since these are used to generate the masters (DAT or CD), and any impairment perpetrated by the mixer is irretrievable and will remain for ever more. Electronics in a piece of equipment such as a mixing desk should be as transparent as possible - no colouration, distortion, noise - within the constraints of cost. In general, VCA's are fitted at the lower end of the market - a relative term, if ever there was one - with the moving fader approach preferred where money permits or quality dictates.

A typical moving fader is shown in Figure 2. Audio passes through the carbon track and onto the wiper as it would in a normal linear potentiometer (fader). There are thus no active devices to add distortion or noise to the signal. However, the fader is actuated by a cord/worm drive/DC servo motor arrangement. The motor positions the fader at the gain or attenuation setting dictated by the automation system, with the servo track of the potentiometer providing the feedback necessary for the control system. Furthermore, the fader knob is made of a conducting material, and is incorporated into a system where the motor drive is disengaged whenever

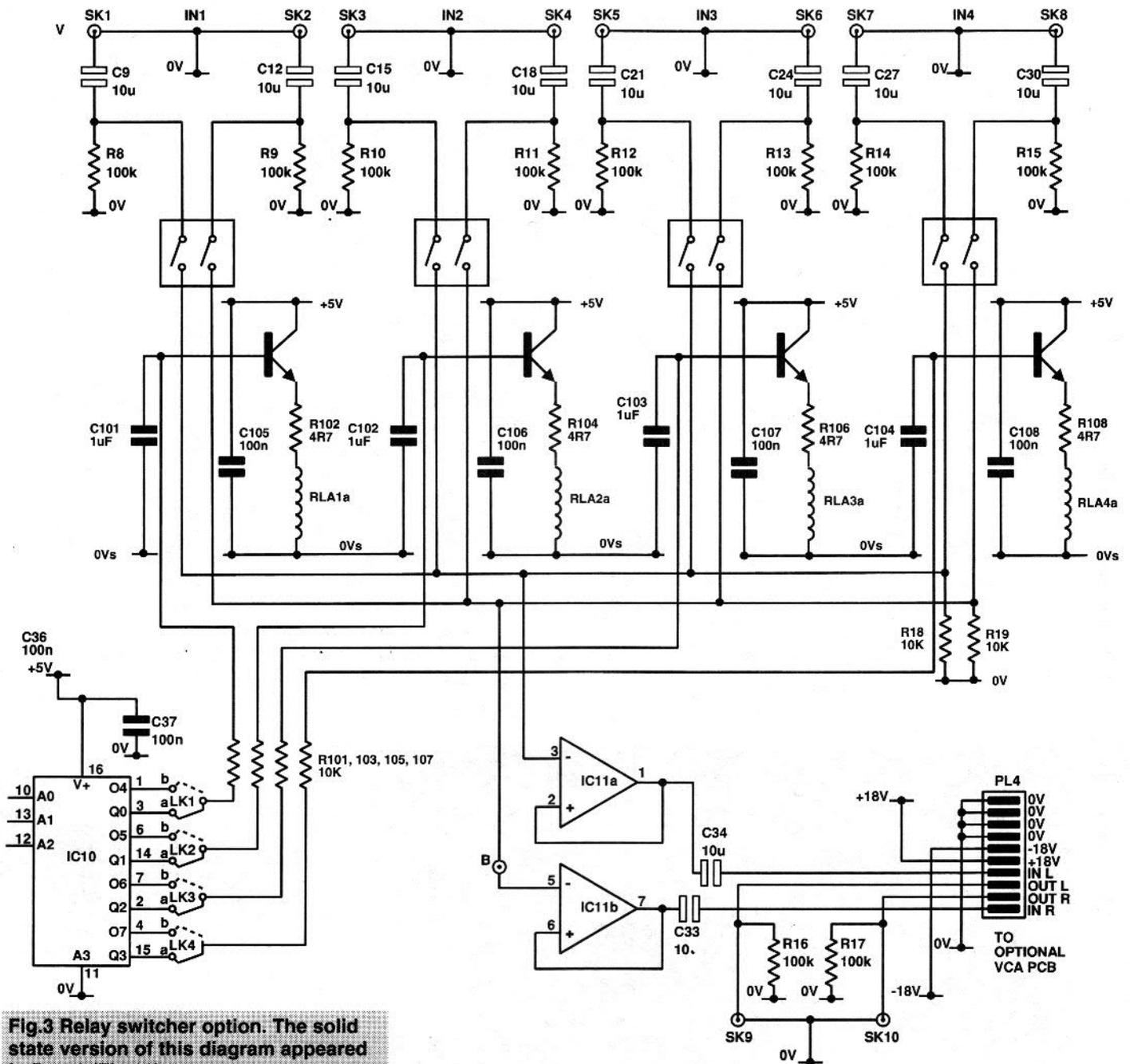


Fig.3 Relay switcher option. The solid state version of this diagram appeared in Part 1 (Fig.12)

a touch on the fader is detected. The engineer can thus move the fader manually, either to create the mix in the first place, or to fine-tune one already down-loaded from the storage medium of the automation, without fear of the motor drive trying to interfere or counteract his/her adjustments.

As far as domestic hi-fi systems are concerned, many of the better examples of the genre where remote control of facilities is still desirable and provided for, do away with the VCA method of volume control and instead use a simplified ROTARY example of the system outlined above - the motorised volume control. I may, at some time in the future, look into the feasibility of

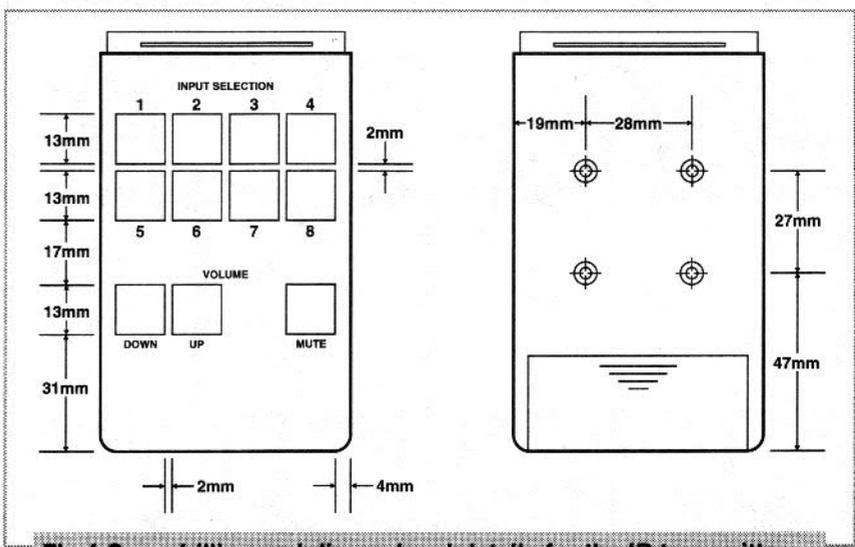


Fig.4 Case drilling and dimensional details for the IR transmitter

providing such an add-on for The Switcher.

Finally, a further board which will definitely feature as an option at some time in the future will be The Balancer. This will provide preamplification and unbalancing of balanced audio sources (which are ubiquitous in a studio or professional audio environment). It would also provide balanced/unbalanced output capability, and so might be of great use where it is necessary for many balanced feeds to share a common input (perhaps a mixing desk channel...) The mind boggles. As they say in the advertising industry, watch this space.

Switcher Main Analogue/PSU board (Relay version)

- R1,3 1K8
- R2,4 220R
- R5,6,7 4K7
- R8-17 100K
- R18,19 10K
- R101-104 10K
- R105-108 4R7
- SIL1 100K Single In Line 8-way resistor array

- C1,3 1000µ/40V radial electrolytic
- C2,4,5 220n polyester
- C6-8, 33-37 100n polyester layer
- C9,12,15,18 } 10µ/50V non-polarised radial electrolytic
- 21,24,27 } 30,33,34 }
- C101-104 1µ polyester
- C105-108 100n polyester

ICs and Diodes

- IC1 7805
- IC2 LM317T
- IC3 LM337T
- IC4-7 omitted
- IC8 4071
- IC9 4042
- IC10 4028
- IC11 LM833
- Q1-4 ZTX 653
- D101-104 1N4002
- BR1 S005 2A, 50V Bridge Rectifier

Additional Parts

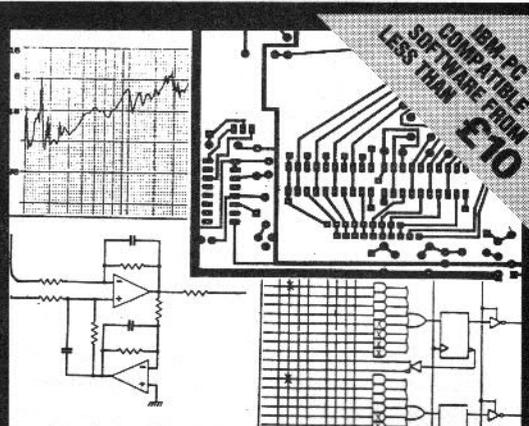
- RLA1-4 PCB-mounting DPDT reed relay (Maplin FX90X)
- SK1-10 PCB mounting phono sockets
- PL1 4way Minicon latch plug
- PL2-4 10 way Minicon latch socket
- FS1,2 5 x 20 PCB mounting fuseholder, 500mA A/S fuses to suit PCB, DIL IC sockets to suit, 18-0-18-0 15VA Toroidal Transformer
- TO220 vaned heatsink, case and front panel, IEC fused mains inlet (Front Panel Interface Parts List as for Solid State version of Part 1)

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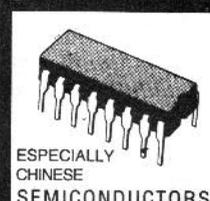
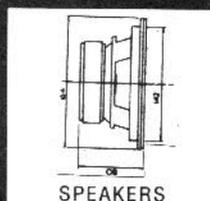
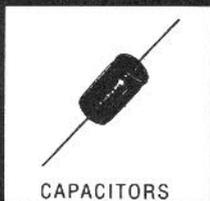
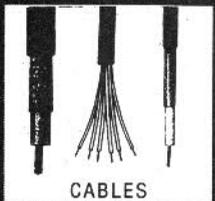
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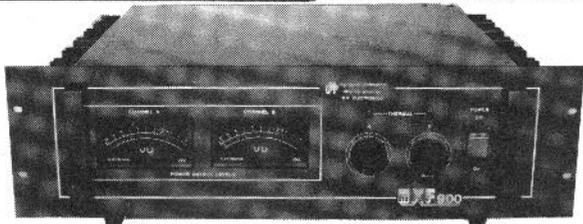


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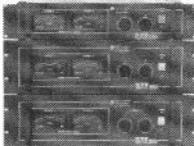
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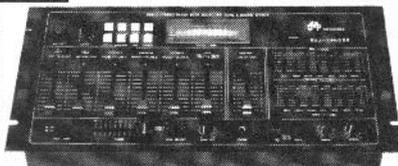
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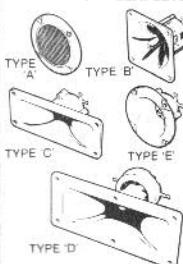


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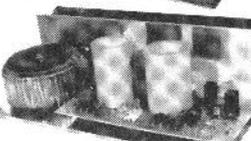
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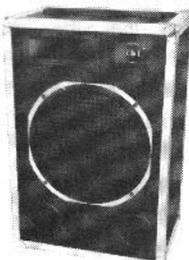
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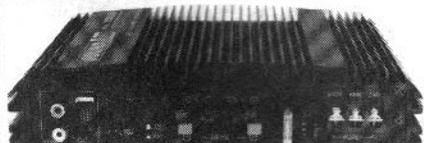
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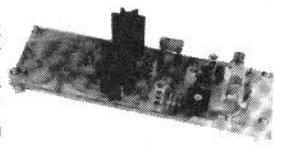


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Signal to NOISE

The Editor, Electronics in Action, PO Box 600, Berkhamsted, Herts. HP4 1NL

It's that Vocoder again

After having read a copy of your magazine for the first time, I was very impressed with your project for a vocal harmoniser. I have been involved in electronics for several years now, but only in the capacity of putting together projects from magazines. I try to do my own little projects but soon become stumped when it does not work properly.

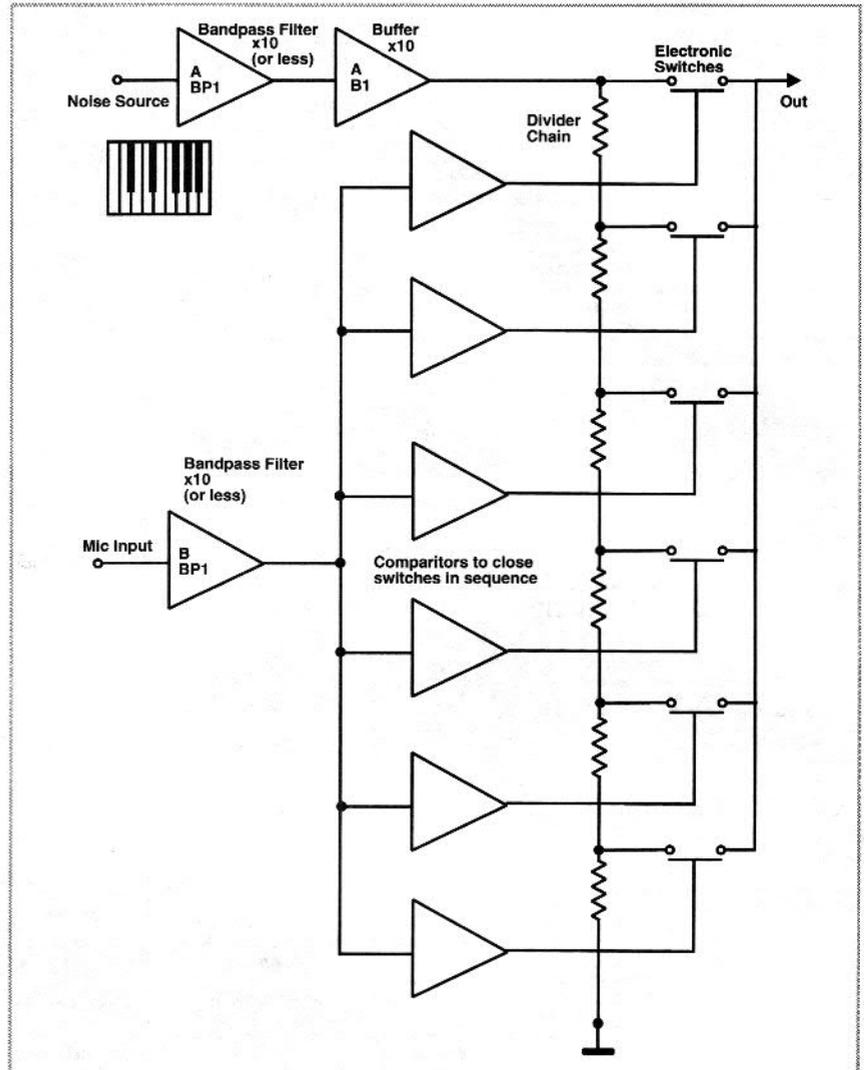
I have been trying to make what is known as a vocoder for five years now. This is a type of voice synthesiser. As there has not been any such projects published that I know of makes it difficult to find out how it works. I have made various attempts but have been doomed to fail. What I do know about these devices is that it uses spectral analysis and filtering. There follows a description of how I believe it would work. I'm sure this would make an interesting project.

Circuit Description

The first thing is for a noise source say from a synthesiser to pass through some band pass filters, i.e. Band 1 at 32Hz (as in the spectrum analyser). The next part is to divide the voltage with a divider chain to get about 10 amplitudes from low to high volumes. The various amplitudes from the divider chain are then connected to electronic switches which are normally open. There is an identical set of band pass filters for the microphone input, but its the microphone input that controls the electronic switches via comparators of a bargraph display driver with 10 outputs set for linear dB scale. This should then modulate the noise source with the signal from the microphone.

Mr. D Crook
Epsom
Surrey

I know of only one vocoder home constructors project and that appeared in 1980. This was a large 16 filter job and all of these were placed on one PCB - a sizeable project! Thank you for your comments we will see what can be done - Ed.



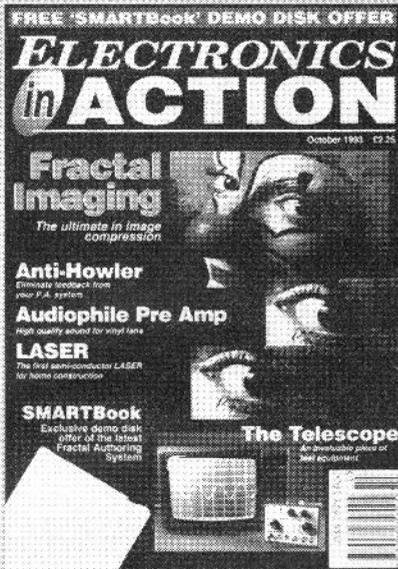
More Ideas for future articles!

We have purchased the last several issues of your magazine, particularly on account of an interest in the articles by Mike Meechan on The Switcher. The Switcher was particularly interesting because it maintained a true hi-fi approach. We have previously connected our computer (Macintosh) to our hi-fi (Revox) via an RS232 link to give extended timed-recording capabilities, and simple icon-driven control of the hi-fi. The Switcher gave prospect of extending the number of signal sources which could be accommodated, allowing the addition of satellite radio and extra tape-recorders, for example. But to make it work most conveniently, an RS232 link to The Switcher would be needed.

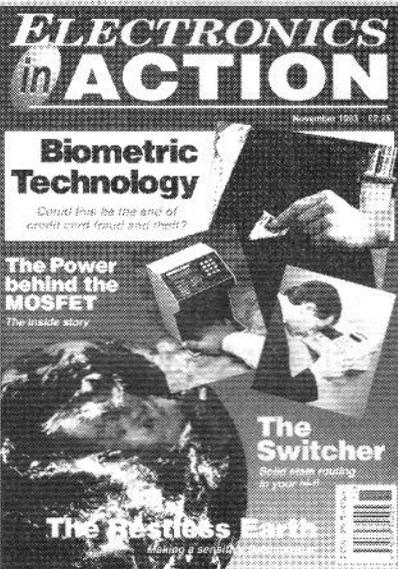
Links to allow control of a satellite aerial positioning device would also be useful. The general subject of computerised control would therefore also be of interest.

The recent article by Steve Brown of Celtel was also of great interest, and we will be exploring his system more fully. More articles on this theme would be most welcome - theoretical & practical, because I am sure that there are practical pitfalls to be avoided and it would be useful to know what they are! We are building a new house, and more on home automation & building management systems are therefore of keen interest to us.

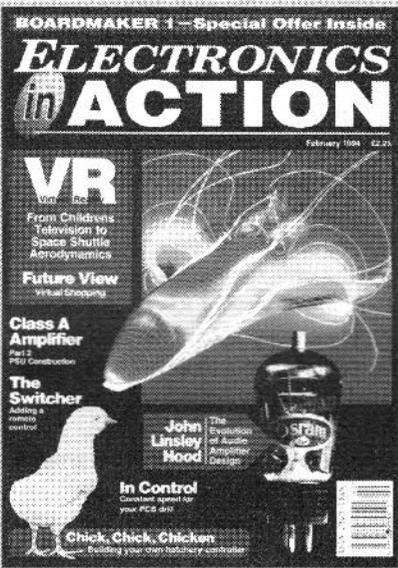
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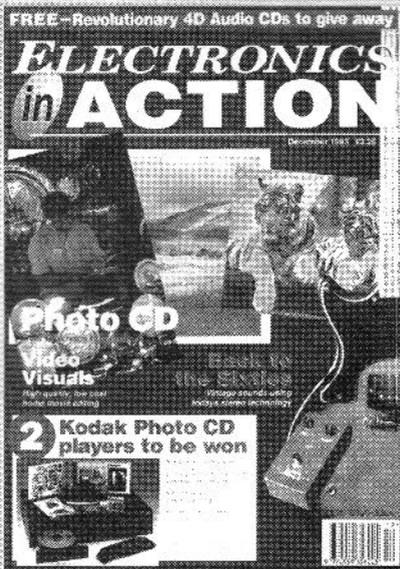
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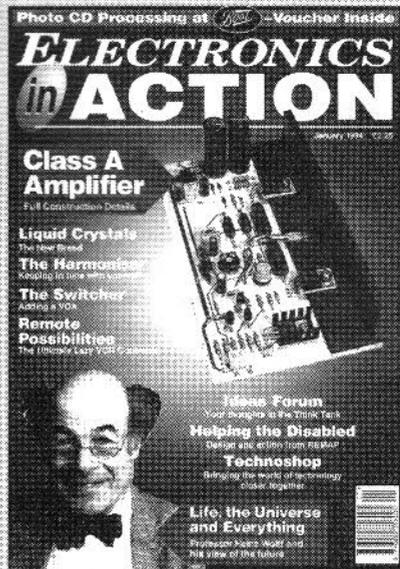
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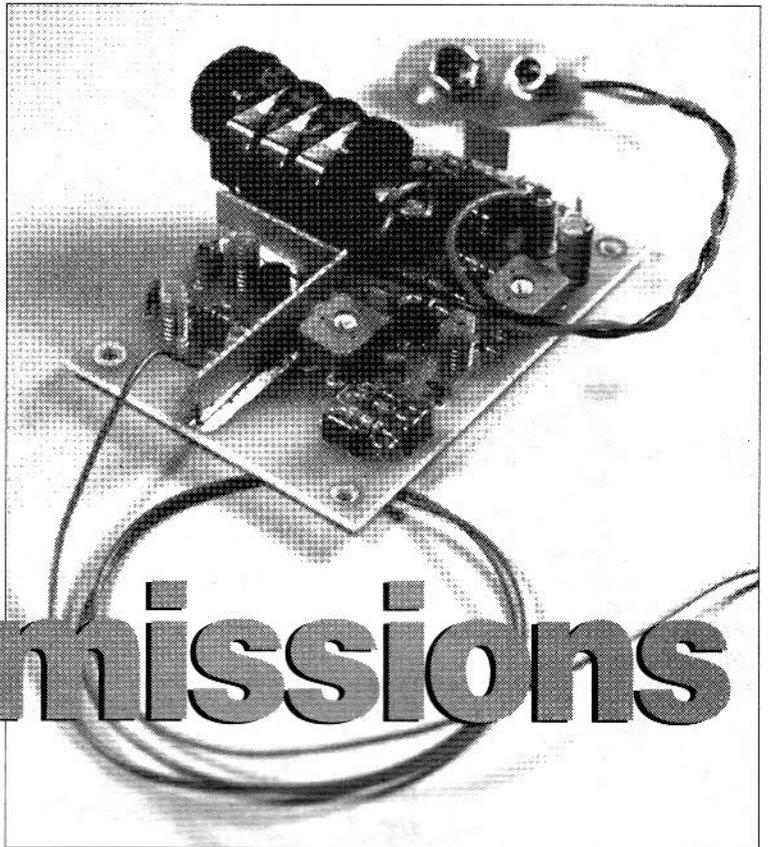
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Transmissions

A reader wrote to Electronics in Action to ask if the magazine could do a cordless guitar project. The good news is that it can be done; the bad news is that this type of project is not legal in the UK, due to DTI restrictions, though it is believed that it is acceptable in many parts of the world to which Electronics In Action is distributed.

For other readers, this project can serve as an example of how a cordless design works (and there are many types of cordless design which are legal in the UK). When I was a student I regularly got down to reading projects I didn't intend to build just to learn more about how electronics works.

There are two obvious approaches to try to design a cordless sound system of any sort: infra red and radio. I ruled out infra red because it needs a line of sight signal path, which cannot be guaranteed when a guitarist is moving about on stage.

The simplest radio system uses the FM broadcasting band, with a standard radio as the receiver. Obviously this can only work in (the majority of) areas in which there is at least one channel not in use.

FM broadcasting uses wide-band frequency modulation, rather than the narrow-band modulation used for amateur radio. What does this mean? Without getting deep into maths (this is probably not the place to digress into Bessel Functions) a frequency modulated signal theoretically has an infinite bandwidth, but the majority of

the power is concentrated in an bandwidth of approximately the deviation frequency plus the modulation bandwidth. So, for an FM signal with 3kHz deviation and 3kHz bandwidth, the majority of the power is within 12kHz (don't forget that the deviation is either side of the nominal carrier frequency).

Wideband FM uses a deviation greater than the modulation bandwidth, which is hard to achieve with a crystal oscillator. To modulate a signal this widely either requires a crystal oscillator (possibly as part of a synthesiser) with complex circuitry, or a simple LC oscillator. This latter is the approach chosen for this design.

Frequency Stability

Simple circuits I have seen published to transmit on the FM bands have used a single modulated oscillator to provide the transmission. This works, but the oscillator normally needs an aerial to give a useful range. The aerial inevitably forms part of the tuned circuit determining the oscillation frequency. This means that any variation of the capacitance of the aerial to surrounding objects alters the frequency. Clearly the guitarist moving around will affect the frequency and cause break-up of the reception.

The circuit of Figure 1 avoids this problem by using a separate oscillator and output stage. Capacitive loading on

the aerial will have a negligible effect on the oscillator, so the frequency will remain the same as the guitarist leaps about.

Oscillator Circuit

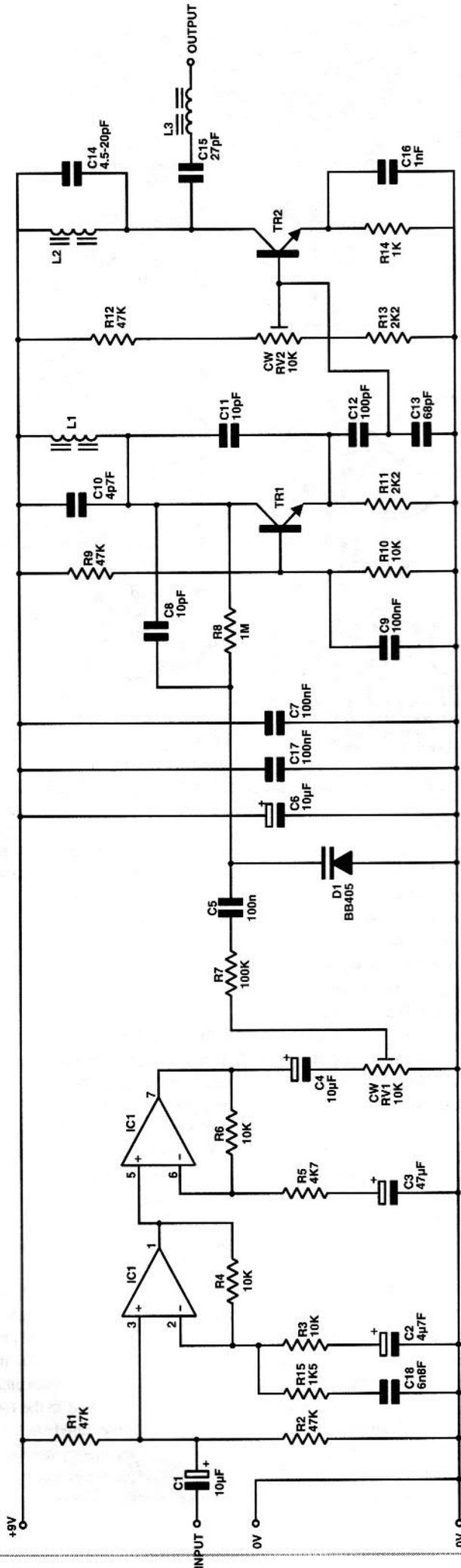
TR1 works as an oscillator. It is connected as a common base amplifier, with feedback from collector to emitter. The collector and emitter signals are in phase, but a different impedances, so the feedback network (C11, C12, C13) must match from the high collector impedance to the low emitter impedance. The stage provides significant power gain, but, in effect, the emitter requires a high current low voltage signal, while the collector provides a high voltage low current signal. The capacitive network shown works in the same way as a tap on a coil (or an auto-transformer).

The frequency of oscillation is set by L1 and the total capacitance to RF ground from the collector of TR1. From the point of view of RF, the positive supply and ground are the similar. The aim of the power supply decoupling is to keep the positive supply at zero RF potential.

The total capacitance to RF ground comprises C10 (chosen to set the frequency range), The series combination of C11, C12, and C13, plus the effect of the varicap diode, D1, in series with C8.

The operating frequency can be set by

Fig.1 Circuit of cordless guitar



adjusting L1, which is an adjustable inductor available from Cirkit. The frequency range can be chosen (within limits) by choosing the value of C10.

Frequency modulation is provided by the varying capacitance of D1 as the modulating signal is applied to it. It is biased to the supply voltage via R8, because a varicap diode must be reverse biased to a significantly higher voltage than its modulating signal amplitude to provide approximately linear modulation. Equally, if the rf signal is large compared to the reverse bias voltage the diode will generate RF harmonics.

To digress briefly, a varactor frequency multiplier diode (widely used in Amateur radio 70cm transmitters a few years ago) is simply a high power version of a varicap diode. The capacitively stored charge dumped when the voltage across the diode changes significantly generates harmonics. Television tuners use varicap diodes for tuning, and people are surprised when they multiply the frequency of every taxi, CB, radio amateur transmission into the TV frequency range, generating their own interference. Luckily the signal level in this project is low enough to minimise the generation of harmonics, and most of what are generated are filtered out.

Output

The output from the oscillator is fed to an output stage, with extra matching provided by the ratio of C12 and C13. In fact the impedance at the emitter of TR1 is less than that at the base of TR2, but the aim of this design is to disturb the oscillator as little as possible while providing only just enough output for the required range.

TR2 is operated in class AB, which generates some harmonics. These are largely removed by the tank circuit, L2 and C14, and by the output filter C15 and L3. This is a series tuned circuit, which has a low impedance at resonance, and a high impedance at frequencies far from resonance. The overall effect of this is that, if the range at the wanted frequency is 30M, the harmonics are unlikely to be detectable at over 3M, too short a range to cause anyone any interference.

The output power from the transmitter can be adjusted by varying the bias to TR2, or by changing the ratio of C12 and C13 (to vary the drive signal). The values of C12 and C13 have been chosen to provide the most likely suitable range, but these values may be

changed while keeping the same total series value to vary the drive to the output stage. If the drive is set to the lower end of the suitable range, the bias to TR2 will be correspondingly greater to achieve the same output power, and because the stage will be operating closer to class A than to class B in this circumstance, there will be less harmonics generated in the first place.

Audio Gain

The output signal from the guitar is not sufficient to modulate the transmitter fully, so an audio preamplifier is needed. To achieve good low noise low distortion amplification a 5532 op-amp is used. This is one of the lowest noise op-amps available (though the LT1088 is better but costs 10 times as much) and it does not suffer from phase reversal if its input is overloaded. What is phase reversal? Well, if you exceed the common mode range of some op-amps, and increasing negative input signal on the positive input of an op-amp can cause an increasing positive output signal on the output.

The gain is spread over two stages to minimise the distortion which results from asking relatively modest op-amps to provide high gain. FM broadcasts use increased treble on the transmission (called pre-emphasis) with a matching treble reduction in the receiver to cut the noise level. The first op-amp has an appropriate pre-emphasis (75 μ s) provided by C18, with R13 limiting the rise of gain as frequency increases to within the audio range. Without this, the gain would rise with increase of frequency until the op-amp ran out of gain.

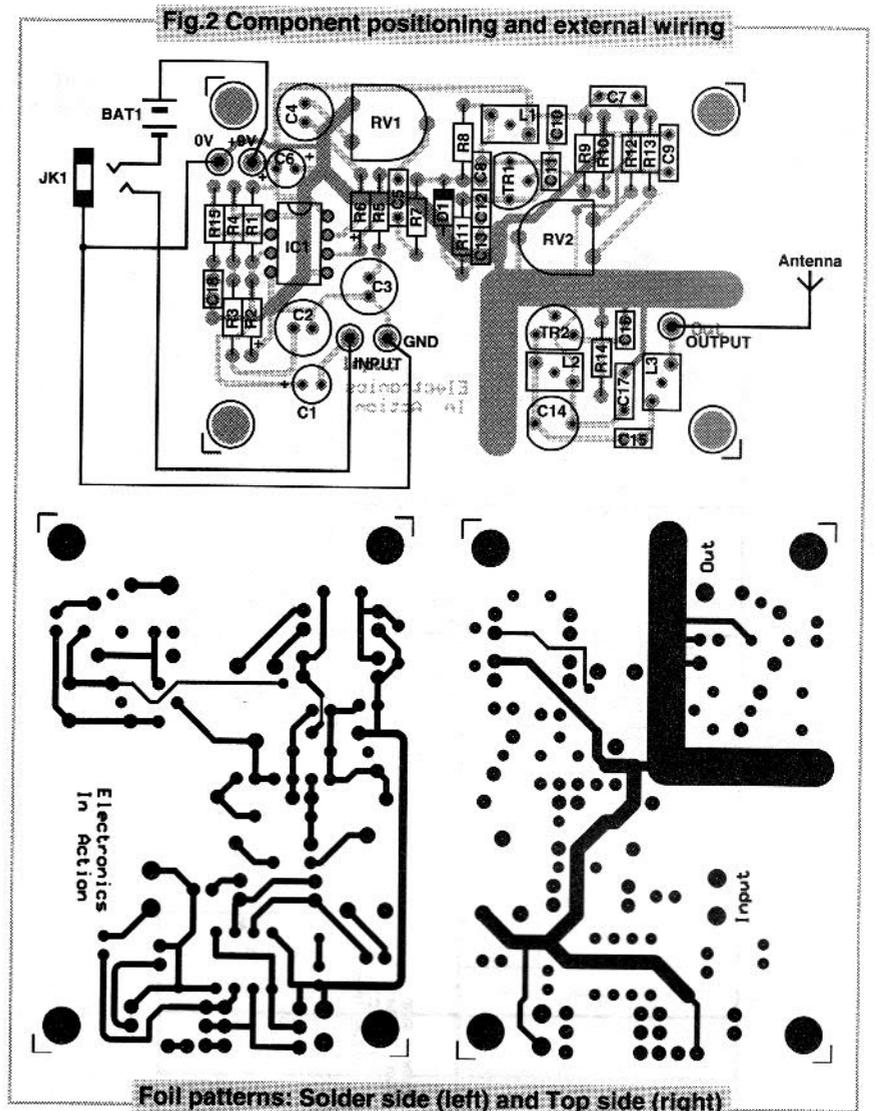
C17 reduces any tendency for interference from, for example, the local taxi firm to affect the sound.

Construction

This project is best built on the printed circuit board designed for the purpose. The layout is critical to the proper functioning of the unit, and although experienced rf constructors may be able to achieve a good result with their own layout, there is a danger that the oscillator will not remain stable if the layout is altered.

Check the pin connections of the transistors. The 2N2369s on the prototype had the collector and emitter connections the reverse way round compared with standard BC182s

Screening is also needed to keep the oscillator stable and any harmonics inside the case. The PCB overlay shows where the screens should be fitted. The screens



consist of strips of double sided copper clad board (unetched pcb) soldered to the top tracks provided for the purpose. The prototype used extra-thin board, of the type used to make multilayer PCBs. However, the standard thickness type will work just as well, but it is more difficult to cut. The screens on the prototype are only 10mm high, which allows for a better photograph. This height of screen worked well on the prototype, but it would probably be better to increase the screen height to 15mm.

The output from the unit is fed to a short length of wire acting as an aerial. Approximately 12 inches of wire should be connected to the "output" pad on the pcb, and fed out of the metal case via a small hole.

The case chosen for the unit is a die-cast box available from Cirkit. Space has been allowed to the left of the output stage screen to fit a standard jack socket when the unit is in its case. There is only just sufficient room, and some makes of socket may not fit. It is worth checking the space for any unusual type of socket before trying to fit it.

The power switching can be done either with a switch, or by linking the

negative terminal of the battery via the first signal input to ground in a stereo jack socket. This will disconnect the battery if the guitar is not plugged in, and is probably a more certain way to prevent the battery being left switched on by accident. This is illustrated in Figure 2.

Adjustment

Several adjustments must be carried out before the cordless guitar attachment is ready to use. The first thing to do is to find a free channel on the FM band. If there is not any free channel in your area, there is no point in building the project. If there is a vacant frequency, the oscillator must be tuned to this frequency. This should be possible by adjusting L1 (using a non-inductive trimming tool if available). Should the available tuning range be inadequate, the value of C10 may need to be changed. If you do this, do not forget that the varicap diode and the series chain of C11, C12, C13 all add to the total capacitance of the tuned circuit.

When the frequency has been adjusted, reduce the power using RV2 until the signal on the test receiver is

noisy, then adjust C14 for maximum output, with the core of L2 about half in to the windings. If C14 is at one or other end of its adjustment range, then adjust the core in L2 to achieve maximum output. Take care to use to correct trimmer tool and not to apply much pressure to the cores or else they will break.

The output filter does not need adjustment. It is there to reduce any harmonics, which are probably not severe enough to be antisocial, to a slightly lower level to make sure that no interference is caused.

Then move the receiver to the operating range required and increase the power (using RV2) until the signal is no longer noisy.

Finally, plug in a guitar and play at the maximum volume to be used. Adjust RV1 so that the sound output from the radio is similar to that from an ordinary broadcast station. The unit is now ready to use, and need only be readjusted if it is to be used in an area where the blank channel is different from the one originally chosen, or if it is to be used with a guitar having a different audio output.

- R1,2,9,12** 47k
R3,4,6,10 10k
R5 4k7
R7 100k
R8 1M
R11,13 2k2
R14 1k
R15 1k5
RV1,2 10k (e.g. Cirkit 48-10307)

- C1,4,6** 10µ electro
C2 4µ7 electro
C3 47µ electro
C5,7,9,17 100n
C8,11 10pF
C10 4.7pF
C12 100pF
C13 68pF
C14 4.5-20pF trimmer (Cirkit 06-20007)
C15 27pF
C16 1n
C18 6n8

Semiconductors

- IC1** 5532
TR1,2 2N2369
D1 BB405

Audio Filters

- L1,2,3** Toko E514HNE-150023S15 (Cirkit 35-10854)
Die Cast Box Cirkit No 21-95003

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The Evolution of Audio Amplifier Design

The dawn of a new era - transistor audio amps.
By John Linsley-Hood.

In the last part of this article I described the state of audio amplifier design, and the progress made in ancillary equipment, up to the late 1950s - early 1960s. By and large, the average user was very well contented with the performance of his (valve based) audio amplifier gear, and his major grumble would probably be the existence of a certain amount of background 'hum', partly due to the various 50/60Hz AC lines within the amplifier itself, and partly caused by 'earth loops' and such-like problems in his inter-connections.

Typical power amplifier output power ratings were in the range 10 - 75 watts, with relatively low cost DIY designs such as the popular Mullard '5-10' occupying the lower end and massive commercial amplifiers by Radford, McMurdo and McIntosh, at the top, with KT66 or '807' type output valves, depending on whether the design was British or from the USA. However, loudspeakers were becoming less efficient, as large open-baffle or folded horn systems gave way to heavily padded, closed box, multiple unit designs.

The main debate among the DIY fraternity, at the time, was about the relative merits of triode connected beam-tetrodes, compared to power triodes - these latter would have directly heated filaments fed from an AC supply, an arrangement which would nearly always lead to some mains 'hum' - but were said to have a 'nicer' sound, or about the various forms of output transformer primary winding connections, where the trade-in was between distortion and output power and output stage efficiency. Overall negative feedback was now almost invariably used, but this would demand care in the choice of the amplifier circuit and the specification of the output transformer if the amplifier was not to oscillate.

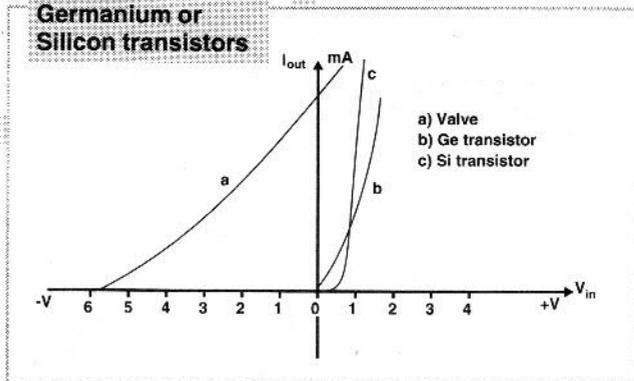
The advent of the transistor.

Most people working in electronics in the late '50's would have seen and probably played with 'transistors', but these were still mostly thought of as laboratory curiosities, tiny devices in a variety of strange packages, fabricated from small pieces of single-crystal germanium or silicon, which would operate (usually for a relatively short time) from a voltage supply of a few volts. They all had, in common, three wire connections, and could be made to amplify if an input current was fed to their 'emitters' from a low source impedance, when almost the same current would emerge from their 'collectors', but at a high enough impedance to drive, say, a 10k collector load. However, they were easily damaged, and most electronics bods soon accumulated a collection of 'late' devices.

The maximum permitted working voltages and currents for contemporary

transistors were far too low, for most of the device types then on offer, to encourage any thought of their use in hi-fi audio power amplifiers, but they clearly had a considerable potential in battery operated portable radios, as a replacement for those using 1.4V/90V valve types. They also might prove useful as 'hum-free' low-

Fig.1 Comparative characteristics of a triode valve vs Germanium or Silicon transistors



level audio amplifier stages, but low-distortion circuitry was not well developed at that time.

However, although the early devices weren't much practical use, progress continued, and improvements in manufacturing techniques soon gave the choice of 'small signal' or 'power' transistors, and between devices based on germanium and silicon. Initially these used different types of manufacturing process, and the resulting devices had different characteristics, and both types

differed from valves in their performance in ways which meant, in general, that the circuit designer had to start learning his trade all over again.

'Hot glass' vs. 'solid state'

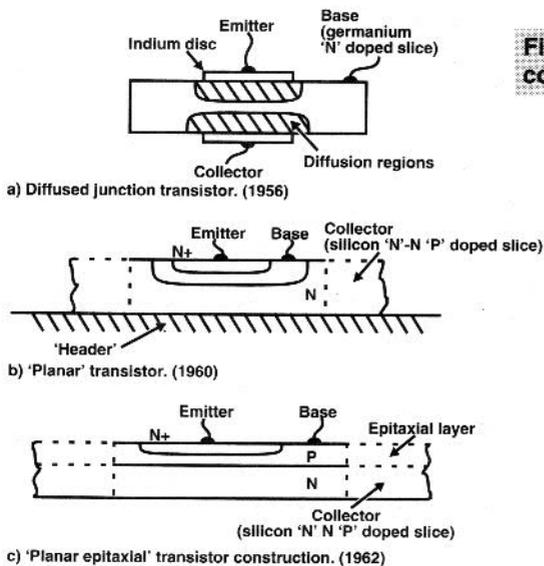
The first difference between thermionics and 'solid state' is that transistors will work at relatively low voltages, but this advantage is offset by the difficulty that they can only dissipate relatively small amounts of heat - particularly in the case of devices made from germanium, where, above some 100°C, the crystalline impurities could start to migrate, and the current gain and breakdown voltage characteristic would

20 watts, and this meant that some form of 'push-pull' output configuration was essential - which led to other problems.

A further difficulty was that transistors were essentially current operated devices, though ways were found to avoid this limitation, and finally, by comparison with valves, they were very non-linear in their characteristics, as I have shown, in the input voltage vs. output current graphs of Figure 1, and, although we now have much better devices, their performance characteristics remain the same.

Originally, the manufacturing process used for junction transistors was based on the diffusion of some impurity into

Fig.2 Transistor construction methods



start to change.

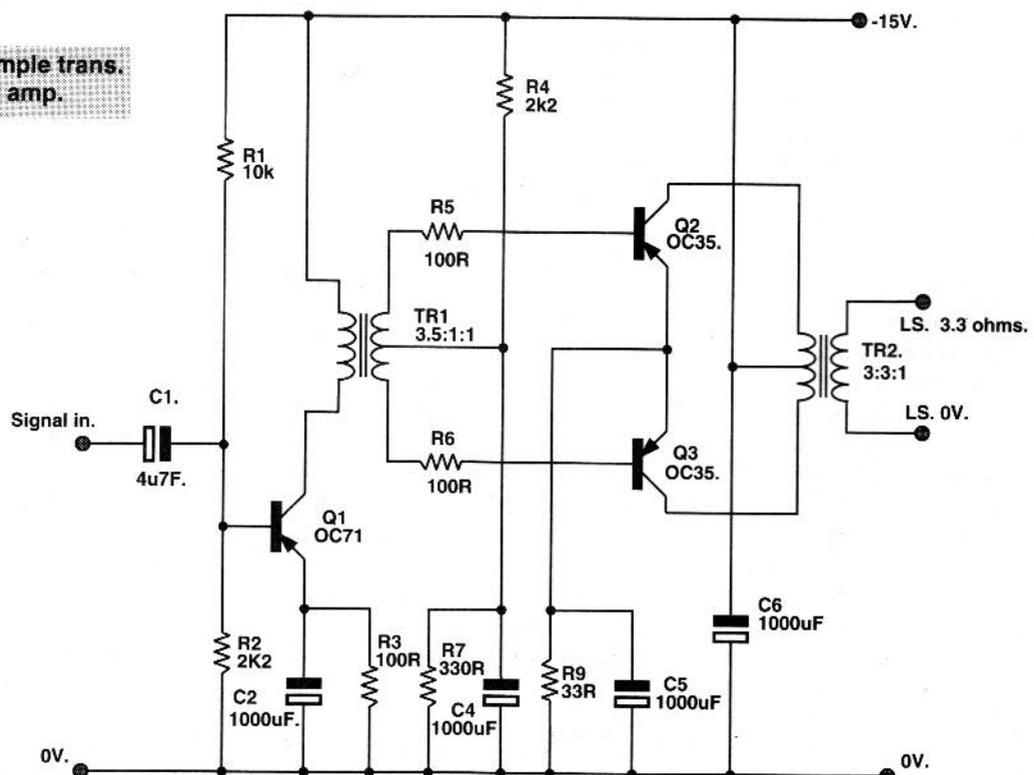
For example, a typical 'small signal' transistor can only accept a few hundred milliwatts of power lost as heat within its package. Even after the metal 'TO3' type encapsulation had been introduced for power transistors, the maximum dissipation permitted for a germanium device, such as the OC35, was still limited to about

the opposite sides of a thin slice of the semiconductor, as I have shown in Figure 2a. This technique worked quite well when the impurity was 'P-type' indium, and the substrate was a thin wafer of 'N' doped germanium, which then made a 'PNP' device. Although, in theory, it should be possible to diffuse an 'N' type impurity, such as antimony, into a 'P' doped germanium substrate, to make an 'NPN' transistor, this technique didn't work very well, so almost all the early germanium transistors were 'PNP' types, and the circuitry used had to be adapted to this.

At this time, a few small-signal 'NPN' type silicon transistors were beginning to appear, but these had relatively low current gain values, and didn't lend themselves very well to incorporation into germanium transistor circuits. So, when engineers first began to consider making audio power amplifiers - for, say, the LS output of a transistor radio - they turned to the type of circuit layout used in early valve amplifiers, with a push-pull input driver transformer, and a centre-tapped output transformer, to drive the loudspeaker, using the kind of circuit I have shown in Figure 3.

With two coupling transformers in the audio signal path, the use of overall negative feedback (NFB) to improve the circuit performance was not a practicable proposition, but, in any case, the aim was portability, and economy in battery life, not 'hi-fi' quality, so the

Fig.3 Simple trans. coupled amp.



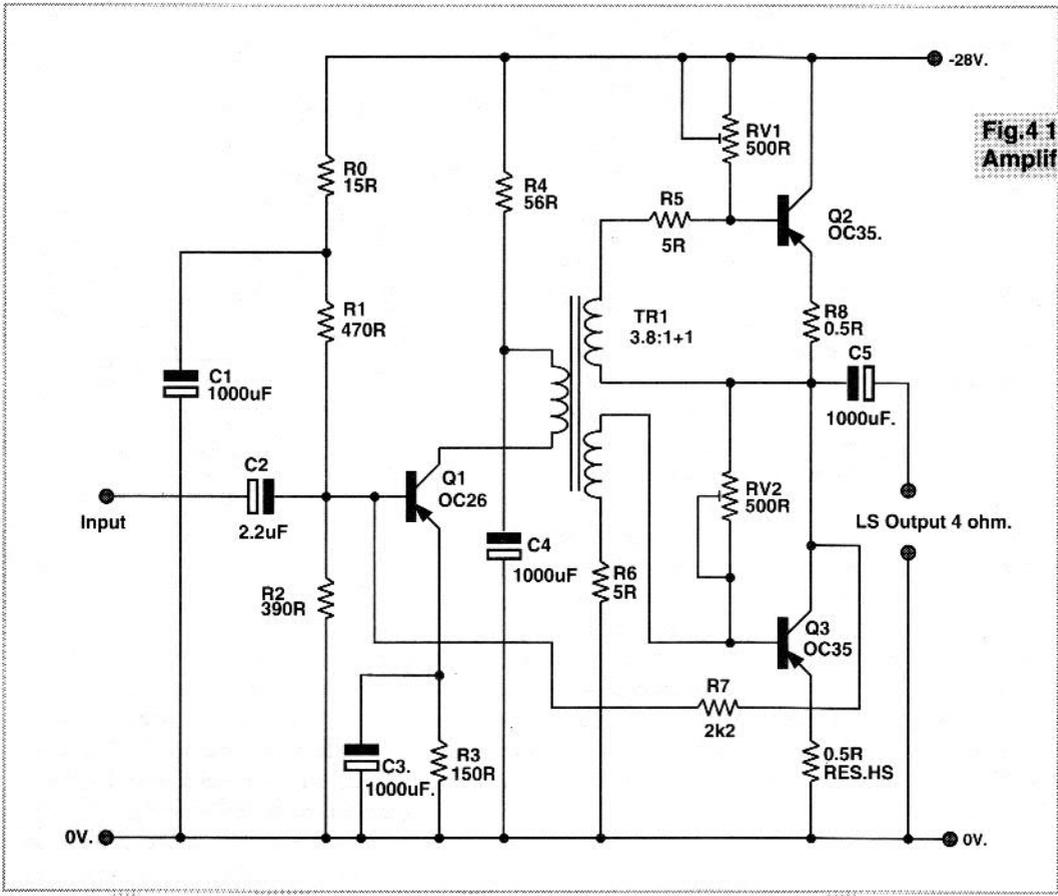


Fig.4 15watt Audio Amplifier

performance given, so long as it was economical of current and didn't offend the ears too badly, was seldom of great importance.

Higher quality transistor amplifiers.

Inevitably, the thoughts of design engineers began to turn to the possibility of making transistor operated audio amplifiers which might begin to compete in the 'hi-fi' field with, say, the Mullard '5-10' valve amplifier. This would mean the use of overall NFB to reduce the amount of harmonic distortion, and improve the audio bandwidth - and this, in turn, meant getting rid of one of the inter-stage coupling transformers. An ingenious 15 watt design, due to Mullard, is shown in Figure 4, in which the harmonic distortion (mostly third) was a bit less than 2% at full output power.

Since this design only used one coupling transformer, (needed to generate a push-pull drive to the output devices), provided that this was well designed, feedback could be taken from the output back to the input to reduce the distortion level. As with most amplifier designs of that period (1962), some adjustment had to be incorporated to cater for the variability from unit to unit of the device characteristics - in this case RV1 and

RV2, used respectively for setting the quiescent current and DC output voltage level. This should, ideally, be half the supply line voltage to allow the maximum output voltage swing.

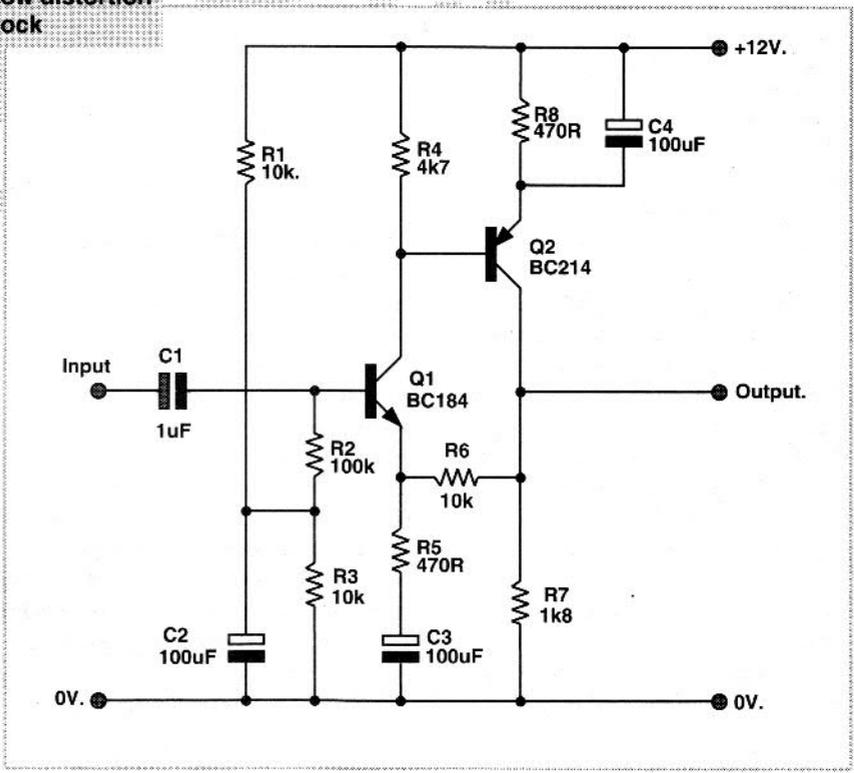
Silicon transistors arrive.

Silicon transistors had been around for some years, usually made by similar techniques to those used for their germanium half-

brothers, but their performance was poorish, and, while they were made as one-off devices, their higher cost reflected the greater manufacturing difficulties, due to the higher melting point of silicon, and the higher temperatures required for the diffusion of 'doping' impurities.

This situation changed abruptly in 1960 when the Fairchild Corp. introduced the 'planar' manufacturing

Fig.5 Low distortion gain block



process, shown in Figure 2b. In this, a largish wafer of mono-crystalline silicon was sliced from a rod of bulk material, and, by the use of a combination of masking and diffusion techniques - based on the fact that the oxide of silicon, silica, is very hard and chemical resistant, but can be etched, through a photo-deposited mask, by hydro-fluoric acid - a large number of devices can be formed, at the same time, on the surface of the crystalline slice, by diffusing suitably chosen impurities in through the exposed face.

Because very thin base junction layers can be formed this way, 'planar' transistors, such as the popular BC107/109 types, can be made with current gains up to 400 or more, with working voltages up to 40-50V. Moreover, for the first time, transistor manufacture ceased to be a one-off process - indeed, depending on the size of the silicon slice used, several thousand devices could be made in one go, bearing in mind that the chip size for an individual BC109 is only about 0.5mm square. This, and a good moulded epoxy resin encapsulating system, (BC109's used a small tin can, filled with resin to hold and protect the transistor), made cheap, high quality, small-signal transistors a practical proposition.

Also, by the correct choice of dopant and diffusion impurities, good silicon PNP transistors could be made with equal ease.

However, there was a small drawback to this 'planar' process, which was that, having diffused, say, a 'p-type' impurity into an 'N' doped slice, to make the transistor base region, one then had to diffuse a much more concentrated 'N-type' impurity, over the top of this, to turn the outer layer of the 'P-type' base back into an 'N-type' emitter, and this increased concentration of impurities in the emitter region worsened its reverse voltage breakdown characteristics.

The solution to this problem, also invented by Fairchild, in 1962, was to grow, from a hot vapour of suitably doped silicon hexafluoride, an 'epitaxial' (i.e. from a single side) layer of, say, 'P-type' silicon onto the 'N-type' substrate. Another 'N-type' emitter layer could then be diffused into this 'P-

type' layer without such an overload of impurities.

This structure, shown in Figure 2c, became known as the 'epitaxial planar' system, and typical devices are the BC414/416 transistors, though I suspect that most modern transistors are made this way, because it saves one mask+diffusion stage and is therefore cheaper to do.

Although the planar/epitaxial process was originally introduced for small-signal devices it is such an enormous improvement over the previous two-sided single-chip diffusion method it is almost certain that all modern silicon power transistors will also be made this way, with the probable exception of germanium devices, which do not lend themselves very readily to this process, and are now, for all practical purposes, obsolete.

Fig.6a and 6b
Darlington emitter
followers

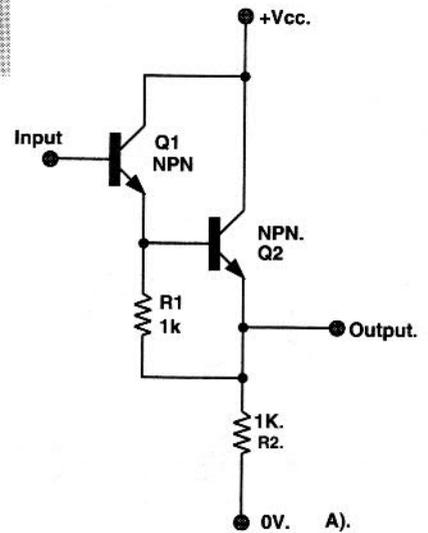
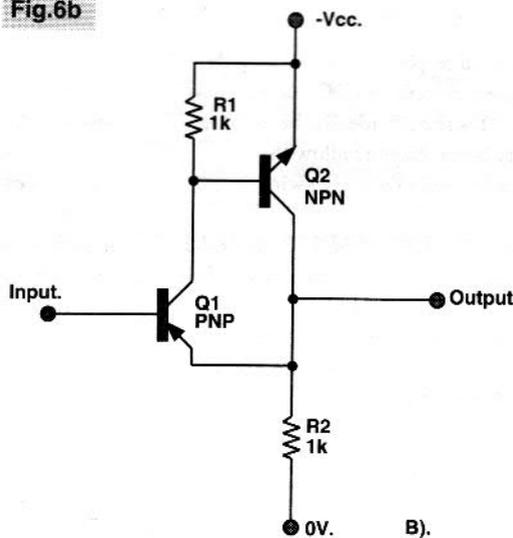


Fig.6b



Low distortion transistor circuitry.

From my point of view, the sudden availability, in the mid-1960's, of high-gain, low leakage, cheap plastic encapsulated transistors, in NPN/PNP complementary types, made it very easy to design low-distortion gain blocks, of the kind shown in Figure 5, which requires no set-up adjustments, has a high input impedance, a flat frequency response from about 5Hz-500KHz, an output voltage swing of about 3V. RMS, and a THD which never exceeded about 0.02%.

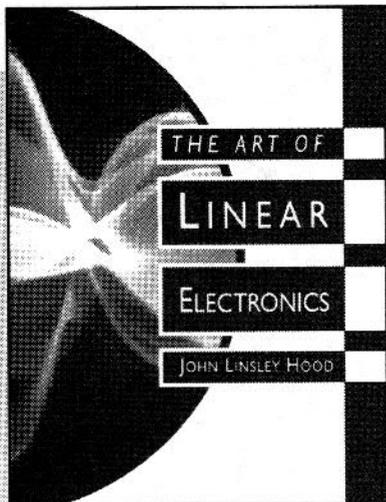
My own reaction to this type of

circuit possibility was to replace all the valve type pre-amp. stages preceding my existing 'Williamson' valve audio power amp., which gave me, for the first time, a quiet, 'hum' free background to my gramophone record listening.

So far, so good, but although silicon planar power transistors were beginning to appear, they were, as yet, not easily available in PNP types, and this meant that circuit designers did not enjoy the same freedom in power output stage layouts that they did in the small signal circuits, such as that shown in Figure 5. In particular, there was not an easy way, without using a transformer, of matching the high output impedance of a small-signal gain stage to the low drive impedance required for a loudspeaker.

The ideal answer would be to use either the 'Darlington' layout shown in Figure 6a, or the 'compound emitter follower' circuit shown in Figure 6b, both of which used the same type of power transistors, and would allow a good impedance match to be made. Indeed, an audio amplifier circuit, using both of these types, in a push-pull output stage layout, had been shown, some years before, by an American circuit designer called H. C. Lin. This arrangement was adopted, with enthusiasm, by audio amplifier designers - who claimed 'hi-fi' performance for their efforts.

Sadly, this claim was false, and the loss of confidence in transistor amplifier performance, and designers claims, which this led to marked the parting of the ways in 'hi-fi'. I will look at the slow climb back from this pitfall, and the ways in which the remaining circuit faults have been alleviated, in the next part of this article.



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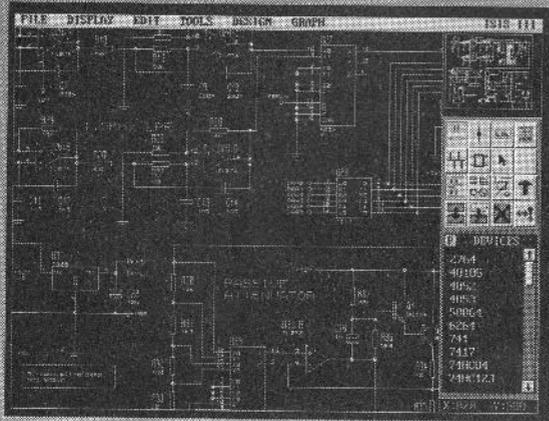
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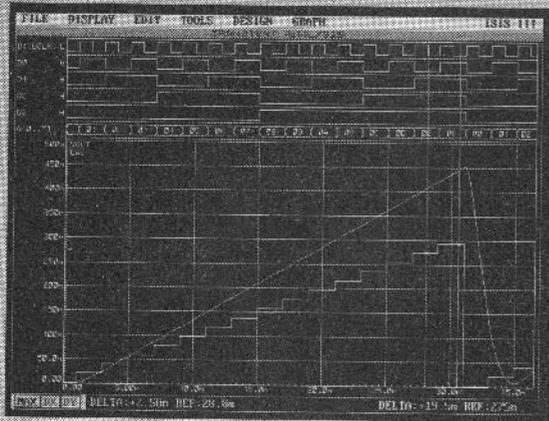
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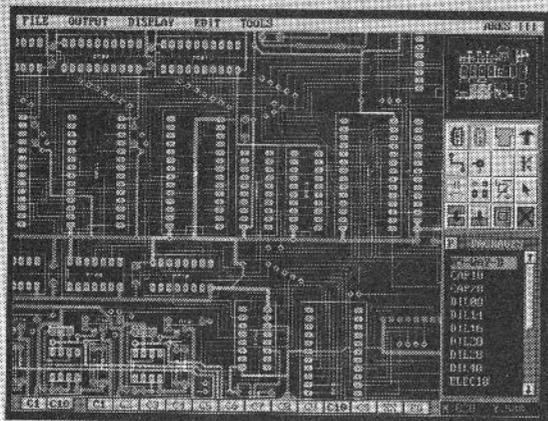
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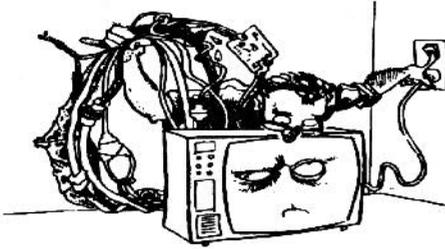
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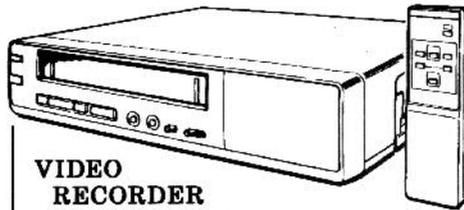
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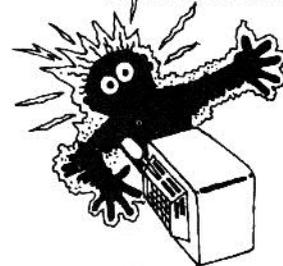
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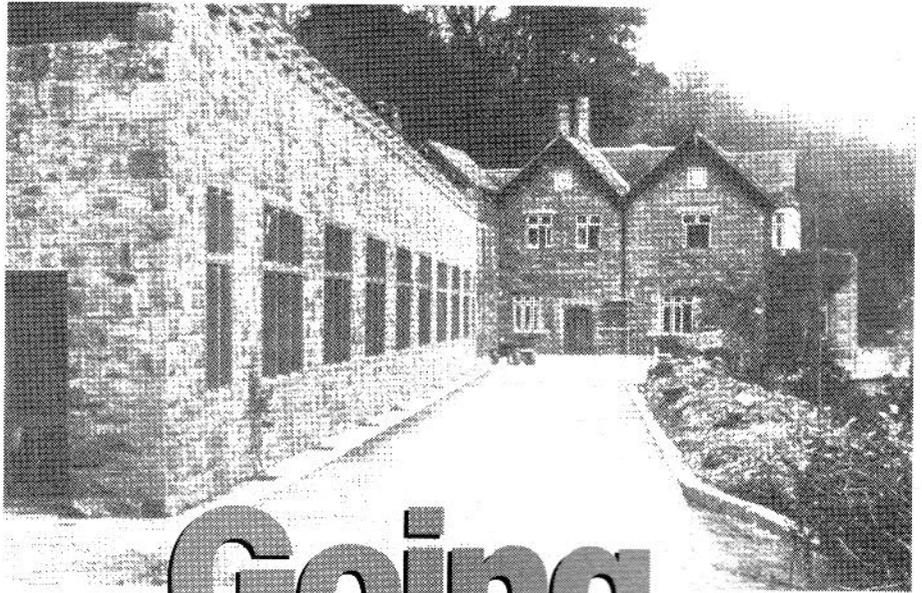
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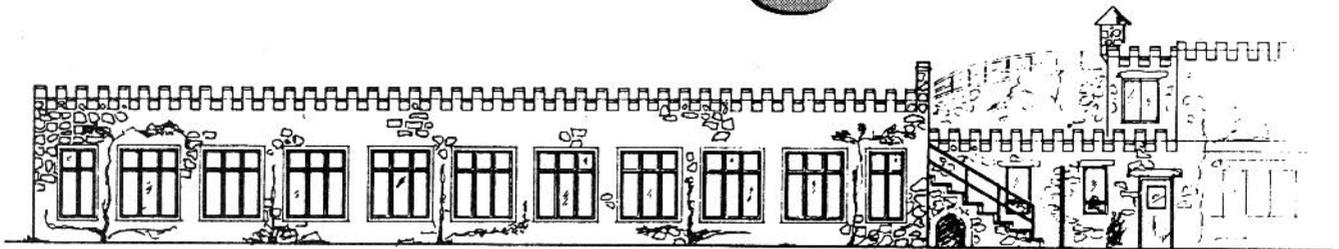
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How do you keep a building warm the whole year round without any input from man-made energy? The answer lies in the soil. A report by Paul Freeman-Sear.



Going Underground



Nestled into a hillside in Wales is a very unconventional house. Not you may think from it being a long rectangular house with all its windows facing to the south nor perhaps for its battlement facade, no this house

Unconventional it may be, but Peter is "constantly amazed that after 5 years or so of having the only home in Europe which stays at a comfortable temperature year in - year out, without any supplied energy, the house still attracts interest

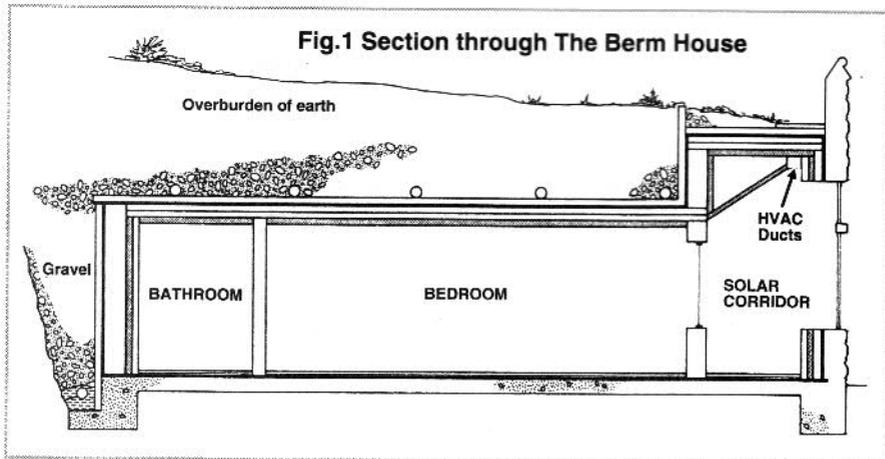
with an ambition and is an example of a house where huge energy savings can be made.

The site faces 30 degrees west of south and is cut into a bedrock of red sandstone. The building uses considerable quantities of concrete, brick and stone and although the outlay was much greater than on an equivalent size conventional house it benefits in the long-term from savings of low maintenance costs to keep the building functional for a very long time. The thermal stability helps to eliminate all space heating costs.

86% of the building surface is in the ground and this produces a constant outer wall temp of 10 Celcius. The combined effect of this, the 1m thick back walls, and the 4" of insulation between wall surfaces reduces the heat loss to a minimum. This insulation is expanded polyurethane and any cracks were filled with aerosol polyurethane foam.

Peter says the standard of insulation in the building is similar to that used in commercial deep freeze units and is 6 times better than current building

Fig.1 Section through The Berm House

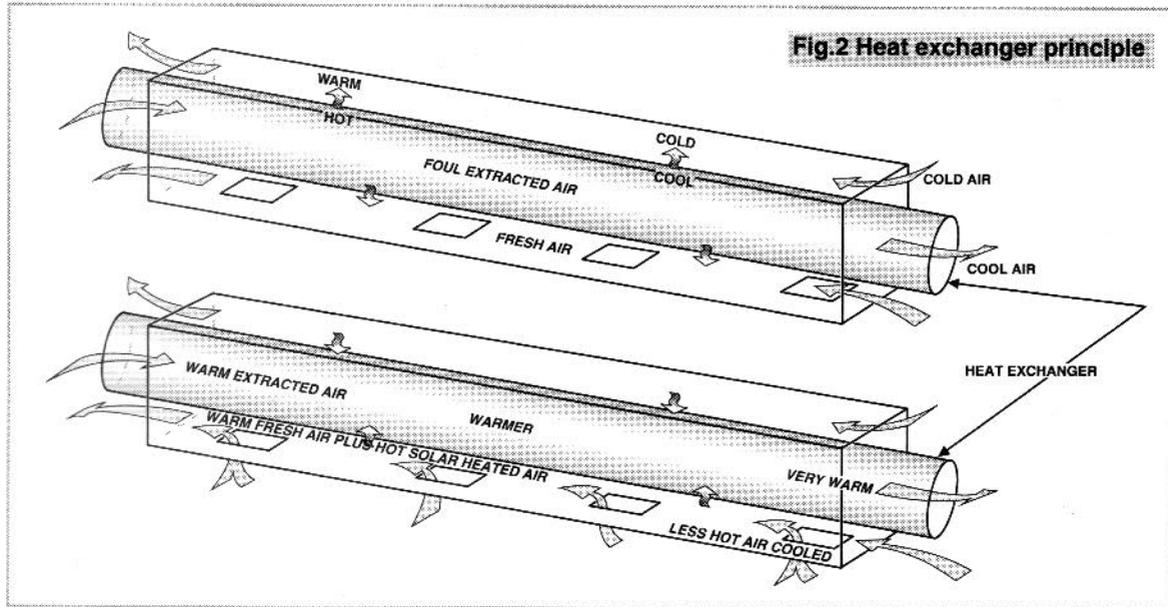


is unconventional because most of the building is underground.

The Caer Llan Berm House is a Conference Centre owned by Peter Carpenter and has been built to his specifications.

from books, newspapers, magazines, conferences and students and not from the hotel industry, local authorities or others with horrendous heating and cooling demands".

This building is the result of a man



regulation requirements.

Losing heat by convection through drafts is a great problem with many conventional houses but here as 86% of the house is surrounded by soil, drafts are not a problem. Doors have tight fitting seals and are self closing.

Good Circulation

Fresh air is circulated to the rooms by a ducting system. During the winter months any incoming cold fresh air is preheated by running the input ducting over the outgoing hot stale air. It also runs above the ceiling along the solar corridor collecting any solar energy on the way. See Figure 2.

Peter reckons that in cold weather this heat exchanger is about 65% efficient. It also helps to keep the corridor from overheating. Further round the clock temperature stability is achieved by the inner corridor wall being painted black which acts like a storage radiator absorbing sunlight

The building is covered on top with a selected and drained top soil to a depth of 1.5m. This earth provides the insulation

during the day.

Air can enter the building by two different routes selected by closeable vents. During summer, air enters the building at the bottom of the front walls and is heated in the solar corridor and rises to the top of the sloping ceiling. From their ducting takes the warm air throughout the building assisted by fans. Total air flow can be controlled by adjusting fan speed. Stale air from each room runs along the back of the building

and then through a cylindrical aluminium pipe placed down the centre of the incoming air duct and out the end of the building.

In the winter cold fresh air is admitted to the building through a single vent high on the front wall. This vent switching eliminates and cold draughts along the corridor.

The combined effects of careful design for the Berm House is said to lose about 3kW during the summer and 8KW during a bitterly cold winters day (about ten times less than a conventional house built to current building regulations). This of course must be replaced in order to keep the temperature constant.

Enter the Greenhouse Effect

As we all now know, double glazed windows will reduce conductional heat loss. But when the sun shines on south facing windows, great use can be made of the greenhouse effect, a conversion of

high energy rays to trapped lower energy heat rays provides a very useful heat gain. In fact, the front southerly aspect with its large windows

absorb more heat from solar radiation throughout the year than it loses. The Berm House windows provide between 2 1/2 - 5 1/2KW of heat input over a normal year. The glass used in the windows is a low emissivity glass called Kappafloat and is made by Pilkington Glass.

Soil insulated roof

The building is covered on top with a selected and drained top soil to a depth of 1.5m. This earth provides the

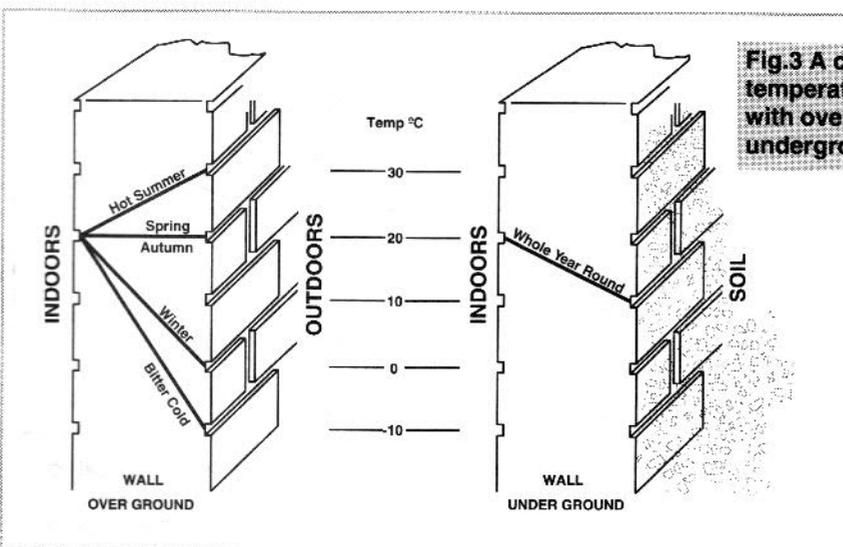
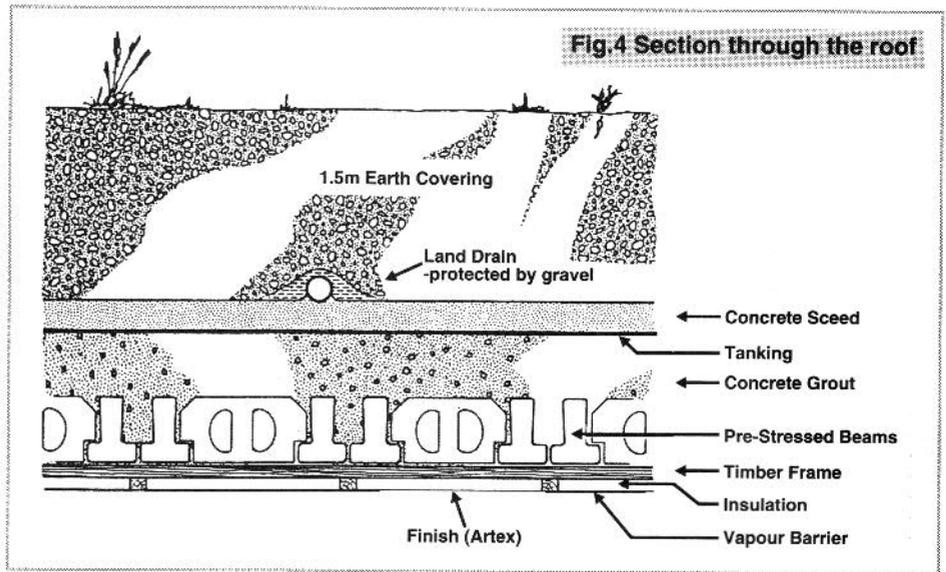


Fig.3 A comparison of temperature differences with overground and underground walls

Should the temperature in the corridor rise, the passive heat exchanger in the ducting system goes into reverse and removes the unwanted heat



insulation and as a result the ambient temperature on the outer side of the wall that remains underground is 10 Celcius. There is no problem with dampness

due to several factors:

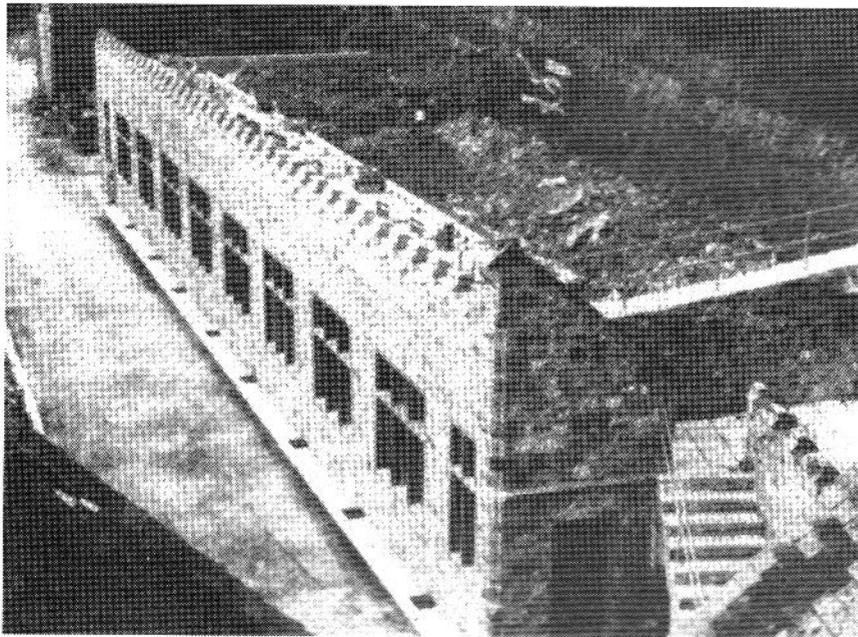
A high sun on vertical windows produces a lower solar gain owing to reflection. There is no heating effect

pumps the heat through the drainage pipes heating up the soil.

Also choosing different coloured surfaces outside the front and back doors will produce a pressure gradient for the air to ventilate the corridor when the outside doors are open. The different reflectivities of white and black surfaces produce the required draught.

The earth cover acts as a huge stabilizer. The temperature of the soil at depth remains at around 10 Celcius all year and provides the same predictable cooling gradient at all times. Peter says the corridor does get quite warm on sunny days but this temperature rise is quickly dissipated into the structure of the building. Over heating in conventional homes during the summer months occurs because they can't cool off, he says. The ambient temperature is too high, but this is not so with an earth shelter provided the soil is deep enough.

Caer Llan Berm House is a long thin house and getting light to the rooms is not a problem. The vertical windows are conventional types and are roughly South facing. Bathrooms situated at the back rely upon artificial light. Peter says



owing to considerable measures being taken with the roof structure (See Figure 4). The easiest way to prevent water getting in is to tank the building. See the thick black line in Figure 4. A number of different materials are available for this, but a torch-on bituminous membrane was used for the Berm House.

A passive building

Peter says there are no control electronics. The building is very passive. The doors have self closures which minimise unwanted infiltration. There are also variable speed controls on the ventilation fans so that when the building is empty for any length of time some heat can be saved by lowering the ventilation rate.

The building does not suffer from overheating in the summertime. This is

from the sun through the soil on the roof.

Deciduous trees cut some solar gain in the Autumn.

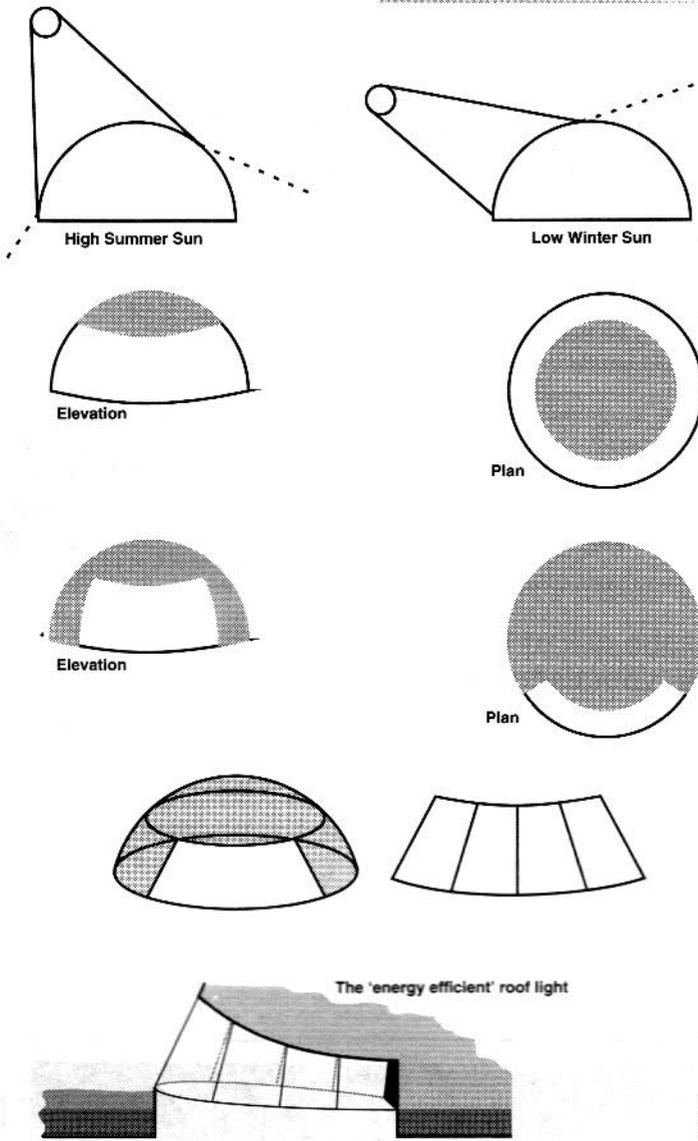
As the internal temperature increases, the rate of heatloss increases (Not true of overground houses).

Should the temperature in the corridor rise, the passive heat exchanger in the ducting system goes into reverse and removes the unwanted heat. If the temperature goes any higher, a thermostat operates a fan which

INDOOR TEMPERATURE °C	16	18	19	20	22
OUTDOOR TEMPERATURE °C	CONDUCTION HEAT LOSSES in KW				
Summer 22	1.7	2.5	2.8	3.2	3.5
Spring/Autumn 10	2.8	3.6	4.2	5.2	5.5
Winter 4	3.8	4.6	5.2	6.1	6.5
Frosty 0	4.3	5.7	6.2	6.7	7.2
Bitter Cold -10	6.5	7.7	8.1	8.7	9.3

Table of calculated heat losses under varied conditions. Using solar heat only house temperature will settle in shaded area

Fig.5 Dome experimental shapes



purposes. He says that using a complete dome may be good for light but in the summer the heat gain may be excessive and would need to be vented. In winter when the sun is low, most of the energy gets through on the south facing side. The heat gained from entering the dome rises to the top where the greatest losses occur. The solutions to these problems can be seen in the diagrams. Cut the top off and the North, North-East and North-West bits and use what is left of the section for windows See Figure 5. Although 80% of the light has been cut out compared with the whole dome, the section can be enlarged. The result is that summer light enters without overheating and in winter any heat gained is used and not lost as the high points are insulated.

Burrowing Animals

As this is an underground house you might expect burrowing animals to be a problem. Peter's reply was firm. They have trouble getting through the 450mm thick concrete roof or the 1m concrete block rear wall but occasionally we see a vole poke his nose out of one of the drain pipes which form a network to drain the overburden of soil. In fact nothing, he says, gets through the envelope - Not water, draughts, Radon gas, animals nor insects, no ultra violet light and no noise. The corrupting forces of moth and rust are hopefully held at bay for several centuries.

...nothing gets through the envelope - Not water, draughts, Radon gas, animals nor insects...

that of his other designs, (not yet built), they will have atria to get light into the inner rooms. One problem with Atria and roof lighting, although they give excellent light levels, the designs are inherently energy inefficient.

Creature Comforts

The house does not have a solar hot water system and Peter has incorporated some other measures. The Berm House is a conference centre and people pay good money for their creature comforts

he says. "The amount of hot water used is phenomenal and to make a dent in the supplied energy costs we would have to have a huge pre-heat tank and correspondingly large area of solar collection". "Since it is doubtful whether even preheated water from solar collection is cost effective in the U.K. (It might just be for the DIY enthusiast with a long suffering family) and also our 'household' is 15 times the normal size, the cost ineffectiveness (times 15) added to the fairly brutal capital outlay has made this not too attractive a proposition".

Open to Design

Peter has been considering dome sections for lighting and heating

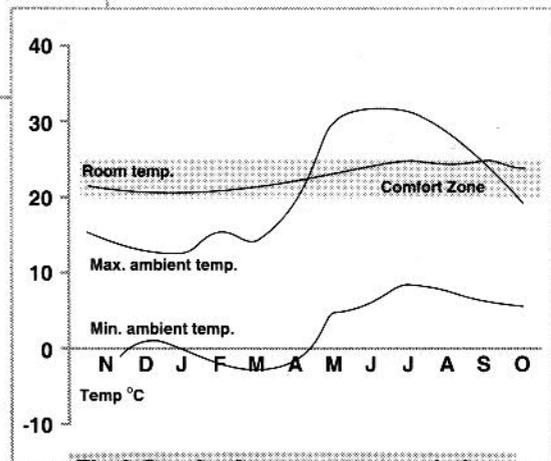


Fig.6 Graph of temperature variations

As can be seen from Figure 6, despite the large temperature variations occurring throughout the year, the internal temperature of the Berm House varies very little around the 'comfort' zone of 20 Celcius and all at zero heating cost!

Acknowledgements

Our thanks go to Peter Carpenter of the Berm House for supplying information for the preparation of this article.

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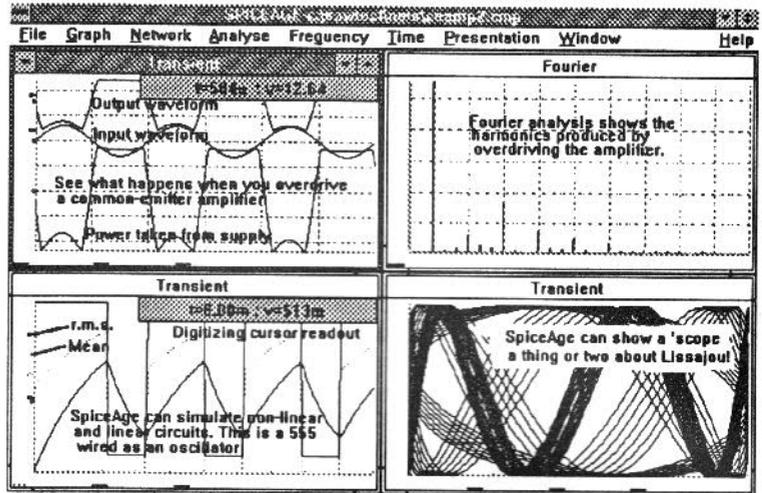
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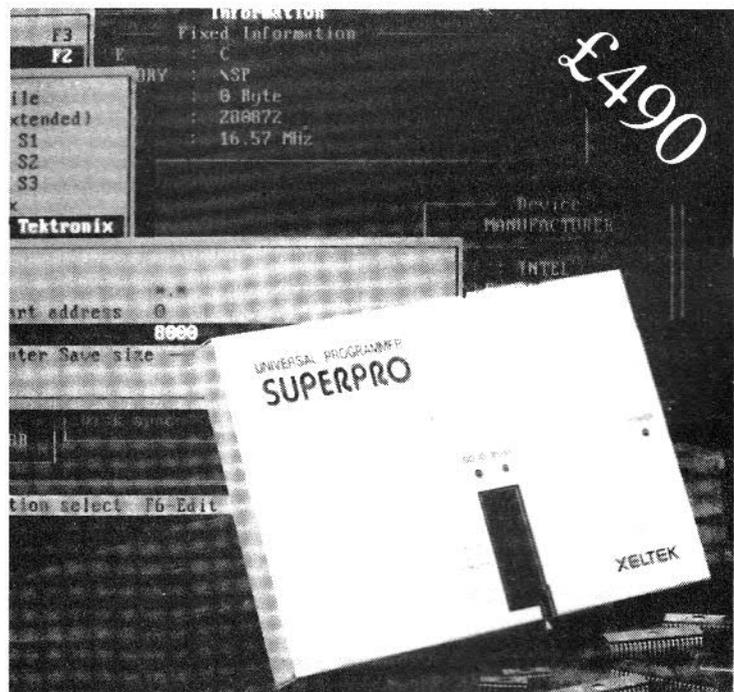


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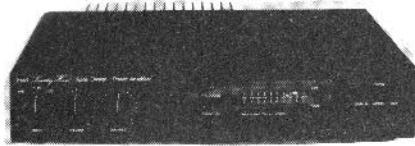
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Sound Level Measurement Circuitry

by Douglas Clarkson

Circuits which measure sound pressure levels with high levels of precision can be made from a range of discrete electronic components although this requires a high level of skill to design and implement. In order to make life easier for the electronics designer developing such circuitry, various manufacturers have introduced a range of specialised analogue integrated circuits. The effective use of such circuit components, however, does also require a more general appreciation of the science of sound measurement.

Nature of Sound

Sound waves are detected as small pressure disturbances superimposed on the static atmospheric pressure value. Even for relatively loud sound, the ratio of dynamic pressure amplitude to static pressure amplitude is less than about 1%. The microphone acts like a transducer, translating a pressure signal into a voltage signal. In the design of sound measurement circuits, it is important to determine the range of sound pressure amplitudes which will be detected, the corresponding sensitivity of the microphone and the gain of any pre-amplification circuit. The sensitivity of any subsequent level measurement circuitry has in turn to match the sensitivity of the previous stages.

The sound pressure level, SPL, in units of decibel of a sound of root mean square pressure P_{RMS} is given by:-

$$SPL = 20 \log_{10}(P_{RMS}/P_0)$$

where P_0 is a reference sound pressure level of 0.00002Pa. (A pressure of 1 Pascal (Pa) is the pressure of 1 Newton per square metre.) It is this scale of sound measurement which provides the principal reference for optimising the

function of the various stages of a sound measurement system.

Based on the above equation, **Table 1** gives a range of values of SPL associated with typical sounds.

This considerable range in the perception of sound poses problems for instrumentation designed to measure it accurately. The range of levels indicated in **Table 1** corresponds to a signal ratio of a million to one. Lower cost sound level meters will typically only allow 80dB of measurement say from 40dB to 120dB to be measured. Professional measurements will allow measurements from 0dB to perhaps 160dB. Most of the routine uses of sound level equipment, however, relate to the use of range 40dB to 120dB since this range covers the likely nuisance levels of noise around 80dB.

Microphone Sensitivity

For a specific microphone with a specific sensitivity, it is important to appreciate the range of input voltages which the unit is likely to generate for a specific sound level. A typical microphone sensitivity is quoted as:

-72dB ±4dB (0dB = 1V/μ bar, 1KHz)

One atmosphere of pressure is equivalent to 1.013×10^5 Pa, the reference of 0dB = 1V/micro bar is

Sound	Sound Pressure (Pa)	SPL
Threshold of hearing	0.00002	0
Quiet countryside	0.0002	20
Quiet living room	0.002	40
General office	0.02	60
Inside motorcar	0.2	80
Near pneumatic drill	2	100
Near jet aircraft	20	120

Table 1: Range of SPL as a function of Sound

equivalent to (0dB = 1V/0.1013Pa) or (0dB = 9.9V/Pa). Also, -72dB is a signal ratio of approximately 1/4000.

Table 2 can be constructed linking voltage signal developed by the microphone with pressure signal amplitude.

Pressure Amplitude	SPL(dB)	Voltage signal
0.0002	20	0.5μV
0.002	40	5μV
0.02	60	50μV
0.2	80	500μV
2	100	5mV
20	120	50mV

Table 2: Calculated sensitivity of a specific microphone

Thus in terms of the dynamic range of the initial amplifier, if the signal is being amplified between +5V and -5V voltage rails, the maximum gain to accommodate 120dB SPL signal at 1KHz (assume +4V and -4V limit of signal) would be 80.

It is also apparent that the level of 0.5μV signal at 20dB will be difficult to separate from noise in the amplifier and associated circuitry. This requires care in the design and selection of operational amplifier circuits.

Figure 1 shows a typical frequency response for an inexpensive back electret condenser microphone (Realistic: Tandy Cat. No. 33-1063). The response is essentially flat over the range of

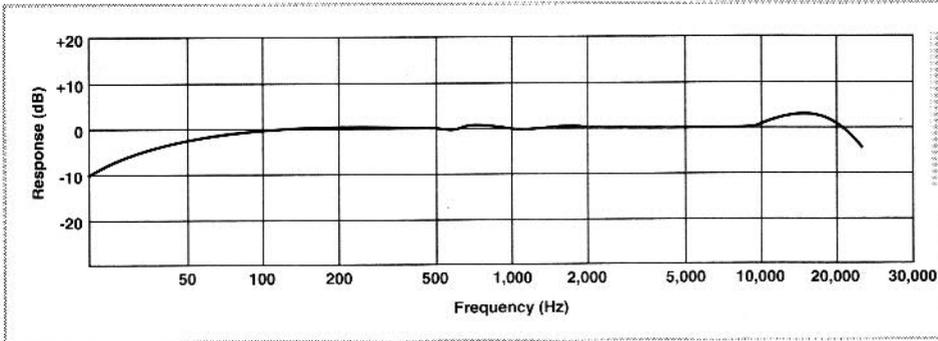


Fig.1 Typical frequency response of an inexpensive back electret condenser microphone (Realistic: Tandy Cat. No. 33-1063).

frequencies between 50Hz and 8000Hz - the area of principal interest for audio measurements. Standard IEC 179 specifies tolerances in respect of frequency response of sound level meter.

Weighting Networks

The human ear, however, due to its mechanical function, is not able to follow the frequency response of an electret microphone. As would be expected, its response tails off for high frequencies (above 6KHz) and for low frequencies (below 250Hz). From measurements of the response of individuals to SPL levels at various frequencies a series of weighting networks has been established as indicated in Figure 2. The A weighting curve was used initially for weighting at low to medium levels of sound though it is increasingly used for measurements at higher sound levels. Values referenced to this weighting network will be identified as dB(A). Thus values of dB(SPL) cannot be used to evaluate apparent loudness.

Such weighting networks can be readily implemented by active bandpass filter designs.

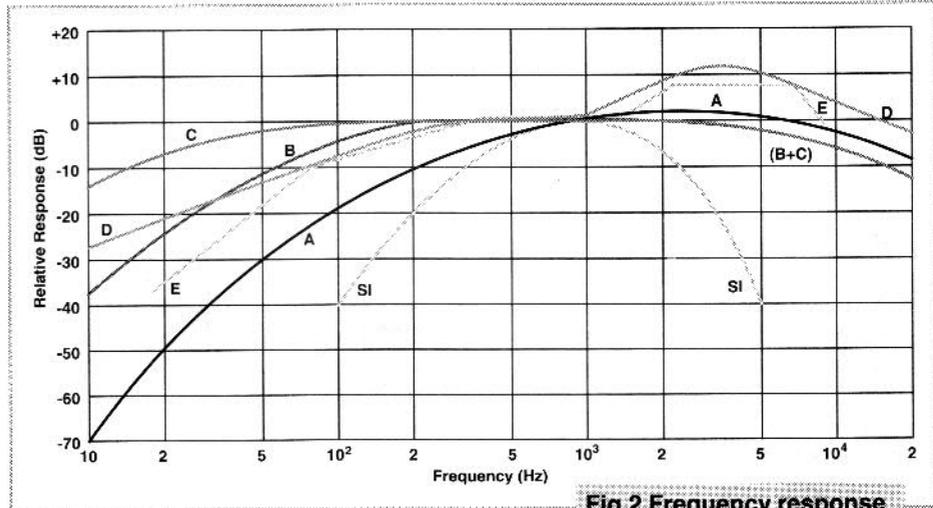


Fig.2 Frequency response of the main weighting networks. The 'A' response is used for sound measurement at low and increasing also at high levels.

obtained, it is possible to extend the range of derived values from the system. It is possible, for example, to measure the peak value using peak hold circuitry. So called Sound Dose Meters can be developed where the dB(A) value is integrated with time. This is of value for summing the noise exposure of individuals over specific time periods.

The SSM-2110 Device

The SSM-2110 (SSM Audio Devices/PMI) precision level detection chip provides a high level of functionality for

the SSM2110. The unit is typically powered from + - 15 supplies although the unit will operate from + - 12 supplies. The current required to power the device is typically 0.5mA on the positive supply and 1.5mA on the negative supply at +/-12V.

The signal input line on pin 17 is an AC virtual ground with about a 1.4 DC voltage offset. The device has a useful input signal dynamic range of 100dB (3mA to 30nA). For use

with input amplifier circuits powered on + - 15V rails, a 10K ohm input resistance will provide the maximum current amplitudes of +/-1.5 mA. It is important that the input capacitance is a low leakage type to DC, otherwise the dynamic range of signals at lower

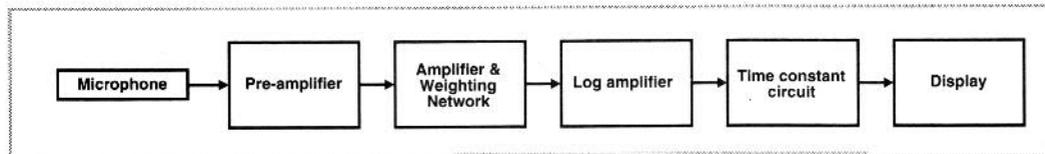


Fig.3 Outline of key units of a sound level measurement system.

Sound Level Measurement Systems

Figure 3 shows the essential building blocks of a sound level measurement system. The microphone input is processed initially by a pre-amplifier/amplifier system which can provide the weighting network frequency response. The log of the RMS value of the signal is required to be derived and the response (time constant) of the sensing circuit selected. LCD units are typically used to display data values.

Once the dB(A) value has been

sound measurement to translate the signal derived from the microphone to a dB(RMS) voltage output. A range of derived outputs however, can be obtained for a specific input signal as outlined in **Table 3**.

Figure 4 shows the block diagram of the SSM2110 with pinouts (top view).

Figure 5 shows the connection options of

Linear Measurement Output	Log. Measurement Output
true RMS*	log RMS**
absolute value*	log absolute value**

Note: * = available independently; ** = available singly

Table 3: Outputs of SSM2110

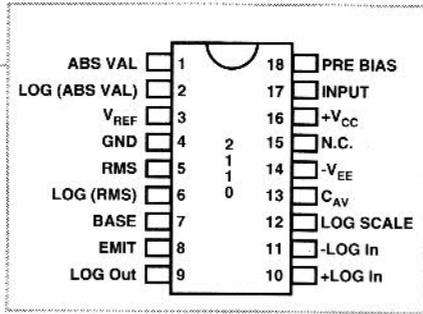
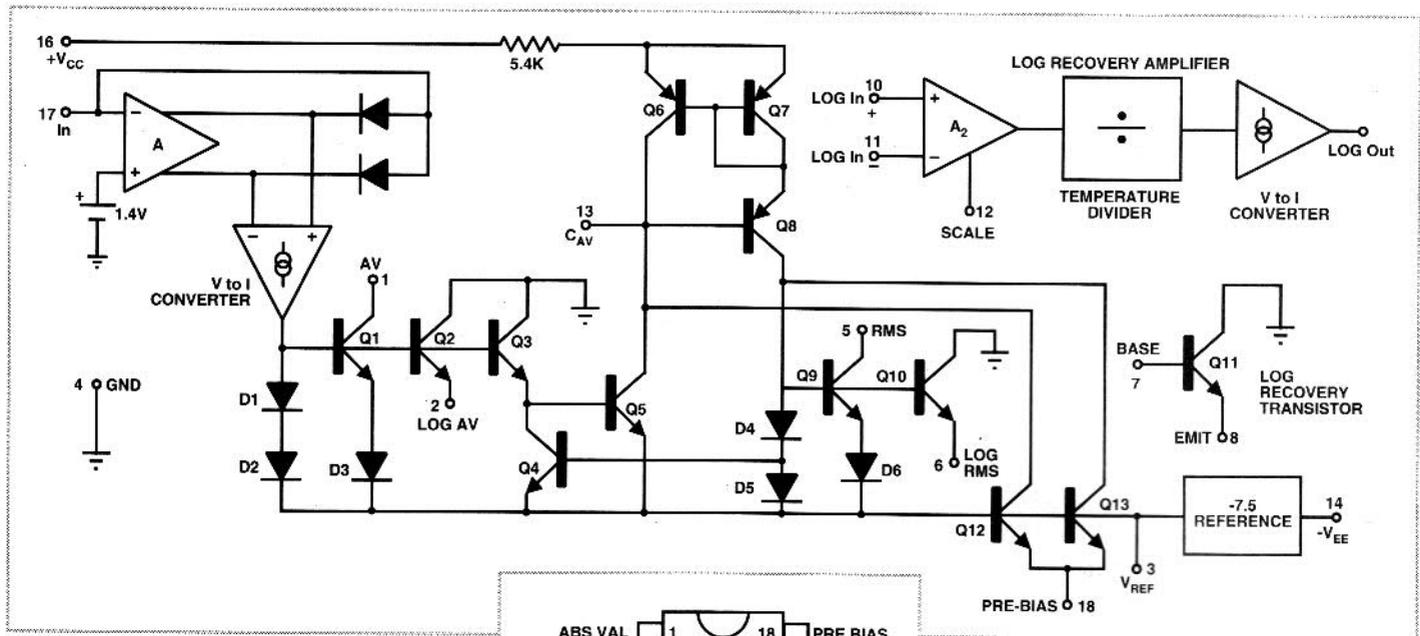


Fig.4 Block diagram of the SSM-2110 audio level detection system with Pinout (top view)

signals will be compromised. Typical resistances of capacitances are in the region of 3×10^{10} ohms. The value of the input resistance affects naturally the frequency response of the input stage. For a 10K ohms input resistor and a $1\mu\text{F}$ capacitance, the ac current signal at 16Hz will be half that of the high frequency limit.

The device implements an RMS computing loop where the output signal I_o is given by:-

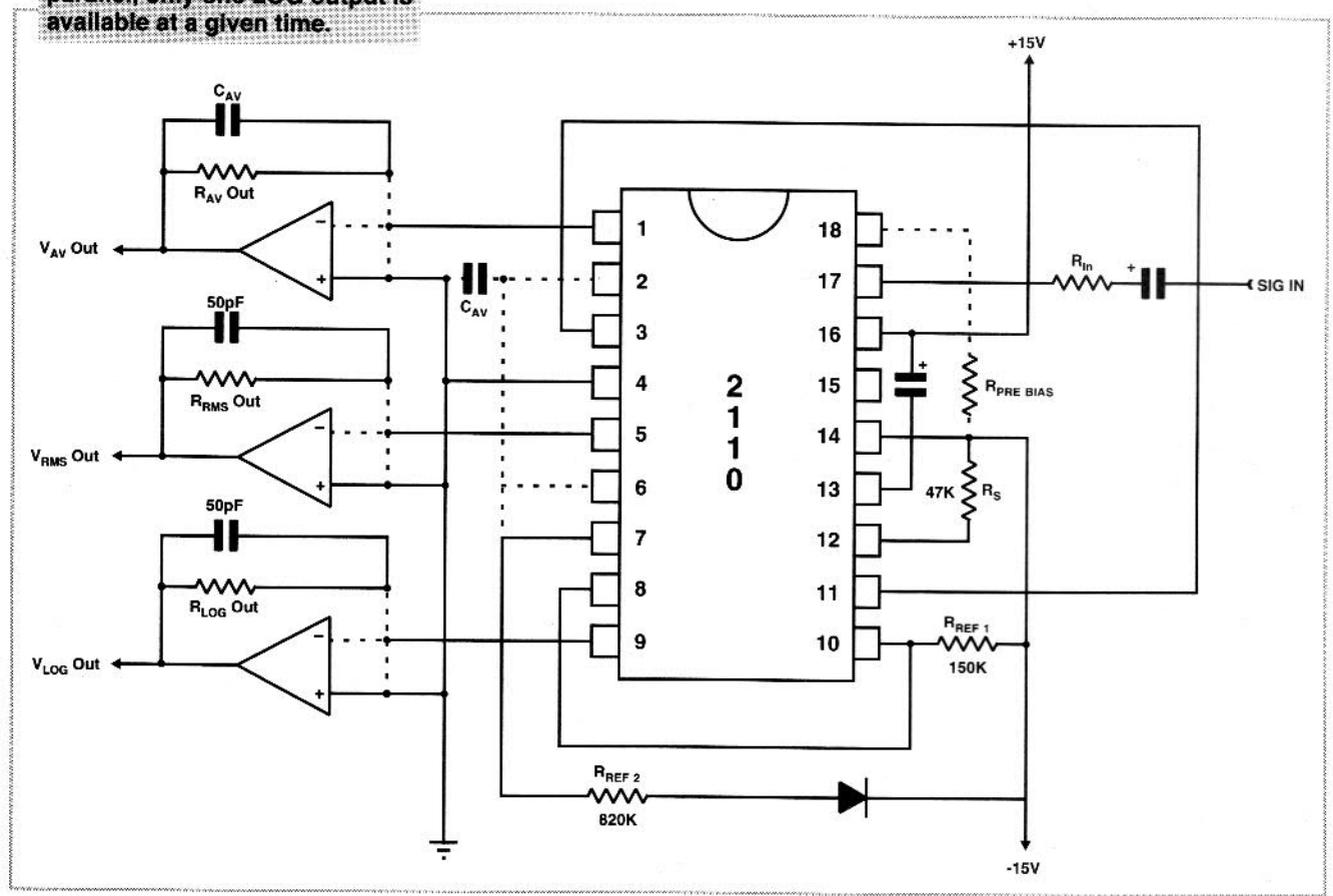
$$I_o = I^2_{in}/I_o$$

where I_o is the average of I_o
 The time constant for the value of I_o is determined by the capacitance C_{int} and an internal resistance with an effective resistance of 10.8K ohms. A very low leakage capacitance must again be used. If this time constant is made very short, then

the circuit will respond to rapid fluctuations of input signal, eg. over the waveform cycle of sound at 1KHz.

The output of absolute value from the device is most usefully obtained via the use of a current to voltage converter as shown in Figure 5. In addition, a capacitance can be used across R_{av} to obtain an average value. An RMS output can be independently obtained by converting the current output on pin 5 to an output voltage via an operational amplifier as indicated in Figure 5.

Fig.5 Connection options of the SSM-2110. While various linear outputs are available in parallel, only one LOG output is available at a given time.



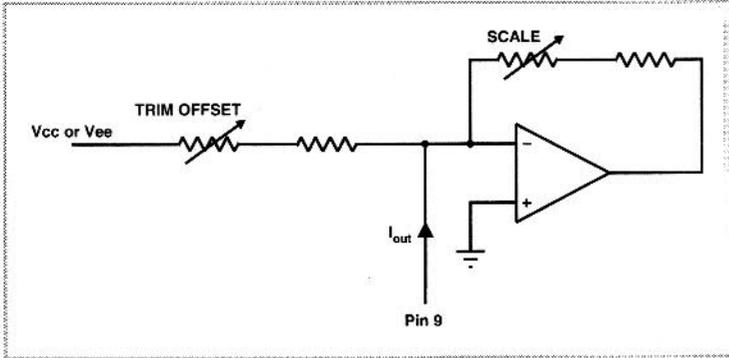


Fig.6 Circuit to provide level shifting and gain setting for the output of the log recovery amplifier unit. This allows the unit to be calibrated to a known sound source.

Most interest, however, lies in functions which translate input linear signals to output log functions. The SSM2110 has a LOG (Absolute value) output (pin 2) and a LOG (RMS) output. These signals require to be buffered, level shifted and temperature compensated in order to be made useful. The LOG (RMS) output is the signal essential for the sound level measurement.

The log recovery amplifier is a specific stage which is provided which undertakes these functions. It translates the voltage difference between pins 10 and 11 into a current signal which can be readily converted to a voltage signal level shifted as required. For a standard configuration with $R_s = 4.7K$ between pin 12 and the negative supply, the output of this unit is typically $3.2\mu A/dB$. Only one log output can be connected to the log recovery amplifier at a time, however. Figure 6 shows how the output from the log amplifier can be level shifted for offset and gain adjusted for calibration. Usually the effective zero of log (RMS) can be set by grounding the SIG IN and adjusting the offset control until zero is attained at the output to the current to voltage amplifier. Circuits which output LOG parameters tend typically to have a high temperature dependence. Within the SSM-2110, however, this effect is minimised by the log recovery amplifier circuit.

Output Time Constants

After the signal has been level shifted and translated to a signal voltage which is referenced to zero and calibrated to a reference sound pressure level, it is necessary to 'smooth' the output signal. Without any form of damping, sound levels would fluctuate significantly on a milli second basis. It is common to use two basic values of time constants - the SLOW and the FAST response. The IMPULSE measures much shorter sound events - eg explosions or fly-past of aircraft. Figure 7 shows how these responses are formally defined.

If a sound signal was applied as a step as shown in Figure 8, then the FAST response (curve A) would lag behind the step response and the SLOW response (curve B) would lag behind the FAST response. Provided the signal is present for long enough, the undamped and the SLOW and FAST responses reach a common value. Where short tone bursts are being detected using FAST and SLOW response circuits, then

significantly different values will be detected. This is why it is important to specify a SLOW or FAST response. Figure 9 shows a simple circuit to simulate such response curves. The equation to express the voltage V developed by the circuit after time t is given by:-

$$V = V_o(1 - e^{-x})$$

where $x = -t/RC$

and V_o is the initial value of the waveform applied to the input of the smoothing circuit. This equation can be modified to determine the dB fall in signal as a function of t and the length of duration of the tone pulse. Taking the log of each side and multiplying by 20,

$$20\log_{10}(V/V_o) = 20\log_{10}(1 - e^{-x})$$

$$dB = 20\log_{10}(1 - e^{-x})$$

Thus as t tends to large values the value of dB falls to zero.

Values of time constants which give a good 'fit' to the response curves are listed in Table 4.

For SLOW response, for example, where $C = 470nF$, $R = 220K$ gives the correct response values approx. More accurate response circuitry than that shown in Figure 9, will typically be required to implement a formal response curve.

Response Type	Value of Time Constant	Capacitance(R=220k)
SLOW	0.11	0.47 μ F
FAST	0.029	0.132 μ F
IMPULSE	0.0085	0.039 μ F

Table 4: Values of time constants which give approximate 'fit' to IEC response curves and capacitance values for R = 220K.

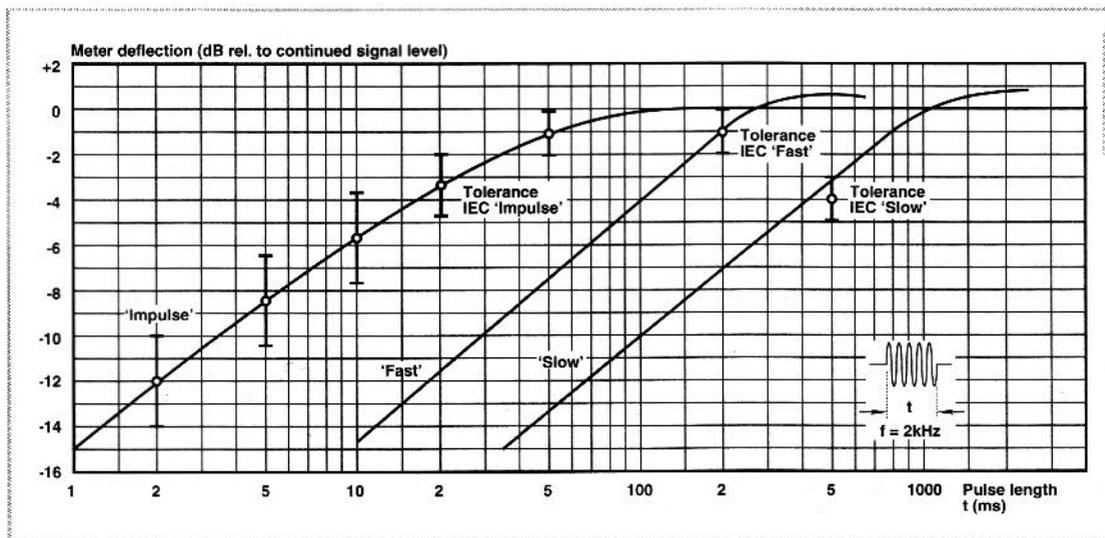


Fig.7 Definition of main forms of time constants - SLOW and FAST.

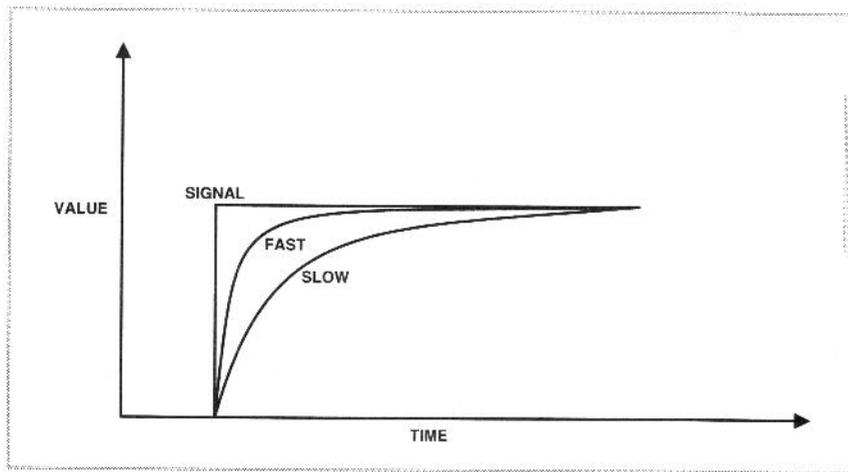


Fig.8 Examples of how a **SLOW** response and **FAST** response circuit would respond to a step sound signal.

Power Supplies

The +/- 15V supply lines of the SSM2110 can present problems when powering circuits from a single battery supply. Where the device is being run from +/-12V supplies, the current required is relatively small - 0.5mA on the positive rail and 1.5mA on the negative rail. These levels of current can readily be obtained using DC to DC converters converting +5V to +12 and -12V though at least 30mA will be drawn from the 5V supply since the devices are inefficient at low power loads. While compact 1W types are readily available as DIL or SIL packages, 700mW types are now available which will reduce further the current required.

Calibration

Some sound level meters claim to have a 'calibration' button which can be pressed to 'calibrate' the unit. This form of calibration is really only checking the post pre-amplifier sections of the sound level meter. Professional sound level meters are calibrated using a 'Pistonphone'. Such a device can be either a piezoelectric sound source or a mechanical device which establishes a specific sound

pressure amplitude. The piezo electric devices tend to be cheaper and provide typically a signal around 90dB(A) at 1KHz.

Summary

Sound measurement circuits are increasingly available as complex analogue ICs rather than an array of transistors, diodes and operational amplifiers. A good knowledge of sound and measurement standards is required, however, to be able to develop equipment to a specific standard. EIA

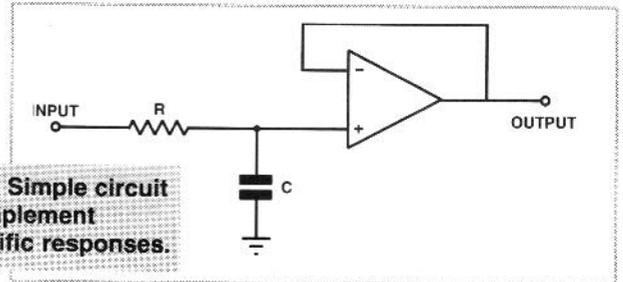
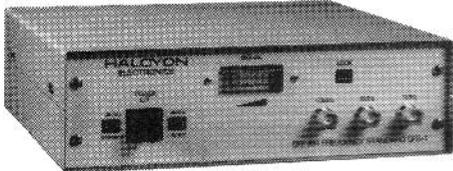


Fig.9 Simple circuit to implement specific responses.

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74LS81			ICL7106	4.85	BCY71	2N2222A	0.15
74LS82			ICL8038	3.05	BCY72	2N2369	0.23
74LS83			ICM7555	0.29	BD115	2N2484	0.24
74LS84			ICM7556	0.78	BD131	2N2646	0.57
74LS85			IH5025	6.50	BD132	2N2904	0.24
74LS86			IH5029	5.25	BD135	2N2904A	0.20
74LS87			IH5033	5.75	BD136	2N2905	0.20
74LS88			IM6403	7.60	BD137	2N2905A	0.20
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74LS94					BF185	2N3054	0.83
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74LS97					BF196	2N3702	0.09
74LS98					BF197	2N3703	0.09
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74LS02					BF258	2N3773	1.68
74LS03					BF259	2N3819	0.26
74LS04					BF337	2N3866	0.99
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79L12 0.23	IN4006 0.26	22UF 35VOLT 0.06
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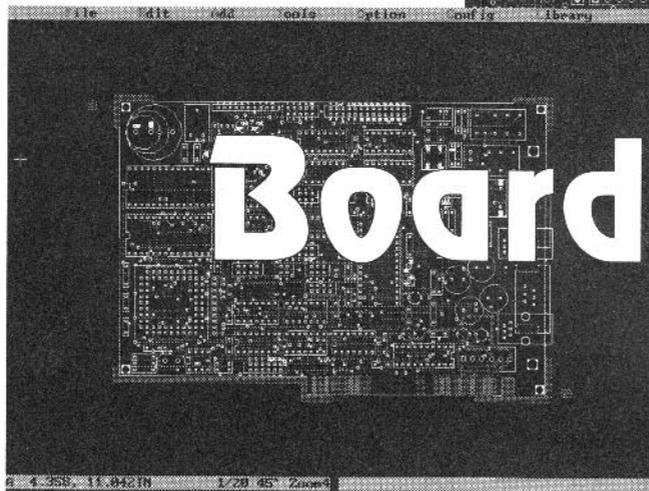
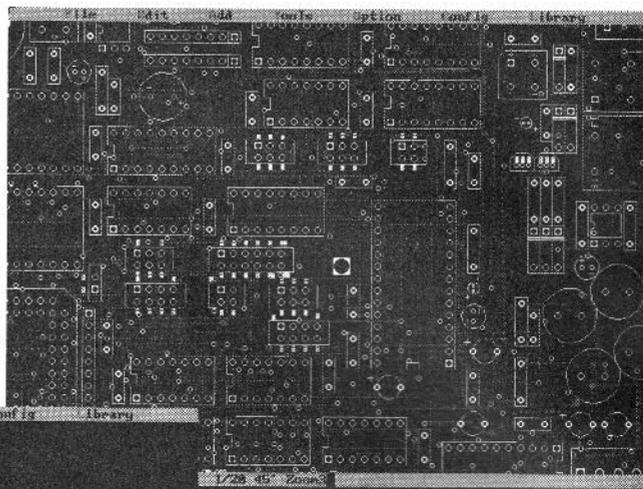
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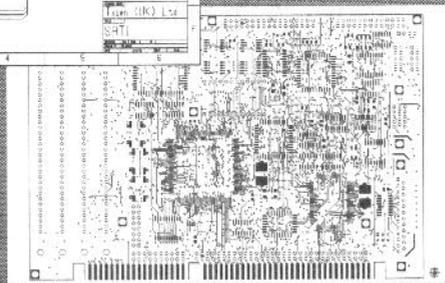
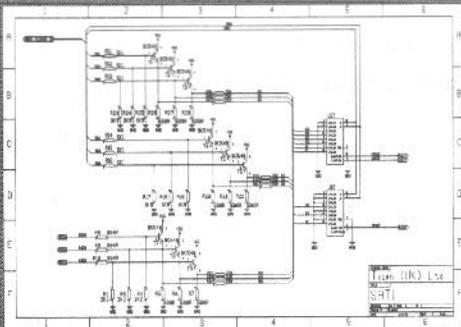
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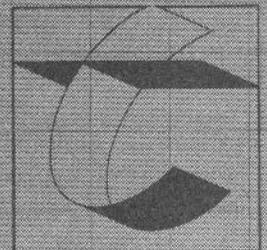
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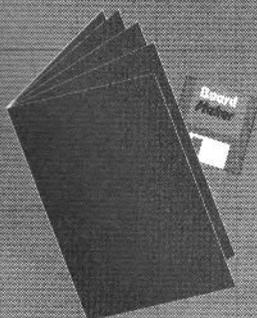
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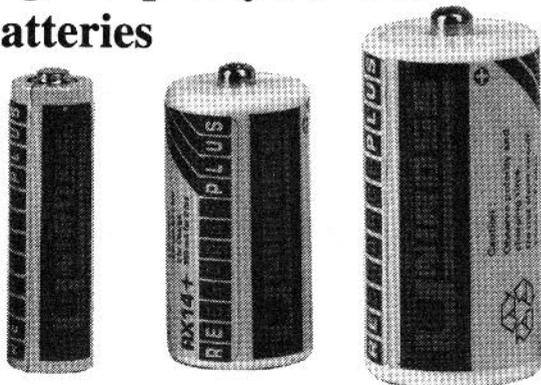
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This special pack contains 4 x AA, 2 x C and 2 x D size cells.

Type	Size (mm)	Nom volts	Capacity (A Hrs)	Charge Rate*
RX6+ (AA)	14.5x50	1.2	0.65	350mA
RX14+ (C)	26x49	1.2	1.5	900mA
RX20+ (D)	33x61	1.2	1.5	900mA

*Maximum continuous charge rate; time for full charge at these rates is 2 hours.

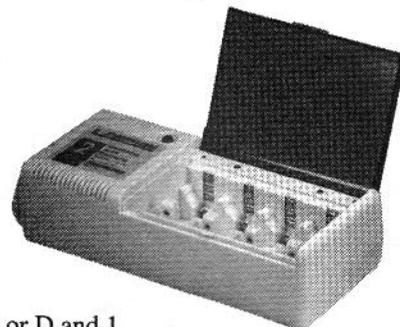
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The unit will charge 2 or 4 of either AAA, AA, C or D and 1 or 2 PP3 cells at any one time. Various combinations can be accommodated simultaneously and LED indicators are included together with reverse polarity protection. Complies with BS3456 Part3.



Battery	Charge Times
RX6+ (AA+)	2 or 14 hours
RX14+ (C+)	2 or 14 hours
RX20+ (D+)	2 or 14 hours
RX3 (AAA)	4-5 hours
RX6 (AA)	10-12 hours
RX14 (C)	10-12 hours
RX20 (D)	10-12 hours
RX22 (PP3)	14-16 hours

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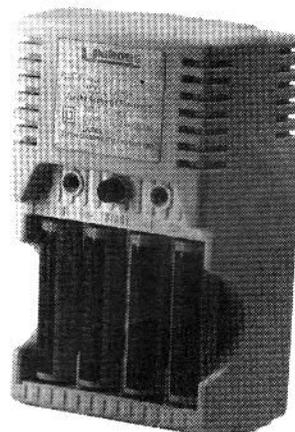
The CX550 is a 2 hour fast charger designed specifically to charge the RX6+ cells. This compact unit plugs directly in to a 13A mains socket and will charge 2 or 4 RX6+ (AA+) cells in only 2 hours. The charger incorporates a 2 hour push button timer, LED charge indicators and reverse polarity protection.

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Supplied complete with 4 x RX6+ cells.

The usual price is **£13.71**

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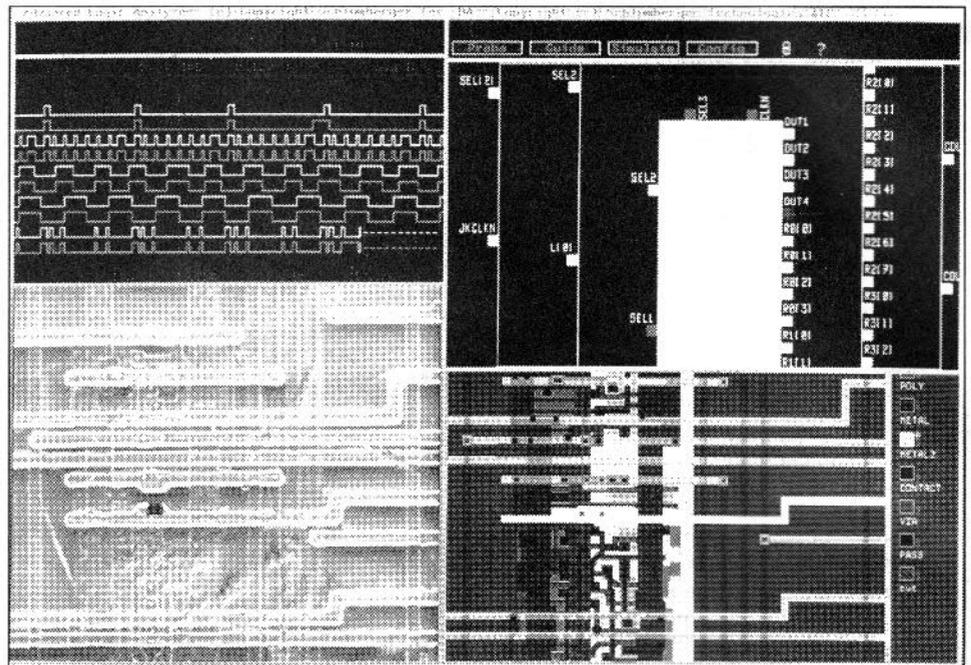
Electron Beam Diagnostics

By A. Armstrong BSc CEng MIEE

The news item about the new Schlumberger E-beam prober raised some interest around the office. It turned out that very few of the people we spoke to had an accurate knowledge of the technology, so here is an overview.

The purpose behind E-beam probing is to test integrated circuits while loading the test points with a lower capacitance than even the best active mechanical probes. Nodal capacitances of smaller geometry ICs are in the range 5 to 10fF (femto-Farads, 10^{-15}F) while even the best active probes impose a load capacitance of 50fF. The measured signal on a node loaded by between five and ten times the normal capacitance may not be representative of normal performance. E-beam probing overcomes this loading problem.

E-beam probing works similarly to a



scanning electron microscope (SEM). As with conventional SEMs, a finely focused beam of electrons is raster-scanned across the IC to be examined. Secondary electrons are emitted where the beam strikes, and these are steered to an extraction field, where the signal from the detector can be used to produce an image as in a conventional SEM. However, voltages present on the device modulate the secondary electron beam. Even the field from buried conductors modulates the beam, as illustrated in Figure 1. This beam is directed into a scintillator/photomultiplier to generate a voltage contrast image.

The photograph shows a typical output from this process showing acquired waveforms.

A conventional SEM is not designed to provide the type of output shown in the photo. The main differences in an E-beam prober are that a lower electron-beam energy is used (Schlumberger uses 1keV), and the addition of precision x-y drives.

Additionally, in order to measure a waveform, the electron beam is pulsed

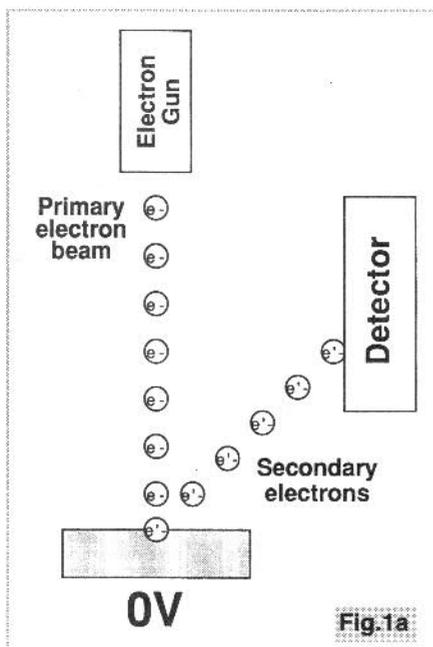


Fig.1a

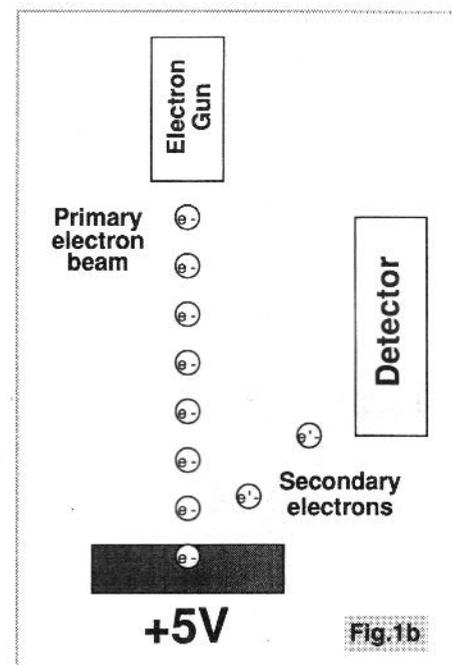


Fig.1b

while maintaining its focus on one part of the device. This gives a sampled version of the waveform present on the part of the device under scrutiny. Clearly, several areas of the device can

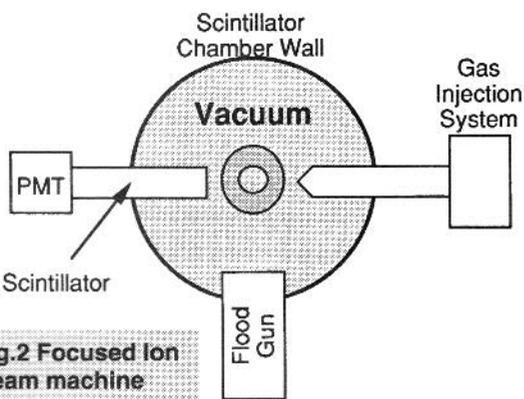
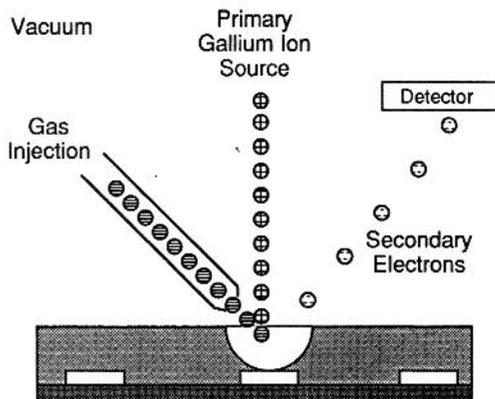


Fig.2 Focused Ion Beam machine



be sampled sequentially because a continuous beam on any one point is not needed. The result is very much like that obtained from a conventional sampling oscilloscope.

The currently available spot size for electron beams is under 100nm, permitting probing of devices with 0.5µm geometry.

A similar technique to the E-beam probe can be used to modify and repair ICs. Focused ion beams (FIBs) are used to cut conductors or to deposit new ones, similar to using a scalpel or conductive ink to modify a PCB. If the

FIB is raster scanned over a 1µm area, this effectively drills a hole, which can be plated to make a connection if necessary. This ion milling can also be used to expose buried conductors to E-beam probing.

To make a new conductor, FIB-induced chemical vapour deposition is used. An organo-metallic gas, such as tungsten hexacarbonyl, is injected into the vacuum chamber close to the surface of the device. The FIB splits the gas molecules into their constituent parts, in this case carbon and tungsten, resulting in the tungsten being deposited on the

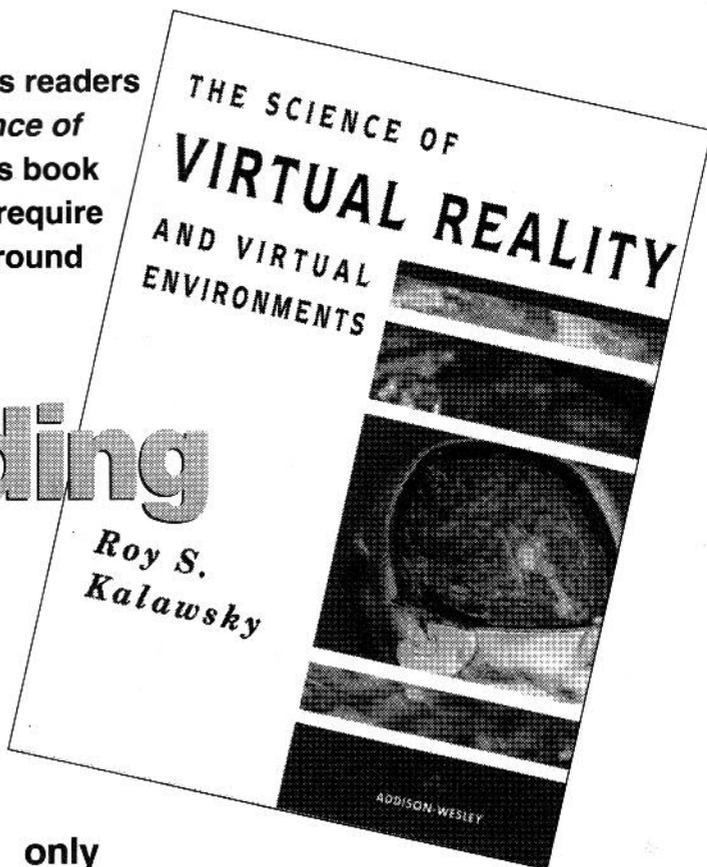
device as a new conductor. An image generated in the conventional SEM fashion is used to position the ion beam to the required accuracy.

The IDS7000 probe made by Schlumberger (see this month's news pages) is a combined SEM prober and FIB machining system, allowing chip repair and modification. Modification of PCBs, including surface mount ones, is commonplace, but I would not have thought a few years ago that the same thing could be done to silicon chips (albeit at much greater cost).

Electronics in Action is pleased to offer its readers Roy Kalawsky's fascinating book - *The Science of Virtual Reality and Virtual Environments*. This book provides a wealth of material for those who require a thorough scientific and engineering background in Virtual Reality whether they be scientist, engineer, student or layperson.

Virtual Reading

Professor Roy Kalawsky is head of the British Aerospace Virtual Environment Laboratory



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March

Geological Aids

A convenient method of finding cavities within rocks and minerals apart from using standard density measurements.

A method of finding weak points in rocks in order to split them open. Would ultrasonics find and show up cracks.

Electronic method of finding small particles of gold in rivers. What characteristics of gold can be detected.

Electro optical method of determining the true characteristics of minerals e.g. differentiating real diamonds from false ones.

Detecting metallic cubic crystal structure within rocks using high frequency radio waves to image returned echoes.

Other ways of measuring hardness of materials other than scratch test. Use a known high force or impulse on a diamond tipped punch on test material then measure the degree of indentation. Very small depths could be measured by wave interference perhaps using semiconductor laser.

Audio

Audio distribution for a four speaker system to create a moving sound image. The sound could be moved around the room electronically. A series of preset switches providing a variety of effects like rotate pan left or right, switch rotate, diagonal alternate pan.

Subliminal Audio

How can many thousands of repeated messages be embedded onto an audio tape without the listener being aware? Tapes and CDs exist with many so-called therapeutic messages. Is there a way to electronically instal an inaudible message for broadcast. Is this all a load of hogwash because the only way to comprehend and act on information is by audible speech.



Ideas Forum

Alchemy may not be possible, but maybe detection is.

Get rich quick! How? I here you cry. Well, first invent a cheap gold detector (if it's at all possible) then pack your bags and take a long holiday in somewhere like the American Mid-West and pan in all the right places. If that all seems pretty far fetched just think about the trouble Alexander Graham Bell had persuading folk that his telephone actually worked.

All great inventions start as little

notions that get scribbled down and expanded upon, and that's what the Electronics in Action Ideas Forum is all about. Now you are the inventors.

The WINDOW SAFE featured in our news section is a prime example of somebody recognising a problem and coming up with a solution. Not all ideas have to be marketed though, they can just be for fun or one-offs to help a disabled or elderly friend.

If you have any suggestions or have developed any of the ideas that have been appearing in this column we would love to hear from you, feel free to drop us a line. **Electronics in Action, PO Box 600, Berkhamsted Herts. HP4 1NL**

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So you don't fancy messing up your best measuring jug with Ferric Chloride, but you still want to make some of our projects properly - with a PCB? This is where we step in. At Electronics in Action we can offer, at very reasonable prices, PCBs for all of our featured projects.

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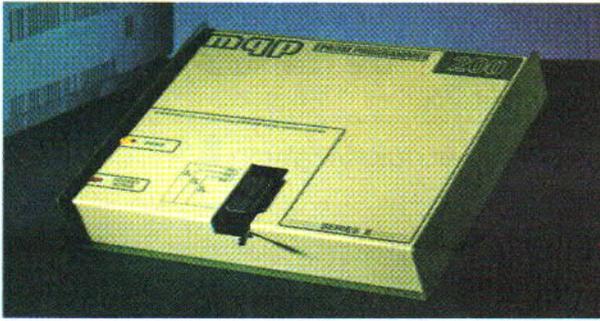
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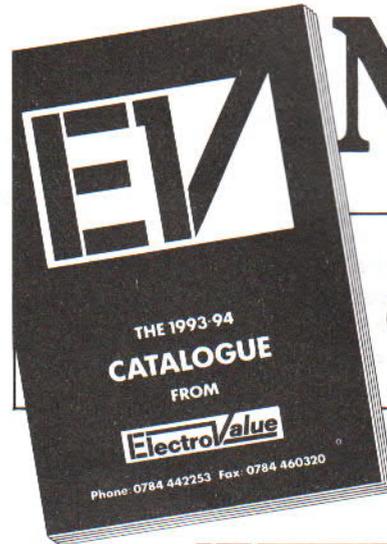


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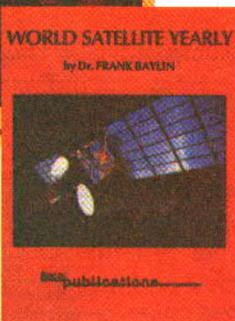
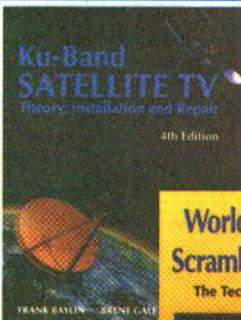
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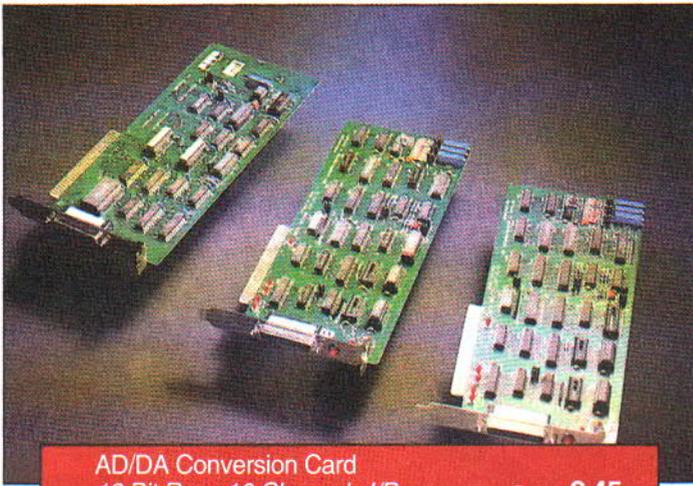
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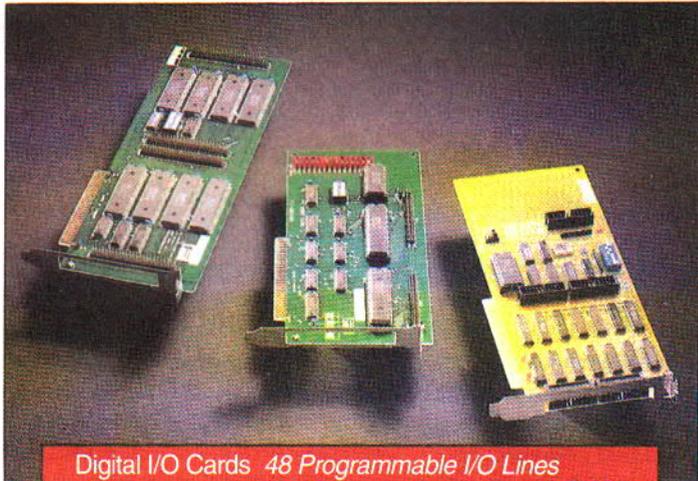
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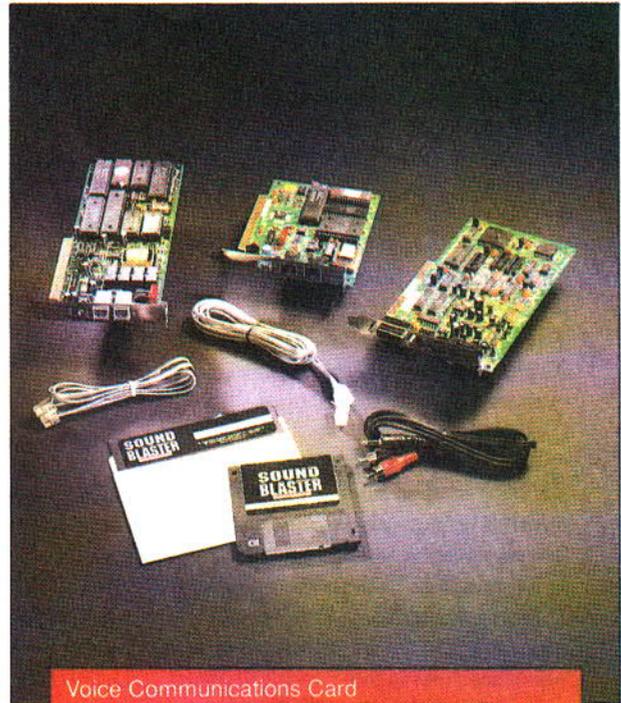
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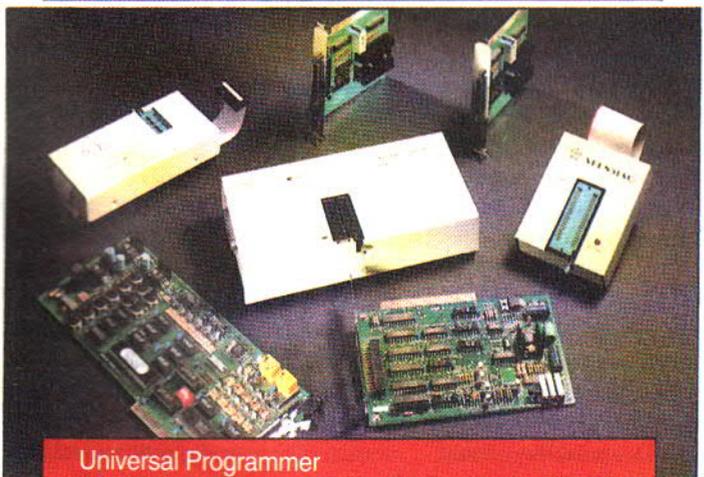
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U Pre-production units available	F In current production	C Commercialised
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Source: Indicates the type of organisation making the offer.		
C Limited Company	E Educational Institution	R Independent Research Organisation
G Government Research	P Private Individual	

5163 F L G **Electroinsulating composition**

The composition is put on the surface of the protected insulated construction via a pulveriser and in 15-20 it becomes dry, forming a stable film, which closely covers the insulators body, preventing it from contact with moisture, acid and other aggressive media. Surface electric strength - 14 kw/cm. The composition is chemically strong, heat resistant.

105462 P L **System for the attachment of plugs on a rectangular, multi contact electrical connector**

prevents the occurrence of connecting errors and key system rejection. Many codes are possible. This process is especially relevant to the data processing and aeronautical industries.

105464 F J **Image memory card PC 4-2-2 and library of functions**

enable operation in the professional television environment, and thus the availability of very high quality images. This product is integrated with a microcomputer. Applications include image synthesis and processing and banks of fixed images.

405515 W L G **Variable frequency microwave furnace**

This technology provides the first microwave furnace that is tunable to a significant degree. This tunability allows

the possibility of optimal frequency sintering for each composition of matter. The variable frequency microwave furnace can be used for materials processing both in production and research. The variable frequency aspects may add a completely new dimension to process control and flexibility for industrial applications such as ore processing, drying and curing of rubber products.

805734 C J G **400MHz personal radio hand set**

The product is a new generation transceiver with the following features: dynamic 80 channel sharing, automatic dial calling, microcomputer controlled, digital signalling, saving frequency resource, low power consumption, small in size and light in weight.

605810 W S C **Electrical potato slicer**

This device allows you to transform potatoes into various shapes. Simple construction of standard material. Ideal for restaurants, snack bars, canteen or take out. Electrically operated.

5843 W L U **Beta and low energy photon field dose and hot particle dose monitors using semiconductor detectors**

Most commonly used portable detectors monitor gamma radiation, but cannot accurately determine beta and x-ray doses to body surface tissues. Using semiconductors and amplifiers, very low

radiation levels can be reliably detected and measured.

205847 W L U

High temporal dynamic range multi layered liquid crystal optical limiters switch

The author has packaged a multi layer crystal switch which can transmit visible to near infra-red signals at low levels but blocks high powered laser signals to protect sensitive components. The switch passes low level signals but shunts high level signals, either instantaneous pulses or sustained lasers.

5854 W L U

Tunable multilayer composite transducer

Combining piezoelectric and magnetostrictive elements within a modulus sensitive composite assembly allows operating frequency of transmitting element to be changed. The transducers operating frequency can be changed by an externally applied signal, which can mean frequency modulated (FM) advantages of clarity and low noise.

6027 W L G

Ground based radio equipment

The basic modification intended for landing in ICAO's category I weather conditions comprises the following subsystems: azimuth fixing aids for guidance in a horizontal plane; elevation fixing aids for guidance in a vertical plane; range finding aids; air traffic control tower equipment for remote control, additional data input and signalling. The expanded modification intended for landing ensuring in ICAO's category III weather conditions includes the addition of back azimuth fixing aids for guidance in a horizontal plane during go around procedure and take off.

106127 L G

Photoelectric transducer with light path of increased length

The invention is especially effective in polycrystalline solar cells in which texturing of its semiconductor surface is difficult. The invention is also effective in a super high efficiency solar cells in which both light-trapping and surface passivation play important roles.

606035 W L G

Catalytic element (electrode) for chemical source of electric energy

The new catalytic base electrode with high electro-chemical characteristics has been obtained using unique technology

of amorphous catalytic materials plasma spraying in inert control medium. The chemical source of electric energy with the use of these electrodes has specific power up to 600 Wth/kg, weightsize characteristics are 2-3 times less and service life is up to 200 hours.

106063 W L U

Class E AC-AC converter

This technology uses a single switch that operates only at low voltage or current, and at low time derivative of voltage or current, thereby achieving very high conversion efficiency. Variation and control of the output waveform requires less complex circuits.

406106 M L G

Photorecording element and liquid crystal cell comprising the same

A photorecording element is disclosed which consists of a transparent substrate, a molecular layer of an organic compound with an ability to change structure reversibly by virtue of light and disposed in direct contact with the transparent substrate and a layer of liquid crystals disposed in direct contact with the molecular layer. A liquid crystal cell comprising the photorecording element is also disclosed.

905949 M J C

Electrical powerline signalling systems

A patented system allows for data transmission over considerable distances via electrical power distribution lines. The principle of the new system has been proved to work and investment is now required in order to develop and build a series of prototype systems. The technology will allow remote reading and tariff programming of domestic/business electricity meters through existing cables.

606147 P L C/P

Main area communication system

A mobile telephone system and beacons. It can operate in a power failure, requires little wiring and maintenance. Ideal for ships, mines and areas of dense metal construction. Battery operated as back up. Sealed units against fire and water.

506423

New electric spray system

replacing pump sprays and aerosols. In this sprayer system a plastic bottle is connected to a module containing an electric pump and rechargeable batteries. Licensees wanted.

6436

Fully automatised system for tinning of integrated circuits

506442

Highly flexible production booths

for the complete assembly of printed circuit boards in surfaces; SMD and DSM (or combination of both).

706448

Circuit board prototype detection system

From hand drawn layout to mechanically manufactured circuit board prototype.

506653

Systems for the pretreatment of printed circuits

with the aid of an electrolytical system. New electrolytes.

106754

Bandaging machine for all coil windings

in medium-to-large-sized electrical appliances. Automatic operation, adaptable to all types of coils without problems.

406767

Low-voltage halogen table

and standard lamp with patented lateral and height adjustment capability.

6770

12V-DC luminiscent lamps

for solar technology, emergency light, interior light for vehicles, boats; consumption 5 to 13W for light output of 75W with 80per cent efficiency; very low heat dissipation; GS and VDE TESTED.

506801

Electronic counter

mains-independent, low-cost with digital display. Operation on optoelectronic or electromechanical basis. For counting persons or items in production or packaging

506857

Semi-conductors

Process for production of long-term stable, layer-depositing solutions for semi-conductor substrate doping.

206861

Production of thin-film hybrid modules

Intelligent sensors with integrated signal processing and micro-systems-technology products. Also: circuit design, testing and production.

106863

Production of printed circuit board
SMD and COB (bare chips on board); also: circuit design, module design, testing and production

506866

Safety switch
capable of actuating any type of switching process without touching the actual switch

806869

Corona electrodes
made of non-metallic electrically conductive materials. Main uses: paper and film production, printing and copying technologies

706871

Electrode and contact surface coating (material)
developed and tested which comprises a mechanically resistant material exhibiting good electrical conductivity. For use in the fields of thin-film and measurement technology

306875

Timer for light bulbs
energy saving since bulbs are prevented from burning unnecessarily. Application areas: household and industrial use

206879

Wind dynamos
for low power applications (10 - 100 watts) for low consumption systems in yachts, electric fence, beach cabins etc.

406893

Electronic circuit enabling change of batteries and accumulators without interruption of operation
in mobile electronic devices (data storage, clocks) with minimum component requirements; no buffer batteries necessary

6906

Car radios
with a new type of remote control, coding, multiple anti-theft protection as well as loudspeaker system, with special articulated mounting components

506955 F S G

Rotor dynamic balancing technique for rotating machinery
three microcomputer aided balancing systems MCAB-I, MCAB-II, MCAB-III are included. They are suitable for a variety of rotating machines such large steam turbine generator sets, centrifuges, fans, pumps, electric motor etc.; for

shaft system, rigid and flexible rotor balancing and whole machine field balancing

307037 W

Portable lamp with solar operated battery
Will provide 3 to 4 hours light every day without the need of conventional source of energy. For houses without connection to the public grid. Camping, caravanning. Emergency light.

607079 W L U

Ultrasonic unipolar pulse/echo instrument
An ultrasonic unipolar pulse/echo instrument uses active switches and a timing and drive circuitry to control electrical energy to a transducer, the discharging of the transducer and the opening of an electrical pathway to the receiving circuitry for returning echoes.

7085 L U

Electrolytic Capacitor and large surface area electrode element
An electrode element for an electrolytic capacitor comprises an electrode body having a plurality of ultra-fine, ribbon-shaped filaments of Al and X (where X is selected from Nb and Ta) interspersed and aligned along an axis of the body.

107099 L U

High power semiconductor device with integral heat sink
A high power semiconductor device with integral heat sink capable of accommodating substantial heat flux on the order of one kw per cm². The integral heat sink is formed on the active surface of the semiconductor and utilises an AlN thin film of high purity to provide a low thermal impedance heat conductor for removing heat directly from the active semiconductor surface.

807142 P S C

The glow switch
Allows easy location of the light switch in the dark eg halls, cellars, hospitals, schools, stair landings etc. The switch incorporates a neon light/LED which glows when the light is switched off.

7197 P L U

Transformer core sensor
Thin film temperature and/or magnetic field sensors for use with laminated transformer cores, electric motors or generators. Air gaps between adjacent laminations are substantially reduced thereby increasing accuracy.

7202 P L U

Digital filtering
A method of filtering electrical signals and digital filtering apparatus capable of filtering an electrical input signal or signals comprising a plurality of samples.

207269 F L C

Synchronous electric motor
This is an AC synchronous motor with the particular feature of including oscillating core which does not rotate but converts the cone shaped movement into a synchronous rotation of the high speed spindle. This brush free motor further comprises a double multi-phase stator, it is self starting under nominal torque conditions in 1/4 wave, it can be supplied in stepped mode. The motor is specially intended for: mechanisms; electrical, electrotechnical systems; automation; handling.

207283 F J C

Preamplifiers and conditioners for PC programmable accelerometers
Company has developed a system fitted with measurement channels with programmable configurations, using a microcomputer (serial interface). Programmable parameters are: type of conditioning (piezo, integral electronic); sensor sensitivity; cut out frequency for low pass filter. The gains on the measurement chain are automatically programmed and optimised through the software.

907310 P L U

Electron wave devices
These devices are a new class of semiconductor devices based on the use of electron waves. Both faster and smaller than existing semiconductor devices, the proposed structures can be combined into guided electron wave integrated circuits. Such circuits could become the next generation of semiconductor technology.

707321 M L U

Optoelectronic devices on silicon
This invention describes an alternative to heteroepitaxy of III-V (or other) light modulators or lasers onto silicon. The process is envisioned for discrete devices a few microns thick and with diameters in the tens of microns or larger. It is believed that this technology provides a superior process for the fabrication and attachment of discrete devices used on a silicon (or other) host substrate.

607331 M L U**Pocket calculator for the analysis and design of steel members/buildings**

This invention is an electronic pocket calculator which can be used by engineers, students and technicians working in the design of steel buildings and/or structures. The calculator's preprogrammed function keys enable the user to make all of the necessary calculations for structural steel members. The calculator has a wide display screen for input and final results and can perform calculations in both the English and Metric systems as desired.

605898 W L U**Sonoelectrochemistry**

The simultaneous application of an ultrasonic field to an electrosynthetic reaction is a relatively unexplored technique and exploitation of this procedure in conventional organic electrosynthesis is novel. Benefits identified to date include lowered cell voltages, enhanced current efficiencies, new products, enhanced chemical yields, less electrode fouling, ease of work-up, and simplified electrolysis systems.

6030 L G**Problem oriented compact EPR equipment**

Ensures new potentials for intensifying investigation and testing of various processes; specification level and high analytical capabilities of the EPR equipment allow a wide range of problems in physics, chemistry, biology and medicine to be solved.

809237 U L C**Ultra slim brushless DC pancake or doughnut motor**

This compact motor has been developed for computer peripherals, delivers 10 oz - in/A at 1 ohm winding resistance and has a hollow rotor with a 40 mm through hole, making it suitable for through shaft and servo applications. It occupies only 1/7th of the volume of a normal pancake motor being 12 mm thick and 100 mm in diameter with a substantial bearing arrangement. The design is especially suitable for applications in hazardous environments.

808007 W L C**Light switch**

A new concept in light switches designed to harmonise perfectly with both traditional and modern room settings, transforming the light switch into a luxury feature. A full proposal for this project is available, together with

samples in the form of pre-production prototypes. The designer is seeking industrial partners to manufacture and distribute the switches.

708783 F L R**Bulbsaver**

is an electronic device designed to vastly increase the life of ordinary incandescent tungsten light bulbs. It works by reducing the power surge at switch-on, limiting the power surges that can occur due to fluctuations in supply. The device is installed behind the wall switch and can be fitted by anyone with a minimum of electrical knowledge.

207950 P L/J G**Safety lampholder**

A new design, inherently safer than existing products has now been devised. The design uses visible electrical light bulb terminals which are isolated from the supply terminals in the absence of a bulb and therefore safe to touch.

7990 W L C**Cable coupling transformer**

is a device to enable the free flow of information to and from a cable anywhere along its length and with no physical connection. In effect, it is a sliding plug and socket and can be used on telephone and loudspeaker extensions, hi-fi units, communications systems and many other applications. It is suitable for use in hazardous environments, with non-ferrous materials, or under liquids where radio or connectors would be inappropriate. A tested prototype exists and the innovator seeks collaboration in the form of a non-exclusive licence.

507987 M L C**U-Beam torch**

This battery powered 'U' shaped torch has a krypton bulb for the directional beam and a fluorescent tube for the lantern worklight. Its 'U' shape enables it to be hooked easily to clothing or rigging etc, leaving hands free. Its other features include rubber grips and rubber push button (easy to operate with cold, wet hands), luminous switch covers (easy to locate in the dark). A working model exists and the innovator now seeks collaboration in the form of a licensing agreement.

407991 W L C**Stereoscopic '3D' video**

A stereoscopic video camera attachment which records two images which can be combined to create a 3D image. The 3D

image is viewed either through a modified TV set for home video use or through a large screen projector viewed through polarising 3D glasses. The latter mode is aimed at satellite TV companies.

209171 C L C**Thick film circuits**

complete line of high quality thick film hybrids and surface mounted assemblies is offered. Circuits offer better performance at high frequencies and high switching speeds and even complex circuits can be manufactured in small quantities. Specialised know-how, production facilities for design in 'thick films' to incorporate the circuits in machinery or products.

808987 C L C**Electronic apparatus having calculator and digital clock functions**

An electronic apparatus comprising calculating section, a digital clock section, and a display section which is commonly used for displaying the results of calculations performed by the calculating section and for displaying time information yielded by the clock section and a switch for selectively bringing one of the sections into operation.

908988 C L C**An arithmetic system including an additional register**

An arithmetic system including an additional register for storing a constant number which is used in calculation with respect to a series of arbitrary numbers. Application - an electronic calculator and cash register.

709112 W L C**'BIOCHIP' photon switching power transcends Silicon electronics**

revolutionary new technology destined to replace existing silicon technology, a uniquely modified photosynthetic process in combination with the latest advances in fibre optics has made this remarkable invention possible. Licensor/developer prepared to sell outright the world rights and to co-operate with licensee in obtaining patent protection.

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Future View

In 1927 John Logie Baird, in association with the GPO demonstrated that a high quality communications cable equipped with a number of suitably spaced TV signal amplifiers could support a two-way videophone conversation between London and Glasgow. Forty years later, measurements by the GPO on lines into an ordinary telephone exchange west of London, confirmed the feasibility of transmitting TV signals. It also showed that very few customers would be able to enjoy a dial-up videophone system without causing unacceptable interference to each other's pictures because of crosstalk between telephone wires. Now, two things in particular have dramatically changed the telecommunications scene: digital switching and transmission and developments in Very Large Scale Integrated circuits (VLSI).

Modernising transmission and switching.

Since the early 1970s, BT has been modernising its telephone network. Now there are over 3 million kilometres of optical fibre in the trunk network. The trunk exchanges have been completely converted to computer controlled switching, followed currently by the local telephone exchanges. By 1996, this programme will be complete and the "Integrated Services Digital Network" will be a practical reality. This new network will be able to offer a whole range of new multimedia services to each home or office - provided these have digital connections to the local telephone exchange.

In recent years, there has been amazing and relentless development of VLSI circuit technology. Currently, we can achieve about 100 million transistors per chip. Such complexity enables formidable processing power for both data transmission and video compression, and when particular chips can be designed to meet a common requirement, we get the benefit of high processing power on a low cost chip.

Two applications are emerging. The



Dr John Thompson, BT's Multimedia Architect, gives his views on how intelligent communication networks will enable a revolution in tele vision - "seeing from afar" - and through multimedia applications, will lead ultimately to the possibility of personal telepresence

first is a complex data modem capable of self-adjustment to compensate for the loss and distortions of any existing telephone line, and of guaranteeing the digital 64kbit/s signals between any home or office and the nearest digital exchange. In the second application, the complicated signal processor squeezes TV signals a thousand times in bit rate so that we can send moving colour pictures over those same local connections and on through the trunk network for unlimited distance at 64kbit/s. Such processors enable seeing through BT's network immediately, without waiting for the cost of fibre to reduce to the home network.

As the visual services market develops, these chips will be manufactured in such volumes that they will reduce to "consumer prices", i.e., a few £10's per set in the late 1990s. In

turn, the market may demand higher quality video for some applications, which could then drive down the cost of providing fibre to the home.

Visual communication has considerable synergy with personal mobility, after all, people have eyes as well as legs! Many of the new applications for tele vision will occur at a distance from fixed network access points and will stimulate the introduction of wireless multimedia technology. Unfortunately, most of the 4 million cellphones and cordless telephones in use in the UK still operate with analogue transmission but the new emerging international standards will take or deliver digital telephony or data signals at bit rates up to $n \times 64\text{kbit/s}$, depending upon system design. Both Radio and Infra Red computer LAN's will also provide wireless components to the short range, mobile periphery of the intelligent network.

Eventually, when these technologies mature, wherever you are from Cheapside to the Isle of Skye, seeing through the network using a camera will become a real opportunity. Just imagine the potential of a public dial-up network, you could look out (with authority, of course) through any one of BT's 26 million phone

sockets - from practically any home, business or call box in the land - to see, play, watch or study. Imagine the services that you might sell from your phone socket - video clips of your mountaineering holiday, access to multimedia DIY manuals, on-demand telepresence at public or private events, or just your contribution to the local neighbourhood electronic newspaper. Vision is the most precious of man's senses, and man will quickly respond to the new opportunity. Using the telephone analogy, we can also imagine many other types of additional "operator services" on a tele vision network. An intelligent network could recognise your face and authorise a home shopping purchase, or search vast databases at lightening speed for that video clip you want to buy for your own multimedia production.

The Intelligent Network

Telephone exchanges are now more like computers than switches, with massive distributed databases containing customer information and interconnected by a comprehensive inter-exchange signalling system. We refer to such networks as "intelligent", since they are capable of knowing where customers are at any one time, and what their immediate and registered telecommunications needs may be. Personal mobility is one service that can reach you wherever and whenever you want. Soon, the fixed network will also provide personal mobility to customers without radio phones, automatically directing calls to where customers are known to be.

ISDN will offer global standardisation - not just for the interface to the local digital transmission equipment, but for the entire set of communication protocols which will allow the full combination of "2B + D" to be used internationally for the maximum possible number of applications. The term 2B + D refers to two Binary 64 kbit/s "traffic" channels plus one 16 kbit/s Data channel. These protocols allow call set - up and management, end to end control of equipment like turning on a TV camera,

multipoint networks and variable rate transmission. For complex services the volume of signalling information could even exceed the capacity required for the voice and picture signals themselves.

Signalling is now the most important issue for the multiservice future. The "value added" by the ability to search and retrieve, and to determine when, how, where, for what price, and courtesy of whom the customer can see and hear through the network, will become equally important to what the customer wishes to see. New control standards like the CCITT Multilayer Protocol T120 will be vital in this respect in allowing interconnection of the many forms expected for tele vision.

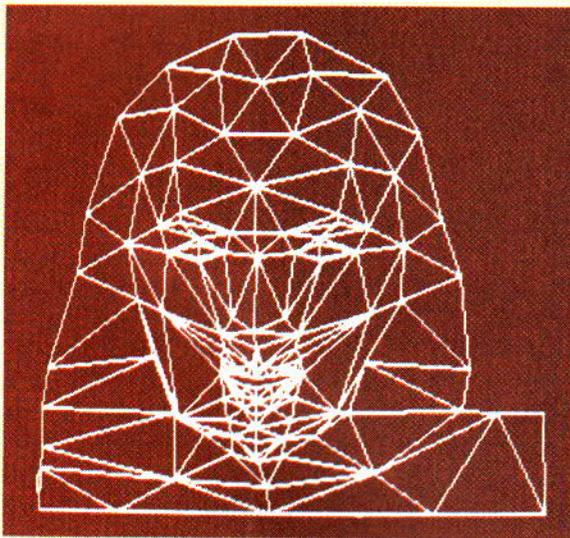
Video compression

The world will break through two compression barriers this year. The first is for the transmission of colour TV on the ISDN. In one version, the codec, standardised by CCITT as H261, fits on one printed circuit board designed to fit a PC. About six years ago, BT Labs realised the potential of "windowing" a moving, networked picture into the screen of a workstation, which would also carry a small colour TV camera - the PC videophone. Chris Frost described in the October issue of

develop applications for seeing through networks and picture retrieval but they will be only one source of tele vision.

In the second development, known as Video on Demand, VLSI modems can achieve bit rates on copper wires much higher than 64 kbit/s, depending on distance from the local exchange. Typically they can support two-way communication at as much as 480kbit/s over a distance of 4.5km and in 85% of all cases. Alternatively, using asymmetric transmission on the same pair of wires, BT could deliver one way "VCR" quality TV at 1.5 Mbit/s to the homes of the 90% of its customers who live within 5km of a local exchange, while simultaneously supporting a two way telephone conversation. For this, we propose to use a variant of the H261 video coding principle agreed by the International Organisation for Standardisation (ISO) Moving Picture Experts Group (MPEG 1) for entertainment video stored on CDs.

And the compression trend will continue ! The next ten years, will see video compression become even more powerful. "Model based coding" will achieve even lower rates for transmission or storage, and offer better quality pictures - even to HDTV standards at $n \times 64$ kbit/s.



operating pan, tilt and zoom controls remotely, starting a remote VCR, or providing a pointing facility on screen to show the remote person with the TV camera what you are interested in seeing. All this would be there with authorisation. It is the signalling "D" channel which via these internationally agreed protocols will enable seeing through the network to become manageable. More complex multimedia applications will develop later requiring

Electronics in Action, how BT and IBM are now about to launch their joint CoCo product - a kit of parts costing about £3,000 to put interactive TV into every 386 or 486 - based PC. In fact, the CoCo board has some 50 times the processing power of its typical PC host. Furthermore, within 3-4 years, the 64kbit/s codec will occupy only 5 chips on silicon and could cost as little as £100! Using ISDN, LAN's and LAN bridges, networked PC's will rapidly

Model based coding was first conceived by Denis Gabor at Imperial College in the 1960s. He suggested that human beings took for granted certain "standard forms" when viewing scenes, and that a transmission system which simply transmitted codewords for (say) trees or sheep and then reproduced these as standard forms, would eventually be able to take out most of the redundancy in TV transmission or storage. Such a compression scheme could reduce the

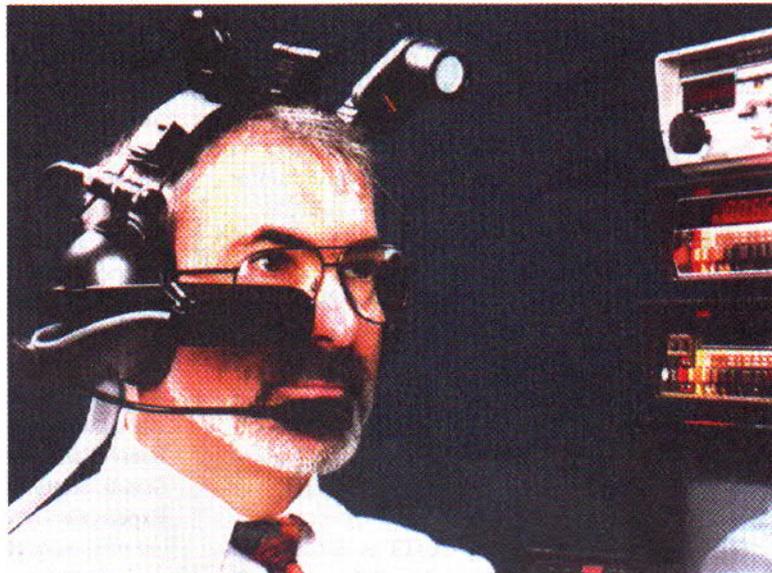
100 Mbit/s inherent data rate of TV signals by the factor of 106 which is normally achieved by the human brain. Sure enough in 1990, using state-of-the-art computing, BT Labs simulated "usable" colour TV transmission at a rate of only 200 bits/sec. Using model based coding, BT Labs developed in effect a computer model of a human head from just one still portrait of a person, and synthesised a whole sequence of TV frames from transmitted short codewords which made the appropriate selection from a predetermined set of eye and mouth positions. The picture on the previous page shows results from a further development which models the outline and head movement. One still frame to give textural information and efficient wire frame coding frame is all that is needed to reconstruct a moving colour picture.

From Multimedia to Virtual Reality

New business and leisure activities are expected to develop from networked access to the many picture libraries and sources of entertainment that exist around the world. BT Labs are working with the MIT Media Laboratory to understand both how such businesses will evolve from current activities like electronic publishing, and also to research artificial intelligence techniques that will provide automatic and high speed library searches.

Compared with telephony, seeing through the network will be revolutionary, but vision alone is not enough for most applications to be really useful. Multimedia is more than just presenting speech, vision and data communication, it is a challenging exercise in systems engineering. Accepting "tele" substitutions for real experience, could be a problem however. Both the Telecommunications and IT industries are now heavily preoccupied with "Applications Engineering" To aid the user's creativity, new dimensions remain to be added like binocular vision and stereo sound, virtual reality headsets, multidimensional joysticks, data gloves to synthesize grip and enable pointing,

smart skins to give remote feel, and even synthetic smell. But first we need some applications, to create the markets, markets which will allow this exciting new industry to develop and generate revenue to improve the technology.



The clearest benefit of tele vision is to make remote knowledge and experience available in situations where someone can get to a scene relatively easily and then rely on other people's skills to complete the job with confidence. At BT Labs, we have developed an experimental headset called CAMNET, shown in the picture, to test the often expressed concern "If only I could see what you can see - then I might be able to help you". Mounting a miniature colour TV camera on a lightweight headset allows a remote operator to effectively sit on the shoulder of the wearer and hold a dialogue while sharing the same view. Addition of a head-up display and laser pointer to the headset allows the wearer and/or remote user to target particular objects with accuracy, while at the same time the remote viewer can send graphical indications and data in support of their joint vision and interaction. The hands-free wearer suffers minimal encumbrance to his task, and with global connection to the ISDN at 64kbit/s (or higher rates if required), the remote user has effective personal telepresence courtesy of the wearer of the headset. Its uses have included equipment maintenance, cameraman/reporter, remote surveillance, and telemedicine.

Telepresence will eventually appear at major sporting events. Virtual reality terminals with a full 360 degree 'fish eye lens' could be located at Wembley or Wimbledon to generate telepresence which would be accessed and controlled

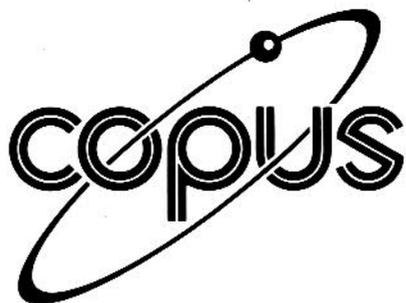
by viewers after swiping their credit card through a home terminal. One might even access a public camera on a communications satellite platform as an interesting way of making your own regional weather forecast! Interactive science museums, or "exploratoria", are beginning to appear in the UK - these could increase their revenue by teleporting their displays to the home or school via the telecommunications network.

And then, there's entertainment: Jump Shot or virtual reality basket ball and personal flight simulators are just two examples. It is difficult to out-speculate the video games industry that will be alive to these prospects. In the US, several senior politicians are already seized with the potential impact on society and the need to anticipate demand with data superhighways.

In Conclusion

With the persuasive power of current IT and global communications, almost anything seems possible. Indeed, experience confirms that good ideas - whether Baird's early ideas on 3D TV or Gabor's notion of standard forms - will happen,.... eventually. The contribution of the engineer to society has always been to know how easily, and when, the possible can be made to happen at acceptable cost. Certainly these are exciting times, when the enabling technologies of virtual reality could have such a beneficial impact on our way of life. Of course there are risks, but George Orwell probably did us a service by impressing on us all the need for privacy and proper control of tele vision technology. Certainly the intelligent telecommunications network is capable of providing all the safeguards that society requires.

Video networking is a "last frontier" in creating a multimedia technology and was confidently predicted by compression research 30 years ago. Who would have thought for example that a personal computer would emerge as the first multimedia interface to telecommunications networks? The PC will be only one source of tele vision however and our CAMNET experiments are providing us with many other applications - all of which will benefit from using the intelligent network.



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