ELECTRONICS in ACTION

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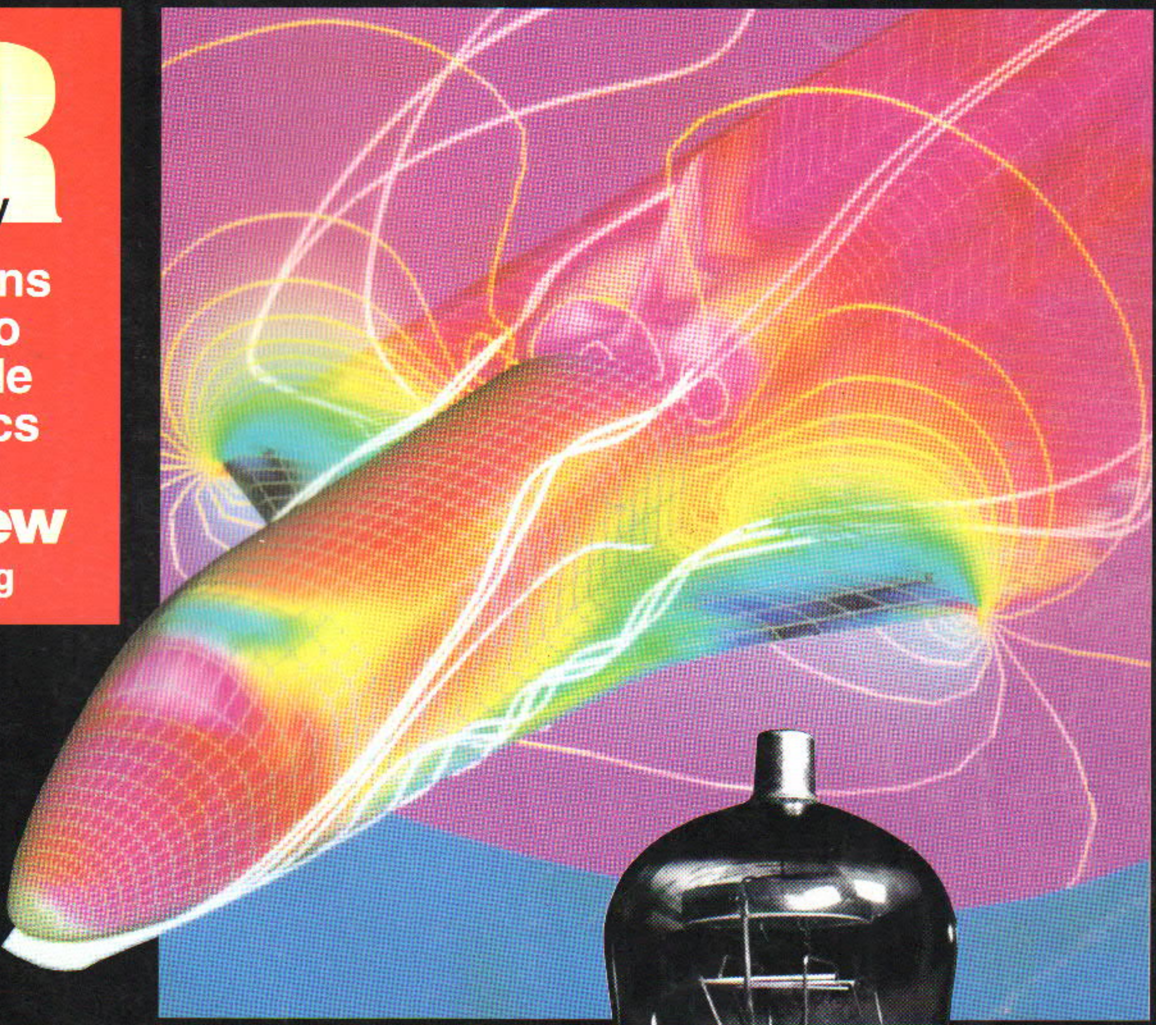
VR
Virtual Reality

From Childrens Television to Space Shuttle Aerodynamics

Future View
Virtual Shopping



Class A Amplifier
Part 2
PSU Construction

The Switcher
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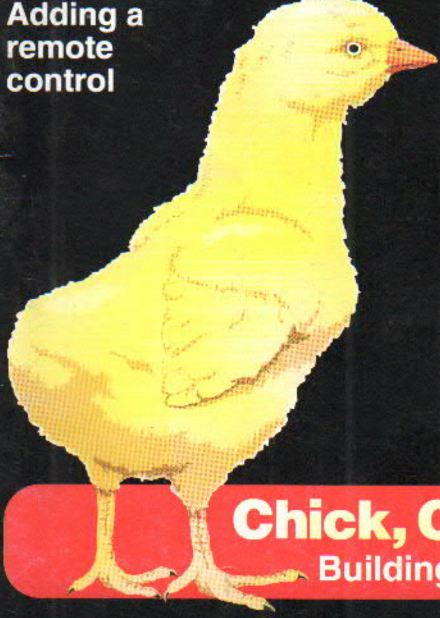

John Linsley Hood The Evolution of Audio Amplifier Design

In Control
Constant speed for your PCB drill

ISSN 0969-3564

Chick, Chick, Chicken
Building your own hatchery controller

ELECTRONICS in ACTION

ISSUE 5 VOLUME 1

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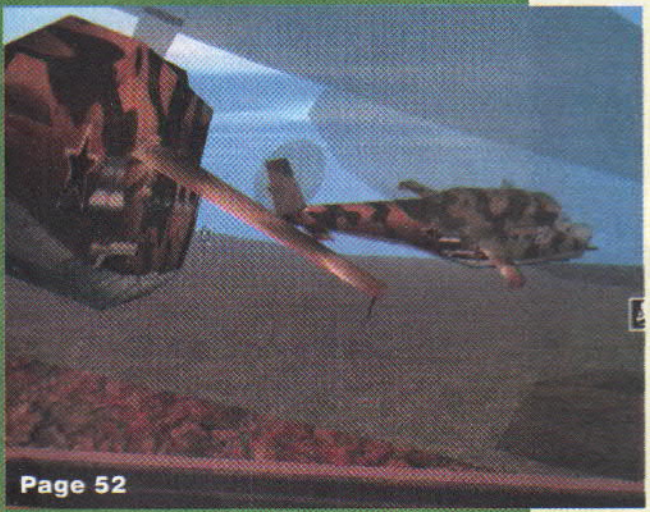

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VR Just like the real thing

In this Virtual Reality edition of EIA we look at what is on offer for this emerging technology and where it will take us in the future.

I am in no doubt that VR will succeed as a form of amusement. Almost total immersion into a computer generated world will always be an attractive idea to escape reality and to effectively achieve the impossible in the quest for adventure.

However, fears have been expressed over the dangers of VR, where long periods of immersion could lead to the extension of those fantasies into the real world, harming oneself and others in the process. But then, that's what they said TV would do.

The positive benefits of VR will make it easier to visualise mechanisms using 3D in molecular chemical processes, prepare oneself for specific activities like future football or cricket matches or even racing circuits and carry out remote operations in space from the comfort of earth.

Virtual Shopping

Some say that teleshopping (buying from the TV screen) will not catch on. If not, then maybe Virtual shopping will. For many, an essential part of shopping is to experience the act of being there. If that is the case, the social interactive nature of shopping could be fulfilled using Virtual reality, meeting virtual people but buying real goods. Only time will tell.

Paul Freeman-Sear

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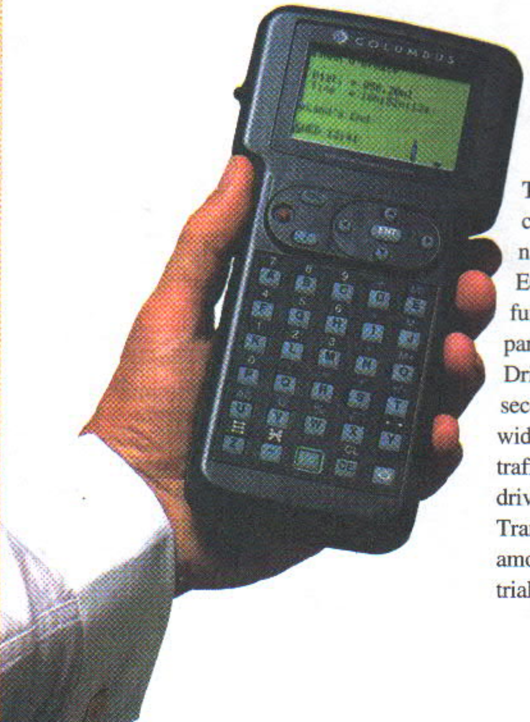
NEWS

Fast PostScript Colour Printers

Mitsubishi has announced an exclusive agreement with BIT (UK) Limited to provide exceptionally fast and accurate colour PostScript printing with the new Zenographics Zscript 1.0 and SuperPrint 3.0 software. Included are Mitsubishi's advanced full A3 bleed and A4 thermal transfer and dye sublimation colour printers. The printer and software packages are available from Bit, the UK's Zenographics software distributor. The complete printer and Zenographics software packages cost £4495 for the G6710 full A3 bleed thermal transfer and the S3410 A4 dye sublimation printers. The S3600 A4 and S6600 full A3 bleed dye sublimation printer packages cost £5995 and £8995 respectively.

The combination of ZScript 1.0 and Superprint 3.0 will work for even difficult products that normally require PostScript printers. ZScript 1.0 software runs an application and interprets



Europe Discovers Columbus

The Columbus handheld routefinding computer will be one of the traffic auto-navigation methods taking part in the EC Drive Programme in 1994. Partly funded by the European Commission and partly by its participants all over Europe, Drive 2 - the programme is now in its second phase - aims to establish a Europe-wide format for communicating road and traffic information to organisations and drivers. The BBC, Department of Transport, British Telecom and the AA are among the organisations taking part in the trials, which include in-car navigation,

Nuclear Safety On Paper

The Health and Safety Executive (HSE) has issued the second edition of its Nuclear Safety Newsletter, published by the Nuclear Safety Division of the HSE.

The four-page newsletter concentrates mainly on reporting the activities of the Nuclear Installations Inspectorate, investigating possible weak points in safety measures. It aims mainly at reassuring people working in the industry that everything is being done to keep watch on safety issues, in line with the HSE's brief. The newsletter reports, for instance, that Trawsfynydd power station in Snowdonia will be decommissioned because metal welds are turning brittle faster than expected, and that Bradwell's turbine cooling intake had been blocked by seaweed and mussels. The reactors were shut down while pump strainers were cleared. "Although the incident was rated as having little nuclear safety significance, it generated considerable public concern", says the newsletter.

The October newsletter carries reports from May to September, and everything appears to be under control. Would they tell us if it wasn't? Nuclear Safety Newsletter appears three times a year free of charge from the Health and Safety Executive - phone 0742 892345 or fax 0742 892333.

PostScript files from almost any source including Windows, DOS, Macintosh and Unix environments. The output files from ZScript can be viewed, imported into Windows applications and output on a non PostScript printer. SuperPrint 3.0 is a 32bit print engine for Windows which provides high speed output to the printer.

The software is device independent, 32bit and multitasking to optimise printing operations.

SuperPrint 3.0 incorporates 32bit Windows Super Drivers which accelerate Windows applications via SuperRip imaging technology. High quality graphics, pictures and text are output at high speed using Windows 3.1's 32bit architecture. Where users have sufficient memory in their PCs then complete images can be rasterised without having to rasterise to disk, providing even faster performance.

SuperText provides SuperPrint 3.0 with effective font scaling facilities. On the fly scaling to screen and printer is readily provided simultaneously for Truetype, Adobe, Bitstream, Intellifont and Nimbus Q fonts.

These dye sublimation and thermal transfer printers can also be supplied for dedicated workstation solutions, and are capable of printing full bleed on A3 and A4 paper respectively as well as on A3/A4 transparency. BIT (UK) Limited can also supply a range of software for use with Mitsubishi printers in workstation applications, such as Easycopy.

The near photographic quality, continuous tone dye sublimation printers provide noticeably fine curves and smooth colour gradations from a palette of 16.7 million colours.

Full page buffer memories are provided and built-in colour adjustment capabilities enable realistic photo images to be easily achieved. Close control is provided for Gamma correction, contrast, density and sharpness and as well as multiple copies, the printers are able to work with three or four colour ink rolls according to user requirements, on paper and transparency.

For further information, please contact either: **Phillip John or Brian Evans at Mitsubishi Electric UK Ltd, Electronic Products Group, Telephone:0707 278614 Fax:0707 278659**

The famous Avometer multimeter, almost a legend in its own lifetime, celebrated its 70th birthday in December. Launched in 1923 as the world's first test meter with multi-range facilities, the Avometer multimeter earned its name (bestowed by inventor Donald Macadie) from its Amps, Volts and Ohms ranges - an imaginative move which paid off in terms of memorability.

Not that the Avometer is anything other than memorable. In continuous production since 1923, with new, extended models following - the Universal Avometer in 1933, introducing AC ranges; the Avometer Model 7 in 1936, notably adding an automatic cut-out in place of the fuse; the robust Avometer Model 40 in 1940 to measure 3-phase voltages for the power industry; the Avometer Model 8, perhaps the most classic model, in 1948.

The heavy-duty black Avo housing with its integral leather carrying-stap became a mandatory symbol of the trade for everyone involved in live electrical

relaying traffic data through the phone network and RDS radio, Point of Information touch-screen terminals in motorway services and other aspects of route-planning using electronics, telecommunications and computing.

Columbus manufacturer Panstar plans to use around 20 new Ford Mondeos, supplied by Hertz Hire, for system trials in the projected London/Paris corridor, codenamed "Pleiades". Trials are due to start in February in the Kent area. Columbus will be specially adapted to receive live traffic data from RDS radio, and further modifications will allow the computer to display and speak the traffic messages received so that the driver only receives traffic warnings relating to his or her journey. The driver will be offered an alternative route to avoid hold-ups.

70 Years for AVO

(later electrical and electronic) engineering professionally or as a serious interest. The company went public as Avo Ltd. in 1957, one year before the 1,000,000th Avo Model 8 was manufactured.

New models have continue to appear as needs and modern components change, but the Avo Meter has kept its classic build, fondly known as one of the few portable test instruments that can double as a tool-stand and doorstop on those awkward in-the-field jobs. We wish Avo an equally successful 21st century.

Information on the latest Avometers can be obtained from:
Avo International, Archcliffe Road, Dover, Kent CT17 9EN. Tel. 0304 202620. Fax 0304 241491.

Leeds University to hold an Information Technology Day

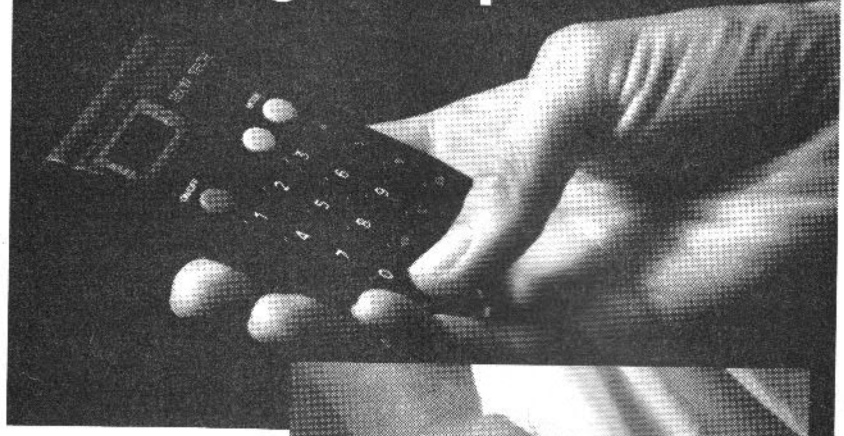
BIT '94 is a one-day conference bringing together over 500 students from further and higher education institutions throughout the UK with people from research, industry and commercial companies. Several other IT conferences will run simultaneously in other parts of Europe, and the sites will be liked in a videoconference so that the debate can be carried on in the proper style - live.

Following BIT, 200 delegates from each country will fly to Toulouse in France for a pan-European two-day conference. This is the fifth IT conference organised by the European Conference on Advance Information Technology (JETAI).

The 1994 theme is the buzzword of the era, Virtual Reality, biased towards its importance to business and industry. The conference, which is already backed by British Telecom, the National Westminster Bank and KPMG Peat Marwick, is looking for involvement from other companies and organisations. Contact with researchers at University level and committed technology students will be one benefit of closer involvement, especially for companies looking to recruit IT staff in the future.

Information about BIT '94, including a list of sponsorship opportunities and exhibition facilities, contact:
BIT '94 Committee, School of Computer Studies, University of Leeds, Leeds LS2 9JT or call Steve Rowette (0532 335461) or Nik Silver (0532 336798).

The Gadget Shop



Above: The talking calculator and digital pedometer

Some of us just love tinkering around with electronic gadgets. There is a new chain of shops to fulfil that demand. Called appropriately The Gadget Shop here are one or two items of interest.

Universal Remote Control

A must for those constantly hunting around for separate remote controls for the TV, Hi-Fi, CD etc., this ingenious device can store all the functions of the others in one unit. Just place on of the existing controls opposite it and copy each function across. (Price 29.95)

Weather Station

This precision instrument measures barometric pressure, comparing it to that over the previous 24 hours and predicts the weather using symbols to denote cloudy, sunny, overcast and rainy. In addition it can function as an alarm, calendar and clock, making the perfect desk accessory. Requires 4 AA batteries. (£89.95)

Talking Calculator

Each time a key is pressed, the function chosen is spoken out which helps to double check calculations as they are typed in. When the calculation is complete the answer is also spoken. Requires 2 AA batteries. (£14.95)

Battery Manager

Until recently it has been assumed that it was unsafe to recharge ordinary general purpose batteries which has resulted in economic and environmental waste. This battery charger is a safe and effective alternative. (£29.95)

Circuit Board Stationery

All the items in this range are made from genuine circuit boards which would otherwise have been binned due to technical imperfections. Each item is therefore unique in its own right and the range includes filofax and notebook covers and clip boards. A good idea for anyone into computers or electronics. (Notepad £5.95; filofax £19.95)

Digital Pedometer

The world's smallest digital pedometer, this is bought mainly by joggers or serious walkers which counts your steps and converts it into the distance travelled (switchable between walking and jogging.) Simply clipped to a belt, it also features a clock, top display for easy readout and is weather proof. Battery included. (£9.95)

For further information, please contact Jonathan Elvidge (0482-871001)

Information services available with a modem

The booklet, The Sportster Guide to On-Line Services, has 40 pages stuffed with brief descriptions of software, bulletin boards, how to set up a modem system, CompuServe and general information which can be retrieved from various sources. The publication is a tribute to US Robotics' Sportster "personal modem", endorsed by TV personality Sarah Greene, which is introduced as appealing to users from children looking for the latest on-line games to businessmen carrying out last-minute credit checks.

It's a handy guide, written in laymen's language, with a glossary explaining terms like JANET, Pseudo Full Duplex and V.32 terbo which baffle the nontechnical and sometimes catch the initiated unawares too.

The Sportster Guide is free of charge on request, and includes a hotline number for more information. For a free copy, contact **Lucy Brown, US Robotics Ltd., 224 Berwick Ave., Slough, Berkshire SL1 4QT. Tel. 0753 811180.**

Light and Handy

Tinkering in the dark is not something to look forward to if you have a breakdown or a power cut to deal with.

Maplin are now offering two low-cost items for difficult jobs. A 24-piece ratchet screwdriver set comes in chrome vanadium with broad-grip rubber-padded handles housing a reversible ratchet mechanism. The latched pivoting mechanism allows the handle to be bent at any angle up to a right angle to help with leverage. The screwdriver is designed to accept .25in hex bits, and an adapter is supplied to hold .25in square sockets. The set comes in 6 metric .25in drive sockets, 6 imperial .25in drive sockets, 4 flat-bladed hex-drive screwdrivers and 6 crosshead bits - 3 Posidrive and 3 Philips.

For breakdowns is a rechargeable torch-lantern which combines an amber emergency flashing lamp, a powerful halogen spotlight torch and a fluorescent lantern with a selector switch for one or both of the two 210 mm 6 watt tubes. The sealed 6 volt, 3 amp-hour lead acid battery is recharged by plugging into the supplied charger and connecting to a normal mains outlet. A battery charge led on the lantern shows when the charger is in use.

This is a handy, ergonomic-looking lantern with many uses.

The offer price until 28 February for the ratchet set (O/N CJ33L) is £7.95, and for the rechargeable lantern (O/N GW44X) is £8.95, both vat-inclusive, from Maplin Electronics, telephone sales 0702 554161, or Maplin stores around the country.

Multimedia Comes To Maplin

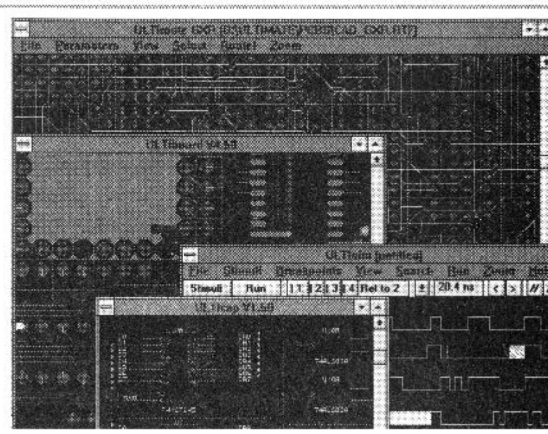
Maplin Electronics reckons that Soundblaster, now in the Maplin catalogue, is the most popular PC sound card in the world. With over a million already installed, Maplin has now produced a Sound Blaster Multimedia Internal Upgrade kit, comprising the upgraded Sound Blaster Pro card, a CD-ROM drive and a collection of CD-ROM software. The upgraded card is compatible with existing Sound Blaster and Ad Lib software, but now has 8-bit stereo and mono sampling and playback with a variable sampling rate from 4kHz to 44.1kHz. The internal 22-voice, 4-operator OPL-3 FM synthesiser gives an increased range of instrumental voices and sound effects. The card has inputs for microphone, stereo line in and CD playback via the CD-ROM audio interface.

The SoundBlaster Upgrade kit from Maplin Electronics, telephone sales 0702 554161, or Maplin stores.

EV Catalogue

If you haven't already got it Electrovalue's '93-'94 catalogue is available for only £1.50 if you 'phone 0784 442253 and quote your credit card number and expiry date or fill in the coupon in their ad.

Let's Rip it Up



ULTiroute GXR, from ULTimate Technology is a Ripup & Retry Autorouter. This Windows based PCB design package offers customised control. ULTiroute GXR is fully supportive of Surface mount devices.

The new versions 4.50 of ULTiboard and 1.50 ULTicap are now 32 bit using a Windows compliant DOS extender. The user can decide whether or not to run in Windows, without loss of performance. Also included are features such as Global Shape editing and expanded libraries.

ULTicap offers several automatic features which reduce editing time these include Autowire, Auto Snap to Pin, Auto Junction and Real Time Electrical Rule Checking.

A utility called ULTihole speeds up the making of prototypes and it now supports HP laser printers as well as Postscript and HPGL plotters.

ULTimate Technology operates on systems from DOS to UNIX and Sun workstations.

Research World

Technical Advances from around the Globe

Building high temperature superconductor circuits

A new technique for building high-temperature superconductor circuits is promised as a result of joint research between AT&T Bell Laboratories and the State University of New York. The technique uses electron-beam apparatus to bore submicron holes along YBCO microbridges, creating the weak resistive links required by Josephson junctions.

In the past, creating such weak links in a controlled manner to build HTS devices and circuits has been difficult. Previous research focused on using grain boundaries of metal-superconductor interfaces to create the resistive link, to mixed results.

The YBCO microbridges are created by standard deposition and photolithography techniques. Using the fine controls of a scanning transmission electron beam to drill a series of holes precisely defines the electronic properties of the junction. The drawback of the technique is that it took the researchers from 5 to 10 minutes per micron to create the junctions but dramatic speed-up could be achieved with higher-powered beams. Other advantages, such as the ability to pattern and tailor complex

Improved micromachines technology

The prospects for micromachine technology have improved now that researchers at Sandia Laboratories have built a power source - a micromotor no bigger than a couple of DRAM cells. The actuator consists of a hollow tube filled with liquid (water in this case, although other liquids can be used) and a piston with a cross section of 6 x 2 microns. A bubble formed at one end of the tube by a polysilicon micro- bridge heater can be made to propagate down the tube. The meniscus captures the end of the piston and carries it along the tube as the bubble expands. In essence, the motor is a tiny steam engine.

Two contact pads are connected to the heater element. When voltage is applied, the liquid is heated to a vapour; the displacement and speed of the piston can be controlled by varying the voltage applied. Sandia said that piston displacement measured on a vernier scale was greater than 20 microns.

The piston, a folded spring assembly, and the bridge are formed from a polysilicon layer. An oxide is deposited, followed by a second layer of poly that partially encapsulates the piston and the channel in which the piston and heater reside.

Improving electro-luminescent displays

The Advanced Research Projects Agency has established a Phosphor Technology Centre of Excellence at the Georgia Institute of Technology, as part of its high-definition display initiative.

Arpa is providing an initial $10 million. The research is aimed at improving low-voltage thin-film electro-luminescent displays, field-emission display films and thin-films for cathode-ray tubes. Other goals include the development of novel phosphor materials as well as new device and array processing techniques.

Centre of Excellence members include the American Display Consortium, whose members are donating a total of $750,000; the David Sarnoff Research Centre, and five universities. Beneficiaries of the research could include the budding US HDTV industry, as well as manufacturers of vehicular dashboard controls, medical instrument monitors, computer displays, virtual environment displays and industrial process-control panels.

Virtual Reality

Equipment incompatibility is becoming an issue, with some members of the Virtual Reality community warning that the lack of standards is a recipe for disaster.

'For the industry to grow, it needs to adopt standards for virtual reality developments,' warned recently retired IBM Corp. researcher Barry Shepherd. 'Without even de facto standards, the technology will not stabilize.'

The usual types of standards are needed, according to Shepherd, to define hardware and software interfaces to which multiple vendors can conform for plug-and-play compatibility. Such standards must address the needs of three-dimensional input devices, such as electronic gloves, head and body position trackers, and exoskeleton joint-angle sensors. Likewise, the standards must also address VR's specialized, three-dimensional output devices, such as tactile pads, force-feedback mechanisms, heaters, coolers, wind machines, vibrators, odour synthesizers and even more exotic devices as they develop.

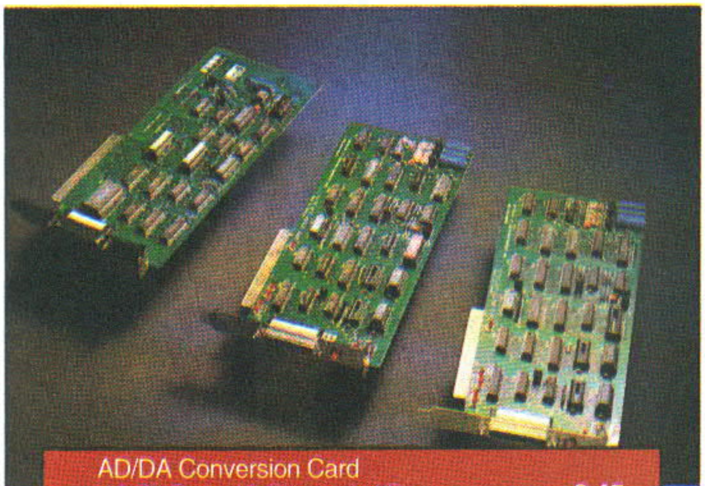
"The first need is to standardize voice-recognition commands, so that navigation knowledge from one virtual reality can be transferred to others," Shepherd said.

Likewise, software standardization for aural feedback needs to be made so that participants used to finding their position with three-dimensional sonic cues can transfer that knowledge when using VR systems from different manufacturers.

Finally, the VR needs standard "world components," according to Shepherd, so that any virtual world built with one design tool kit can be transferred to systems based on different world-design tool kits.

The impetus to making the force display was derived from an idea of startling simplicity akin to Newton's being hit on the head by an apple - that participants in VR want to force objects to move, to feel objects forcing them to move.

The surface display uses a moving planar surface to allow participants to explore a virtual world using their fingertips. As participants push with their fingers, the surface display pushes back with an equal but opposite force, as if their fingers were pushing on a solid object. When participants are "pushing" empty air, the surface display recedes out of reach. A robotic arm tracks the participants' movements and quickly moves a small contact area to model the virtual objects. Texture is modelled with vibrations increasing with increasing roughness.



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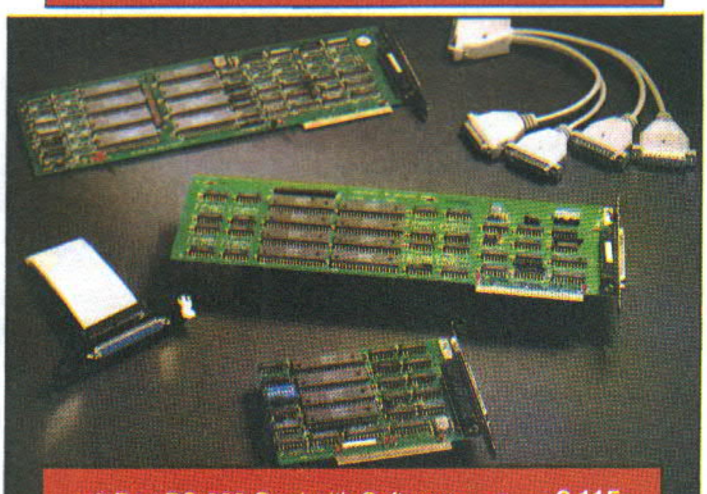

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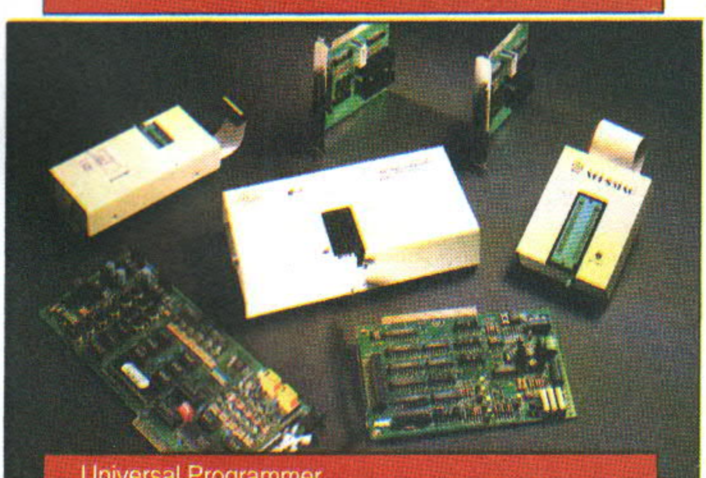

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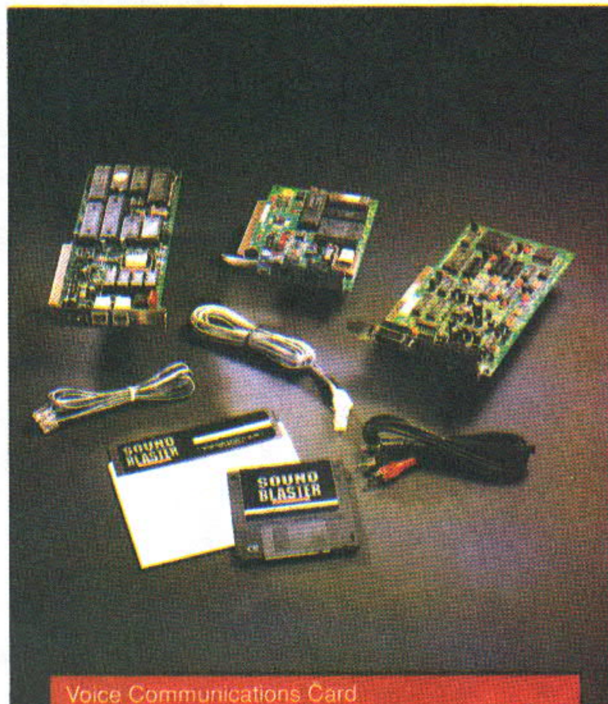

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Egg Patrol

David Silvester plays mother hen and provides the eggnition for the hatch

This project started as a chance remark by a friend who has an interest in the raising of game bird eggs in a home built hatchery. He had been using a lightbulb to warm the hatching box but had found that temperature control was erratic to say the least. He had however raised a good percentage of the eggs and was looking for a better result next year if he could control the temperature more efficiently.

At this point I suggested that I could construct a suitable control unit if he was interested. Thus the project began, but gradually I came to see that the same circuit could have a wider use given small changes to the heating elements and in some cases the temperature sensing circuitry.

The Works

The circuit uses one of the latest semiconductor temperature sensing devices. These devices allow a fixed current to pass through them depending on the absolute temperature of the device. Since zero Celsius (0C) is 273 degrees absolute (273K) and the devices pass one microamp per degree absolute then at room temperature the device passes just under 300μA. This current is independent of the voltage across the device providing it has between 4 and 30V across, sufficient to put in it's linear operating range. The current is unaffected by resistances in the leads to the sensing element which is housed in a standard TO92 or TO18 transistor case. One of the leads in the transistor case is not required and I assume is connected to the device substrate thus the spare lead may be left unconnected or connected to the low potential, in this case the voltage from P13. The sensing limits are -25° to 105°C mainly due to the package for the device. As the temperature varies then the current changes and this can be converted into a voltage output with a simple op-amp circuit.

Figure 3 shows the full circuit for the controller. The temperature sensor fits between P11 and P13 taking a constant current of 273μA at 0°C at which temperature it was decided that the op-amp IC5b would have an output of zero volts. At zero volts output and with the inverting amplifier configuration resistor R13 will not be passing any current.

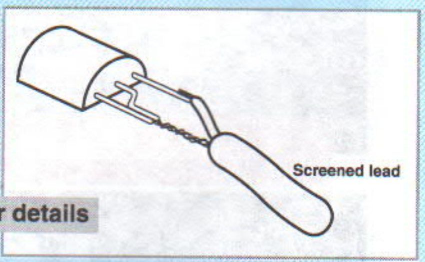


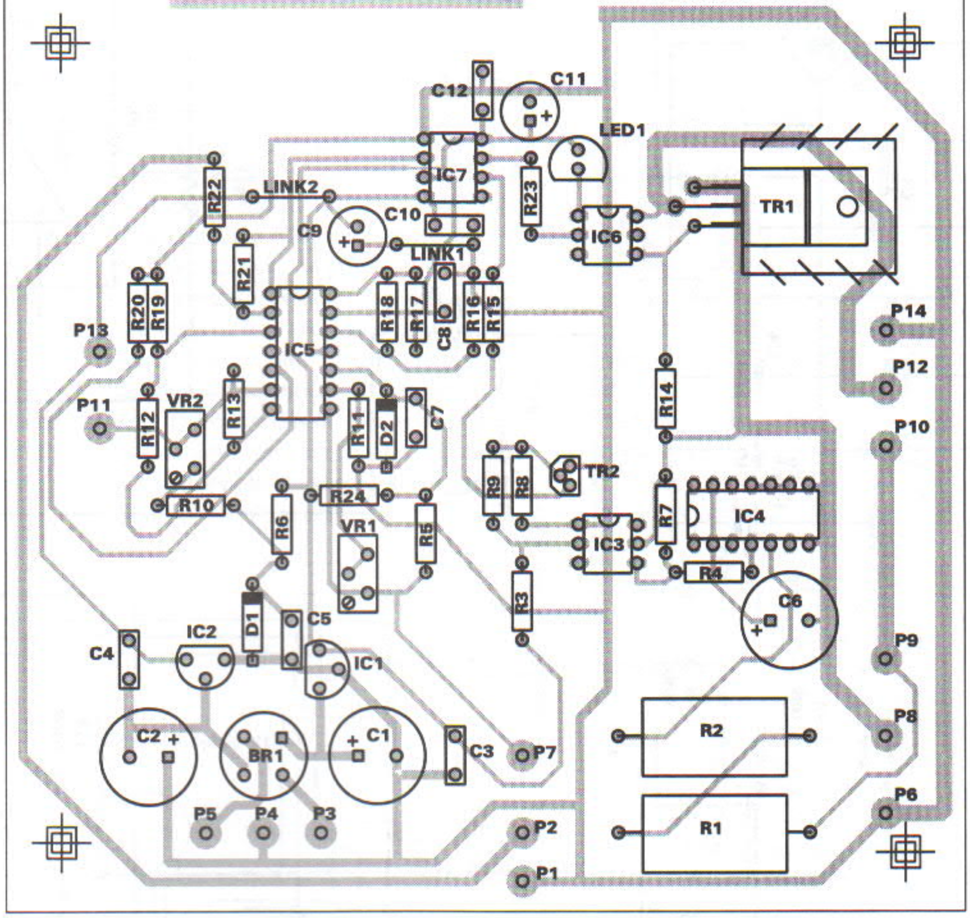
Fig.1 Sensor details

Thus to set the op-amp to zero at 0°C a current of 273uA is supplied by the stabilised supply of R6, R10, VR2, D1 and C5. As the sensor's temperature increases then the current through it increases and the voltage at pin 6 of IC5b tries to fall below zero volts. However the action of the inverting amplifier is for the voltage at the output to rise so that it compensates for the error. With R13 at 100K ohms the output of IC5b rises at a rate of 100mV/°C so that 0°C is 0V output and 100°C is 10V output, the full range of the circuit as shown here. With a simple output voltage from IC5b representing 0 to 100°C a ten turn resistor with a 0 to 10 scale on it was used as the input device for the set temperature. This potentiometer needs to be driven from a 10V stabilised reference and this is supplied by IC5c and it's associated circuitry.

Having the set voltage and the actual voltage we can get on to the control circuit itself. From the centre tap of the pot at P2 arrives a voltage that is the representation of the required temperature in the hatch box. From IC5 pin 7 comes the voltage representing the actual temperature. Op-amp IC5a is a differential amplifier that takes these voltages and outputs on pin 1 a voltage that is a representation of the difference between the set and required values. Without any gain, the difference would still be at 100mV/°C rate, ie an error of 10°C would give either a + or - 1V output depending on whether the sensor was hotter or colder than required. In this circuit the amplifier is arranged so that too high a sensor temperature causes positive output from IC5a. Keep in mind that the amplifier circuit around IC5a does give gain, I shall come to the reason for this soon.

The last amplifier in IC5 is a simple triangle wave oscillator based around C8. In this circuit C8 is charged and discharged alternately by the output of the op-amp via the resistor R17. The op-amp has only two output condition, full on close to either + or - 15V rail. When the output of IC5d is at +15V then C8 charges through R17 up to the point where the input at pin 13 exceeds that at pin 12. Since the voltage at pin 12 is 1/3 of that at the output the op-amp flips at a voltage of 5V on C8. At this point the output of the IC flips to -15V. Now C8 discharges through R17 down to a voltage of -5V on C8 at which point it flips back to the original condition. Thus the voltage across C8 rises and falls in an approximately triangular manner, and at a rate set by the values of R17 and C8. In this case the frequency is set at 5Hz approximately. The fact that the output 'triangular' waveform is curved due to the exponential charge/discharge cycle in no way affects the operation of the device. This 'triangular wave passes to the comparator IC7. IC7 is set up so that it receives the DC error signal from op-amp IC5a and the triangular waveform. Ignore the connection to IC7 on pin 6 for the moment. The comparator is a pulse width modulator producing a low output and therefore lighting the LED and the LED in the opto-triac IC6 when the voltage coming from the triangle waveform is greater than that from the DC error signal. If we assume a steady

Fig.2 Component positioning



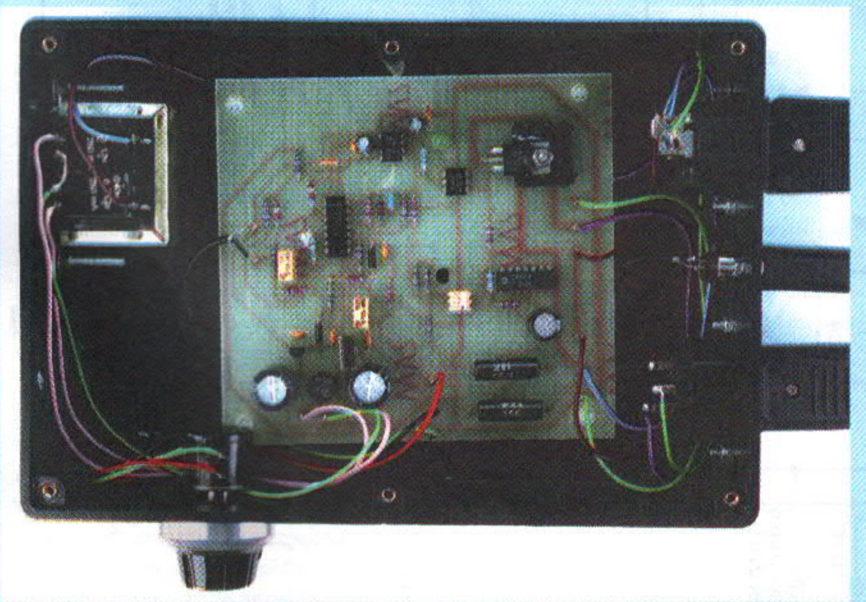
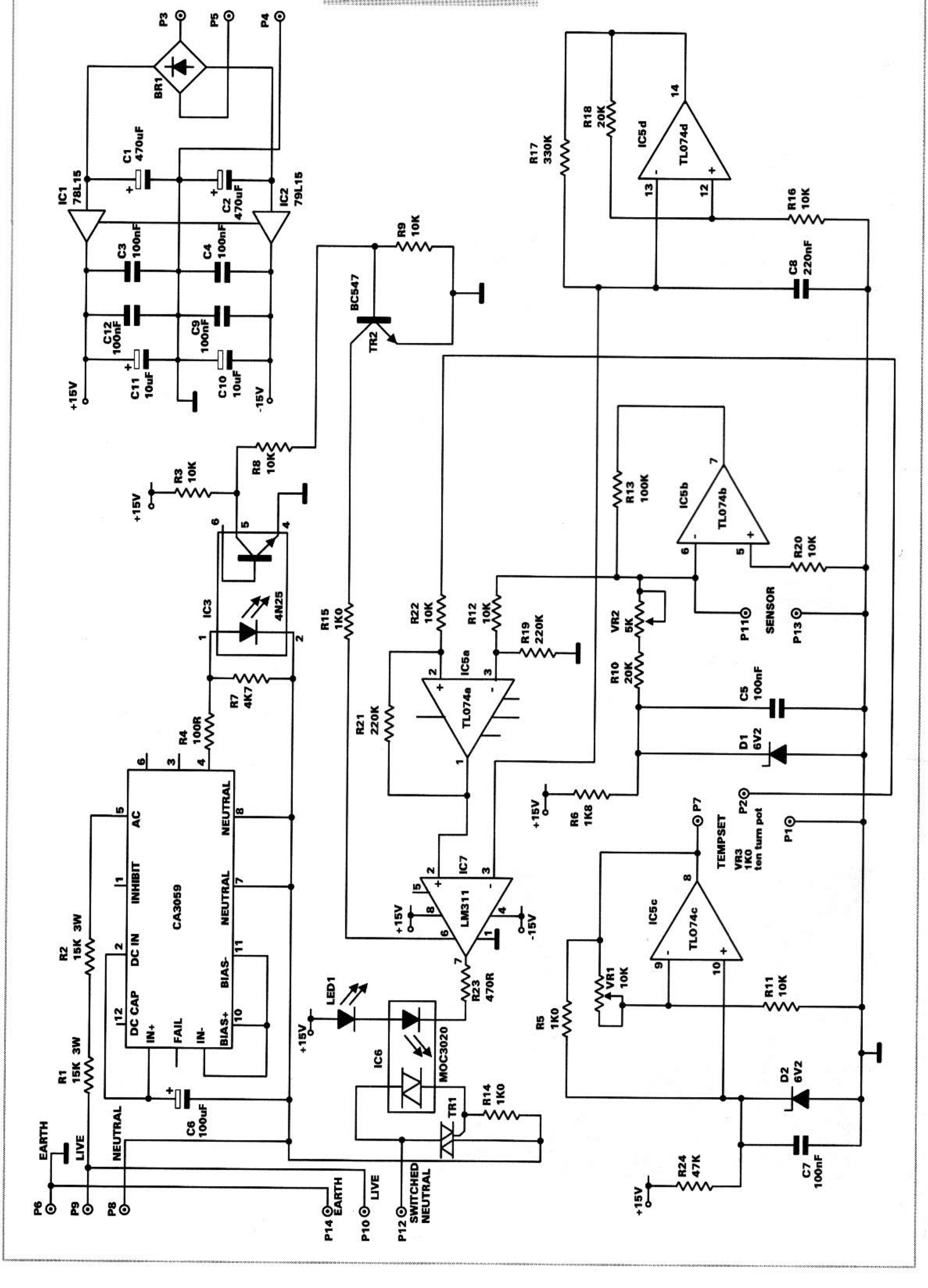


Fig.3 Full circuit of controller



state where the DC error is zero then the output from the comparator will be on for half of the time and off for the other half. If the sensor sees a lower temperature then the output of the error amplifier will go to a lower voltage, and the LEDs will be illuminated for a longer part of the pulse width cycle.

The LED in IC6 fires the triac controlling the heat input to the hatchbox and as the sensor cools the circuit will fire the triac more often to correct the error.

We now come to the gain of the error amplifier. With an input triangle wave of +/- 5V and an error signal rated at 100mV/°C, then the triac will be fully on only if the sensor is 50°C below the setpoint. With this situation the hatchbox would only heat up very slowly and recover from opening the lid in a similar slow way. To achieve much more rapid heating the error amplifier has gain so that the error is rated at 2.2V/°C thus the full on for the triac condition occurs when there is an error of around 2.3°C at the sensor. The gain of the error amplifier is therefore 22 times and this seems to result in a stable temperature in the hatchery box. By increasing the gain of the error amplifier the full on to full off situation can be made to cover a smaller temperature range. With the error amplifier range at 2.2V/°C, the power required to maintain the box temperature varies vastly and the temperature in the box could vary by +/-2.3°C. With higher error amplifier gain this range could be cut but it could produce temperature oscillation during a recovery from say opening the box. The error amplifier gain can be set to any value depending on the ratio of R19 and R21 to R12 and R22. The error amplifier has a FET input device and R19 and R21 can be increased in value, up to any resistor value available. If 1 the value of R12 and R22 is lowered then the lower value of R22 will affect the setpoint potentiometers linearity.

There remains one problem, caused by the high switching speed of the triac itself. If we allow the triac to fire at any point in the mains cycle then by chance the triggering will occur when the voltage across it is about 320V, the highest voltage in the 240V AC cycle. The triac rapidly turns on and results in a very sudden increase in load current which causes RF emissions into the mains that interferes with other electrical equipment. In this circuit the triggering is synchronised to the point at which the mains voltage crosses zero volts. This results in a much lower RF emission from the circuit.

Internal to the CA3059 device, IC4, is a power supply that runs from the mains, using only the electrolytic capacitor C6 to stabilise the DC to some extent. To allow direct connection to the mains live there are two dropper resistors R1 and R2. Anyone familiar with the CA3059 will know that the chip contains all of the components to build a controller. The problem is that the sensor will be directly connected to the mains neutral. Now whilst this may be satisfactory for some circuits and it is shown used in that way in the data sheet for the CA3059 it was not felt to be good engineering practice and certainly not safe enough for use by amateurs. In this design everything is referenced to the earth terminal. Isolation is provided by the two opto-couplers. The CA3059 is wired so that at every zero cross, that is at 100Hz, a pulse will light the lamp in the opto-coupler IC3. This pulse will be for a very short period where the mains voltage is below +/-1.2V (referred to neutral). This pulse turns the transistor in IC3 on and transistor TR2 off. IC7 (LM311) is an interesting device in that it can be disabled, ie the transistor output of the device can be forced into an open circuit condition, and this occurs when pin 6 is grounded via a 1K resistor. The switching of TR2 forces this open circuit condition to occur at all times except when the mains voltage is very close to zero. When IC7's output is open circuit, the output triac cannot fire.

The input to IC7 will determine when the triac should fire. The switching of TR2 will prevent this until zero crossing time. The triac will fire on every half cycle that its voltage is above the error amplifier voltage.

The main triac TR1 is fired by the secondary triac in the opto-coupler IC6. When IC6 LED turns on, its triac turns on and fires TR1. Resistor R14 only receives a very short voltage spike and does not dissipate much power. Tests have shown that R14 remains cold even with the power full on and the triac firing on every half cycle.

The heat producing load, the light bulb in the case of the hatchery connects from the live to the MT2 terminal of TR1. Although the bulb is live all of the time the circuit is safer since a failure of the bulb will leave the TR1 circuit unpowered. The whole circuit is driven by a standard power supply unit of a

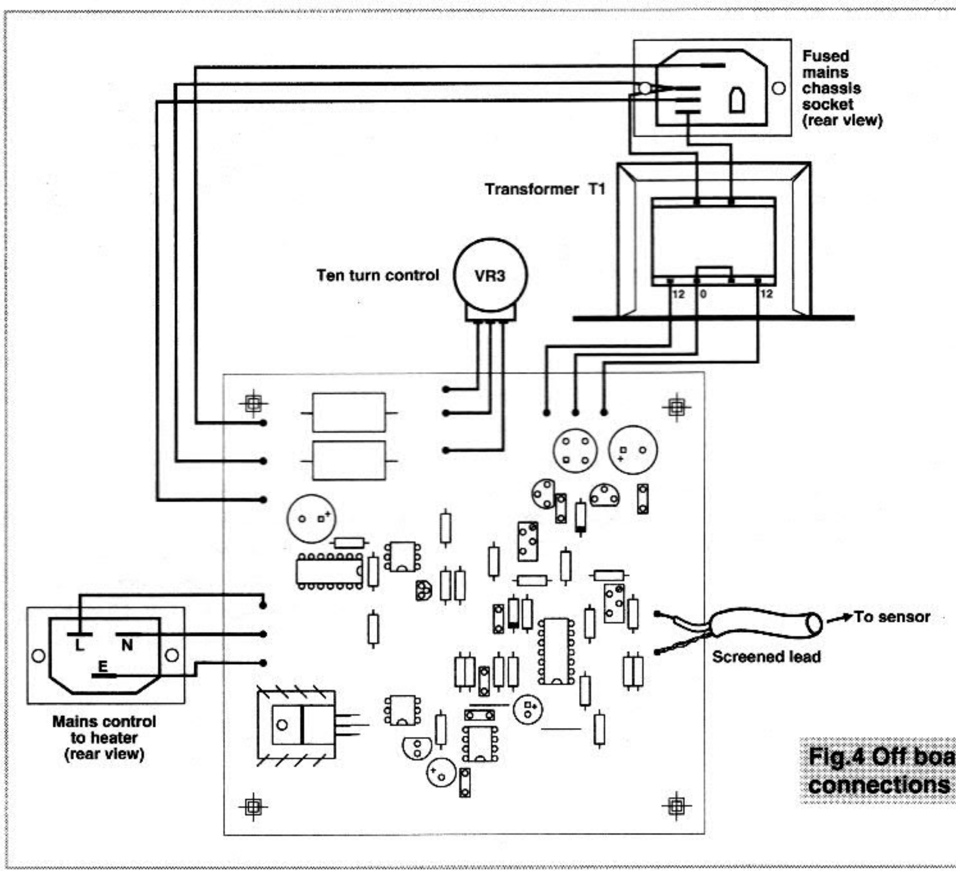


Fig.4 Off board connections

centre tapped transformer and bridge rectifier to give about +/-20V. This occurs from the 12V AC transformer due to a problem called regulation. This leads to a higher output voltage than expected when the transformer is run at a low load current. The 15V supply only operates the op-amp and the sensor and so uses a very small current. The 79L15 regulator would be suitable for use here but the +15V supply powers a number of additional circuits and although a 78L15 has been used for IC1 it becomes very hot. To increase reliability use a 7815 regulator in the TO220 package instead.

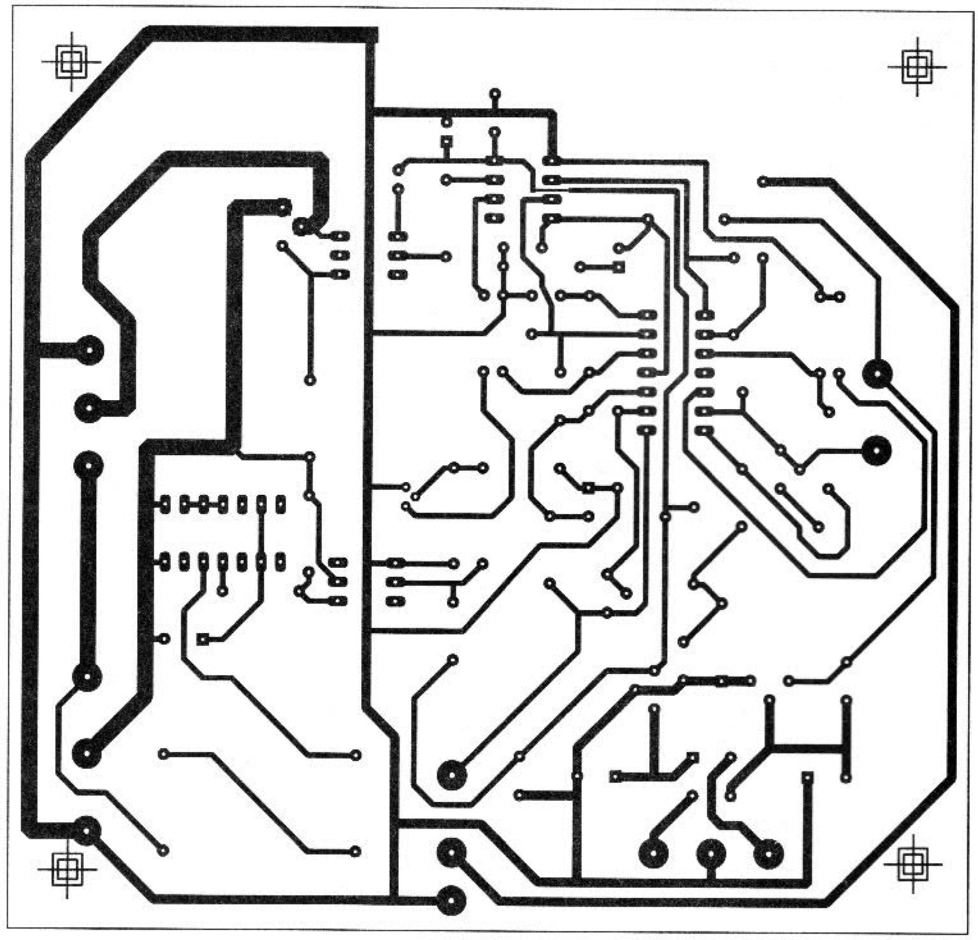


Fig.5 Foil pattern

Construction

Whilst this project has been designed for safe operation, the constructor should remember that the project uses mains voltages. Neither the author or the magazine can accept responsibility for any accidents that may occur due to mistakes. If in any doubt as to your capabilities do not attempt this project.

I started construction with the building of the sensor assembly. The AD592 is a typical TO92 package with three leads on it. Take the device and looking with the wires pointing towards you and the flat of the D downwards, the pin on the left is the sensor negative terminal, see Figure 1. Bend the central wire so that it lies along side the left hand wire and cut to about 1/4inch long. Take a length of audio coax cable and cut back the outer sheath so that you have about 1 inch of bared wire. Tin the screen and cut back giving two wires about 1/2" long. Bare the central conductor for the last 1/4", tin, push over a 1/4" length of shrink wrap tubing and solder to the right hand pin of the AD592. Pull the shrink wrap over the solder joint and shrink the tubing with a heat gun. Repeat for the screen and the other two terminals of the AD592. Finally cover with a larger piece of shrink wrap tubing. This part is very fiddly so take your time. Fit a plug to the far end of the coax and the sensor is complete.

The main circuit board is easy to build following Figure 2. If you prefer to build the circuit in sections testing as you go then you may like to build the low voltage power supply around BR1 first. For the off board connections I recommend the use of terminal pins as these make the final wiring easier. Having built the circuit around BR1 make a temporary connection to the transformer and look for -15V across C4 and +15V across C3 with the central terminal P4 as the ground. See Figure 5 for off board connections.

Moving on to the circuit around IC4, you should find around 6V across C6 and R1 and R2 get hot when running. BE VERY CAREFUL this circuit is at mains voltages. Check carefully for solder bridges around the IC or it will go up with a puff of smoke. Take precautions when testing. If you add IC3 and R3 then using a logic probe or oscilloscope you should find a pulse at 100Hz. With an oscilloscope do not connect the probe screen to neutral, it is dangerous and the repair bill to the 'scope may be expensive, use the Earth pins only. You will see a very wobbly trace due to the difference in voltage between the neutral and earth lines and on top of this a sharp pulse at 100Hz. It is then reasonably simple to complete the rest of the circuit. Those components to the left of the ground track through IC3 and IC6 can have mains on them so special care needs to be taken in this section. The triac TR1 has a small twist vane heatsink mounted below it and then screwed to the PCB. If you use the recommended BTA triac then this contains internal isolation and the heat sink can be grounded. You can use almost any other 400V 4A or higher triac in a TO220 case but then the heatsink will be live.

Rather than use the sensor for testing I calculated that a 47K resistor across 15V would give a current that is a temperature representation of about 45°C. The sensor costs a few pounds whilst the resistor costs pence, the resistor forms a safe option for initial testing.

Take the case and cut the holes for the ten turn pot, the input and output mains connectors and the sensor connector. I suggest the Euro type sockets for the mains connectors and have used an input socket that contains a fuse in it. There is an LED on the board and some constructors may want to have this fitted into an additional hole in the case. This may be helpful if the heating element does not give off light as is the case for our 'bulb' heater.

I should add a few notes about the hatching box itself. This contains the lamp as the heater a small electronics bay cooling fan to blow air across the bulb to keep the temperature even in the box, similar to a fan assisted cooking oven. The sides of the box need to have two holes, one close to the fan inlet to allow fresh air in and the other as an exhaust. The inlet hole size is about 1/4 of the diameter of the fan.

Setting Up and Testing

There are only two potentiometers to be set up for the circuit after the constructor is certain that the board operates correctly. Firstly, connect a voltmeter across the off board connector P1 (ground) and P7 (higher voltage). Adjust VR1 so that the reading is 10V. This sets the voltage across the 'set temp pot' and gives the range 0 to 100°C. With the 47K test resistor in place move the dial of the ten turn pot and check to see that the LED goes from always on with the set temperature low, through a phase where the LED flashes at a fixed rate but with a decreasing on time, to a point where the LED is always off. Remove the 47K resistor across the sensor connectors and fit the wires to the sensor itself. Put the sensor alongside a thermometer and put the voltmeter across P13 and the junction of R19 at the end connected to IC5b. After the temperatures has stabilised set the voltage across P13 and IC5b output to a voltage that works on the 100mV/°C scale, (20°C is equivalent to 2.0V). This sets the calibration of the sensor circuit. The sensor has guaranteed error limits for the type used. This is less than 2°C over the 0° to 100°C range, although there are other more expensive versions with better specifications.

User Modifications

This design may not suit the exact requirements of the user, the prototype being built to power a 100W lightbulb. The triac is rated at 8A at 240V AC and the ballast resistors are also for a mains voltage of 240V. The unit can be used without modification in Europe on 220V mains whilst in the USA on 117V AC, one of the two balast resistors R1 and R2 must be shorted out to allow the CA3059 to operate correctly. The unit is triggered by mains zero crossing but needs no modification for the 50 or 60Hz frequency difference.

As given here the unit is limited to 0 to 100°C by the sensor itself. If required the constructor can modify the sensor circuit to other types and temperature ranges. The 3A fuse in the mains input socket limits the output current.

Parts

Resistors

(All 0.25w 1% unless stated)

R1,2	15K 3W Wire wound
R3,8,9	
R11,12,16	10K
R20,22	
R4	100R
R5,14,15	1K0
R6	1K8
R7	4K7
R10,18	20k or 2 by 10K in series
R13	100K
R17	330K
R19,21	220K
R23	470R
R24	47K
VR1	10K 64y style pot
VR2	5K 64y style pot
VR3	1K0 ten turn pot

Capacitors

C1,2	470µF/25V electrolytic (0.2)
C3,4,5,7	100nF ceramic (0.2)
C6	100µ/63V electrolytic (0.2)
C8,9,12	220nF ceramic (0.2)
C10,11	10µF electrolytic (0.1)

(figure in brackets is lead spacing in inches. Obtain the correct size or the component will not fit in the PCB)

Semiconductors

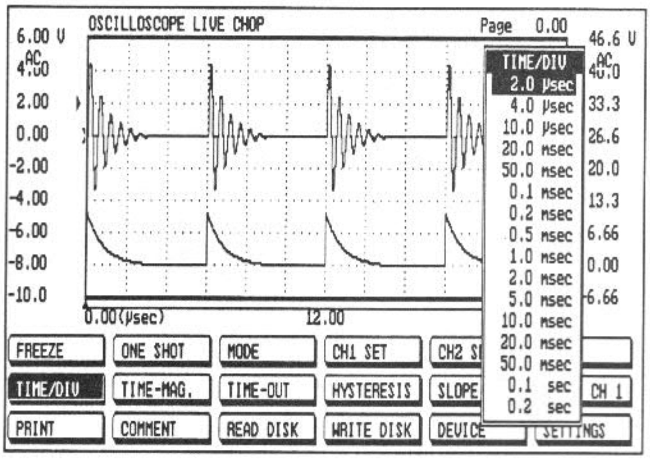
IC1	7815
IC2	79L15
IC3	4N25 opto isolator
IC4	CA3059
IC5	TL074C
IC6	MOC3020 opto triac
IC7	LM311C
D1,2	6V2 400mW zener
LED1	Small LED any colour
BR1	W005 or equivalent
TR1	BTA08-400 internally isolated triac, see text for alternative
TR2	BC547 or any equivalent
Sensor	AD592 A, B, or C (see Text)

Additional Items

PCB (available through Electronics in Action)
PCB standoffs by 4
Twist vane heatsink
Shrink sleeving to make sensor
Plug and socket for sensor
Fused Euro inlet socket and mating connector
Euro outlet connector and mating connector
ABS box (Maplin YN39), mains cable
Mains plug
Transformer 12-0-12V output 3 or 6 watt
Ten turn dial unit
2 metres of audio type coax
Various connection wires as needed but sections of brown, blue and green/yellow recommended to continue the mains colour scheme.

Almost all of the items for this project were purchased from Verospeed in Eastleigh 0703-644555 although they deal only in packs of components rather than single items. Catalogues are available from them direct.

DATA ACQUISITION WITH THE PC



TiePie engineering manufactures a complete range of computer-controlled measuring instruments. Connecting these units to a PC (MS DOS 3.0 or higher) results in a number of comprehensive test instruments:

- oscilloscope;
- voltmeter;
- spectrum analyzer;
- frequency meter;
- transient recorder.

All measured data can be stored on disk or run off for documentation. Because of the many trigger possibilities, a variety of signals can be measured, while the powerful software enables a multitude of measurements to be carried out in a straightforward manner. Application areas include: service; medical research; automatic test systems; research and development; and education.

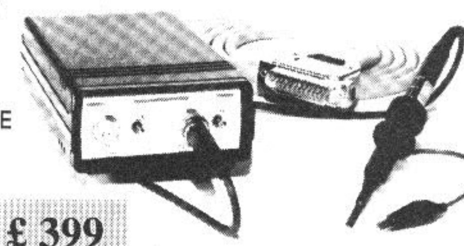
LOW COST: HANDYPROBE

Connect the HANDYPROBE to the parallel printer port of the PC and start the software. Measuring can be carried out at once. The HANDYPROBE does not need an external power supply. Some technical parameters: 0.5-400 V software select input range; one input channel; 8 bits resolution (overall accuracy 2%); A complete software program consisting of a digital storage oscilloscope, spectrum analyzer, voltmeter and a transient recorder is provided. The HANDYPROBE is eminently suitable for servicing and educational purposes.

£ 99

BEST PERFORMANCE: HANDYSCOPE

The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Because of its high resolution (12 bits), the HANDYSCOPE is a very accurate instrument. The measuring rate is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5-20 V (with a 1:10 probe up to 200 V). The advanced software enables many measurements to be carried out. Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors. The length of the cable linking the PC and the HANDYSCOPE is 1.8 m, which can be extended to 3.8 m.



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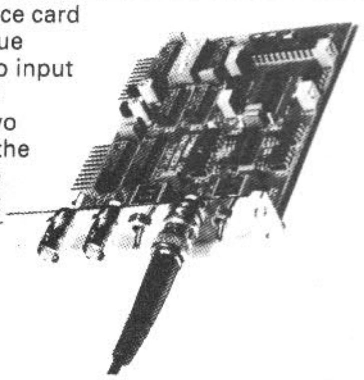
MULTIFUNCTIONAL: TP5008

The TP5008 is an interface card that provides an analogue output in addition to two input channels. This output in combination with the two inputs may be used for the setting up of a complete control loop. The output may also be used as a function generator. The TP5008 has a resolution of 8 bits and a sampling rate of 200,000 samples/sec (200 kHz). The input range may be set to 0.5-20 V full-scale deflection. The output range covers 1.25-2.5 V. The TP5008 is fitted with BNC connectors and is delivered complete with a user manual and software. Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



£ 197

VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring speed of 2×20 Megasamples/sec (8 bits). Phenomena shorter than one millionth of a second can still be measured well. The completely digitized triggering ensures very stable triggering with many trigger possibilities. The TP208 has an input range of 5 mV/div to 20 V/div in 12 steps and an auto calibration function. Since both channels may be sampled simultaneously, phase differences can be measured very accurately. Even single phenomena can be measured since each channel has a 32 KByte memory. Comprehensive software is provided.

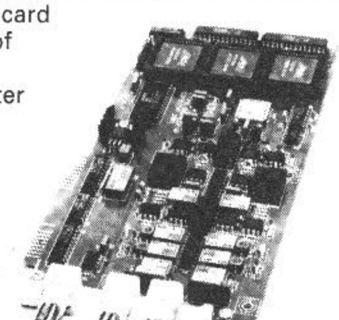


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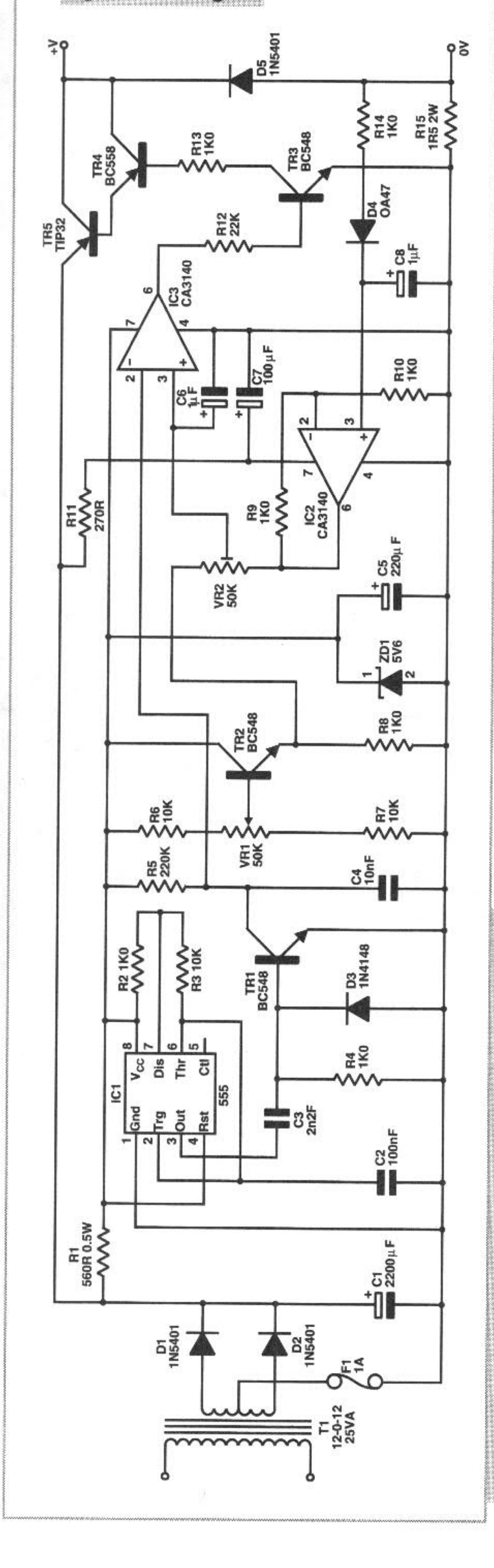
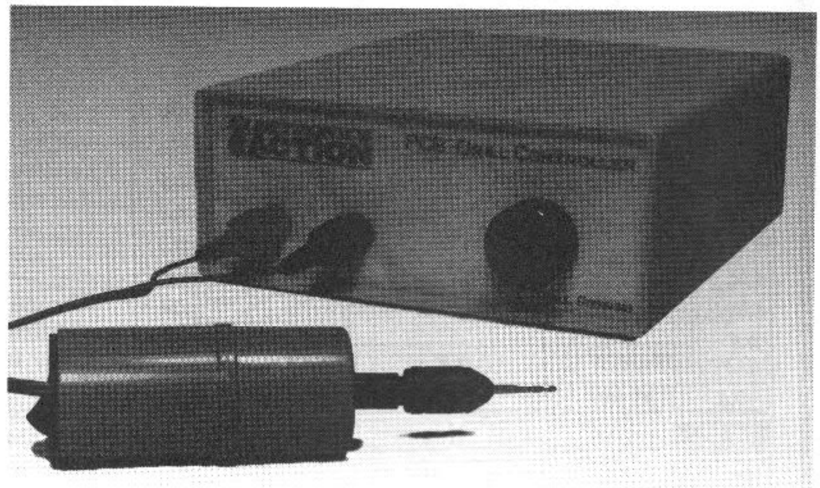
Fig.1 Circuit diagram





In Control

Ever been frustrated by your 12V drill speeding up and slowing down? Paul Stenning's latest project will help you keep your sanity.

One problem with the smaller PCB drill machines is that the speed drops rapidly as the load increases. This can be overcome to some extent by increasing the supply voltage, however the off-load speed is then too high.

The speed controller in this article overcomes this problem by raising the voltage to the drill as the load is increased. The unit uses a basic Pulse Width Modulation (PWM) regulator to reduce the power dissipation.

This unit was designed for the Expo Reliant drill. This popular low cost tool is ideally suited to light duty use.

The Works

The circuit diagram is shown in Figure 1. IC1 acts as an oscillator, running at several kilohertz. The pulses from this briefly turn on TR1, which discharges C4. Between these pulses C4 charges via R5, producing a rough sawtooth waveform.

This sawtooth is connected to one input of a comparator circuit IC3, while the other input is fed from a reference voltage. The output of the comparator controls the switching transistor TR5, via TR3 and TR4.

Thus as the reference voltage is increased, the switching transistor is turned on for a longer period, and the drive to the drill is increased.

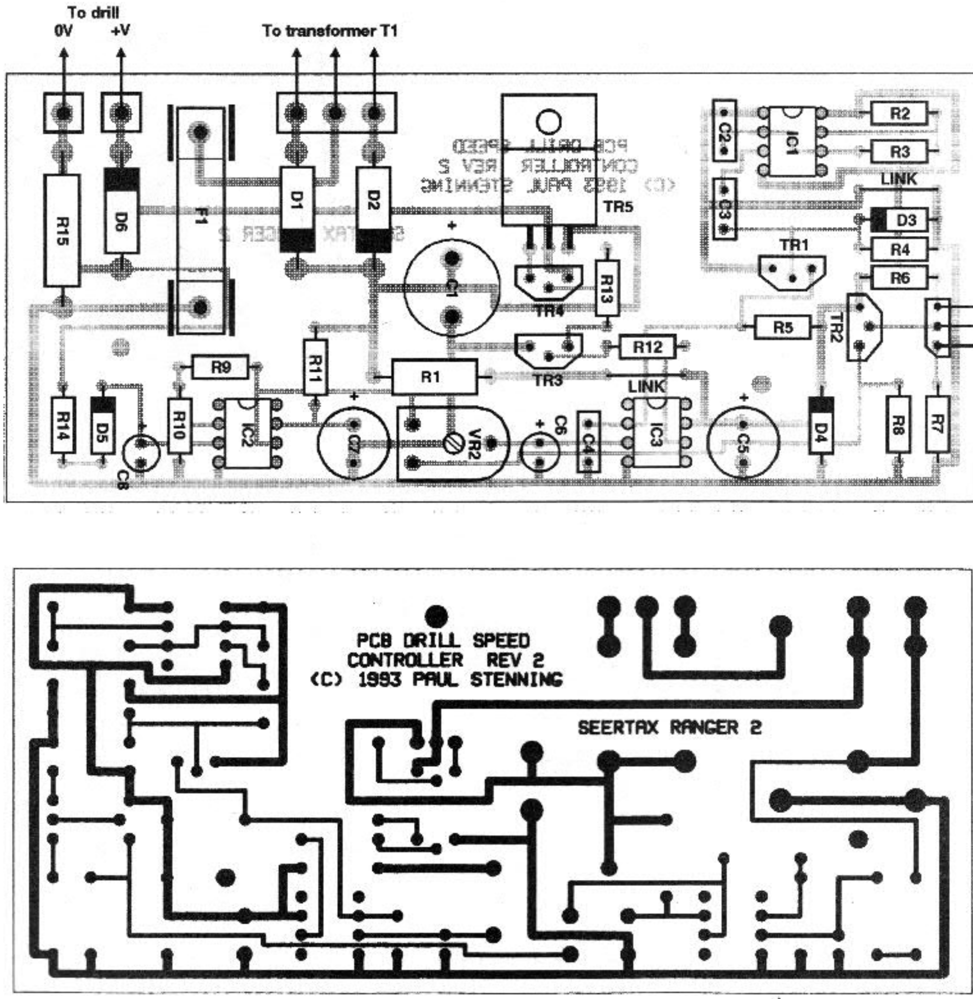
VR1 is the front panel speed control, the voltage from which is buffered by TR2, and fed to the reference input of the comparator circuit by VR2.

R15 senses the current flowing in the drill. The peak voltage across this is amplified by IC2, the output from which is also fed to the reference input of the comparator via VR2.

Thus as the load on the drill increases, its current consumption raises, which in turn causes this unit to increase the drive to the drill. VR2 sets the ratio of control to feedback.

The fuse F1 will blow if the drill is stalled for long period, or if the output is short-circuited. Since the circuit can withstand the short circuit current until the fuse blows, a more elaborate over-current circuit is not necessary.

Fig.2 Component positioning and foil



The controller can power other small PCB drills, as well as other devices containing small 12 Volt DC motors, although some changes to component values may be necessary.

Construction

The circuit is assembled on a single sided PCB, 126mm x 56mm. The component overlay is shown in Figure 2. There is nothing out of the ordinary about the PCB construction, the components are fitted in the usual size order.

A small heatsink may be fitted to TR5 if desired. This runs cool in normal operation, but will heat up if the output is short-circuited until the fuse blows.

R15 will run warm in normal operation and should be mounted a few millimetres above the surface of the PCB. The 2 Watt power rating suggested in the parts list should be regarded as a minimum.

The prototype was built in a plastic case, 190mm x 165mm x 68mm, see parts list for details. Check the dimensions of the transformer before buying the case. A suitable template for the front panel is shown in Figure 4, this may be photocopied and fixed to the front panel with clear self-adhesive vinyl.

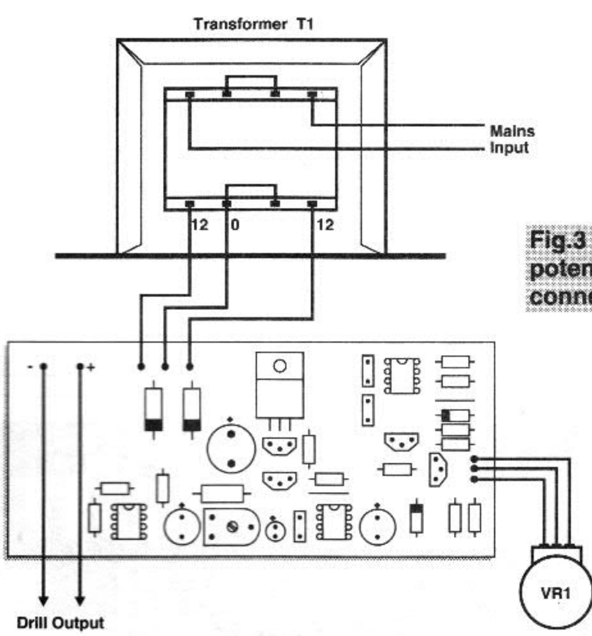


Fig.3 Transformer and potentiometer connections to board

The internal layout can be seen in the photographs and the interwiring is shown in Figure 3. No mains fuse or switch were fitted on the prototype for simplicity, however a 3A fuse was fitted in the main's plug.

Testing

Ensure that main's connections within the unit are well insulated for safety. Set

VR1 fully anti-clockwise and VR2 fully clockwise. Connect the unit to the mains and switch on. Connect the PCB drill to the output terminals.

As VR1 is turned clockwise, the speed of the drill should increase. Set this control to about one quarter, then load the drill lightly by placing a finger against the chuck. Note how much the drill slows.

Now gradually turn VR2 anti-clockwise. The speed of the drill will increase a little. If the drill is lightly loaded again, the speed should remain more constant.

If VR2 is set too far anti-clockwise the speed control will have little effect and the drill speed may pulsate. The suggested position for VR2 is a little more clockwise than halfway.

The unit is now fully tested and can be put into use.

EIA

Parts

Resistors

(All 0.25W 5% unless stated)

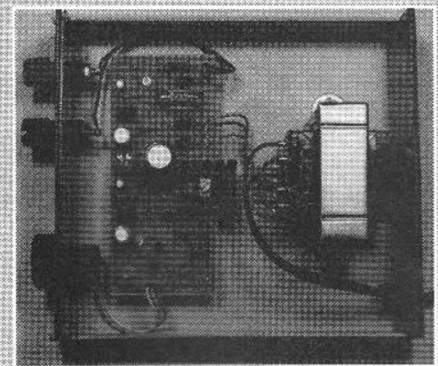
R1	560R 0.5W
R2,4,8 R9,10 R13,14	1K0
R3,6,7	10K
R5	220K
R11	270R
R12	22K
R15	1R5 2W
VR1	50K Horizontal Preset
VR2	50K Lin Rotary Pot

Capacitors

C1	2200µ/25V Radial
C2	100n 0.2" Pitch
C3	2n2 0.2" Pitch
C4	10n 0.2" Pitch
C5	220µ/10V Radial
C6,8	1µ0/25V Radial
C7	100µ/16V Radial

Semiconductors

IC1	555
IC2,3	CA3140
TR1-3	BC548
TR4	BC558
TR5	TIP32 or TIP42
D1,2,6	1N5401
D3	1N4148
D4	5V6 Zener
D5	OA47



Additional Items

X1	12-0-12V 25VA Transformer
F1	20mm 2A Anti-Surge with PCB Fuse Holder

PCB (available from Electronics in Action)

Case

Knob for VR1

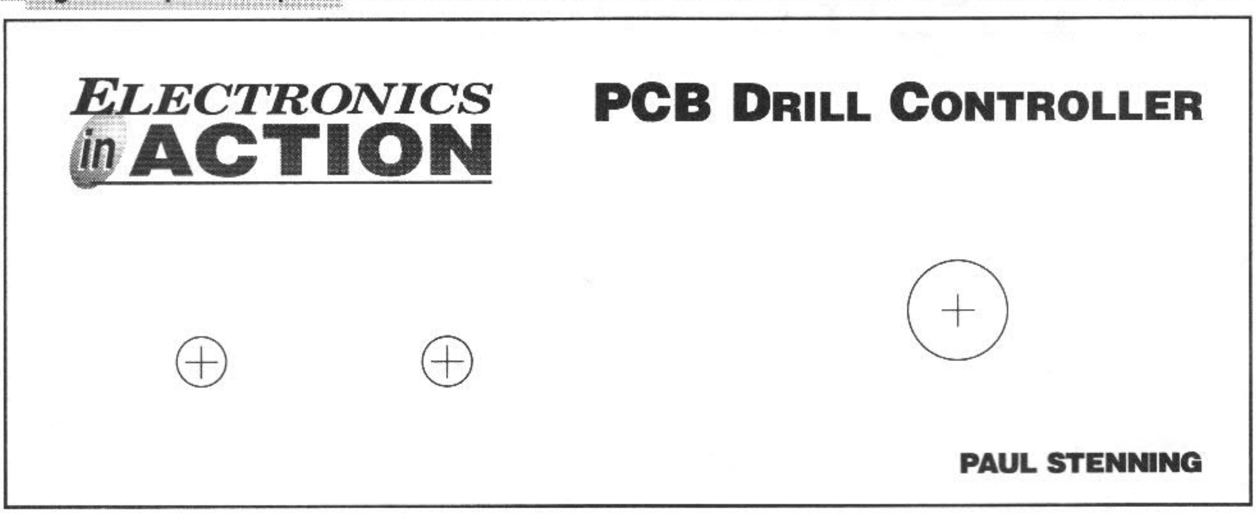
Red and Black 4mm Terminals

Mains Flex

Expo Reliant PCB Drill.

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

Fig.4 Front panel template



Coming soon...

Paul Stenning will be showing us an easy to construct test card and pattern generator, requiring no EPROMs.

Make sure you don't miss it

The Evolution of Audio Amplifier Design

Part 1

The early valve years

by John Linsley-Hood

There is, unfortunately, a continuing divergence between the approach and attitudes of most audio system design engineers and the views of Hi-Fi journalists and a good proportion of up-market Hi-Fi users. By and large the designers, like most practical engineers, tend to rely on calculations based on theory, and explore the performance of their designs by performance tests and other measurements. On the other hand, the journalists and their more with-it readers mostly suspect the validity of measurements, which they feel, like opinion polls, can be made to give any answer which is required. They tend, therefore, to rely on judgments of technical excellence and assessments of sound quality made by a select band of knowledgeable critics.

I read Hi-Fi magazines, though not as many, or as thoroughly as I should because of my rather sceptical viewpoint. I have noted the current views of their correspondents and contributors, and the ideas in (temporary) vogue, some of which I think are just plain daft, while others give me cause to stop and think, and wonder whether there really might be something in what they say.

My problem is I suppose, that long experience of audio systems and circuit design has made me cynical about innovations. I have seen, or heard, a lot of it before, and I often suspect ulterior motives. For example, if Joe Bloggs advertises some super new connecting wire, or freshly re-labelled component, at ten times the price you first thought of, he will obviously extol its virtues as persuasively as his command of adjectives or his understanding of user psychology will allow.

Similarly, if a Hi-Fi journalist hears of some new idea in equipment design or use, especially if it is likely to prove a bit controversial, he will want to publish details in his journal, since it will help to sell more copies. It is obvious, also, that his write-up will have to be favourable; if it isn't, end of story; though if he feels it may prove to be a lemon, within the effective memory span of his readers, he will build in some small let-out phrase among his praise.

In reality, the progress of consumer audio - from the crystal and cat's-whisker, to the modern stereo FM receiver, or from the simple battery operated amplifier, driven by a Rochelle salt crystal pick-up, ploughing its way along the spiral groove of an emery powder loaded 78rpm shellac disk, to the modern transistor amplifier driven by a digital compact disk - has been one of continuous and dramatic improvements.

I sometimes contemplate the effect a 1993 technology demo. would have on a 1933 listener recently woken from a sixty year sleep. I suspect he would not agree with some of the more reactionary Hi-Fi pundits that modern Hi-Fi gear lacks the warmth and musicality of the old.

Battery operated valve amplifiers

For myself, I cut my electronic teeth, as a schoolboy on simple, battery operated amplifiers of the kind I have shown in Figure 1, operated from a 2 volt 'accumulator', and a 120V HT dry battery, available most cheaply from

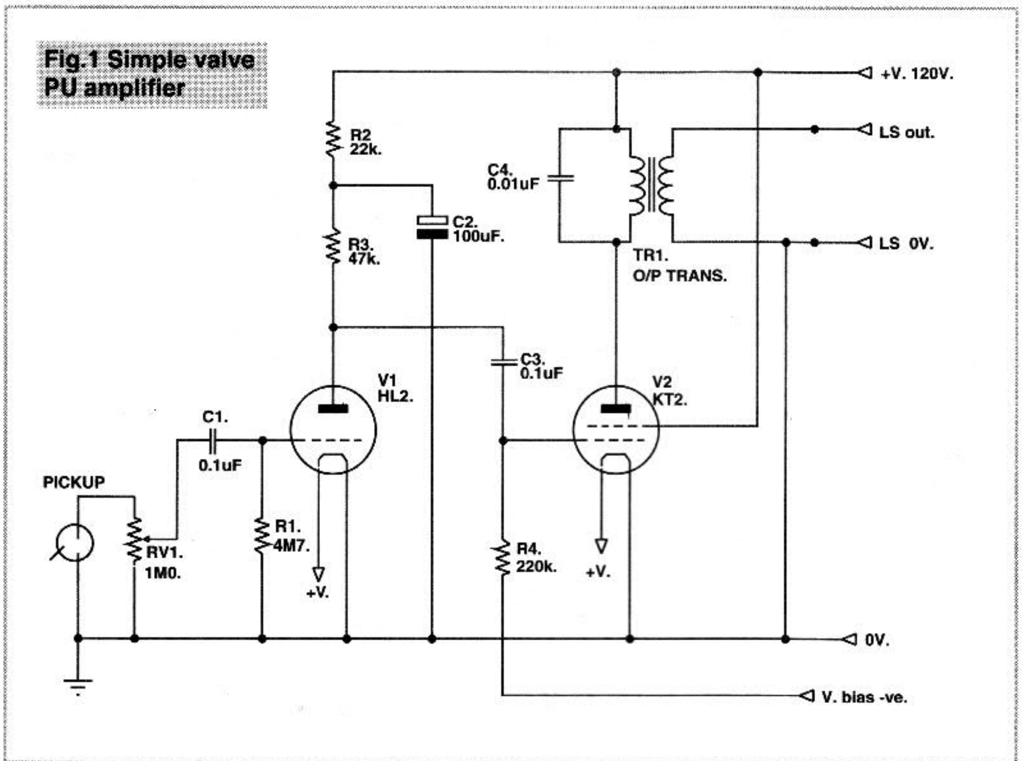


Fig.1 Simple valve PU amplifier

Marks and Spencers!

The gramophone pick-up I used, like most of my friends, was a ‘Cosmocord’ crystal type, in which a postage stamp sized sandwich of crystalline Rochelle salt was caused to twist along its length - and thereby generate an output voltage by piezoelectric action - by the wiggling of the gramophone needle as it followed the undulations of the groove.

The output voltage one could get, on the louder passages of the record, was of the order of 1 volt RMS and the frequency response, due mainly to the record characteristics, began to fall off beyond 1KHz, though crystal and stylus resonances helped improve the flatness of the frequency response up to about 3-4KHz. Generally, some kind of electrical roll-off was used anyway above about 5KHz to try to reduce the loud hiss caused by the record surface.

The maximum rated power output from the KT2 output beam-tetrode, a high quality output valve which had not long been introduced at the time of my 1939 Marconi-Osram valve catalogue, was 0.5 watts, at about 10% distortion - though amplifier distortion tended to be thought of as just a fact of life in those days and was largely ignored. The distortion would mostly be second harmonic, which was not too unpleasant to listen to, but there would also be about 2% of third. The distortion due to V1 was probably less than 0.5%, again mostly second harmonic.

The most obvious effect of these harmonic components was to make the amplifier sound a bit shrill, so a capacitor C4 was connected across the primary of the LS transformer to mellow it down a bit. At the 17k load impedance of the output transformer, the HF roll-off due to C4 would start at around 1-2KHz.

Inevitably with battery operated equipment, there was always a choice between sound quality and HT battery life - since the 2 volt filament supply came from a rechargeable lead-acid battery, one didn’t worry about this too much. HT batteries were expensive and at a 10mA total current, the HT battery life would be about 50-100 hours. If one increased the output valve bias from the recommended 4.5V level, one could increase battery life at the expense of reducing the output power and worsening the distortion. So if one was entertaining friends, one would set the bias at a bit lower voltage.

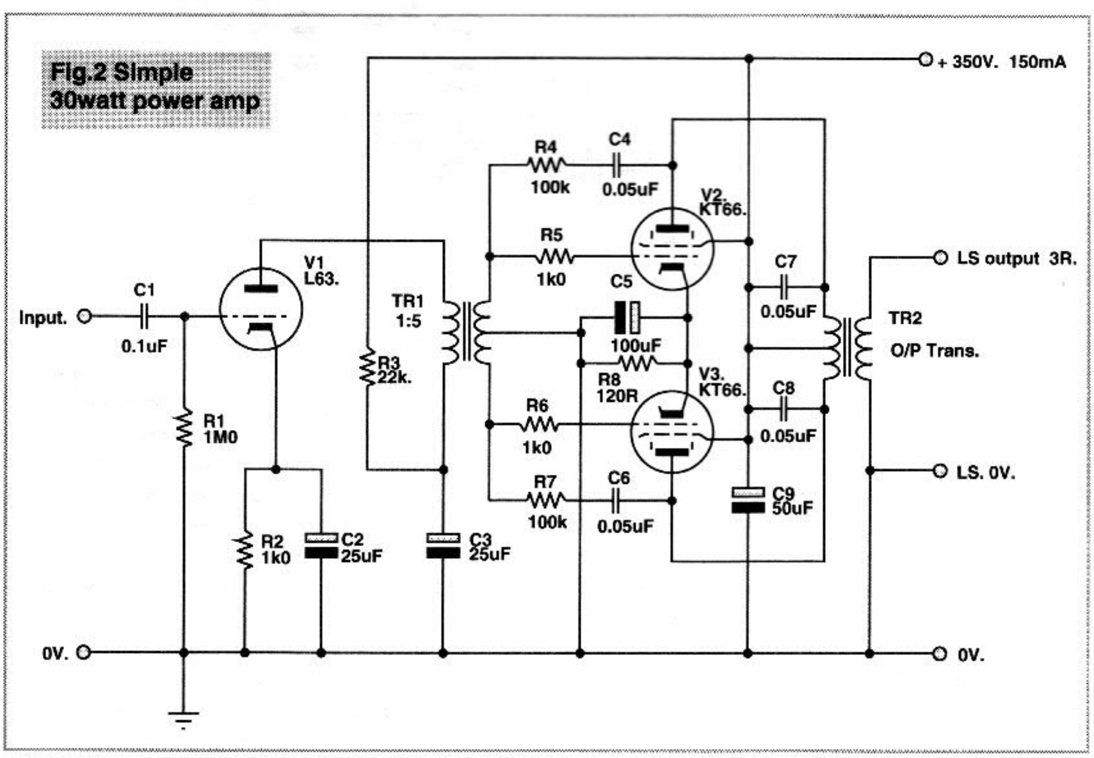


Fig.2 Simple 30watt power amp

Mains powered amplifiers.

The availability of mains operated valves, and for me as a schoolboy, the courage to use them, allowed the design of much more powerful amplifiers. This could be up to 10 watts or more from a pair of KT61s, used in push-pull. In addition to giving a larger power output, push-pull operation of the kind used in the circuit shown in Figure 2, cancelled most of the second harmonic distortion. What was left was mainly third at a much lower level - say 1% at full output power. This last point is important, since the distortion in most valve amplifier designs will decrease with output power, so that at typical listening levels the distortion would probably be below 1%.

A small practical problem with push-pull systems was the need to drive the control grids of the output valves with a pair of anti-phase inputs. A pair of signals of this kind was most easily obtained from a coupling transformer with a centre-tapped secondary winding, such as TR1 in Figure 2. The use of yet another transformer in the signal line, the output transformer was unavoidable. It tended to limit the performance of the design, and prevented the use of overall negative feedback to reduce distortion and increase bandwidth of the circuit.

The bandwidth available, and the distortion produced by a circuit of this kind depended entirely on the quality of the coupling and output transformers. By popular repute, Ferranti - an electrical engineering firm, in those days, made the best, and these commanded a good price in the second-hand radio component shops. With good quality transformers, a bandwidth of 100Hz-10KHz was practicable, and the THD at 1KHz would probably be less than 1%. However, this would worsen to perhaps 3-4% towards the ends of the audio passband. The lower the step-up or step-down ratio of the transformer, the better it would usually be, so 15 ohm speakers became more popular.

Some local negative feedback was often used, for example via R4/C4 and R7/C6, to reduce the third harmonic contribution of the output valves, but some HF roll-off components, such as C7 and C8, would also be added to camouflage this defect.

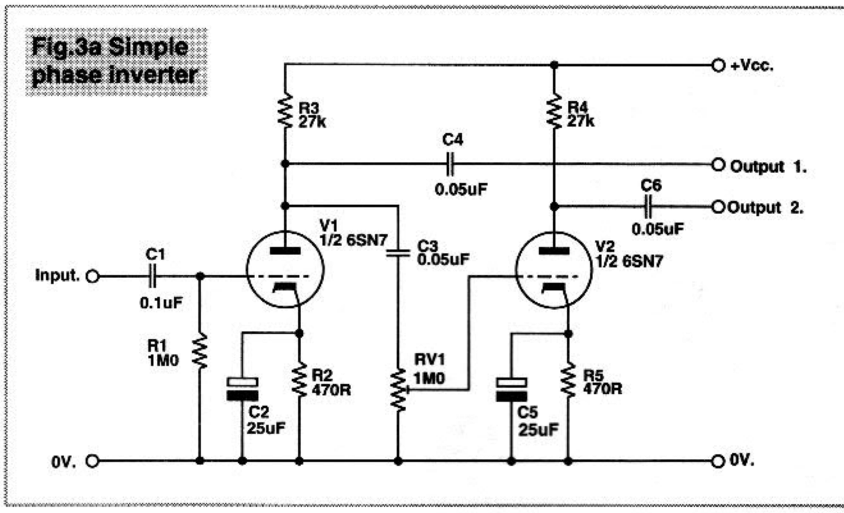


Fig.3a Simple phase inverter

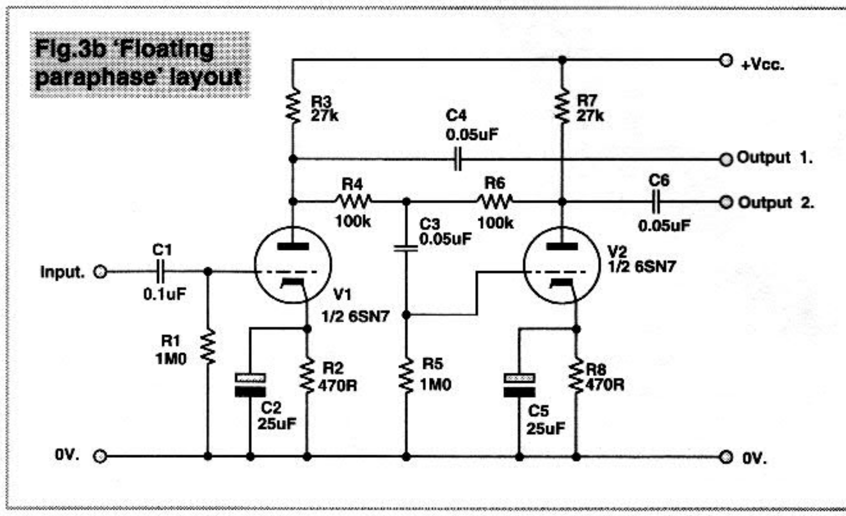


Fig.3b 'Floating paraphase' layout

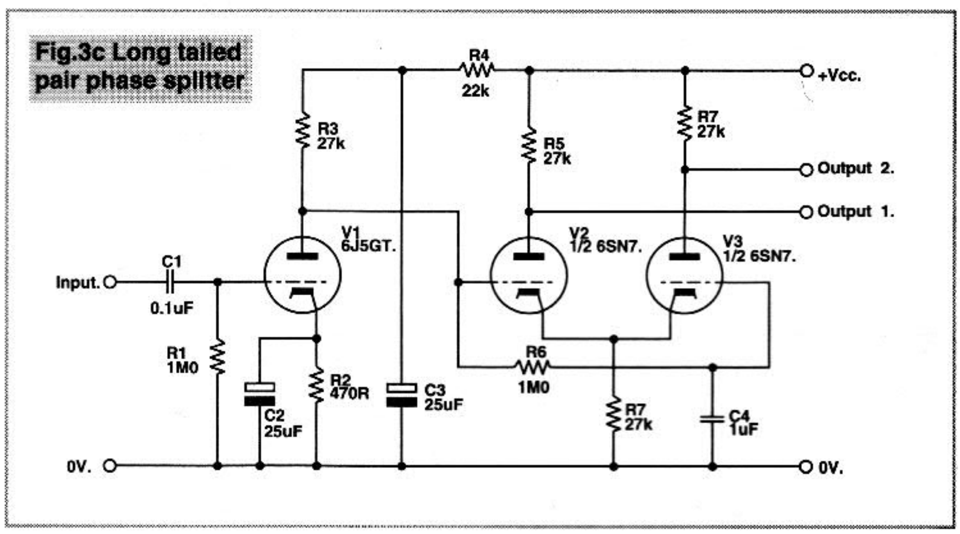


Fig.3c Long tailed pair phase splitter

A problem with all multi-stage amplifiers was caused by signal voltage feedback along the supply lines. It was not, then, as widely appreciated as it is today, just how much such unwanted feedback of signal components could worsen the circuit distortion level: mainly it was only noticed at all when it was large enough to cause LF oscillation - known as 'motor-boating' because of its sound. HT line decoupling elements such as R2/C2 in Figure 1, and R3/C3 in Figure 2, were added to lessen the likelihood of this problem.

At the cost of an extra valve, and some increase in circuit complexity, it was possible to make a 'phase-splitter' stage which would provide the necessary pair of anti-phase signals to drive the output valves without the use of a push-pull input driver transformer. This immediately gave a substantial improvement in circuit performance. Various types of phase-splitter could be used, of which the simplest and crudest was just to incorporate an additional amplifier stage, shown in Figure 3a. The gain could be adjusted by a preset input pot. so that the two outputs were the same in size. Although popular, this wasn't really a good circuit, since attenuating any signal, and then amplifying it again added needless distortion.

Alternatively, this gain adjustment to make the two drive signals the same in size could be achieved automatically by the use of negative feedback, in the 'floating paraphase' layout I have shown in Figure 3b. This had the advantage

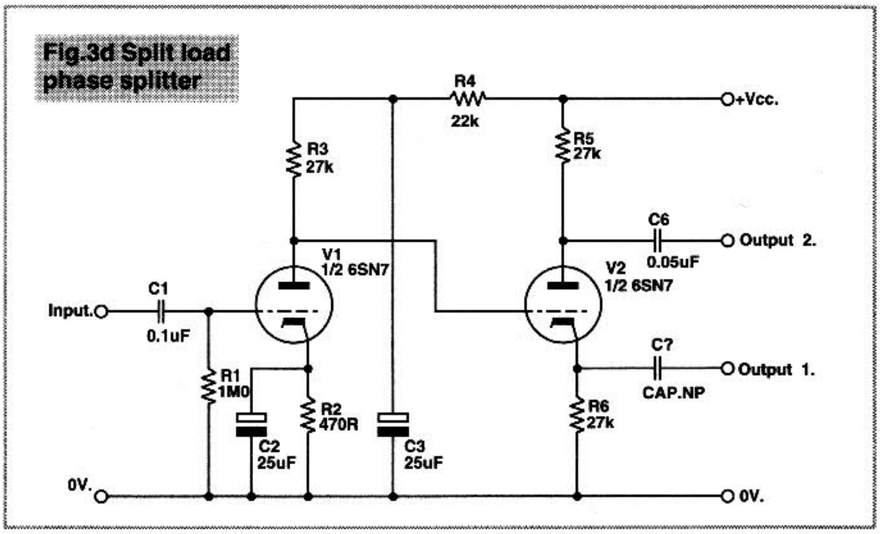


Fig.3d Split load phase splitter

that, since V2 operated with nearly 100% negative feedback, this stage generated a negligible amount of distortion. Other popular layouts were the 'long-tailed pair' circuits of Figure 3c and the split load driver stage of Figure 3d. This last design also added very little distortion, and was the circuit adopted by D T N Williamson in his classic 15 watt Hi-Fi valve amplifier of 1947-8. However, since this stage operated at unity gain, it would generally require a pair of further gain stages between the phase-splitter outputs and the output valve inputs.

I have shown, in Figure 4, an amplifier circuit of my own, dating from 1950-51, using a pair of high gain pentode small signal gain stages, of which the second, V2, was a 'floating paraphase' phase splitter circuit. Local negative feedback was applied via R16/R19 and some 15dB of overall NFB was also used, from TR1, via R23 and R2. I had no way of measuring THD at the time, but I would guess that it had about 0.4%, at its 25-30 watt maximum output. I was very chuffed by its performance, and my friends also must have liked the sound since several of them pleaded with me to make them one too.

The performance of any amplifier of this kind depends on the primary inductance, and leakage inductance of the output transformer, and though quite a lot of firms made 'Williamson' or equivalent output transformers, they were dear, and I had therefore tailored the circuit design of my amplifier so that I could use the good, but much less expensive, 'Wharfedale' equivalent.

Inevitably, I built a proper Williamson amplifier a year or two later, winding the output transformer myself, to the constructional details given by 'DTN' in his articles, which had been, by that time, reprinted by 'Wireless World', (the journal in which DTN's articles had originally been printed), as a small booklet. I probably wouldn't have done this but for the fact that I met an elderly (and relatively wealthy) gentleman who had bought a 'Williamson output transformer kit', complete with wire, laminations, and all the other bits and pieces, but had then lost the courage to complete the job, and so was willing to sell me the bits at a bargain price.

For the record, and because there is a high degree of contemporary interest in amplifiers like the 'Williamson', (which, privately, I still think to be the best of the bunch), I have shown the original Williamson circuit in Figure 5. The brief specs. for the o/p transformer were: Primary load impedance = 10k, Primary inductance = 100H (min.), Leakage inductance = 30mH, (max.), Primary winding resistance = 250 ohms, (max).

The 'Williamson' amplifier established the 0.1% figure for THD at maximum output which has remained the criterion for 'Hi-Fi' amplifier performance. In addition it offered a

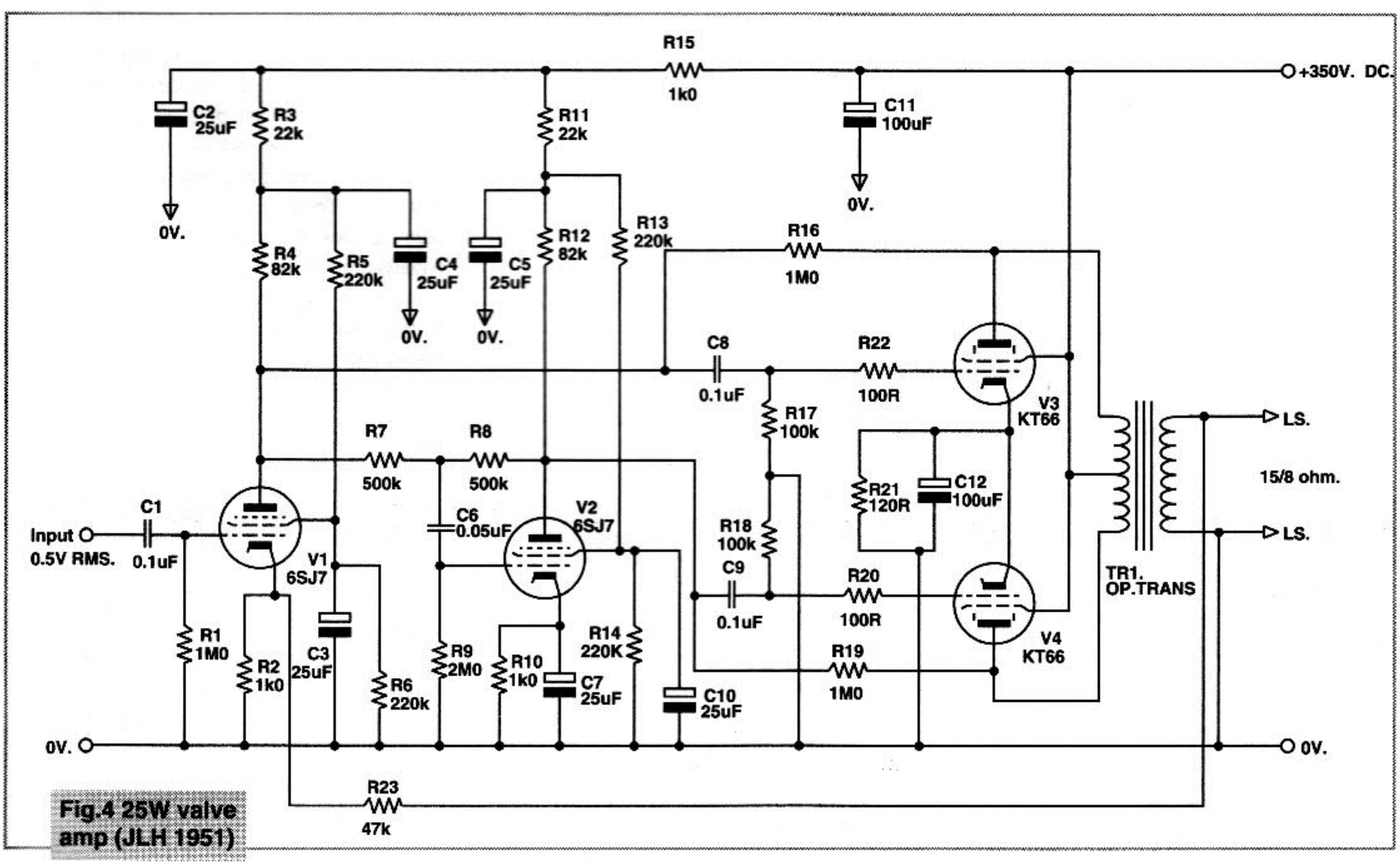
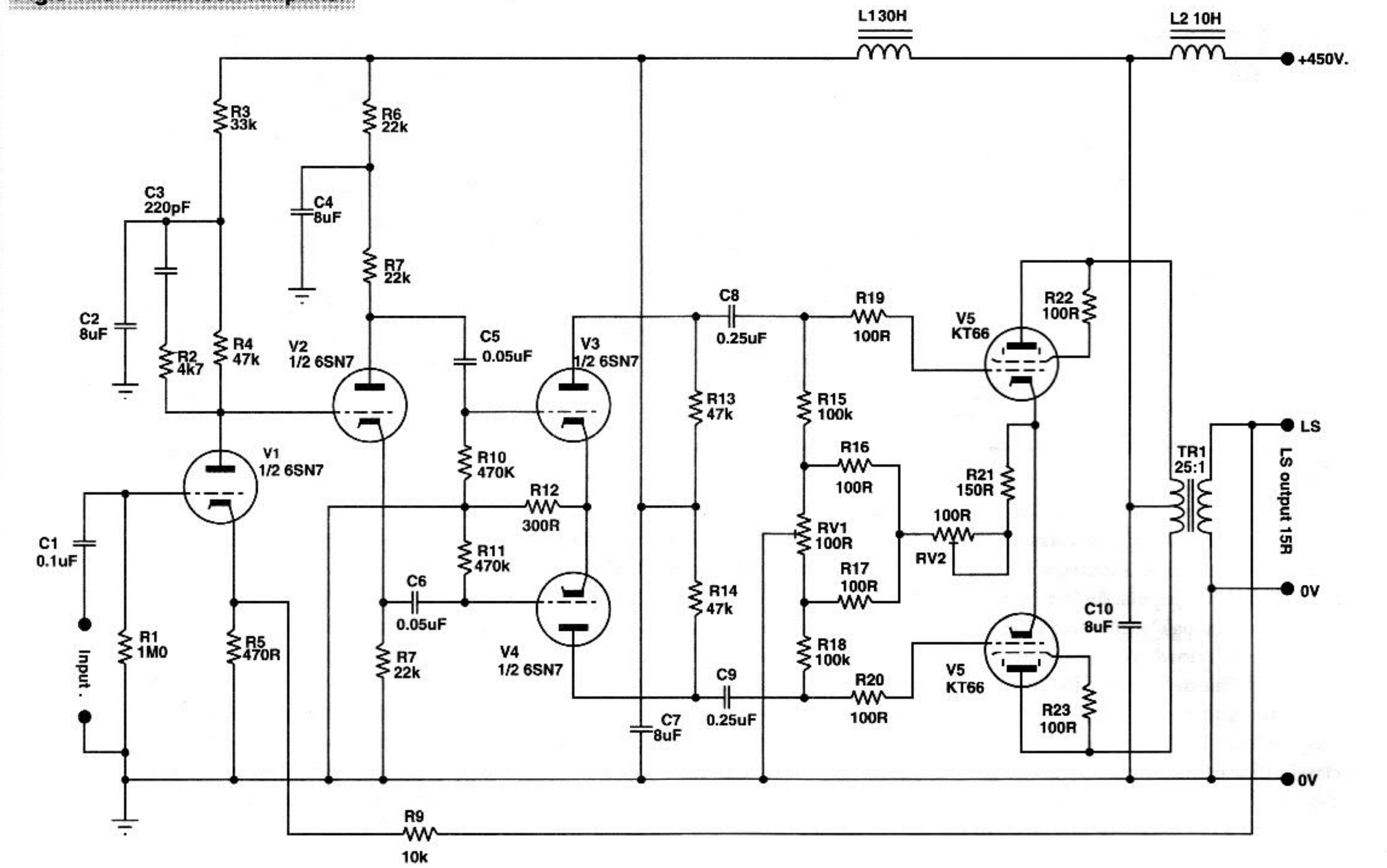


Fig.4 25W valve amp (JLH 1951)

Fig.5 The Williamson Amplifier



bandwidth of 2Hz - 100KHz, an excellent figure for a valve amplifier, even by today's standards.

The 'Williamson' circuit had several features which are beginning to attract the interest of modern circuit designers, such as the unbypassed cathode bias resistors, to provide local negative feedback, and the exclusive use of non-polar capacitors, but its successful use of about 26dB of overall NFB was undoubtedly the major reason for its superb performance.

There were other comparable designs around at the time, mainly using variations of the 'ultra-linear' output transformer layout, in which the screen grids (or sometimes the cathodes) of the output valves were taken to additional tapping points on the primary winding. This generally allowed about twice the output power for the same HT voltage compared to the 15 watts given by the triode connected KT66s used by Williamson.

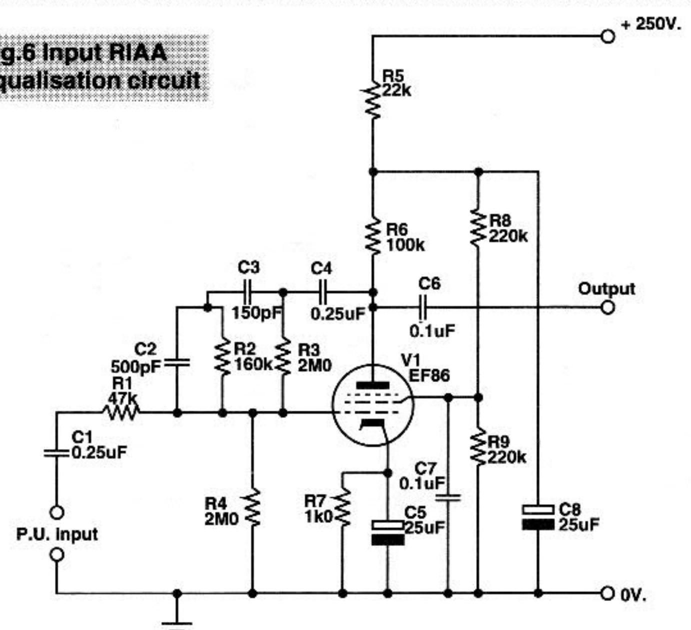
Progress in other audio fields.

So far, the designs shown, from Figures 1 and 2, to those in 4 and 5, all show an increase in quality and performance, partly in response to the designers sharpening their skills, but also to significant improvements in related fields, such as better LS units, using two or more drivers, and 'LP' records.

In particular, the LP record offered most people a signal source with a wider bandwidth, and a better signal to noise ratio than anything previously available, while the growing use of good quality 'magnetic' pick-up cartridges, and agreed recording characteristics meant that circuit designers began to take the requirements of record replay equalisation seriously, with the aim of achieving a flat replay frequency response from 30Hz - 20KHz. I have shown a contemporary gramophone pick-up input equalisation stage in Figure 6.

So far, all of the design and product improvements had brought about a clearly audible gain in sound quality, and there was little feeling amongst the music loving fraternity that anything might be amiss. However, into this cosy environment crept the junction transistor, and all of a sudden, doubts arose about the whole basis of 'Hi-Fi' and I will look at this event in the next part of this series.

Fig.6 Input RIAA equalisation circuit



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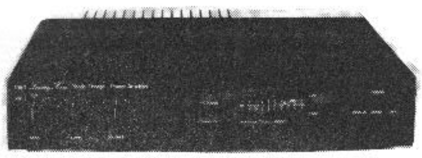

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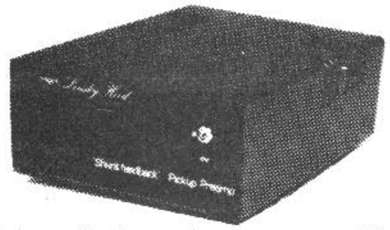

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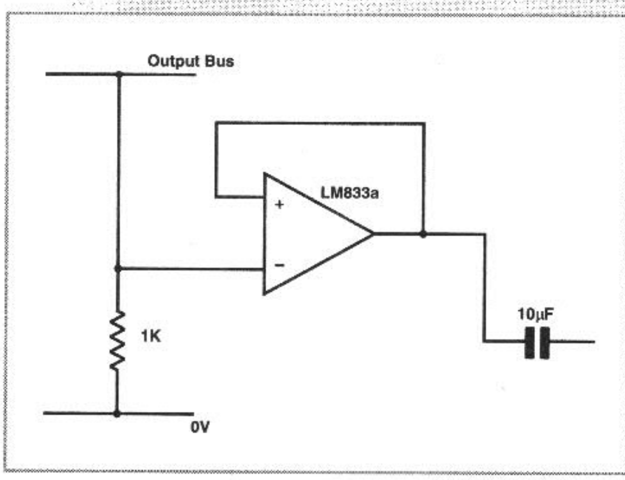
A selection of your views and thoughts

Switch to Audio

Firstly, congratulations on the new publication. It really is very good indeed and seems to cover my particular interest (professional quality audio) very well.

Just a note about the correction to "The Switcher" project published in the December edition. Now firstly let me say that I consider "The Switcher" to be one of the finest audio projects I've seen in any magazine for an awfully long time, however, I'm sure I won't be the only one to notice the deliberate mistake in the correction, i.e. the missing connection symbols. I assume the idea was to provide a 1K input impedance to the LM833 op amps being used as output buffers, however your "correction" shows no connections to the busses, whereas I guess one resistor should be connected to the Left Output Bus and the other to the Right, something like the drawing above. The question I have is this. Why choose a 1K input impedance? The SSM2412 data sheet specifies the distortion with a 5K load and the graphs bear out the fact 1K that a 1K load will increase the distortion at 1KHz from 0.001% to around about 0.02%. Admittedly this is quoted with a Va of 10V RMS, but I'm sure there will be a comparable increase in distortion at lower levels. I realise we're talking about a very low THD to start with here, but I would be interested in the reasoning behind Mike Meechans choice, rather than (say) 4K7.



While I'm in nit-picking mode here, the Distortion graph for the SSM2412 printed as Figure 8 in the November part of "The Switcher" (Page 23) has a misprint... the second curve up from the bottom labelled R_L = 2k, V_{in} = 10V RMS should read R_L = 5k V_{in} = 10V RMS.

Apart from that I wish you every success with this new venture, I for one will certainly be buying every issue from now on and as soon as I can afford it 'The Switcher' is one project I will definitely be building. My ancient Quad 44 ran out of line level inputs several years ago, and before you mention the intrinsic distortion present in the Quad inputs is due to their use of 4066 CMOS switches, let me assure you that I am four years into building Ben Duncans excellent AMP-02. Just one more module to go (and the chassis) and I'm finished.... maybe another year or two if I'm lucky!.

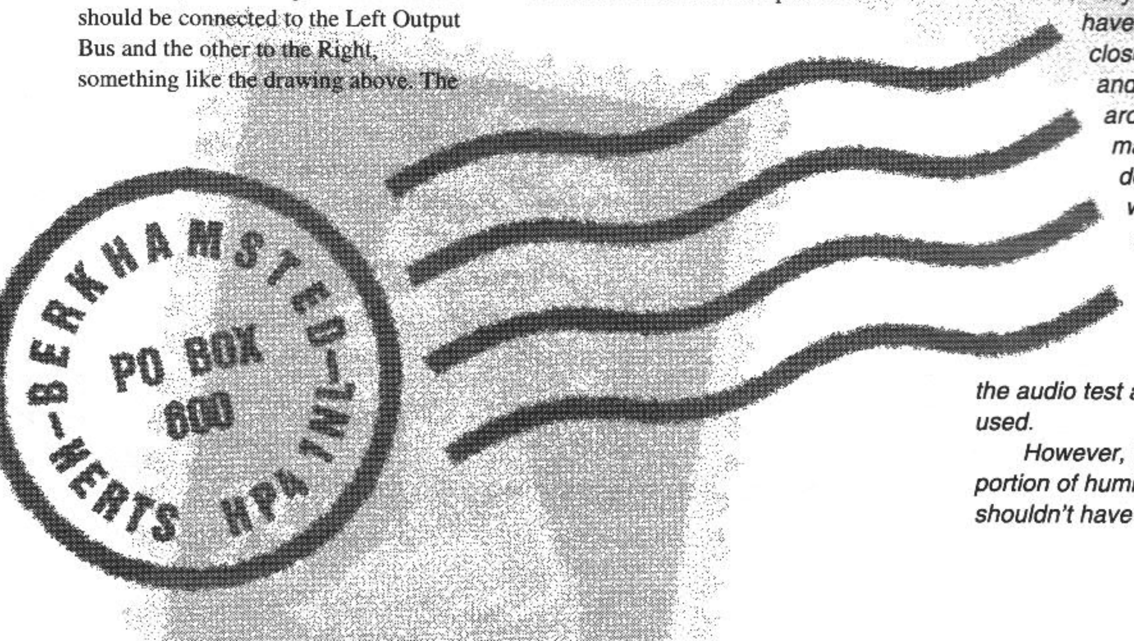
J R Evans
Director
Robin Evans & Associates Ltd.
Stansted, Essex

Mike Meechan replies:

I shall answer the points you have raised (or otherwise) in the order that you have posed them. Yes, the correction should have been as you have shown it, with the 1K resistor providing a DC path to ground for both the Left and Right busses and the op-amp NON-INVERTING inputs. Your diagram shows the INVERTING input connected to ground via the resistor, with feedback returned to the NON-INVERTING input. Your diagram, too, seems to have suffered from the gremlins which plagued mine and the magazine's - less a deliberate mistake and more of technology getting its underwear somewhat in a twist.

As far as the value was concerned - mea culpa. I chose 1K as an arbitrary value but I should have perhaps looked more closely at my own graphs and chosen something around the 5 or 10K mark, although noise does increase slightly with larger values of resistance. In my defence, even with 1K, distortion was below the measurable limits of the audio test apparatus which I used.

However, I'll eat a generous portion of humble pie and say that I shouldn't have worsened distortion



performance unduly with this carelessness. Well spotted, sir.

Finally, thank you very much for the very generous praise - all of it ill-deserved - which you heaped upon me in the opening paragraphs. You might be interested to know that forthcoming hi-fi/pro-audio projects include The Alchemist (a Moving Coil preamp) and the Equaliser, a 1U high 2 channel mic/line preamp with High Pass Filter, 4 band parametric equaliser and Pan and Fade facilities.

Wireless Guitar

I am currently studying for a Communication Engineering degree at the University of Plymouth. I am now in the final year of the course and I am required to design and build an electronics project of my choice I have chosen to build a VHF receive/transmit system for use with an electric guitar or microphone in order to eliminate the need for a connecting lead between the device and it's associated amplifier. I am writing to see if you can supply me with any relevant information.

Neil Allies
Plymouth

S**uch is the popularity of a project like this that your wish is our command. Look out in next month's issue. Many thanks -* ***Ed.

Chemistry in Action

Congratulations on your new electronics magazine, its three plus months old now and I'm looking forward to every issue but I have a feeling that your title could be wrong as we seem to have a large number of electronic magazines on hand and having read Ideas Forum in the December issue, the write up gives me the impression of electrochemistry so why not rename your title Electronics and Chemistry in Action. Try and obtain the American science magazine titled 'Science Probe' a very interesting magazine. However, the young student or experimenter would like more projects to build, fault finding in electronic circuits especially digital, such as clocks, timers, burglar alarms, PIR sensors and of course not forgetting Ideas Forum.

N R Dobson
South Shields
Tyne and Wear

Shocking Stuff

After all other enquiries have ended in disappointment, I am advised to write to you direct seeking your valid assistance. As a youngster, 60 years ago, I was given an Electric shocking machine powered by a low voltage torch battery. The overall measurement would not have exceeded 6" with a coil diameter of a little over 1". A knurled thumb screw adjusted to make and break action and a hollow tube could be extended from the centre to increase the power of the harmless shock.

I also recall about forty years ago, kits to make this type of machine were freely available from electrical shop.

I would very much like to make one of these for my young grandsons, and have the use of several engineering machines to make a worthwhile model, but I am unable to find either a plan or kit, (I would prefer a plan) which would allow me to proceed. Is there any way you could assist please.

G Hall
Sunderland
Tyne & Wear

***M**y how times have changed and indeed only in such a short space of twenty years. I speak of ethical and cultural changes. Looking further back, Victorian society used electrical treatment - there was no shortage of magazine adverts claiming to cure all sorts of ills.*

I can even remember in my youth in the 60s making a shocking machine from the 'Meccano Electrikit' instruction book (The kit must be worth a few bob now!) and taking it to school to excite my colleagues. But now everything has changed, the curiosity and fascination has gone in what electricity can do to the person. Remember Tesla was fascinated in what effect electricity had on the person. He also went to great lengths to show that AC electricity was 'safer' than DC.

But rather like Mercury being a bad substance and banned from use in schools, society has placed a very different emphasis on electricity as a 'potential killer'.

Getting back to your point Mr Hall, these devices are easy to construct and still to this day, the principle of transformer induction is being taught in schools. You will find such diagrams as electric bells, ignition coils and induction coils in any school Physics text book as they still form part of the curriculum.

Whilst I would applaud anyone for wanting to understand how electromagnet induction works and to put it to good use, I would certainly not want it to be abused. That is the black side. On the positive side, we all learn by experience and receiving a 'safe' electric shock would tell us what a shock is and how bad it could be. The difficulty here is how safe is safe, for we are all slightly different in our makeup and so tolerance levels can be very different? - ***Ed***

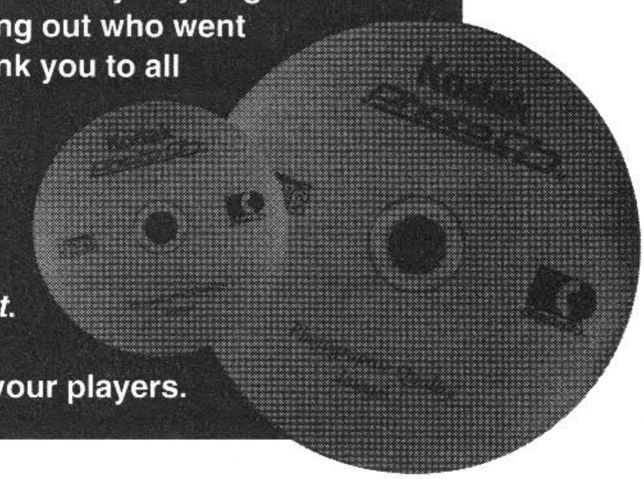
CD Winners

We received a heap of entries to our Kodak Photo CD player competition and not many of you got the answers wrong, so sorting out who went in the hat was easy. Thank you to all those who entered.

The lucky winners were:

Mr F.R. Stephens from Worthing in Sussex
and Mr J.M.G. Davies from Ferndown in Dorset.

Well done to both of you and we hope you enjoy your players.



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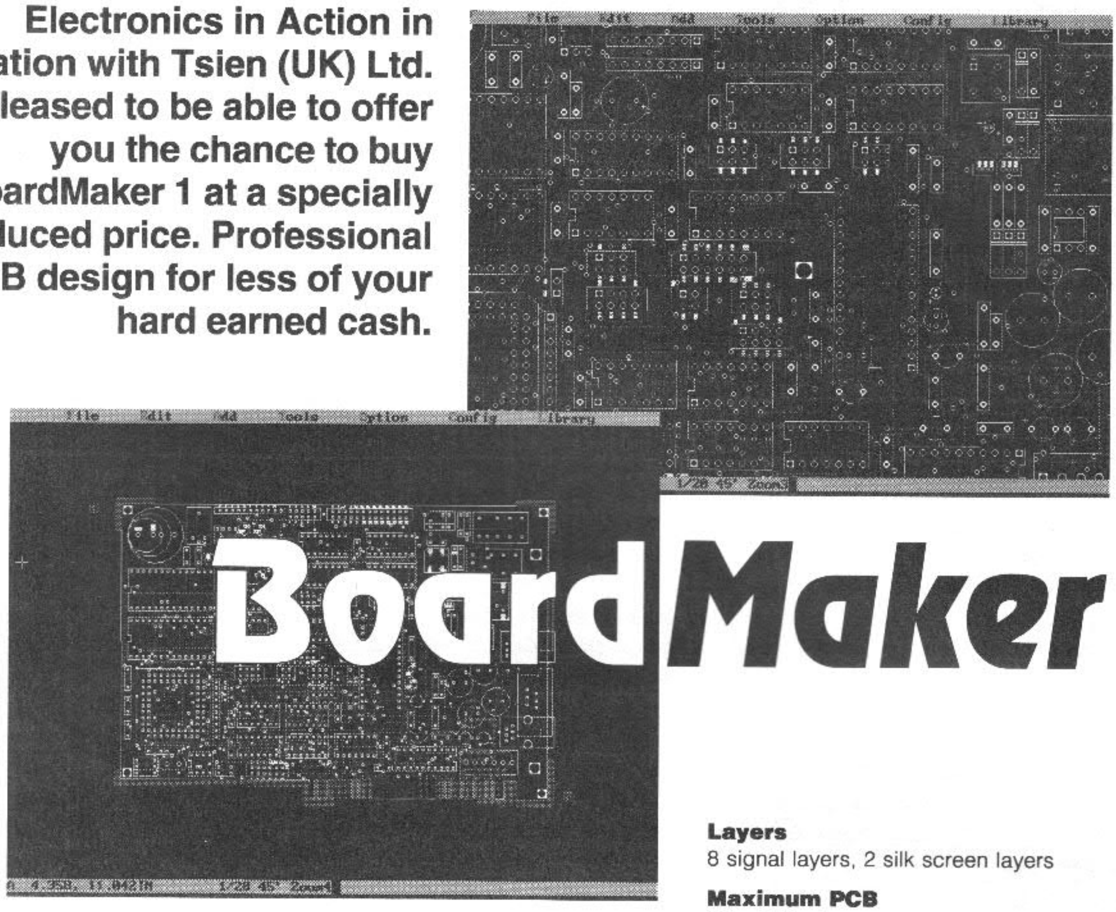

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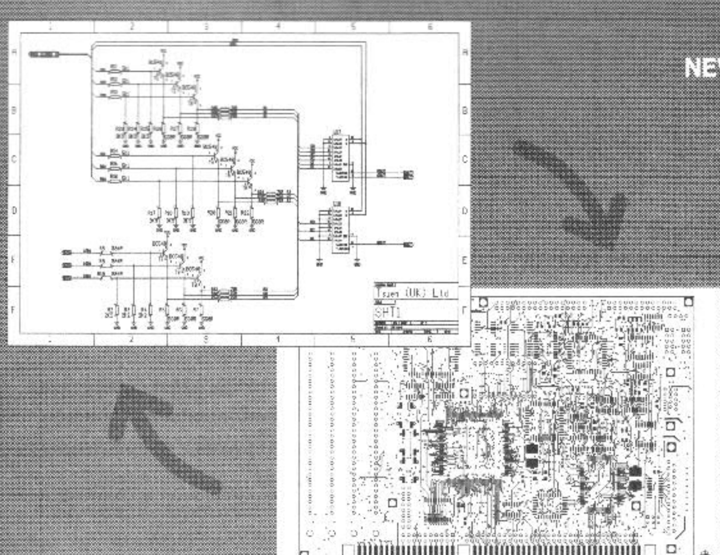

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505055 G
Electromagnetic radiation transducer

Transducers transform invisible electromagnetic radiation into the visible one. They can be used in opto and micro-electronics for the laser system and electron microscope tuning, for visual evaluation of light spot uniformity and as gamma - radiation dose meters. Luminescent composition, operating in clearance and reflection mode is the base of visualisers.

605120 W L G
Magnetic valve-type reactor

is a high power inductive reactance, smoothly regulated in its value by magnetic biasing of magnetic circuit with direct current. The reactor magnetic circuit is of a special transformer type design which cores operate in high saturation conditions. The cores incorporate mains, control and the converter transformer windings in one.

105254 F L G
Automatic system of heat moisture treatment control for concrete products

A multichannel temperature controller RTM-3 is a digital regulator on microschemes of H 561 series with programmes generation. RTM-3 is aimed for the control of reinforced concrete products heat treatment in various technological units; steam curing chambers, thermoforms, printed circuit boards etc.

105236 G
Transient electromagnetic system

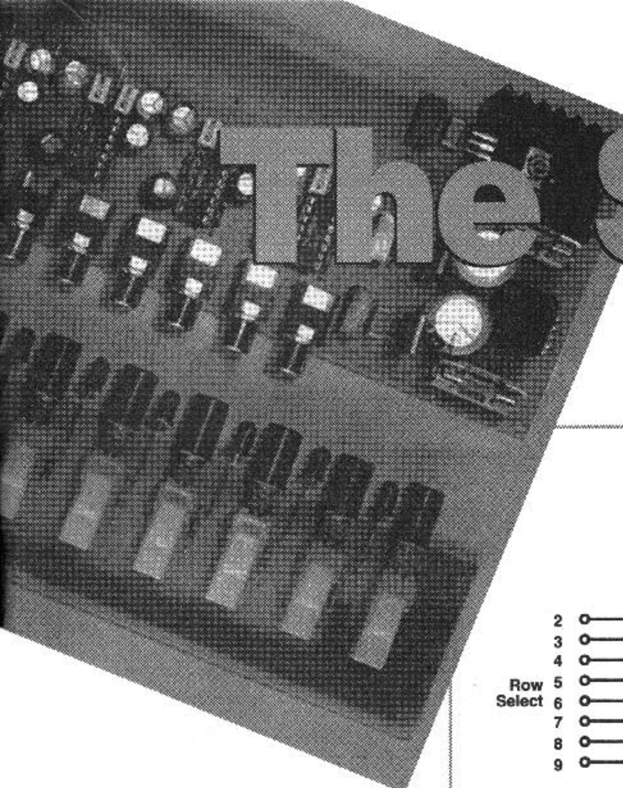
The 'Cykl' TEM system is a high power ground of borehole electromagnetic system designed to determine the complete geoelectrical sections from the surface to depths of 4000-5000m. The system comprises the 4-channel receiver with time range of 50s -50s and the transmitter in two modifications (45.4kw) compatible on the electrical and logical levels and synchronised by cable or crystal controlled clock.

705266 F J G
Universal positive-negative photoresist. Production forms PhSN-3 and PhSN-3PV

A new photosensitive composition which includes polymer components (phenol formaldehyde and/or epoxy resins), a light sensitive component and a mixture of organic solvents. Production forms make it possible to prepare photoresist layers of 0,3-3,0mm thickness. This adds new possible applications of the photoresist, in particular, in the lift off lithography.

105429 C L/S C
Starodyne: synchronous electric motor

includes an oscillating core, which does not rotate but causes a high speed spindle to rotate. Advantages: very low response time, compactness, robustness, easy to service, adaptable, no power limit. Applications: mechanisms, automation, handling, electrical systems.



The Switcher

Part 4

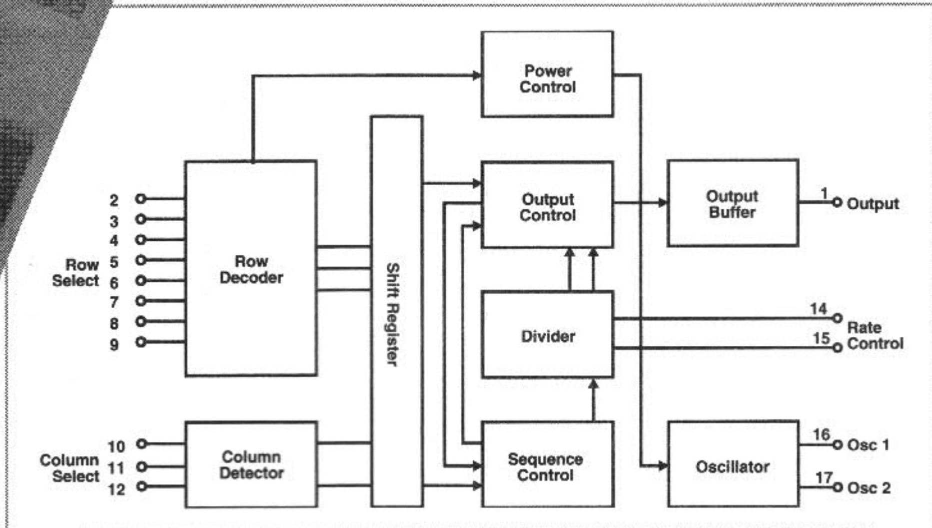


Fig.1 MV500 Remote Control transmitter - Functional Block diagram

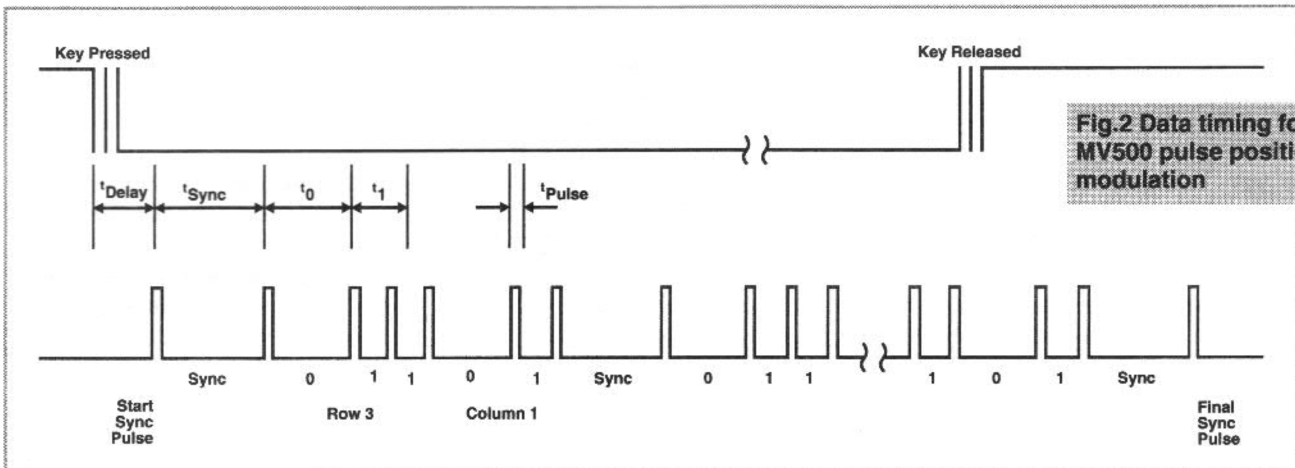


Fig.2 Data timing for MV500 pulse position modulation

Last month, we looked at the optional VCA section of The Switcher. Before we present constructional details and line-up procedures for this board, let us look at the final optional facility. I should mention at this point some major league gremlins crept in to last months episode. The PCB layout and circuit were of an earlier design. The correct layouts and amendments will be shown next month. My apologies for any confusion this has caused.

Why Remote Control?

In recent years, much of our consumer society seems to have becomes increasingly concerned or obsessed even with convenience. Most consumer goods these days come preprogrammed with a multitude of different operating configurations and setups. Whether most people actually make use of more than 10% of these facilities is open to conjecture. For many adults, the new science and technology invading their otherwise orderly lives is an unwelcome intrusion. Being able to cook food in two minutes is all very well, but we'll have to READ the manual and learn something new!

The ability to gain new knowledge and to process new information quickly and efficiently seems much less pronounced when one is working within an infrastructure where it is "the norm' to do so. High level disciplines such as science, technology and other similar ones such as medicine and law are filled by fraternities of people who have a learning curve with a much shallower gradient. This means that when it comes to gathering new (or updating old) information, it is expected that individuals in these areas and disciplines take a much shorter time to assimilate and remember information of a complex nature. Now, just what has all of this got to do with remote control?

Pause to consider the typical video cassette recorder - and accompanying remote control handset - which reside in just about every suburban home in Western society.

How many healthy, intelligent, and otherwise completely normal adults seem to physically pale at the thought of programming such a beastie to record, for argument's sake, two programmes which are on at different times on

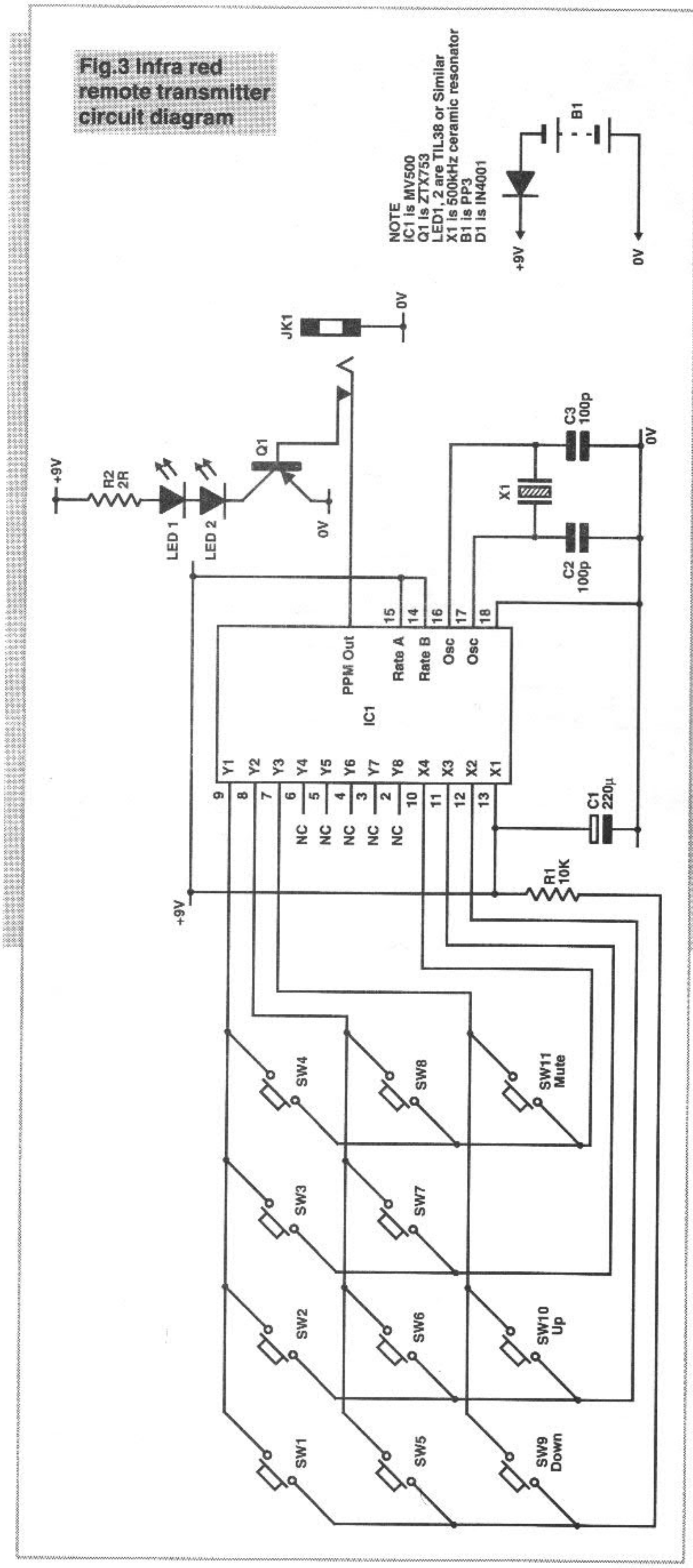


Fig.3 Infra red remote transmitter circuit diagram

The Works

Remote Control Transmitter

The IR Transmitter has just one IC, some IR diodes, a handful of passive components, a matrixed switch array and a battery. All of the clever stuff is done in the MV500 IR Transmitter IC. The MV500 should more correctly be called a 'remote control transmitter IC', since it can be used with hard-wired, twisted pair data links, or indeed, ultrasonic remote control applications. We will concentrate on Infra-Red data exchanges.

It is an 18 pin device with very low power requirements, the capability for operation from a wide voltage range, and uses a minimum of external components for basic operation. Selectable data rates mean that a kind of device multiplexing can be achieved - ie when fitted with the appropriate receivers, two completely different devices can be controlled, independently, from one handset. Code synchronising pulses before the main code word provide reliable decoding and immunity to spurious response.

A block diagram of the IC is

different channels, the first one of which commences a week on Thursday? It is the kind of scenario which is guaranteed to strike fear and dreading into the hearts of a large proportion of the adult population. What about children? Actually, they're fine. Youngsters don't yet have this inbred techno-fear or intellectual arrogance. They'll read the instructions, carefully and logically, undertake each of the specified operations by rote, and by the third or fourth time, they'll have it off pat and will then try and tell Mum or Dad, patiently of course, how to do it for themselves.

In many instances, it is the manufacturers of consumer goods who are at fault, and not the people trying to operate it at home AND stay sane. The manufacturers - engineers, product designers, boffins - seem to assume just a mite too much on the part of the average individual user of said equipment. Design teams can manage to make a simple operation complicated and an involved one impossible - it's a malaise which is far to prevalent for the long-term good reputation of the industry.

The Switcher remote control DOESN'T have sixty buttons on it, It's uncomplicated, easy-to-use, and above all, effective. In any case, what isn't there can't cost money.

There are just eleven buttons on a fully equipped handset. These control the input select switching, the optional remote attenuator - VCA - and a mute function (which is also part of the VCA circuitry. The infrared part of the data-exchange link between the remote handset and the switching unit itself could be replaced - or supplemented - by a hard-wired, twisted pair data link. This might be useful if you have a second set of speakers sited remotely and in a different room, say, from the primary pair, but wish to control the volume/

shown in Figure 1. Keys are arranged as an X-Y matrix, with a switch closure creating a crosspoint which is then decoded by a row decoder and a column decoder in the front end of the IC. When a key is pressed, and either or both of the 'rate' pins are asserted high (more on this later), the device comes out of power conserving stand-by mode and the oscillator starts. A delay is imposed before the keypress data is inputted to a shift register and a change in the output can occur. A sync pulse is outputted before any data is transmitted. This is then followed by a unique codeword which is repeated for the duration of any keypress. Once a key is released, the codeword is allowed to finish before another sync word is transmitted. The device then enters stand-by mode again. The system uses pulse position modulation which is transmitted without carrier, with timing and synchronisation information derived from a low-cost 1-2% ceramic resonator. A resonator working at 500kHz has been used for this application and a pulse timing diagram after a typical keypress is shown in Figure 2.

The rate pins, Pins 14 and 15, determine the data exchange rate and whether or not the device is in power down (stand-by) mode or normal mode. One of three data rates is available, as well as an 'output inhibit' mode. (Data rate on the associated receiver side of things must match the transmitter data rate setting). The inhibit mode is used where current consumption is minimal and isolates the oscillator and the logic from the supply when no keys are pressed. SPST switches have been used for the keyboard. There is also no 'TRANSMIT' button to be pressed at the same time as one of the function keys. Realising this function from the available hardware was an impossible task. Current consumption is still around 0.5mA when stand-by operation is not invoked, so a PP3 should last for some time.

Two infra red LED's are connected in series and driven by a transistor with a high current gain and a fast switching speed, since it must operate in saturated mode and with very low collector voltage. With a low 3V min supply with the CMOS devices present in the IC, the transistor gain expected will be very low, and the transistor current drive will be below that required for correct operation at normal distances. The range is directly proportional to the diode current and sourced by the transistor. It is for this reason that I have used a 9V supply rail instead of the more usual 3V one, since a higher supply voltage allows a series connection for the diodes, which in turn reduces power consumption for a given operating current through each diode. R1 simply limits the diode peak current to around 150mA.

The 3.5mm jack socket has switched contacts. When no jack plug is inserted, the PPM output drives the output transistor TR1. Inserting a jack breaks the signal from this stage and the pulsed output is transmitted instead via the socket/plug over a fixed wire data link. Maximum distance over which the PPM waveform can be transmitted and subsequently decoded is determined, ultimately, by the noisiness, electrically-speaking, of the immediate environment.

source selection of the amplifier/second set of speakers from this remote location. It avoids having to use long runs of screened lead, which would be prone to hum and other noise pick-up and contamination, and which would require a second amplifier/selector in any case. How many commercial designs can offer this kind of facility as an option? Certainly not many, if at all, in any price range in the domestic equipment market. The fitting of this particular option necessitates only two extra 3.5mm jack sockets, and a lead of the desired length which is terminated at each end with 3.5mm jack plugs.

Construction

IR Transmitter

There are no complicated constructional procedures to follow with this board. Components are soldered in order of ascending size, starting off with wire links (some of which reside underneath the IC sockets and which must be soldered before the IC sockets), IC sockets next - paying careful heed to the aforementioned advice -resistors, small capacitors IR LED's etc., then the two Veropins, and ending with the larger electrolytics, 3.5mm jack socket, front panel push-button switches and the battery connector. The LED's are mounted with their bodies parallel to the surface of the board, i.e. with a right angle bend in the legs and facing towards the front of the PCB. The switches MUST be aligned as shown in the component overlay, that is, with the flat on the switch body lying inline with the PCB. Mounting them at 90° to this will mean that both halves of the switch will be permanently shorted together since each pin shares a parallel connection with its neighbour. Some care is necessary when soldering the ceramic resonator to the board as the pins are fine and fragile and easily damaged. This advice holds true for all of the soldering operations. Because of the diminutive size of the PCB, and the packing density of it, some of the tracks are VERY fine and as such, easily damaged. Great care is necessary throughout the construction stage if these aren't to be damaged.

Construction of the IR Receiver is very straightforward, with the technique detailed above being followed closely. The IR phototransistor must be mounted at right angles to the PCB. If the board is to be used solely for remote control of sources - no VCA board fitted - PL2 can be omitted and the board can be mounted either horizontally (alongside) or vertically with respect to the main analogue board orientation. Minicon connectors (straight or right-angled) must be fitted as appropriate. When the VCA and the IR Remote board are constructed, the IR Receiver board MUST be mounted vertically. It is better, where this is the case, to fit the Mincon socket to the Receiver board and a straight Minicon plug to the Main Analogue board, since it raises the Receiver board fractionally above the VCA and makes the whole assembly more secure.

Setting Up - Remote Control section

Transmitter

There are no setting up procedures necessary for the transmitter. Functionality of each of the keys must be checked, of course, but this requires use of the receiver section.

Receiver

Firstly, fit a 9V PP3 battery to the transmitter. Now, carefully plug the Receiver/VCA board into the main analogue board so that the two sockets

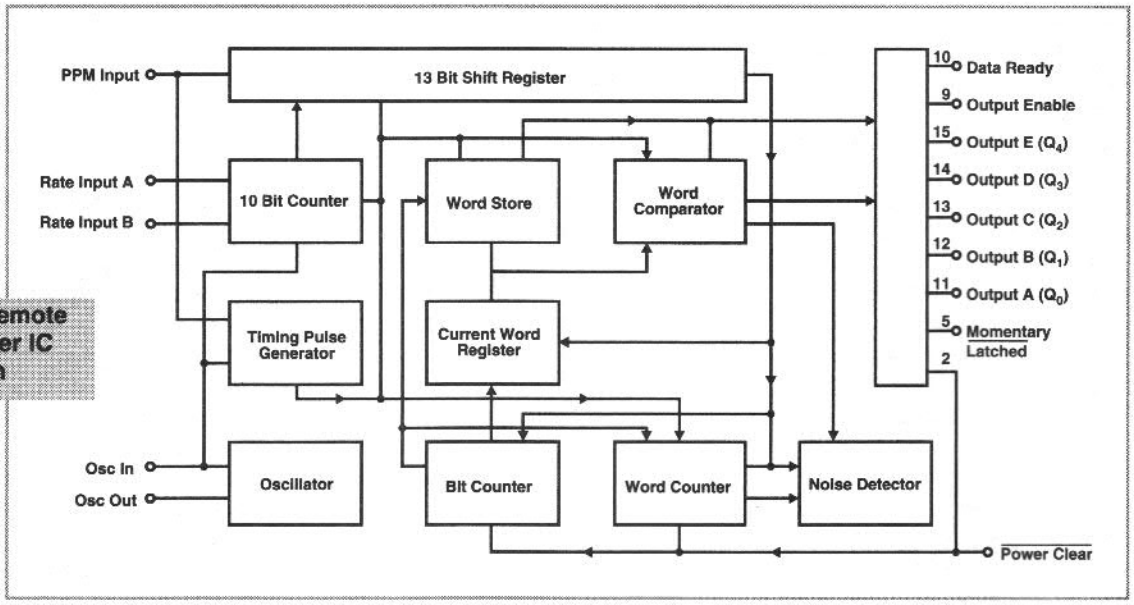


Fig.4 MV601 remote control receiver IC Block diagram

mate fully with the corresponding plugs. Apply power to the main board and with the transmitter pointing towards the receiver and within a 3 metre 30° arc, systematically check that each of the source selection keys causes the correct LED on the front panel switch board to light. Check also that the selection can be made manually via the front panel switches. Make a short length of lead terminated at each end with a 3.5mm jack plug - this is used to check the wire-link data interface. Once both plugs are connected to the sockets on the Transmitter and Receiver boards, check the functionality of all keys. Fault finding is confined to checking that all polarity-conscious components are correctly fitted, the presence or otherwise of the 500KHz square wave on the both the transmitter and receiver boards, and the generation and correct decoding of the Data Ready signal.

Construction - VCA

The VCA board can be constructed in one of two ways. If used with the IR Receiver board, the 4-way plug, PL2, shown in the circuit diagram of last month should be soldered in place

The Works

Remote Control Receiver

The MV601 IC is designed for use with the MV500 transmitter. When data rate and operating frequency corresponds to the transmitter - using a matched ceramic resonator (within 4%) - the device generates a five bit tri-state binary output. This corresponds to the PPM transmitted code and to the switch address generated by the MV500. Two identical words must be received before the output responds. The IC produces a Data Ready signal after the output has settled.

Prior to the MV601 decoder is IC1, a TBA2800 infrared preamplifier. It has three amplifiers, the first is gain controlled for wide dynamic signal range. This gives interference free operation even in bright sunlight. Furthermore, it allows the IR transmitter to be very close to the receiver, without causing any malfunction from overdrive.

The second stage is a normal amplifier, whilst the final stage separates the pulse shaped signal from noise. Both positive and negative going outputs are available.

MV601 is shown in Figure 4. Serial PPM data is applied to the input pin. The input is insensitive to pulse width, but the incoming pulses must remain high or low for at least one clock cycle. A capacitor to ground (C6) is normally connected to the Power Clear pin, and with an internal 150K resistor, generates a logic low upon power up. This resets the internal logic.

The Rate pins are set for a rate of 1024 as in the transmitter. The Momentary/Latch controls the output. Whilst latching mode would be more attractive for operation with only the input select switching board - no separate data storage necessary - it is not applicable to the VCA control, where counters ramp up or down when the keys are pressed. Our application requires momentary mode of operation, with the data on the output pins remaining only whilst a code is at the PPM input.

Data Ready and Output Enable, show when valid data is present at the output pins A to E, and determine whether these outputs are enabled or tri-stated.

Receiver Multiplexer Interface

As the MV601 generates a 5-bit code, and the source selection requires a 3-bit word for correct operation, the first three lowest significant bits are connected directly to the main analogue board and OR-ed with the 3-bit word generated by the front panel switch interface. The low-active Data Ready signal generates a positive pulse (via C10, R5, IC3d trailing-edge detector) and is implemented as a latch enable signal for the 3-bit address from the MV601.

One of the remaining two most significant bits - bit D detects keypresses from keys 9-16 (9-12 in our application). Rather than use a 4 to 16 line demultiplexer like the 4067, the address is decoded by a 1-of-8 decoder/demultiplexer (IC4) with the low-active Output Enable pin used as the fourth, most significant address line input. The low-active Data Ready signal and Q3 of the MV601 address lines generate the fourth line. The Data Ready line is inverted using IC3c and NANDed in IC3b with Q3. As the multiplexer Enable pin is only activated (forced low) when the fourth address line AND Data Ready are asserted, the multiplexer does not respond to the lower 8 of the 16 possible ghost addresses generated by the MV601. Doing it this way uses otherwise redundant NAND gates and saves about £2.00 over the cost of using a 4067. The three multiplexer outputs control the VCA according to the component overlay. As well as the 'Down', 'Up' and 'Mute' signals from the IR Receiver board, the +5V supply is also derived from this plug. So if the IR Receiver board isn't fitted, the +5V supply must be come from another source. Where this is the case, a 4-way socket is fitted to the edge of the board, next to PL1 on the VCA PCB. This mates with the corresponding plug on the Main Analogue board and transfers power between the two. The capacitor, C33, is beside this socket when fitted.

Construction is straightforward - place links, DIL sockets, resistors and diodes first, then small capacitors, transistors, presets next, before finishing off with larger caps, the LED's, plugs, Veropins and switches. Note here, the link labelled 'A' which joins Veropins 'W' and 'X' should be left unsoldered. The PCB is densely populated with tracks, and many of these pass between the roundels underneath DIL sockets. Extra care should be taken when soldering in the vicinity of such areas as these tracks are easily bridged. There are 38 links on the board and should be counted off when soldering in.

Volume Up, Down and Mute. The Y input, pin 3, is held low, since the three Z outputs required for VCA control are low-active. When a valid address is applied to the three address pins and the chip enable pin is asserted (for addresses more than 0111), the corresponding Z output goes low. Address 1000 corresponds to Volume Down (Q0 low), 1001 to Volume Up, and 1011 to Mute.

The Volume Down and Up signals are NANDed with manual signals from the front panel via IC1a and IC1d, where they control the Up/Down circuitry.

The mute signal flips the Q output of IC4b. The Q output toggles to load a value into the up/down counters to provide 20dB of attenuation. This signal is ORed with one generated by a power on parallel load.

The lower address lines also respond to ghost codes. Nothing inhibits the response to the upper 8 of the 16 possible four-bit numbers from the MV601. Arranging that no clock (latching pulse) is sent to the analogue board, when A3 is asserted high, is the most likely and most economical solution. A3 is inverted and ANDed in the D1, 2, R6 diode AND gate. Pulses only pass through the gate when A3 is low.

Fig.5 Infra Red Receiver

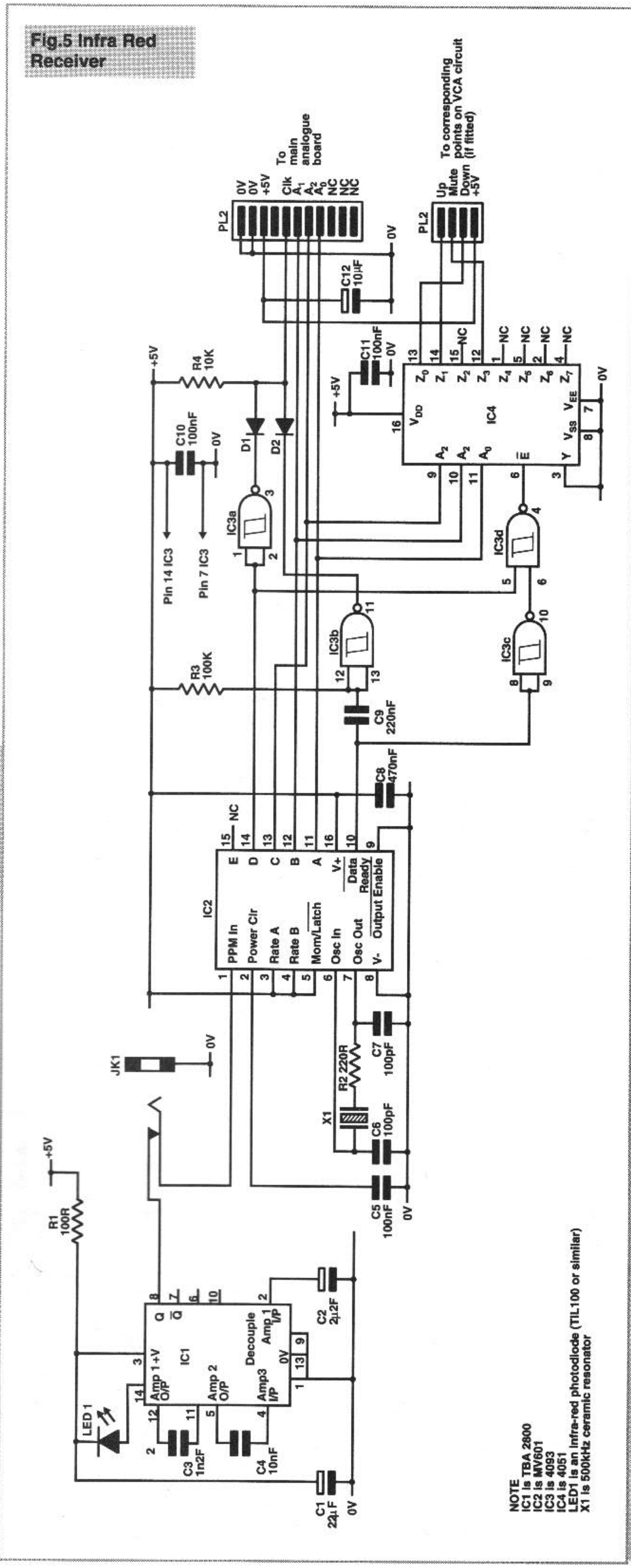
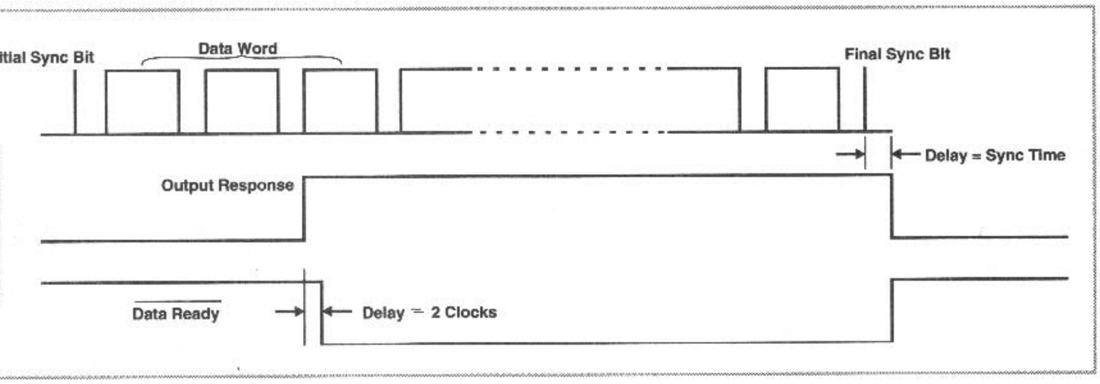


Fig.6 Timing diagram for MV601 in momentary output mode



Setting Up - VCA Board

Setting Up procedures for this board are slightly more complicated. With no IC's plugged into their sockets, mate the VCA board with the Main Analogue one and apply power. Check for the presence or otherwise of +18V, +5V and -18V on the relevant pins of the DIL IC sockets and if all is well, disconnect power and plug all of the IC's into their sockets, being aware that IC's 1 - 6 are CMOS and should be handled with the appropriate care. Once this has been done, reapply power and watch for the premature expiry (heralded by cracking noises, flames and horrible smells) of any of the aforementioned devices.

If nothing appears to be amiss, correct operation of the UP/DOWN keys must first be verified, using both the front panel keys and the IR handset to test for this. Check firstly that the Clock Active LED flashes when the Up or Down keys are pressed. Check also that the LED stops flashing about 13s after the Up or the Down key is pressed.

D/A Convertor

Once you're satisfied that the digital counter section is working correctly, it can be used as an aid to the line-up of the DAC, since a full count - 11111111 - and an empty count - 00000000 - are needed to adjust full scale reading and to null any offset respectively.

1. Using the front panel up key, press until the LED clock active indication stops flashing. The counter is now in an all 0's state.
2. With a DVM connected to the output pin of IC8 op-amp, pin 6, adjust PR1 for a reading of exactly 0.000V on the meter.
3. Using the front panel down key, press until the LED clock active indication stops flashing. The counter is now in an all 1's state.
4. Adjust PR2 for a reading of 2.8V
   1 LSB = 2.8 - 2.8/256
   = 2.789V
5. Repeat 1 to 4 above.

The DAC can now be considered to be fully lined-up.

VCA

We've mentioned already that untrimmed audio performance of the SSM 2018 - albeit, in certain operating modes - is pretty darn good and probably of a high enough quality that MOST discerning listeners will be more than satisfied. However, for those dedicated few among us who strive for the impossible (what are you doing building a system with a VOLTAGE-CONTROLLED AMPLIFIER in it!), I'll include some rudimentary line-up procedures just to appease you.

Symmetry Trim

Both trims affect offset and control feedthrough performance. The symmetry trim also affect distortion performance and so while mandatory where the Class AB mode of operation is used, it is desirable but not absolutely necessary when the VCA is operated in pure Class A.

Where both trimming operations are to be undertaken, the symmetry adjustment should precede the offset one. It should be mentioned that an audio signal generator (tone source) is necessary for both adjustments while a scope/distortion meter is needed for the distortion trim. It is also desirable when adjusting the offset, but an amplifier and a good pair of ears can make a quite satisfactory substitute.

A 1KHz sine wave of around +12dBu should be connected to one of The Switcher input sockets (left channel initially) and that particular source selected as an output. PR4 should then be trimmed to minimise the distortion seen, measured or heard at the left channel output sockets.

Transfer the signal source to the right hand channel of the same input, the 'scope, distortion meter to the Right channel output, and repeat the above trim operation, this time using PR6.

Offset Trim

Considering the control null trim is of most relevance where the device is employed as part of the fader automation system of a large mixing desk. VCA's used in this way are likely to have their attenuation settings changed rapidly and frequently, and this is where 'zipper noise' (the generic term for control breakthrough) is likely to be most objectionable. Still not convinced that you don't really WANT to go through with the offset trim operation? Then read on, suckers, and be ACTIVELY dissuaded...

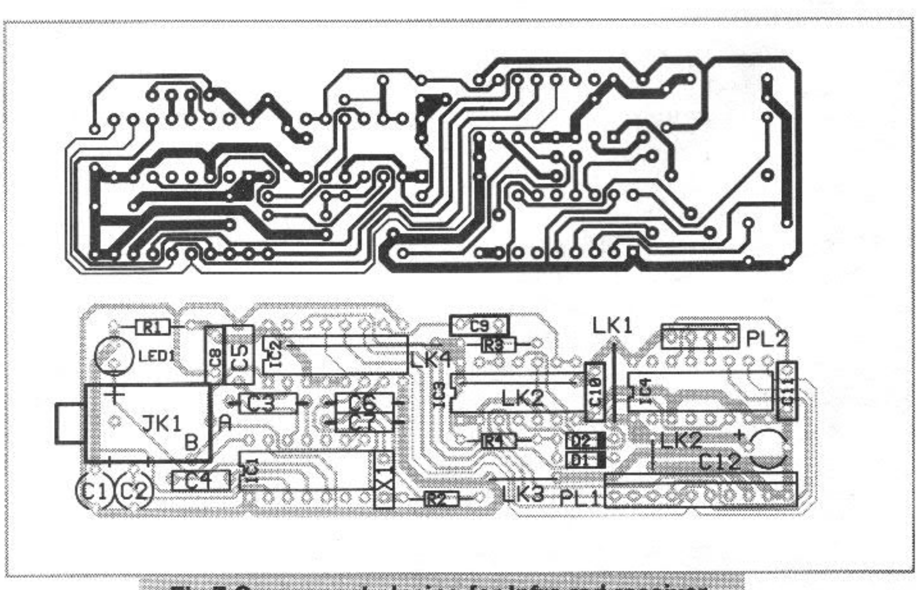


Fig.7 Component placing for Infra red receiver

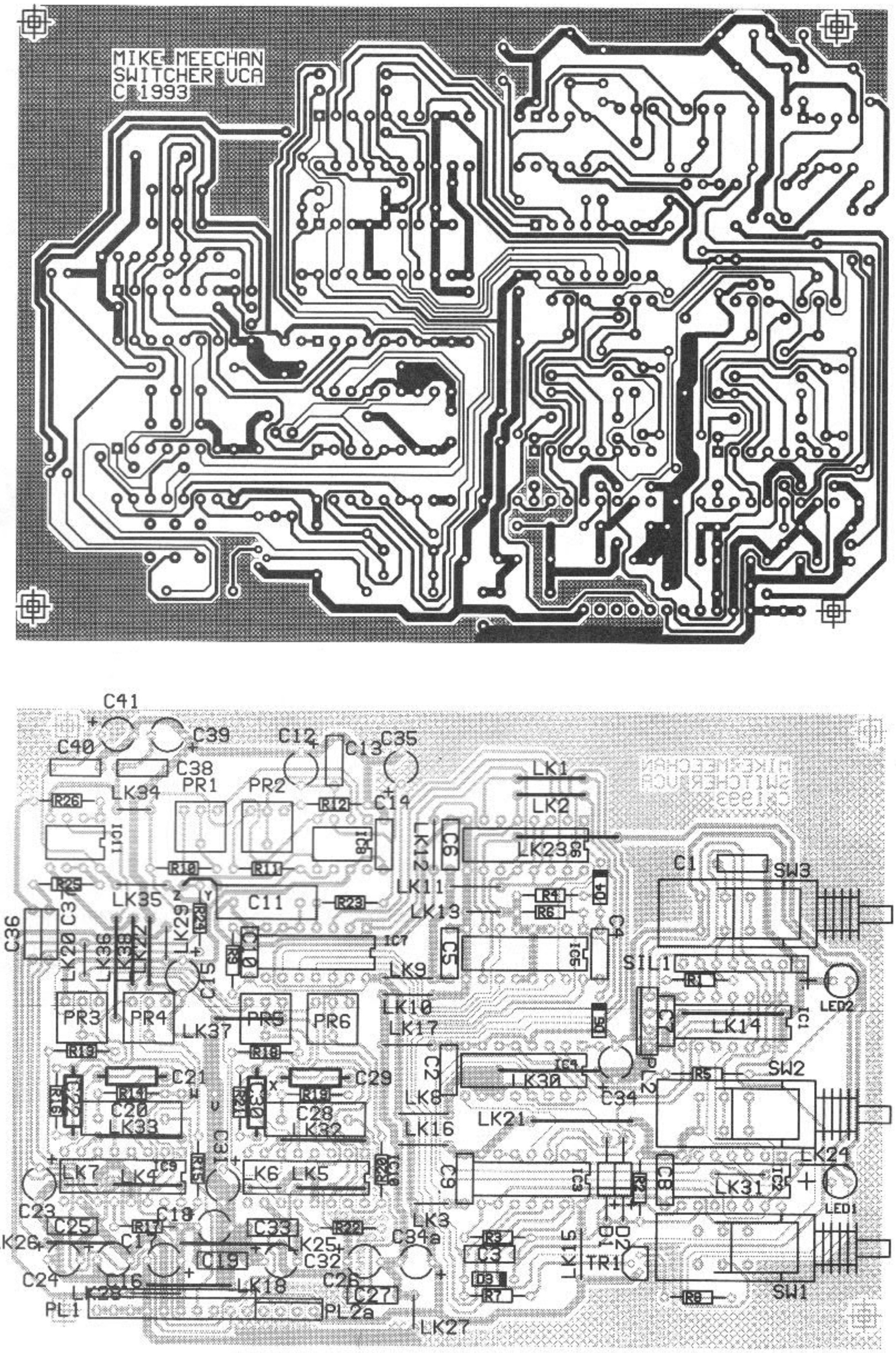
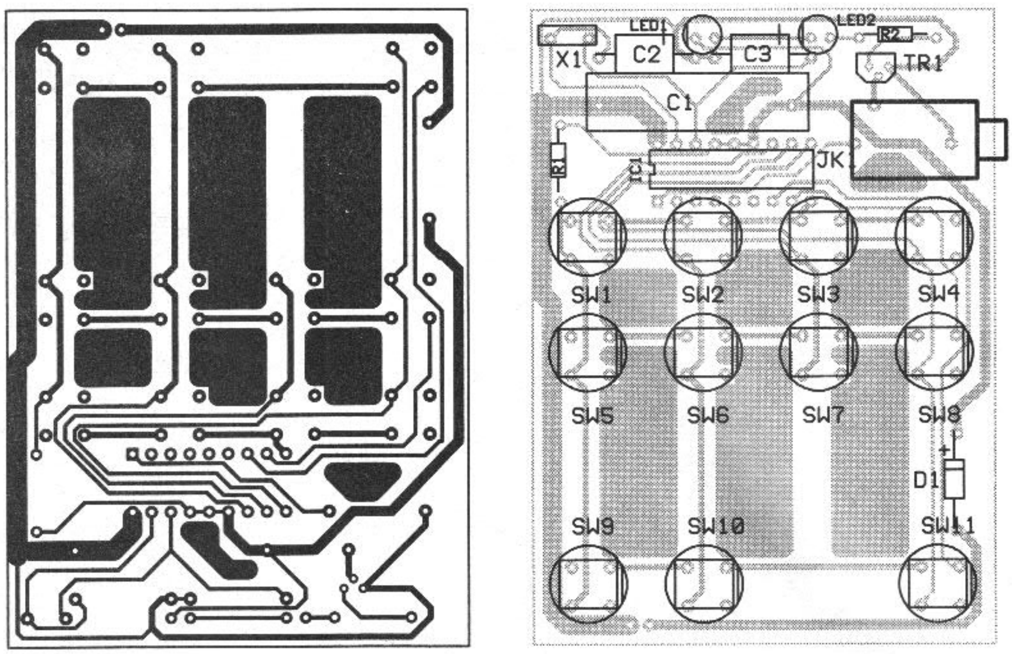


Fig.8 Foil and Component placing for VCA Board

Firstly, disconnect the signal source and ground the left channel VCA input by temporarily connecting Veropin 'W' to Veropin 'V'. Now connect a 60Hz sinewave to Veropin 'Z'. The sinewave must swing between a voltage necessary to give 30dB of attenuation (+840mV) and one with a maximum gain, which in our case is 0dB (and 0V). PR3 should then be adjusted for minimum feedthrough of the 60Hz signal. A 'scope could be used, or the left channel output could be connected to an amplifier/loudspeaker and PR3 trimmed for minimum audible breakthrough of the 60Hz signal.

The right channel VCA can now be trimmed, this time temporarily connecting Veropin 'X' to Veropin 'W'. The 60Hz signal is injected at the same point but adjustment for minimum is made using PR5. Once that you're happy that control breakthrough has been minimised, remove the temporary grounding jumpers and solder wire links across 'Y' and 'Z'. The system is now fully lined up and operational. If you don't wish to trim the VCAs, simply omit the aformentioned procedure and solder the links at the onset.

Fig.9 Foil and Component placing of Remote Controlled transmitter



Housing Benefits

The only component which is critical as regards housing in an enclosure of some sort is the IR Transmitter. The PCB has been designed to fit snugly and securely into the hand-held box specified in the Parts List. With other boxes, care with the internal dimensions must be taken. The front panel and the IR aperture must be cut according to the pattern shown in Figure 9. A craft knife fitted with the associated fine-toothed sawblade attachment, or a small Abrafile, are the best tools for the job. Open the holes out to the nominal size shown in the drawing and then use a fine warding file to fine tune the apertures so that the bodies of the switch caps don't foul the casing edges. The PCB is secured using PCB standoffs - M3 tapped spacers - which support it at the distance required below the panel facia.

Unfortunately, the box specified doesn't have a parabolic reflector for the infrared emitting diodes, so some improvisation is necessary. Red celluloid or similar is ideal, but any optically-transparent material would suffice. It is left to the constructor's discretion.

Overall System Housing

The boards have been designed with a 19' rack-mounted enclosure in mind. All of the PCB's will fit - albeit tightly, height-wise - into a 1U case if all of the specified components are used. The RS Components toroidal transformer is the only one I could source which was of a height sufficiently small enough to fit into the required 44mm of space. Even so, great care is needed when securing this component to the chassis since the central securing bolt must not be allowed to contact the top and bottom parts of the enclosure simultaneously. This would constitute a shorted turn and cause irreparable damage to the transformer.

The only other caveat, dimension-wise, is the depth of the enclosure, and then, only if PCB-mounted phono connectors are used, since these must protrude through the rear panel of the enclosure while the switches and LED's must protrude through the front. This leaves a front-to-back dimension of around. Unless you're very lucky in your choice of ready-made enclosure, or trim it accordingly, or manufacture your own, it is unlikely that the dimension for the depth of the case and that specified as necessary for the PCB's will coincide. Basically, it's a case of shopping around.

The black anodised panels of the rack-mounting cases are particularly aesthetically-pleasing and so don't stand out from other similarly-coloured components in a typical hi-fi stack. The only aspect of their appearance which makes them slightly incongruous is the width. At 19', they're around two inches wider than the almost-industry-standard-for-hi-fi-components 17'. To paraphrase a more widely circulated text than this, 'If your ears offend, cut them off'. In the biblical sense, I am, of course, referring to the 1' rack mounting 'ears' of the 1U enclosure. Careful removal of an inch of metal from either side of the panel makes it the same width as just about every other full-sized domestic hi-fi component.

The front panels should be drilled, then legending can be done using Letraset dry lettering or similar. This should then be lacquered for protection. Should you wish to use a turntable with The Switcher, might I suggest The Audiophile RIAA preamp from the first issue of EIA. This can be interspersed between one of the inputs and the cartridge signal source. Happily, the RIAA preamp uses supply rails similar to those of The Switcher.

There is a minimum of internal wiring, due, in the main, to the plug-together nature of all of the boards. A total of two plug assemblies are required if the full system complement is constructed. One carries AC power onto the main analogue board from the toroidal transformer. The other transfers remote volume level/mute information and +5V from the IR Receiver PCB to the VCA board. This 4-way plug-to-plug assembly should be as short as possible.

Mains power for the transformer should be derived from a rear panel mounted IEC mains inlet or similar. All 240V connections should be properly shrouded, and an 500mA inline fuse wired in the 'Live' side of the supply. As all of the boards have been tested individually for functionality and correct operation, all that remains is for the completed and enclosed assembly to be tested once more to see that nothing has come a cropper during the assembly process.

And finally next month, any loose ends will be tied up of bits that couldn't be fitted in here plus any updates.

Once it all has been done to your satisfaction, connect up some live signal sources and an amplifier and speakers, find your favourite armchair, get out the cocoa and furry slippers, choose between CD, DAT cassette or NICAM video, and proudly resume couch potato status...

IR Transmitter

Resistors

- **R1** 10k
- **R2** 2R

Capacitors

- **C1** 220u 16V axial electrolytic
- **C2,3** 100p polystyrene

Semiconductors

- **IC1** MV500
- **Q1** ZTX753
- **LED1,2** TIL 38 IR LED or similar

Additional Items

- **SW1-11** PCB momentary PCB-mounting pushbutton
- **X1** 500kHz ceramic resonator
- **JK1** PCB-mounting 3.5mm jack socket
- PP3 battery clip
- DIL sockets to suit
- PCB (available from Electronics in Action)
- Pushbutton caps, case

IR Receiver

Resistors

- **R1** 100R
- **R2** 220R
- **R3** 100K

Capacitors

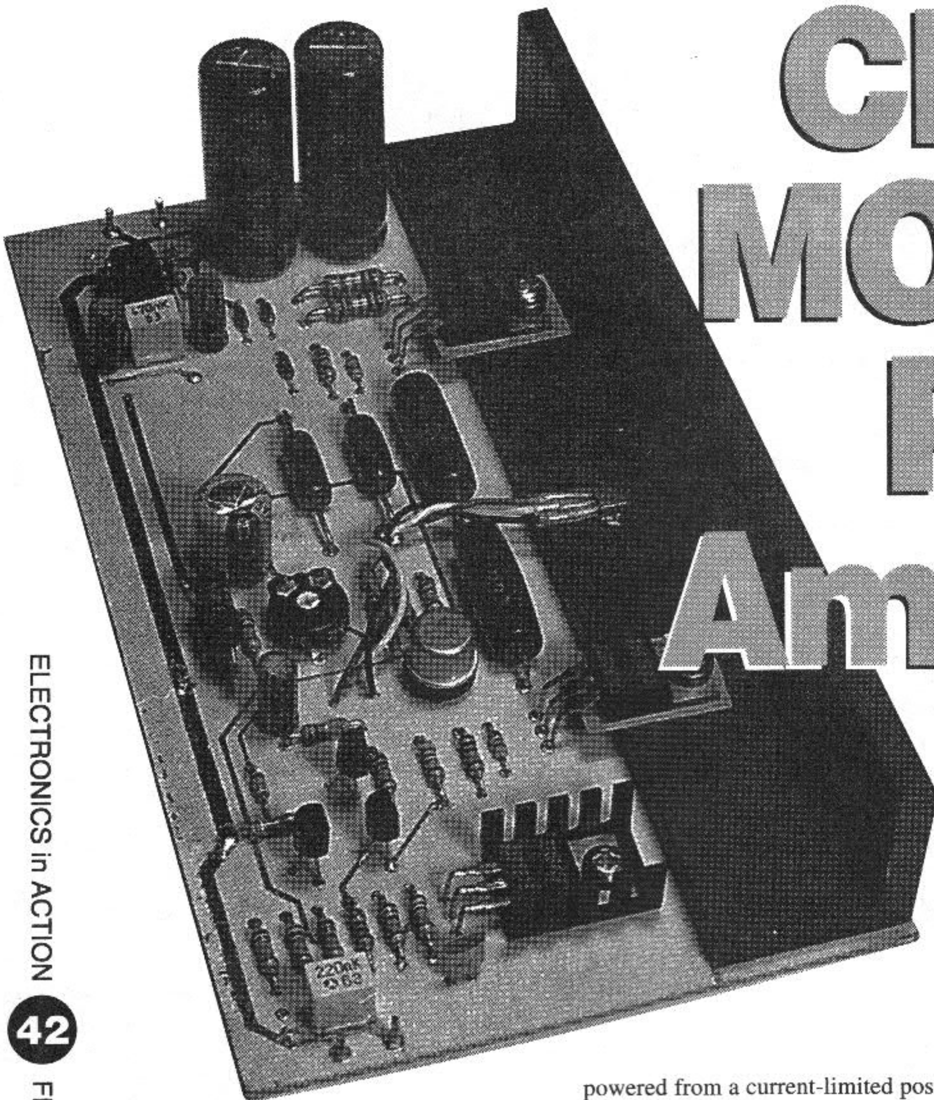
- **C1** 22μ/16V radial electolytic
- **C2** 2μ2/63V radial electrolytic
- **C3** 1n2 polystyrene
- **C4** 10n polyester
- **C5,10,11** 100n polyester
- **C6,7** 100p poycarbonate/polyester (10%)
- **C8** 470n polyester
- **C9** 220n polyester
- **C12** 10μ/16V radial electrolytic

Semiconductors

- **IC1** TBA 2800
- **IC2** MV601
- **IC3** 4093
- **IC4** 4051
- **D1,2** 1N4148
- **LED1** TIL100 infra red photodiode or similar

Additional Items

- **JK1** 3.5mm PCB-mounting jack socket
- **PL1** 10-way right-angled Minicon socket (see text)
- **PL2** 4-way Minicon plug
- **X1** 500KHz ceramic resonator
- DIL IC sockets to suit
- PCB (available from Electronics in Action)



Class A MOSFET Power Amplifier

Part 2

Testing and Adjustment
by Andrew Armstrong

The power amplifier featured here and last month adopts Class A operation at lower power levels and Class AB on the louder parts.

Before testing the amplifier, set the quiescent current adjustment potentiometer fully anticlockwise. As an initial test the amplifier should be powered from a current-limited positive and negative supply set to between 18 and 20 volts. The output voltage should be measured, and should be within 10mV of zero. VR1 should then be adjusted for a suitable quiescent current. To determine the quiescent current, measure the voltage across R19 or R20 with no signal and no load. The voltage drop is 2.2mV for every 10mA flowing.

What constitutes a suitable quiescent current depends on the use of the amplifier. It will work quite successfully if biased conventionally into class AB. On test, the crossover distortion had conclusively disappeared on the oscilloscope at 150mA quiescent current, so this level is recommended for class AB operation. As the quiescent power dissipation is not too high in this mode, I suggest a power supply voltage of around 30V. This will permit a power output of approximately 40W into 8R

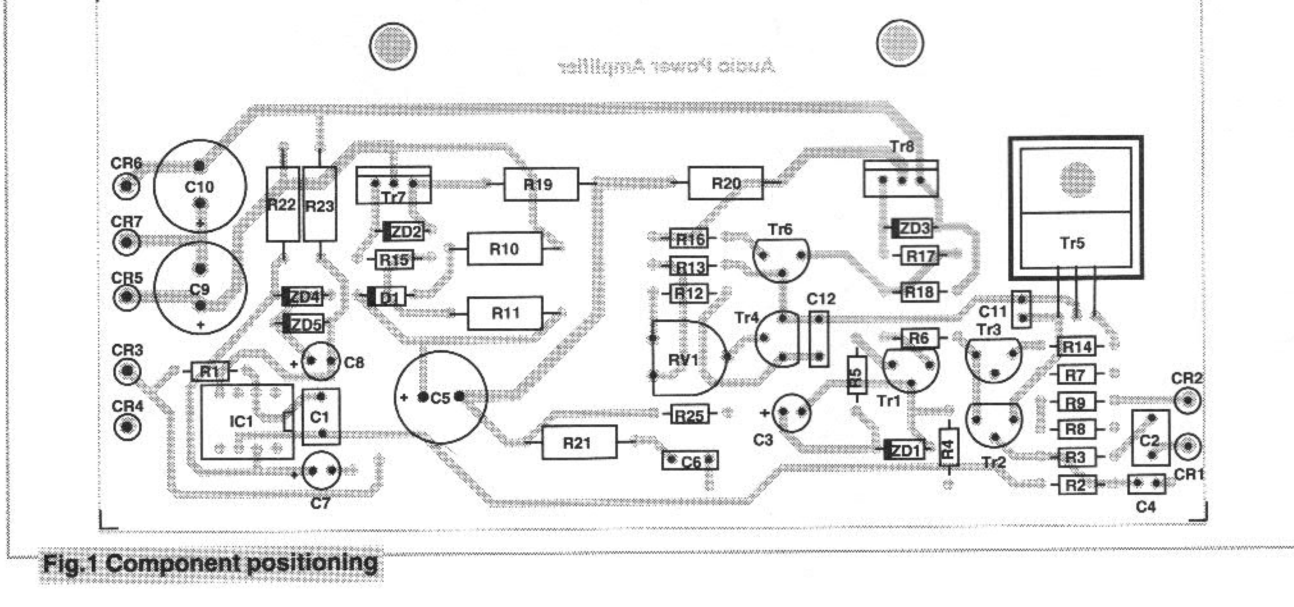


Fig.1 Component positioning

and 80W into 4R.

It is intended that this design should be run in class A for a greater part of its operating cycle, and if adequate heatsinking is available, the quiescent current should be set between 500mA and 1A. This will ensure that playing music at medium volume is always in class A. It is, after all, under these conditions when distortion is most obtrusive. No distortion could be heard with loud music even though it may be bad enough to stand out in quiet passages.

At above a certain signal level, depending upon the quiescent current, one or another of the output devices will cease to conduct. This will happen softly, and as it does, the loop gain will halve. Because the signal path is fast and uncomplicated, the negative feedback can deal with this in a way that it cannot be expected to deal with conventional crossover distortion. There must be some distortion at this point on the waveform. However, every audio component contributes some noise or distortion, no matter how slight and this distortion is likely to be masked by the volume of the sound. I certainly could not detect any waveform distortion on the oscilloscope.

It is unfortunate that class A operation is very inefficient, otherwise the amplifier could be run in class A all the time. People with extremely sensitive ears may find it worthwhile fitting truly massive amounts of heatsinking and increasing the quiescent current. At 2 amps, with +/- 25 volt supplies, 100 watts must be dissipated continuously. This may be regarded as a practical maximum, as the thermal conductivity between transistor and heatsink will not permit much more to be dissipated safely.

In class A, with 22V supplies, the amplifier can provide 18W into 8R.

If class A biasing is to be used, set the quiescent current, then wait half an hour for thermal stability, then reset it.

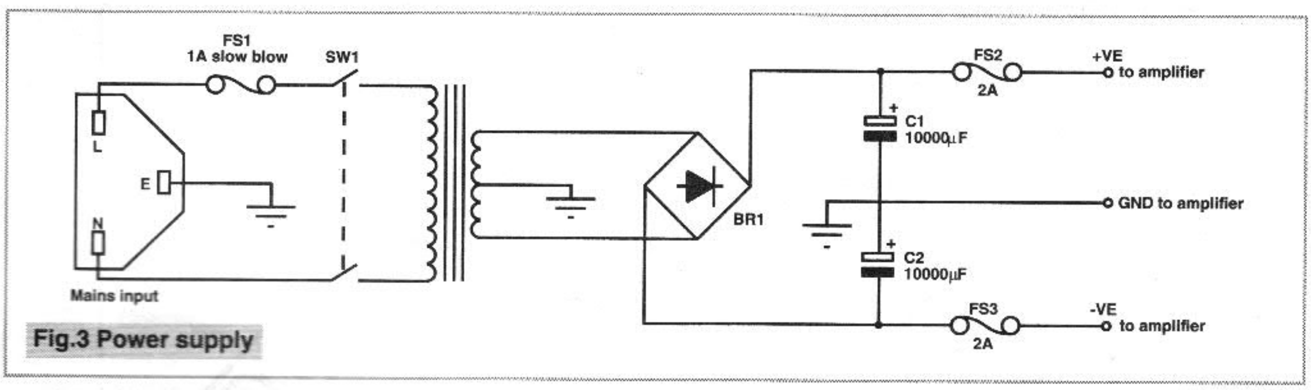


Fig.3 Power supply

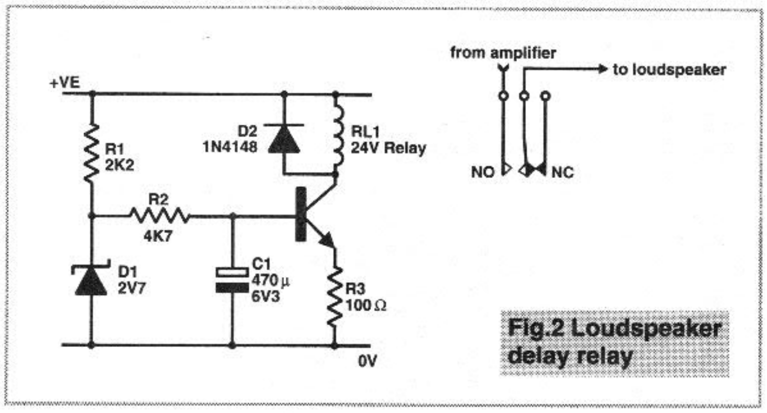


Fig.2 Loudspeaker delay relay

500mA corresponds with 110mV across R19 or R20.

In Use

The amplifier has been tested with a resistive load and various input waveforms. With a squarewave test, the output rise and fall times were similar to those from the signal generator, at 4µs. With sinewave drive, just below clipping amplitude, the central part of the waveform, expanded on the oscilloscope screen ,showed no trace of crossover distortion, as one would expect. When tested with a hi-fi speaker (a small JPW model), with the input fed via a potentiometer from a CD player, the sound was completely satisfactory.

On the lab bench, running with an unregulated 22V power supply and playing an Iron Maiden CD in mono, the heatsink was warm, but not too hot. One minor snag I have noticed on testing is that, at switch on, there is a thump in the loudspeaker, as the amplifier servos its DC level close to 0V. If this bothers you, I would suggest the use of a relay to connect the loudspeakers, with a time delay to switch it on after the amplifier has had time to reach 0V. A suggested circuit (as yet untested) is shown in Figure 2.

This circuit provides approximate current limiting so that the relay will not overdissipate on higher voltage supplies. If a stereo pair of amplifiers are to be protected, then R3 should be reduced to 47R, and two relays should be used, with their coils in parallel.

I recommend that a fuse should be placed in series with the output. There is no output protection on this amplifier, which removes one possible source of distortion, but it leaves the loudspeakers somewhat vulnerable. A 2A fuse will provide worthwhile security.

It has been pointed out to me that I did not explain in part 1 why such a fast op-amp is used to provide DC servo action for the amplifier. The reason is that it must work as an integrator over the audio frequency range. If it runs out of gain x bandwidth and ceases to integrate, positive feedback (admittedly heavily attenuated) will be applied to the input, with resulting distortion.

Power Supply

Tests have shown the amplifier is relatively insensitive to power supply variations, so use an unregulated supply. The circuit is shown in Figure 3.

If the amplifier is to be biased in to class A, an 18V transformer is recommended, to keep the quiescent dissipation within reasonable limits. If you use class AB biasing, with 150mA quiescent current, a 25V transformer is more suitable. This power supply design is for one amplifier. If a stereo pair is adopted, either use two separate supplies to eliminate interaction, or the components can be uprated as shown in the second parts list.

Parts

Note: There have been some parts list revisions to the main amplifier as a result of testing:

R11 changed from 470R to 1k **R12** changed from 1k to 220R
R13 changed from 470R to 100R **RV1** changed from 2K2 to 470R

Resistors

(0.25W metal film unless otherwise stated)

R1	1M
R2	100K
R3,8,25	10K
R4	3K9
R5,R7	1K2
R6	2K2
R9	1K
R10,13	100R 2.5W
R11	1K 2.5W
R18,RV1	470R
R14,16	10R
R12,15,17	220R
R19,20	0R22 2.5W
R21	10R 2.5W
R22,23	1K5 0.75W

Capacitors

C1	470n polyester
C2	220n polyester
C3,7,8	10µ 16V electrolytic
C4,11	220p ceramic
C5	100µ 63V electrolytic
C6,12	100n polyester
C9,10	470µ 63V ELNA RSH series electrolytic

Semiconductors

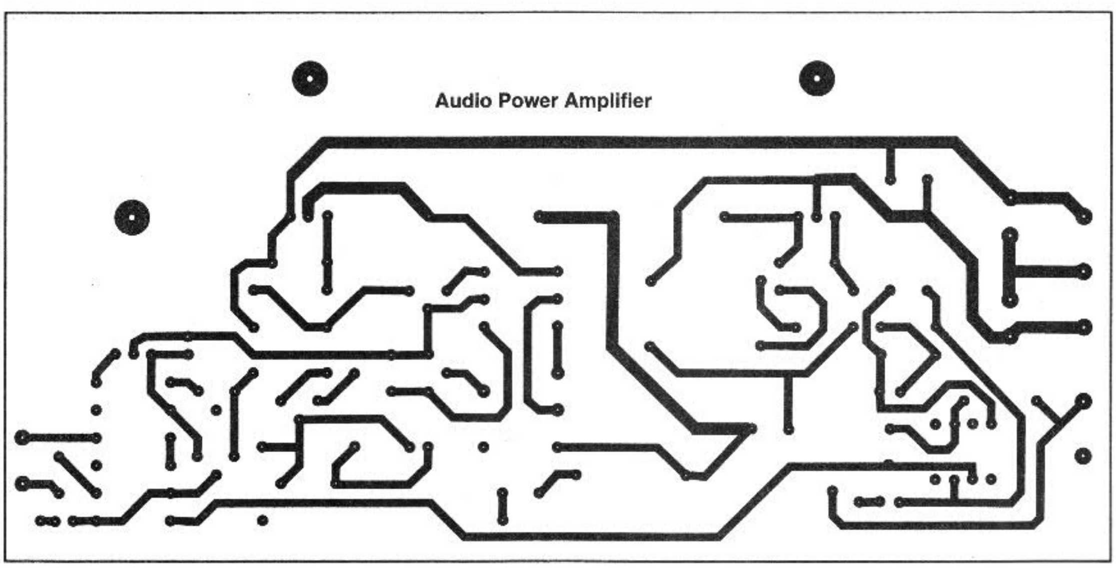
D1	1N4148
ZD1	BZX796V2
ZD2, 3	BZX79C15V
ZD4,5	BZX79C12V
TR1,2,3	BC212B
TR4	BC182B
TR5,7,8	IRF630
TR6	BC461
IC1	TL061

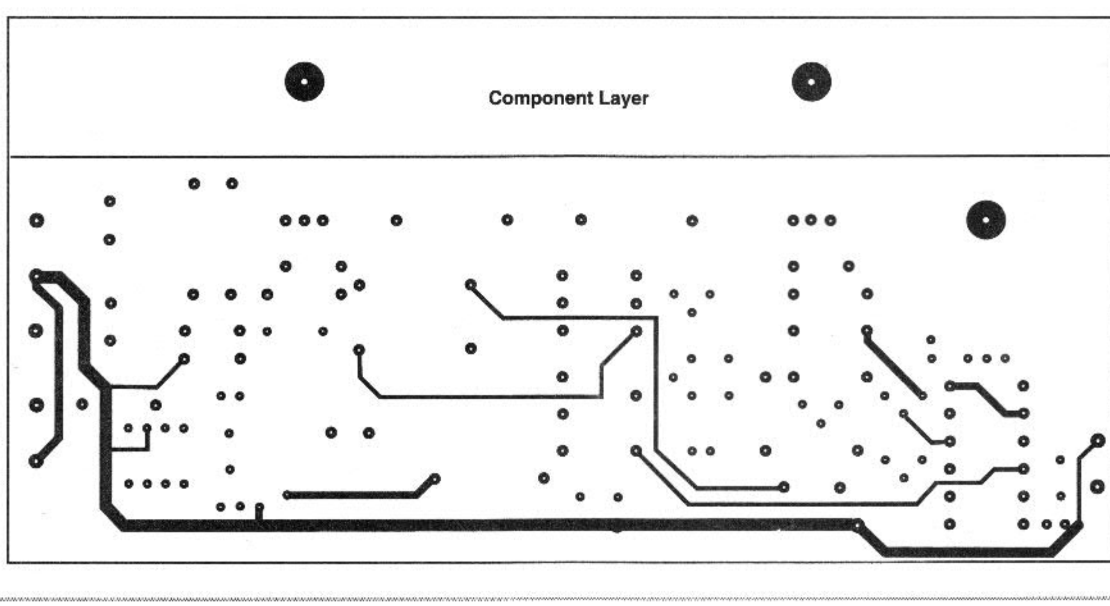
Power Supply

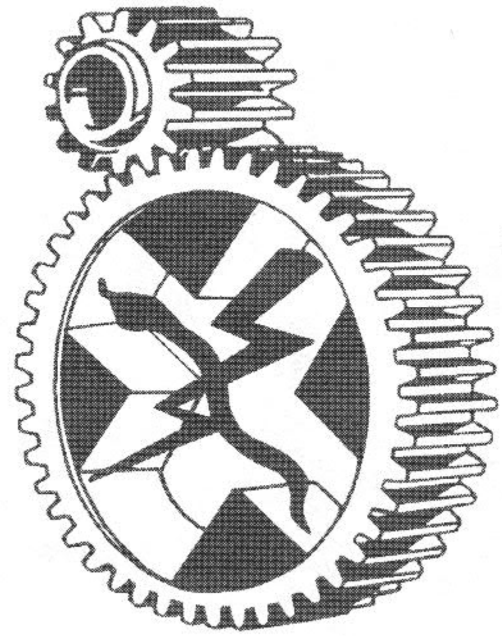
C1,C2	4700µF radial 50V or 63V
BR1	Bridge Rectifier 50V 4A or greater
T1	Transformer 18V + 18V, 50VA or greater OR, for class AB, 24+24V, 60VA or greater
F1	1A slow blow
F2,3	2A
SW1	double pole mains switch Fused IEC mains input socket

Power Supply for stereo pair

C1,C2	10,000µF radial 50V or 63V
BR1	Bridge Rectifier 50V 8A or greater
T1	Transformer 18V + 18V, 100VA or greater. *OR*, for class AB, 24V + 24V, 120VA or greater
F1	1A slow blow
F2,3	2A
F3,4	2A (fuses for second amplifier)
SW1	double pole mains switch Fused IEC mains input socket







REMAP

Technical Help for Disabled People

By Andrew Chadwick

Part 2

We continue our look at the many ideas suggested for the disabled with a second example. This is a unit designed to allow a man paralysed from the neck down to change TV channels without having to call someone else. Various possibilities were considered and rejected on grounds of cost or complexity. The design finally adopted consists of the outer case of a felt tipped pen fitted with a number of contacts to form a mouth operated switch and linked to the standard remote control handset. The client uses the tip of his tongue to bridge the contacts for the appropriate channel.

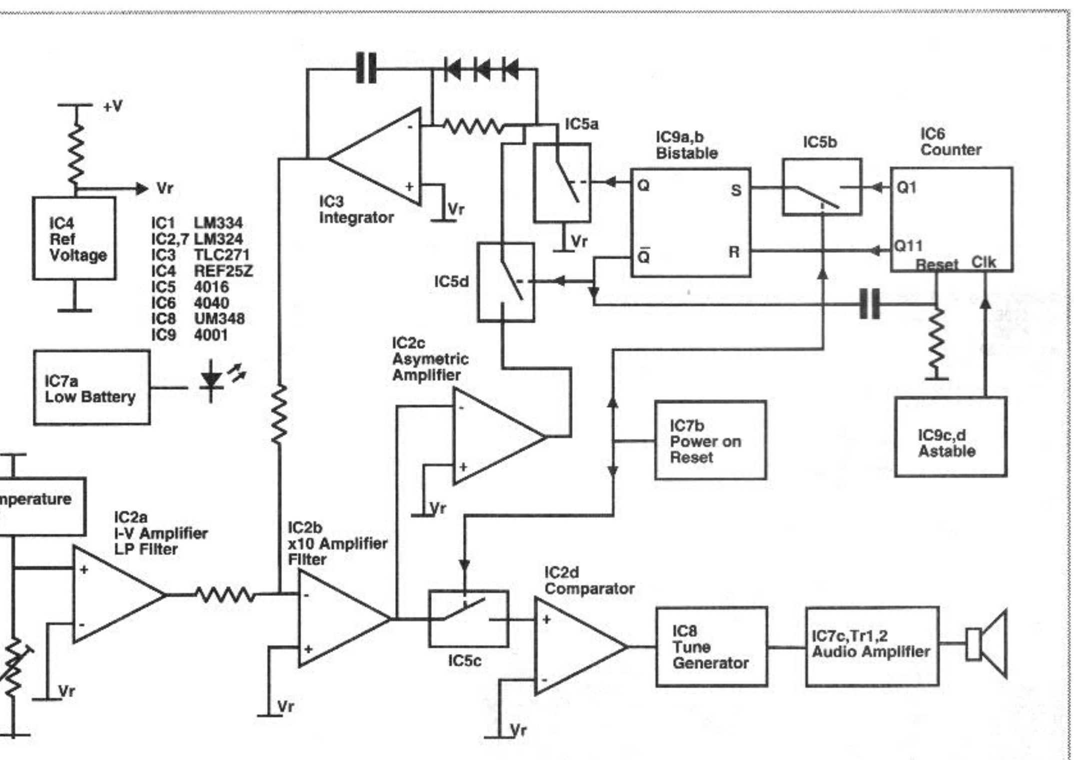
One particularly ambitious project that appeared in the 1990 yearbook was entitled "sonic headlights". This was an ultrasonic radar to enable a blind person in a wheelchair to guide himself around his home. A later development was the addition of an ultrasonic beacon to enable the user to guide himself across large open spaces. This equipment has since been refined and a similar system built for another user.

One of the advantages of devoting your ingenuity to REMAP projects is that there is always a market for the product. True, that market may be limited to one customer but their appreciation will make up for the lack of financial reward. Having said that there is no restriction on ideas generated as a result of a REMAP job being developed into commercial products and there has in fact been some interest in the epilepsy alarm described previously.

One of these was a request for a toilet training device for a mentally handicapped boy. The boy had already been successfully trained to use a potty by means of a commercially available reward device. These usually operate by sensing the presence of urine in the potty by means of conductivity probes triggering an audible reward. However, he was now growing too big for the potty and the staff wanted him to use a full-size toilet.

Obviously, sensing the presence of liquid was no use in this case as there would always be some present in a toilet

Fig.3 Toilet trainer Block diagram



Changing TV channels using the tongue

bowl. I toyed with a number of possibilities but finally decided on temperature or more precisely change of temperature as the simplest solution. A rough calculation showed that the minimum change in temperature of the water in the toilet bowl when the boy performed would be about 0.2° Celcius. The normal temperature of the water however might vary from about 2 to 25° Celcuis. The block diagram of the circuit I designed is shown in Figure 3. The circuit is insensitive to slow variation due to changes of ambient temperature. However any rapid rise in temperature triggers a musical reward.

An LM334 adjustable current source IC is immersed in the toilet bowl. This IC produces a current proportional to absolute temperature which is converted by IC2(a) into a voltage corresponding to a range of about -5 to 30 degrees Celcius. The output of IC2(b) is the difference between this voltage and a feedback voltage from IC3. IC2(c) tries to maintain the output of IC2(b) at VR (a reference voltage) by adjusting the feedback via IC3. However IC3 acts as an integrator with a very long time constant so that although rises in temperature are eventually nulled out by feedback there is a temporary increase in the output of IC2(b). The magnitude of this rise is related to the rate of change of temperature and if sufficient will trigger the comparator IC2(d) which in turn enables the tune generator.

The time constant required for the integrator IC3 is about 1800 seconds which is totally impractical using a simple RC circuit. IC6 and IC9 generate a 5KHz clock with a mark-space ratio of 1024 to 1. This clock controls analogue switches IC5(a) and IC5(d) in anti-phase hence only allowing the integrator to operate for 1/1024 of the time. This increases its basic time constant by roughly 1000.

On first turning power on, the integrator capacitor is uncharged. In order to reduce the time taken for the circuit to stabilise, analog switches IC5(b) and IC5(c), which are normally closed, are held open for a short period. This disables the alarm and also the clock signal so that the integrator operates at 1000 times the usual rate. Both IC2(c) and IC3 also deliberately respond non-linearly to provide rapid stabilisation after a drop in temperature which occurs when the toilet is flushed.

Whilst developing the circuit I discovered two interesting phenomena. One was the effect of light on the leakage current of clear glass-bodied diodes and the other was the reduction in insulation resistance of a PCB due to traces of surface moisture. Both caused considerable frustration at the time but the design eventually worked very successfully.

If you would like to know the location of the nearest REMAP panel then please contact:

Eur Ing J J Wright
REMAP GB
Hazeldene
Ightham
Sevenoaks
Kent
TN15 9AD
Tel: 0732 883818

HiJaak Pro 2.0 for Windows

by Paul Stenning

Most software packages can be summed up in one or two words - Word Processor, Spreadsheet and the like. HiJaak is not so easy - it offers graphics conversion, image manipulation, screen capture (DOS and Windows), image management and graphics viewing. I suppose you could call it a Graphics Toolkit.

My original interest in the package was for the graphics conversion. I needed to convert the DXF or IFF output formats from my electronic CAD software, to a form that was suitable for the DTP system used for this magazine.

Installation and Manuals

The software is supplied on three high density disks, while a fourth contains 300 clipart files. There are also two manuals, totalling 10mm in thickness. The product was contained in a large display box, along with some folded cardboard and lots of fresh air!

The manuals give adequate information, without getting bogged down with the technicalities. However the writing style is rather dry, which makes manual reading tiresome. On-line help is comprehensive, and possibly more useful than the manuals, since the information needed is immediately available

Installation is straightforward. The installation routine advises the use of a disk cache such as SmartDrive to speed the process. They mean it - installation took an hour without SmartDrive, and five minutes with! This is mainly due to the large number of small files on the clipart disk.

After a Bad Start . . .

The initial behaviour of the software was rather worrying. The dreaded "General Protection Error" and "Fatal Application Error" messages from Windows appeared regularly, and the system locked up on a couple of occasions. The technical support department in the USA diagnosed the problem was due to incompatibility with my video card, and suggested adding the line INTREG=OFF to the HJPRO.SET file. I don't know what it does but it worked!

If you don't know what format you need to convert to, you can enter the target software package and HiJaak will choose the best format for you.

Graphics Conversion and Screen Capture

The graphic conversion facilities are comprehensive, and I had no problems loading the files created into other applications. The software can handle over seventy different raster and vector formats. I was interested to see Kodak PhotoCD listed, but slightly disappointed to find the First Publisher *.ART format was not included. If you don't know what format you need to convert to, you can enter the target software package and HiJaak will choose the best format for you.

There are numerous facilities for image manipulation and enhancement. Cropping, resizing and rotating; altering colours, contrast and brightness - the list of features goes on, and I spent several enjoyable hours playing with them. With practice some impressive results can be achieved.

The Windows screen capture worked OK, although there were slight colour variations. I could not get the DOS screen capture to work in graphics mode, but I have only spent a few minutes testing this. The manual gives little information on the Windows capture, and almost nothing on DOS capture.

Image Browser

The HiJaak Browser is started from a separate icon, and detailed in a separate manual. "Thumbnails" of the images on the hard disk are created - these are small views that allow you to search rapidly through the files. The thumbnails are stored in a file that is created in the same directory as the images. Once the thumbnails are produced, searching for a particular image is easy.

However the thumbnails take a ridiculously long time to create, although this can be done automatically in idle time. The thumbnail files are not as small as they might be (about 150K for ten images), which may be a problem if hard disk space is at a premium.

And the Rest

A wide variety of images are included on the clipart disk, and thumbnails are included. It's worth taking a good look through these - I've used a few already! The clipart disk is a free extra and may not be included with all copies of HiJaak Pro.

The package has many more features, which I have not had time to try or write about. With this sort of software you discover things as you use it!

Technical support is available from the USA, which could prove expensive if a long telephone call is needed. Unfortunately we cannot benefit from the American freephone number. However the time difference allows us to call in the evenings when the telephone charges are lower. If you purchase the product from Software Compatibility Centre Ltd, they will offer UK technical support themselves.

Conclusion

HiJaak Pro offers a good range of features for a reasonable price. I am most impressed with the image conversion, manipulation and enhancement options. If you have a requirement for this type of software, and you have the hardware to run it, HiJaak Pro deserves a serious look. However the package may be too expensive for the casual user.

The software ran a little slowly on my 25MHz 386SX, particularly the screen redrawing. A more suitable system would be a 486 with 4MB of RAM and a decent SVGA graphics board. Dream on!

Availability

HiJaak Pro for Windows is published by Inset Systems, 71 Commerce Drive, Brookfield, CT 06804-3405, USA. Tel. 0101 203 740 2400, or Fax 0101 203 775 5634 (from the UK).

The UK list price is £165. At the time of writing (December 1993), the best price I could find was £82 from Shareware Marketing, 3A Queen Street, Seaton, Devon, EX12 2NY. Tel. 0297 24088 or Fax 0297 24091. Their catalogue number for the product is ISI-106 (HiJaak Pro is not a shareware product).

The product is also available from Software Compatibility Centre, 68 Ross Way, Eltham, London, SE9 6RL. Tel 081 319 1478 or Fax 081 856 9993. Their price of £117.50 includes UK technical support.

Software Reviews

Calling software publishers and distributors - if you have a product that may be of interest to our readers, we will seriously consider reviewing it. We would prefer products of a more specialised nature. Please send details to Paul Stenning, 1 Chisel Close, Hereford, HR4 9XF.

From Paper to PCB

David Silvester reports on an inexpensive way to produce your own Printed Circuit Boards

Whilst most of the constructors in the UK who are now reading Electronics in Action will have no trouble in obtaining a printed circuit board for a project that interests them, what happens to readers who may be outside the UK. The simple answer is to make their own board from the published layouts in Electronics in Action, and the very white paper that the magazine is printed on used actually helps in this job.

The process is extremely simple and if the constructor is willing to make the UV exposure box it can be cheap as well. What you require is a simple photocopier which must by now be the most common piece of office equipment and there are also a large number of businesses that will make photocopies for a small charge.

The revolution in the production process has come about by the use of laser printers for PCs as these use an identical method of reproduction to the photocopier. In both a toner is deposited on a sheet of paper where the dark areas are needed and a heating bar melts the toner to fuse with the paper. However it was found the laser printers and photocopiers were ideal for making overhead projector slides, the only problem being the heat. Recently transparency film has been available for laser printers and photocopiers that do not warp or shrink when making a copy. This type must be used to make the positive.

Making the positive

STEP 1

Have the circuit layout printed in EIA photocopied onto one of these transparencies. It is advisable to check that the copy is actually 1:1 scale with the original. Within a few seconds you will have a negative that can be used for the generation of the PCB using the photo etching process.

Expose the PCB material

STEP 2

Experiments I have carried out have shown me that it is cheaper in the long run to buy pre-coated PCB material, having had a total lack of success with boards that I have coated myself. The UV exposure unit consists of two 8 watt UV bulbs in a wooden box and a sheet of glass about 6cm above them onto which the photocopied negative and the PCB material are compressed by a heavy weight. This sort of unit although of a much better design and construction than the author could manage can be bought easily and although costly will last a lifetime.

Exposure time for the pre coated boards in my unit has always been 8 minutes for many different types and ages of the board material.

Develop the exposed board

STEP 3

The exposed photoresist is developed in a 0.7% solution of Sodium Hydroxide (Caustic Soda) or one of the proprietary developers which as far as I can see are the same thing. The 0.7% solution does not have to be accurately measured, I use one heaped teaspoonful of the pellets to one litre of water, tap water will do. The development takes place in a photographic developing tray that is rocked continuously to keep fresh solution on the board surface.

Etching

STEP 4

The etching of the now exposed copper can be carried out with a number of mixtures. The most obvious and possibly the easiest to obtain is a solution of Ferric Chloride. This is a very messy material being a dark red solution that stains anything it come into contact with and will even attack stainless steel leaving marks that are impossible to remove. A cleaner option and the authors favourite is a 30% solution of Hydrochloric Acid (Spirits of Salts from a local ironmongers, sold as toilet de-scaler, diluted 1:3) to which is added Hydrogen Peroxide solution (from the chemist/druggist in the next door shop). Although 20 vol. Hydrogen Peroxide will work it is much better if you can get 100 vol. as it prevents the dilution of the acid. This acid mix is also much faster at etching, taking only a few minutes whilst the Ferric Chloride etchant seems to take ages to work. As with all chemicals extreme care is needed but do not be afraid of them as fear leads to accidents. Always wear safety glasses when the chemicals are around and rubber gloves if you are worried although a drop on the hand if washed off quickly will cause no damage. Protect the surfaces on which you are working as the chemicals can stain.

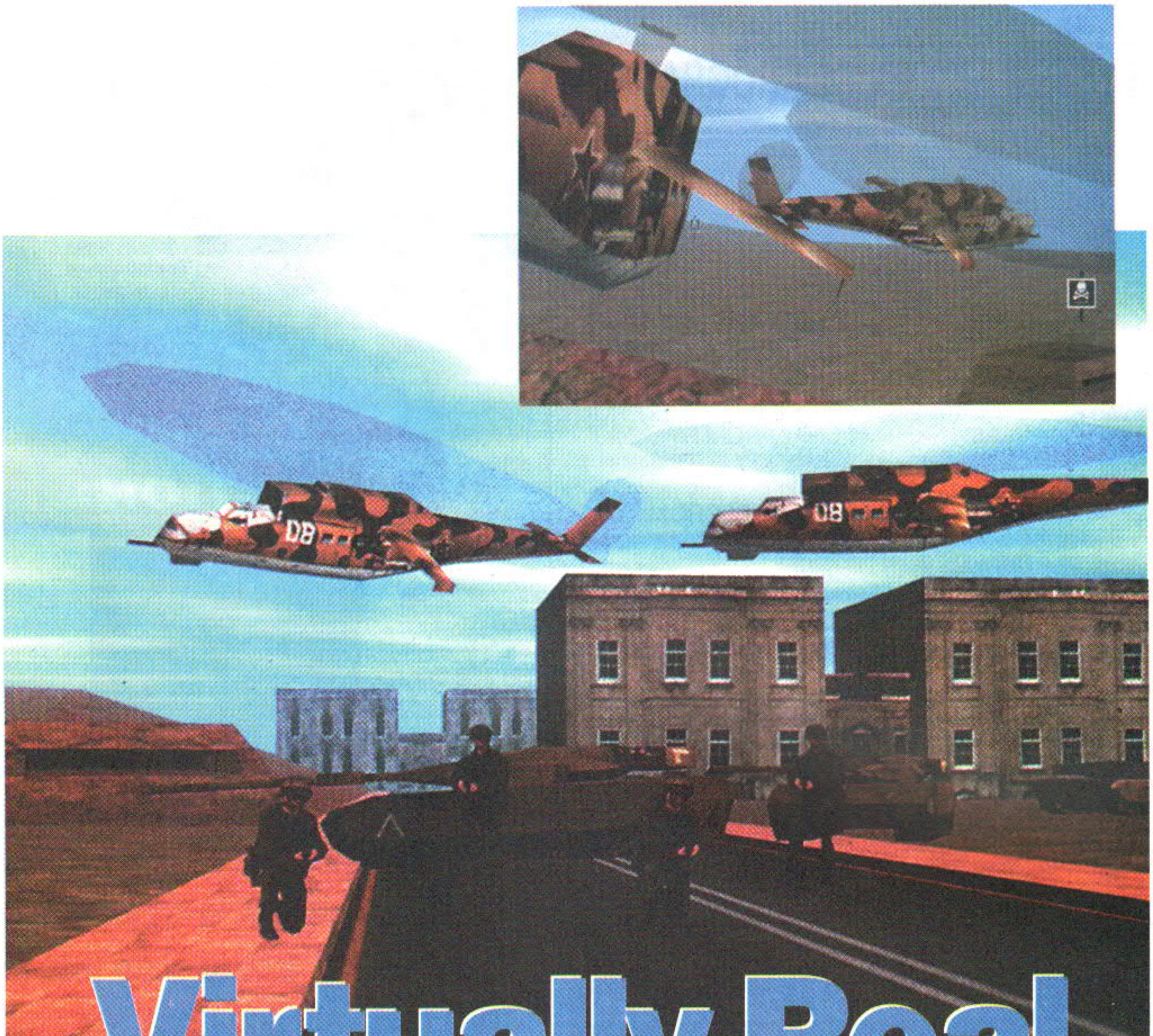
Wash & Drill

STEP 5

The final stages are to wash the board in water to remove all of the chemicals that were used in the production, remove the remaining etch resist with Acetone (from the chemist, it's used as nail polish remover), spray coat with a lacquer to prevent atmospheric action on the copper tracks and drill the holes.

Take care and enjoy making those PCBs. EIA

If you don't feel like making circuit boards for yourself, then why not buy them from the EIA PCB service. Turn to page 63 for more details.



Virtually Real

Helen and Andrew Armstrong report on the latest Virtual Reality developments from the VR User Show

Never mind amusement arcades; virtual reality is getting on in the real world. In a few years, if computer graphics systems continue to get faster, memories expand, and costs shrink, virtual reality applications will be as commonplace as word processing is now.

Virtual reality is a computer simulation that mimics the look and feel of a real environment. Ideally the user could move around the simulated space in real time, apparently interacting with it as if it were a real place containing real people and things. Inevitably, even simple applications need a great deal of computing power, but though the ideals of genuine real-time response and complete sensory interaction are still some way off, the groundwork has been laid.

Some sorts of virtual reality have been around for years. Flight simulators, for instance, are full-scale mock-ups of airliner cockpits, usually a real, fully-fitted cockpit section moved bodily by hydraulic rams. Simulators mimic an aircraft's controls and behaviour with such accuracy that trainees frequently have to rest up after an "emergency", although they know intellectually that the risks are zero. Modern simulators have computerised headup displays of the view from the cockpit window. To the pilot, though, it is the hardware which is the link with the real world.

Virtual Reality USER SHOW

The same principle is exploited in games which use moving cockpits and computer graphics to create a feeling of absolute reality. The ultimate aim in entertainment VR is to create an "environment" which combines reality with fantasy, or which moves right away from everyday environments into worlds of the imagination. It's theoretically possible to do this, by manipulating sound effects, movement and touch response so that they affect our senses exactly as they would if they were real.

But for real-world applications accurate reproduction of an existing

Finding the Target

The most popular display at the show, judging by the queues to have a go, was a shoot-em-up game used by Division Group to demonstrate their VR technology.

Division Group supplies immersive VR systems and image-generation technology for entertainment, collision testing, and living environment simulation. A walk-through immersive display of projected designs for a housing development in the Netherlands speeded up the rate of sales dramatically before the houses were built.

But "virtual worlds" are not the match of the real world yet. Goggle-screens are limited in their effectiveness by their reduced size.

In the words of our designer, Iain, his shoot-out was like watching the world through tracing paper. I had to agree with him. The helmet was an older model, as demand for display helmets is high.

VR helmets cost from $7,000 to $70,000 now, but that may change when game companies like SEGA move into VR games, perhaps in 1994. Resolution is from 320x240 to 400x300, but designers are working towards VGA resolution.

Division makes VR workstations and graphics accelerators, and markets the VR software environment DVS. The Unix-based stations use 486 processors for management. An array of transputers carries out fast message handling, and a series of I860 processors do the VR processing. This is true parallel processing: one I860 could be given the task of detecting all object collisions in the simulated space.

The multi-user, multi-machine system can link users by over a telephone line. Each end of the line must start from the same point with the same world data, after which communication via modem keeps both models updated.

Simulation and training applications include hazardous environments like space. Within two years, training for missions like the Hubble Space Telescope repair will take place largely on VR, rather than underwater as at present.

situation is essential. They need the same hardware and software techniques, but there is no room for a spatial error or a mistimed response when, for example, carrying out surgery from a distance by telepresence. Much of the ingenuity of virtual reality is in the software, but most of these ground-applications will depend on special hardware as well. Most important are movement sensors and other transducers, without which virtual reality would just one more display medium.

On Show

The VR User Show exhibition and conference at the Hammersmith Novotel, London was dedicated to virtual reality as a business tool. The conference on the second day explored some future possibilities, but the first day and the exhibition provided a sampler of what the art is doing now.

What virtual reality is doing for industry and science now is both more diverse and less mind-bending than you might imagine. I went expecting to see a VR helmet on almost every stand, and hoping to find VR feedback gloves in use as well. This wasn't the case, although there were several visual projection helmets and one motor-sensor helmet on display. We found a lot of mouse-driven applications. And yes, the most popular exhibit of the day, with obvious students, boffin types and business-suited executives queuing patiently for a turn, was the Division Group's VR shoot-'em-up.

British companies are at the heart of VR development, and it is said that the British are better informed about VR than Americans. It seems a lot of VR development is carried out in Britain, but the most important market is America, closely followed by Japan. One pundit quoted ***Dimension***, ***Division***, and ***Virtual Reality*** as the three major British companies in the field.

VR Technology

Virtual reality visualisation demands specialised hardware and software. The most essential element is the 3D display system. This can be a VR helmet, or a conventional monitor with shutter-spectacles (described later).

The field of vision should be as large as possible in systems requiring psychological acceptance of realism, because, say psychologists, if the field of vision exceeds about 60x, it is more readily accepted as real by the subconscious.

In all but the simplest systems, a head position sensor is necessary. If you turn your head, you must naturally see what you would see in a real scene. The software and hardware should ideally provide a full sphere of vision.

A widely used method of position sensing is the three-coil method, in which three orthogonal sensing coils are attached. Three larger fixed coils are pulsed in sequence, and the relative phase and amplitude information from the sense coils is processed to determine three dimensional position and three orthogonal angle measurements. The American company Polyhemus supplies such a system.

Much of what is required from the software is available on conventional 3D CAD systems which use normal 2D computer displays. A wireframe model of each object is generated, then texture (colouring effects) and lighting are added to surfaces. One time-consuming processes is to determine which surfaces are visible from a given direction, and which are hidden. Parts of an object which are "hidden" behind another object must also be computed.

This computation provides one view of an object. For VR visualisation, a second view from a point displaced by the visual width of one eye must also be generated, to give a stereoscopic image. The left and right views are shown to the left and right eyes. The only fundamental difference is that the focus of the eye does not need to adjust to cope with objects apparently closer or farther away. In practice, this fact does not seem to disturb the 3D illusion.

To update the moving images in real time needs very fast computation.

Continued on page 56

COMPONENTS

74LS SERIES

74LS00	0.10
74LS01	0.10
74LS02	0.10
74LS03	0.10
74LS04	0.10
74LS05	0.10
74LS07	0.38
74LS08	0.10
74LS09	0.12
74LS10	0.10
74LS11	0.10
74LS12	0.10
74LS13	0.17
74LS151	0.25
74LS14	0.21
74LS15	0.11
74LS20	0.11
74LS21	0.11
74LS22	0.11
74LS24	0.32
74LS26	0.11
74LS27	0.11
74LS28	0.11
74LS30	0.11
74LS32	0.12
74LS33	0.12
74LS37	0.13
74LS38	0.13
74LS40	0.13
74LS42	0.22
74LS44	1.60
74LS47	0.50
74LS48	0.45
74LS49	0.61
74LS51	0.11
74LS54	0.11
74LS55	0.13
74LS73	0.20
74LS74	0.15
74LS75	0.21
74LS26	0.21
74LS77	0.42
74LS83	0.34
74LS85	0.34
74LS86	0.22
74LS90	0.24
74LS91	0.50
74LS92	0.29
74LS93	0.24
74LS95	0.38
74LS96	0.46
74LS107	0.25
74LS109	0.25
74LS112	0.25
74LS113	0.25
74LS114	0.25
74LS122	0.32
74LS123	0.32
74LS125	0.27
74LS126	0.21
74LS132	0.28
74LS133	0.24
74LS136	0.21
74LS137	0.62
74LS138	0.23
74LS139	0.25
74LS145	0.57
74LS147	0.86
74LS148	0.69
74LS153	0.27
74LS154	0.70
74LS155	0.24
74LS156	0.24
74LS157	0.20
74LS158	0.24
74LS160	0.31
74LS161	0.31
74LS162	0.31
74LS163	0.31
74LS164	0.29
74LS165	0.47
74LS166	0.52
74LS168	0.58
74LS169	0.52
74LS170	0.65
74LS173	0.55
74LS174	0.23
74LS175	0.23
74LS181	1.46
74LS182	1.56
74LS183	1.56
74LS190	0.24
74LS191	0.23
74LS192	0.28
74LS193	0.38
74LS194	0.38
74LS195	0.23
74LS196	0.23
74LS197	0.23
74LS221	0.35
74LS240	0.31
74LS241	0.31
74LS242	0.31
74LS243	0.31
74LS244	0.31
74LS245	0.32
74LS247	0.31
74LS249	0.65
74LS251	0.23
74LS253	0.34
74LS256	0.50
74LS257	0.23
74LS258	0.23
74LS259	0.48
74LS260	0.28
74LS266	0.14
74LS273	0.31
74LS279	0.24
74LS280	0.85
74LS283	0.48
74LS290	0.23
74LS293	0.23
74LS295	0.57
74LS298	0.62
74LS299	1.16
74LS322	1.56
74LS352	0.76
74LS353	0.86
74LS365	0.23
74LS366	0.26
74LS367	0.25
74LS368	0.27
74LS373	0.31
74LS374	0.31
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ZN423	0.92
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AM25S07	4.99
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AF124	0.78
AF126	0.46
BC107	0.12
BC107B	0.13
BC108	0.11
BC108B	0.13
BC108C	0.14
BC109	0.13
BC109C	0.14
BC140	0.24
BC141	0.26
BC142	0.30
BC143	0.33
BC147	0.33
BC148	0.33
BC149	0.11
BC157	0.11
BC158	0.11
BC159	0.11
BC160	0.29
BC169C	0.16
BC169C	0.16
BC171	0.11
BC177	0.17
BC178	0.17
BC179	0.17
BC182	0.07
BC182L	0.07
BC183	0.07
BC183L	0.07
BC184	0.07
BC184L	0.07
BC212	0.07
BC212L	0.07
BC213	0.07
BC213L	0.07
BC214	0.07
BC214L	0.07
BC237B	0.08
BC238B	0.08
BC308B	0.08
BC327	0.09
BC328	0.09
BC337	0.09
BC338	0.09
BC477	0.33
BC478	0.33
BC479	0.33
BC517	0.19
BC547B	0.07
BC548B	0.07
BC549B	0.07
BC557B	0.07
BC558B	0.07
BCY90	0.20
BCY71	0.19
BCY72	0.19
BD115	0.49
BD131	0.36
BD132	0.36
BD135	0.19
BD136	0.19
BD137	0.19
BD138	0.19
BD139	0.22
BD140	0.23
BF180	0.30
BF182	0.30
BF185	0.30
BF194	0.18
BF195	0.18
BF196	0.19
BF197	0.19
BF198	0.19
BF199	0.19
BF257	0.32
BF258	0.35
BF259	0.32
BF337	0.35
BFR40	0.38
BFR80	0.38
BFR81	0.38
BFX29	0.28
BFX84	0.30
BFX85	0.30
BFX87	0.43
BFX88	0.43
BFY50	0.28
BFY51	0.25
BFY52	0.27
BFY53	0.46
BFY55	0.46
BFY56	0.46
BSX20	0.26
BSX29	0.52
BSY95A	0.46
BU205	1.39
BU206	1.40
BU208	1.55
MJ2955	0.75
MJE340	0.35
MJE520	0.44
MJE521	0.59
MJE3055	0.84
MPSA05	0.27
MPSA06	0.27
MPSA12	0.27
MPSA56	0.17
MPSU06	0.55
TIP29A	0.30
TIP29B	0.30
TIP29C	0.31
TIP30	0.31
TIP30A	0.31
TIP30B	0.30
TIP30C	0.30
TIP31A	0.30
TIP31B	0.30
TIP31C	0.31
TIP32A	0.30
TIP32B	0.30
TIP32C	0.31
TIP33A	0.65
TIP33C	0.71
TIP34A	0.68
TIP34C	0.74
TIP35A	0.99
TIP35C	0.99
TIP36A	0.99
TIP36C	0.99
TIP41A	0.35
TIP42A	0.35
TIP120	0.37
TIP121	0.34
TIP122	0.36
TIP141	1.05
TIP142	1.05
TIP147	1.10
TIP2955	0.59
TIP3055	0.60
ZTX107	0.17
ZTX108	0.17
ZTX109	0.17
ZTX300	0.16
ZTX302	0.19
ZTX341	0.22
ZTX500	0.14
ZTX501	0.22
ZTX502	0.22
ZTX504	0.22
2N2219A	0.27
2N2222A	0.15
2N2369	0.23
2N2484	0.24
2N2646	0.57
2N2904	0.24
2N2904A	0.24
2N2905	0.20
2N2905A	0.20
2N2906A	0.20
2N2907	0.19
2N2907A	0.19
2N2926	0.14
2N3053	0.26
2N3054	0.83
2N3055	0.55
2N3442	1.32
2N3702	0.09
2N3703	0.09
2N3704	0.09
2N3705	0.09
2N3706	0.09
2N3773	1.68
2N3819	0.26
2N3866	0.99
2N3903	0.09
2N3904	0.09
2N3905	0.09
2N3906	0.09
2N4026	0.16
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7815	0.23
7905	0.25
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7915	0.25
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8 PIN	0.06
14 PIN	0.10
16 PIN	0.14
18 PIN	0.14
20 PIN	0.15
24 PIN	0.18
28 PIN	0.20
40 PIN	0.24

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IN4004 ..	0.25
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22UF 35 VOLT	0.08
47UF 10 VOLT	0.08
47UF 16 VOLT	0.09
47UF 25 VOLT	0.06
47UF 35 VOLT	0.08
100UF 16 VOLT	0.09
100UF 25 VOLT	0.09
100UF 63 VOLT	0.12
220UF 16 VOLT	0.10
220UF 25 VOLT	0.11
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Continued from page 53

Ordinary desktops like Macs and PCs/compatibles are normally considered inadequate, and both Silicon Graphics and Sun hardware was in evidence at the show. Even with a fast machine, software must compile efficiently, so it was no surprise that C and its variations are widely used.

The Nuclear Dump

Virtual Presence had the only other stand with a VR headset, and this was a viewer rather than a complete helmet. The game is a practical one: you must pick up a spent radioactive fuel rod in a mechanical claw, and deliver it to a ceiling-mounted hopper - good training for teleoperated robot control.

The picture was clear and bright, though the subtlety of the graphic images was less than the shoot-out game. By the time we tried it, the 1.5kg helmet had suffered from constant manhandling and adjustment, so that the left eyepiece would not focus perfectly. Although the helmet had to be altered quickly to only a rough fit (and pinched) we found it quickly became intuitive to use. Not everyone took to it so quickly.

The system uses a pair of CRTs, with rotating coloured disks in front of them. Alternate rasters are in red, green, and blue, with two sets of coloured filters per disk rotation to avoid the need for an absurdly fast spin.

It is likely that in the long run LCD technology will take over completely from CRTs. In the near future, Virtual Presence plans to use LCD shutter technology to switch the colours in front of its CRTs.

The private eye

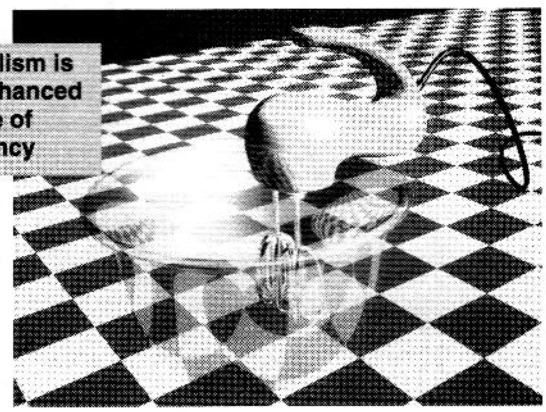
The **Infodisp** Portable Information Package (PIP) makes its appearance as a medium-sized belt-pack holding a digital storage box which can display up to 100 screens of text and graphics. Each page may display text, graphics, line drawing or a combination. In future will be possible to send data to the portable unit by means of licence-exempt short-range radio, or via one of the national mobile data radio networks.

The picture shows the portable information pack in use as a car repair manual, though at a cost of 840 it might be cheaper to take the car to the garage! But the PIP is user-reprogrammable, and images can be compiled into a document on a PC using PIP Publisher for Windows software, downloading images to the PIP's memory via an RS232 interface.

The Private Eye display screen (made by Reflection Technology) has a resolution of 720 x 280 pixels, and gives a bright red image on a black background, resulting in startling clarity. The principle of the 2.25oz, headband-

Unrolling the texture

Evans and Sutherland was displaying its Freedom Series graphics accelerators for Sun SPARCstations. A graphics accelerator builds images from image data, using object-oriented techniques and as many short-cuts as it can to build the type of graphic scene the user requires as quickly as possible and with minimum processing overhead on the central processor.



Scene realism is greatly enhanced by the use of transparency

One of the main techniques used is texturing, a fast-result alternative for picture building. The standard means of building objects for VR visualisation is to generate a series of polygons, each with its own shape and colour. An image may use millions of polygons, not all visible. To achieve less computing-intensive real-time animation, bitmaps are used for objects which do not have to move and change shape. In one demonstration, of driving a train into a station, the people on the platform are collectively a texture. Equally, a map of the terrain in, say, a flight simulation may be a wireframe to give the contours, with a texture dropped on to it. Close up, such a texture is not realistic, because it does not contain all the right details, but viewed from a distance a texture with blurs of colour and shading looks realistic.

Evans and Sutherland provide software for many industries. They claim 80% of the world market for flight simulators, as we as providing simulation software and optical systems.

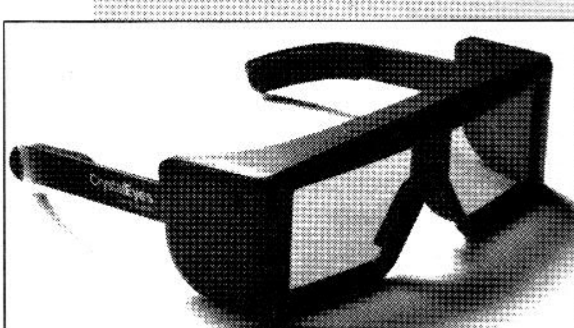
Military combat pilots often fly in a helmet mounted display, rather than relying on watching their real surroundings, partly to protect them from optical flash weapons which would blind them. These helmets are in effect advanced virtual reality helmets. Target acquisition by looking at the target, then giving a verbal fire command is possible. Possible inputs for VR display in this situation are from cameras and other optical sensors, RADAR, and control panel simulation.

A system used by automobile designers generates mathematically accurate shapes as the artists draw, so that it is possible to mill the shape straight from the design drawing. Cost, of course, is another question.

Crystal Eyes

Ambitron's Crystal Eyes spectacles caught my imagination, partly because I see myself using it with a CAD system in the next few years. Looking at a computer monitor through the spectacles, with suitable software, makes the monitor image appear in 3D.

The image is shown from two different perspectives, on alternate fields (complete scans of the monitor). The spectacles have liquid crystal shutter lenses, which show the even fields to one eye and odd fields to the other. The spectacles are synchronised to the monitor display via an infra-red link. The infra-red transmitter sits on top of the monitor, and a tiny sensor built in to the glasses receives the digital synchronisation signal. The specs are powered by a lithium cell, and are quite light. At the moment, the system, at £2500 plus VAT, is a little too expensive the individual engineer, but companies are making encouraging claims for increased productivity using 3D viewing instead of conventional 2D screens.



mounted screen is that it sits in the "glance down" eyeline of the user's dominant eye. When the user glances at the small display, the brain "sees" an image approximating to a 12in display screen floating a few feet in front, carrying a clear image of the text and graphics. The hands-free system does not cut the user off from the real world in the way that immersive virtual reality does, so that practical work can be carried out at the same time.

The screen sounds tiny, but we found it very clear to read. The "dominant eye" principle was voted a bit of a red herring, as some people preferred to have it set for the other eye, and treat it simply as a small, clear information display close to their eyeline.

Another VR application is 3D molecular modelling. This helps pharmaceutical companies to simulate drugs to weed out potential designs which will not work properly. Before computer aided design of drugs, maybe 10,000 prototype combinations would have to be tested to get one effective drug. Using molecular modelling, this number is reduced to about 500.

3D visualisation for molecular design is carried out using **Crystalise** LCD shutter spectacles. Before LCD shutter spectacles were discovered, industry used a mechanical shutter technique of slotted drums - nicknamed "spinning beercans" - rotating in front of each eye, synchronised so that each eye received the image alternately, giving the illusion of stereoscopic vision.

Design and engineering get together

Two days of conferences brought engineers and marketing executives from all over the world to swap notes on practical applications. Jim Humphries, Chief Engineer at the Systems Scientific Division, Federal Systems Group of Sterling Software in the USA, gave an overview of development with NASA, the motor industry and ground-breaking early work in immersive VR and helmet technology.

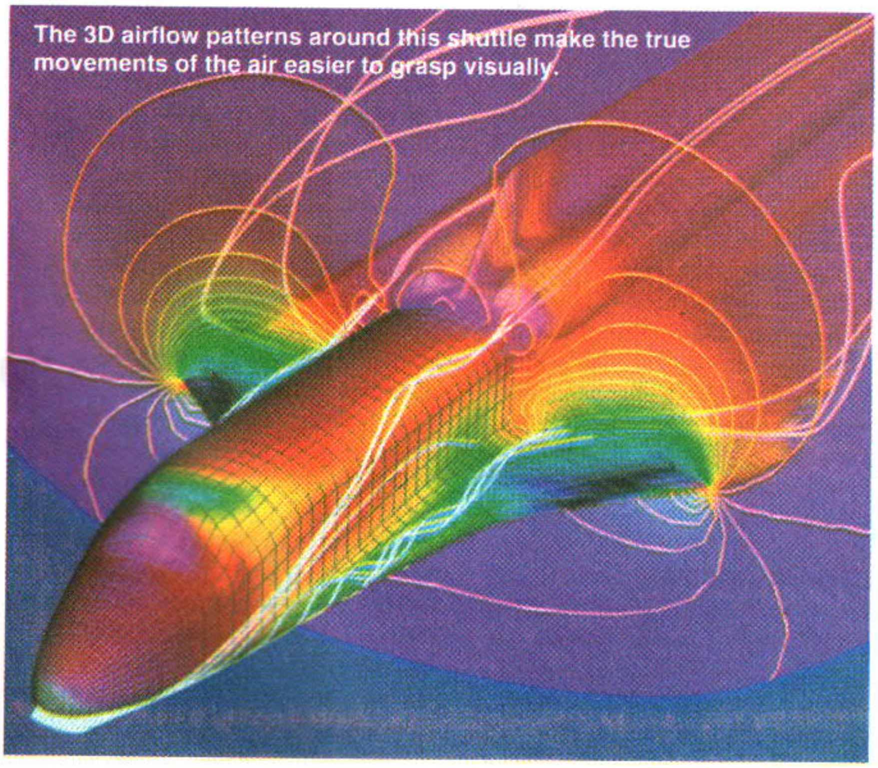
A psychologist by training, Humphries has worked on "classic" VR with 3D display headsets since 1984. Sterling has been developing VR as an adjunct to CAD systems, to aid visualisation of airflow patterns. Jim Humphries reasoned that if the engineers could follow an airflow track in 3D, this would help them to gain the necessary insights for innovative design. Virtual reality visualisation software and hardware was added to flow analysis software toolsets, as an alternative to normal conventional screen displays.

Jim Humphries

In 1984 the project started with the aim of producing a system for under $2M. It required a 3D display with at least 45x horizontal and vertical range - and a light head-mounted display. An initial $10,000 was allocated for feasibility study.

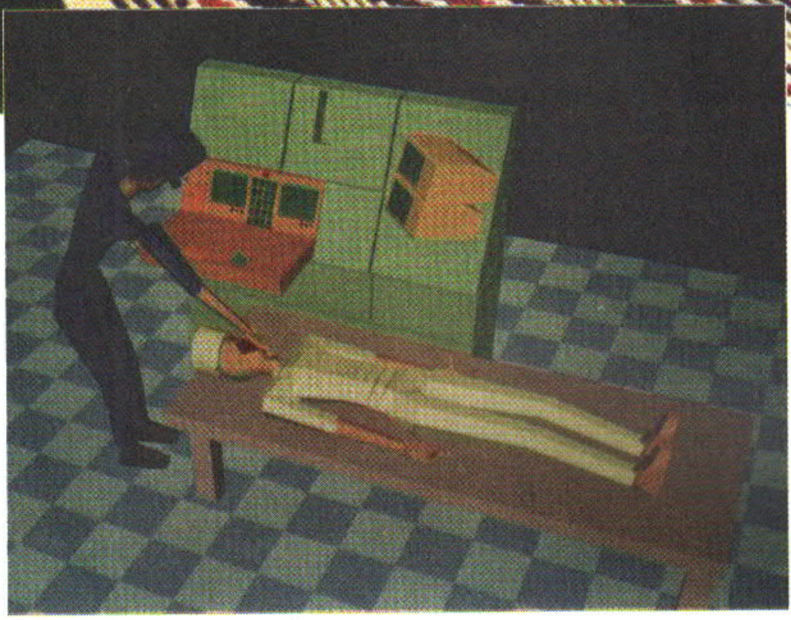
Liquid crystal displays were chosen for lightness and safety. They need no high voltages, and there is no danger of implosion. At the time, the rate of improvement of liquid crystal display technology was expected to be more rapid than has happened.

The first unit was monochrome, with a resolution of 100x100 pixels for each eye, 100 degrees (h) by 70 degrees



The 3D airflow patterns around this shuttle make the true movements of the air easier to grasp visually.

A *Jack* figure moving across a room lit with radiosity lights



Hit the Brakes, Jack

Goodwin Marcus Systems' Jack is a human modelling system with applications in Computer Aided Design (CAD) and ergonomics development software. The diagrammatic figures imitate the characteristics of the human body which must be taken into account when designing hardware and software for direct interactive use.

(v) viewing angle, and a 10lb headset. The next model had the same performance, but the headset was a mere 2lb. The aim is a visual area of 120 x 120 degrees for true immersive VR, a "sense of being there" at a price affordable for industry.

Using VR for simulation, **Sterling** can provide training systems for pilots to supplement work in a full simulator, as well as simulating engineering tests which would be expensive to carry out with real hardware. Simulating events in a car crash enables engineers to carry out more tests to improve crumple zones, etc.

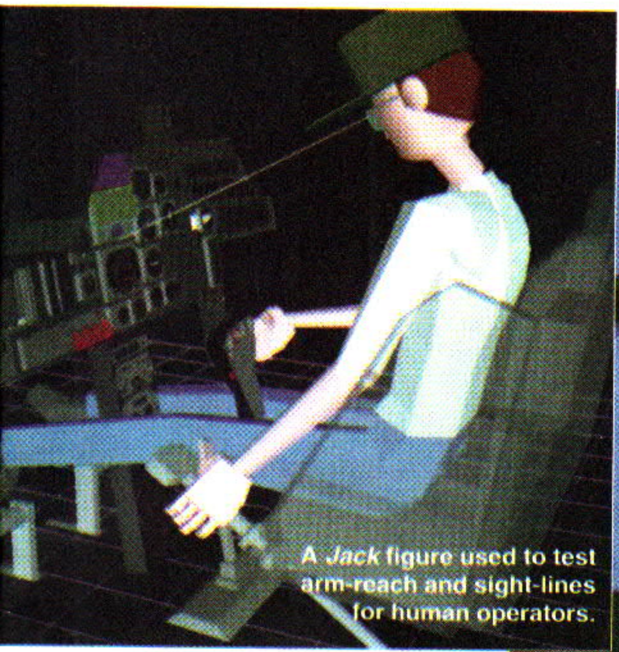
The potential drawback of electronic simulation is that analogue and mechanical structures rarely behave in exactly the way predicted by electronic logic, so that real prototyping still has to be undertaken to make sure that the simulation is accurate. A VR system can, after all, be programmed to break the laws of physics. If the program were to deviate from reality in a subtle way, it could be hard to detect the error. On the other hand, VR demands massive computing power, so that the overhead of using smaller steps in finite element analysis is less significant than for most CAD.

Nevertheless, VR allows early and physically difficult designs to be developed faster and at lower cost. Engineers and visual designers can work on the same virtual model at the same time, the designer introducing new shapes and the engineer checking whether a new grille shape might cause the engine to overheat, crossing what Jim Humphries calls "The Wall" between design and engineering.

Virtual reality will be a part of future space projects, not only in training simulations, but as part of telepresence, where Earth-based operators will control remote robots using datagloves as a major control device. In situations where screen-based data and programming is more appropriate, the operator can be surrounded by virtual screens and see the situation at a glance.

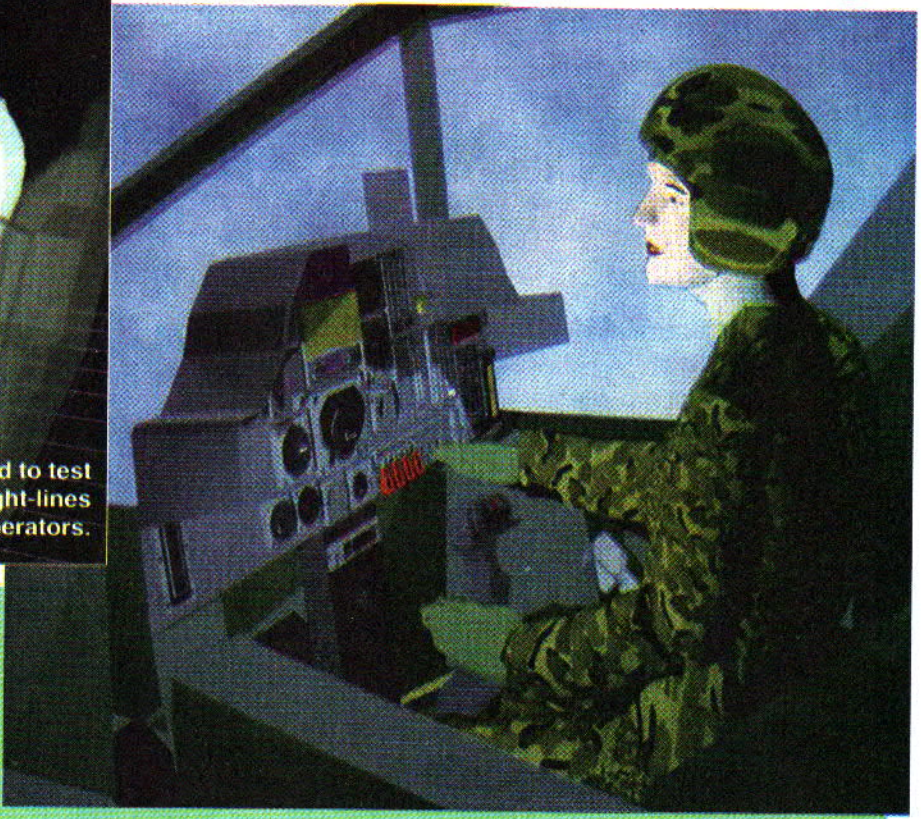
The cat in a hat

Ratz the cat is a TV-presenter cartoon character put together by UK broadcast technology company TeleVirtual. The character is literally a "talking head", floating in free space and interacting with human presenters and viewers who phone in. The face is animated by a collection of operator-driven electronic inputs. Ratz, which was sculpted and set



A *Jack* figure used to test arm-reach and sight-lines for human operators.

Below: A female *Jack* pilot with realistic facial features. The sky and camouflage uniform are achieved through texture mapping



Reach, freedom, rotation and torque load in joints, balance, eyelines and visual fields, stretch, strength and comfort are some of the factors which can be tested in software using Jack figures. Fully contoured body models with textures and realistic facial features can also be generated.

Modelling software of this type is used to test and display physical human factors before building expensive hardware prototypes. They are also handy for demonstrating systems to potential customers well before the hardware is built, reducing development costs and increasing the understanding and involvement of end-users at an earlier stage.

Misunderstanding between makers and clients have been a major source of contention since computing first appeared, as users of home micros to the biggest industrial networks will testify. Unsurprisingly, cheaper, more predictable and more accurate test and demonstration applications are now the most widespread and fastest-growing market for virtual reality in business and industry.

up in eight weeks, uses sliders, a foot pedal, a helmet with two on-face motion sensors for the operator's mouth, and the "Flying Mouse", a magnetic pulse-detector which spins the head around in space.

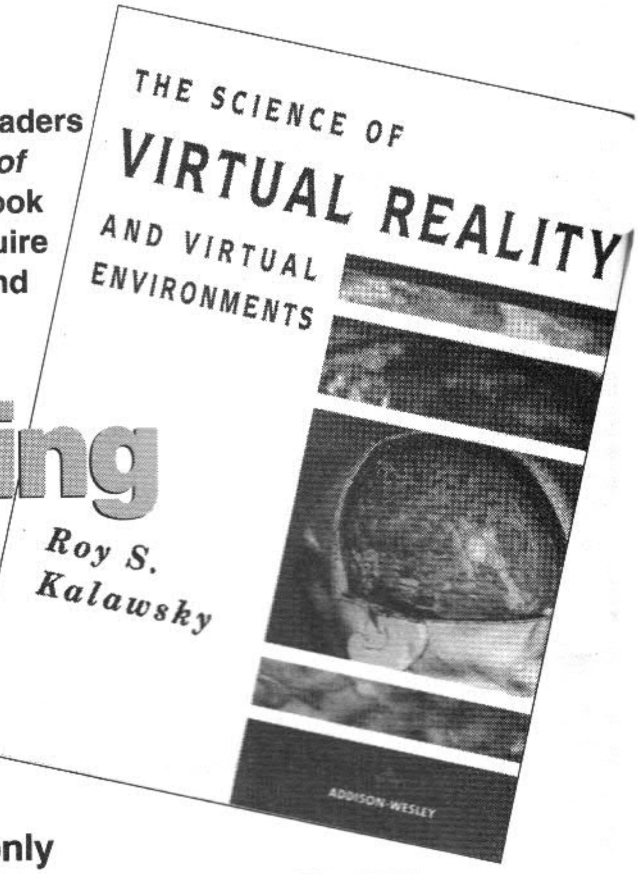
RATZ is operated by comedian Paul Brody, strapped into a modified ice-hockey helmet which traces his head positions, and the "Facial Waldo", a rig made up of two button-sized motion detectors stuck to his skin, one just below his mouth and one just to the right of it. The pads are connected to potentiometers by thin pieces of piano wire and a rack and pinion drive, and pass information about the relative position of his lips so that, when he speaks, the virtual character's lips move in synchronisation.

The "Flying Mouse" is a tiny hand-held sensor on the end of several feet of cable. The mouse is connected to a Polhemus tracking device and detects magnetic pulses sent out on three axes from a coil box, defining its position in space. Position information is passed back via the cable to a decoder box. Held and moved around by the operator, it can shift the character's head around freely, including 360-degree turns. Although it will be possible to "read" free movements from a live actor quite soon, it is not possible in a cable-linked helmet. Many VR helmets are designed to limit head-movement. The helmet worn by Paul Brody - which is an animation helmet rather than a virtual reality one - is based on a ice hockey helmet, and developed for use with motorised characters like Jim Henson's Muppets.

Ratz's eyes are blinked by a foot-pedal. A slider moves through a series of hand-closing commands and brings up a cordless telephone image at the far end of its travel. Two other sliders can rotate his hand and elbow. A joystick produces a range of extra cartoon-expressions - exaggerating yawning, nose twitching, and so on. It's possible to have most of these expressions, and eye movements, driven by further facial pads on the operator's eyebrows and mouth. Ratz's controls were worked out with Paul Brody for ease of movement and control of the cartoon's features.

The software behind the star is SimGraphics Engineering's VActor (Virtual Actor) system, developed in the United States. TeleVirtual is now working on other VActor characters and environment for television in Britain and Germany. There is room for many more character movements to be driven directly from motion sensors on the operator. Eventually, no doubt, these could be added to a VR headset to animate your own icons in cyberspace, when virtual communications comes of age.

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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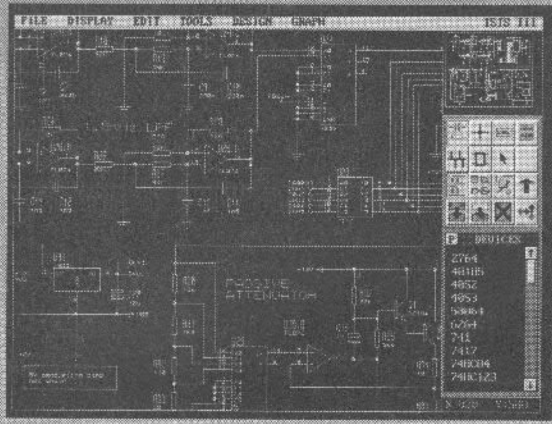

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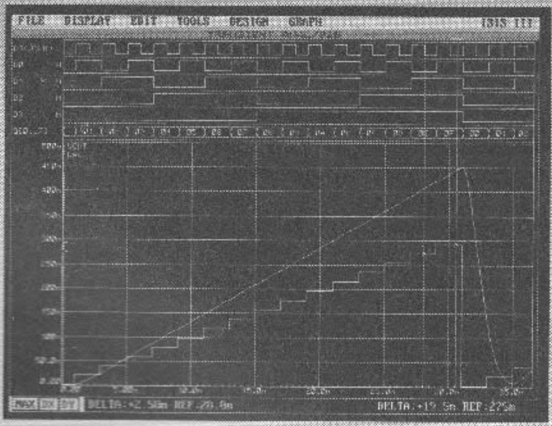

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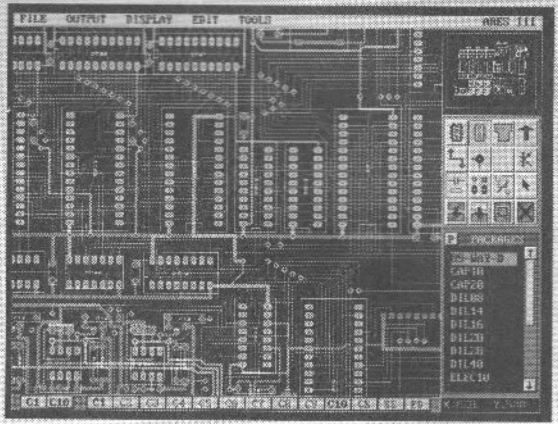

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Ideas Forum

Scribble pads at the ready, brains in gear and component catalogues to hand. Its thinking time again

Has anyone out there thought of an idea for an electric butter warmer that softens the butter but doesn't turn it to a liquid? A microwave would do the job but that is a little too much like overkill. You may think we are joking but this could be just the sort of useful thing an elderly or disabled person would require.

Coming up with the initial ideas is half the battle really and this is where Ideas Forum comes in. The intention is, each month, is to list a whole host of notions and thoughts that could be expanded into fully fledged projects. So far none of you have taken the plunge and contacted us with the project of the century, but then maybe you're all hard at work putting on the finishing touches.

If you have any suggestions or have developed any of the ideas that have been appearing in this column please send them in to us at:

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

February

Security
High Voltage electric fence. Although suggested to us, this is in fact against the law, but it seems that people are still prepared to go to these measures. Electronic tagging ought to be encouraged so that not only does the article have a unique identity but also it could be tracked if the tag is a transmitter. This is currently being experimented with in the car industry.

Telephone projects
Interactive games by 'phone link to computer.
Credit card reader to initiate transactions over the phone from home

Signature Analyser
Need to develop a two dimensional flat plate positional detector.

Music Effects
A simplified Vocoder. This is a bank of filters to treat and mix incoming signals for special effects. Vocoders were used on ELO records in the 70s.
An octave pedal for guitars that gives you the choice of one or two octaves below the guitar signal plus the original signal, thus fattening the sound.
Audio Compressor to keep sound levels constant.

Video
Video mixer for editing home movies.

Around the Home
Warning devices with time out facility. e.g. Deep fat friers can easily be left on. An audible warning is required after a preset time. Many devices in the home do not seem to have this, even computer hardware.
Butter warmer as mentioned in the text opposite (some people still like real butter).
Making light bulbs last much longer by usage of circuitry to reduce input voltage.
Cordless stereo headphones to wander around the house listening to your favourite music.

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November issue			
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☐	QH1193-2	Telescope Input board	£5.50
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ADVERTISERS' INDEX

Bob Stone, Technical Manager of Advanced Robotics Research Limited and Visiting Professor of Virtual Reality at the University of Salford, considers the future of VR as it could affect industry by explaining the background to the Company's Virtual Reality & Simulation Initiative - Europe's first industrial VR project, supported by 13 British companies.

If a newcomer to the field of Virtual Reality (VR) happens to acquire a copy of The Virtual Reality Primer (Larijani, 1993), he might be forgiven for assuming that the UK had very little effort under way in VR and that the Country was not considered worthy of an entry under a section entitled "Other Major Players: Germany, France & Japan", in Chapter 15. If the author and editor had performed their research with just a little diligence, then they might have discovered that, not only does the UK lead Europe in its VR endeavours, but the so-called other major players openly admit this fact as well!

Telepresence

The UK's Advanced Robotics Research Centre (ARRC), based on the campus of Salford University in the North of England, was the first establishment in Europe to exploit VR technologies as a means of achieving telepresence for hazardous environments (e.g. nuclear, space, subsea). Essentially, telepresence - one of the first serious VR development areas pioneered by researchers at NASA Ames in California in the 1980s - means that the human operator of a remotely controlled robot receives sufficient information about the hazardous environment, displayed in a natural or intuitive way, that he feels as if he is physically present at the remote site. In effect, VR is a form of telepresence in that typically, a VR system "immerses" its users into a "remote", three- dimensional environment, albeit computer-generated, monitoring body movement and updating the view of the environment accordingly. From 1989, research at the ARRC concentrated on the use of VR hardware and software as tools for achieving telepresence, not only to provide the means of displaying and interacting with three-dimensional computer models of hazardous environments, but also to demonstrate the power of being able to convert remote sensory data (relayed from those environments using a scanning laser rangefinder) and to control real robot manipulators and vehicles. In addition, related research addressed new forms of sensory display for virtual environments, such as large-screen 3D projection and glove-based tactile feedback, new hand controllers and input devices, head-controlled stereoscopic TV, and VR for advanced microscopic inspection (Stone, 1992; 1993).

Contrary to early expectations, it is not computing technology which is letting VR down.

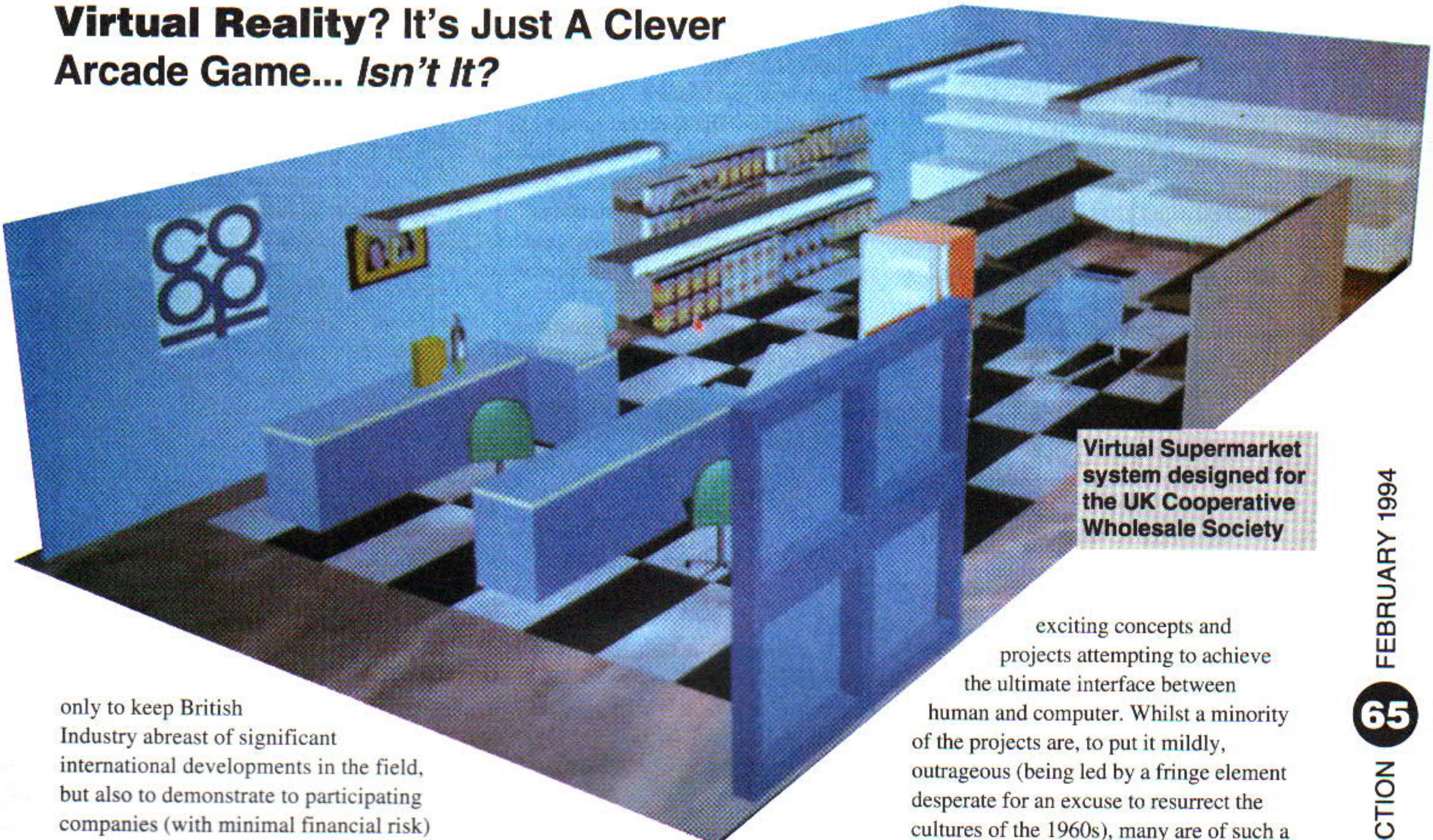
As the end of the ARRC's initial 5-year period of Government part-sponsorship drew nearer, decisions had to be made as to which key research areas should be selected for taking forward as the Centre took on its full commercial status in the form of Advanced Robotics Research Limited. As far as VR was concerned, and despite numerous presentations to Government bodies, emphasising the general importance of the technology, not just to Salford, but to the UK's VR community, very little interest could be generated. VR and its associated technology base is, without doubt, a very exciting and stimulating field in which to work or carry out research. But one question had to be answered. Had VR "matured" to such a level that it was reasonable to expect that there might be real industrial applications which warranted - technically and commercially - the introduction of this radically new form of human-system interface? Certainly there were, and still are, a wide range of potential applications being researched across the globe, from medical visualisation and molecular modelling to architectural "walk-throughs", from advanced fighter cockpit and future infantryman research to virtual Olympic stadium design and skiing trainers. Yet, in the main, these applications are still confined to research laboratories. Even at Siggraph '93 in Anaheim, one of the world's most prestigious advanced graphics exhibitions, questions similar to those being asked over 3 years ago were still evident - superb graphics, excellent real-time performance, but what are the applications?

After 18 months of intensive lobbying of industry, these questions were answered and a range of novel applications had been found. In May of 1993, what was to become Europe's first and largest collaborative VR venture was launched under the general title of Virtual Reality and Simulation (VRS). Space does not permit a review of the short history leading up to the launch of the VRS Initiative; further details can be found in Stone (1993). In brief, and following a short feature on the BBC's 9 O'Clock News in January of 1993, enough interest and financial support was secured from a range of British companies to put together a programme of research and development into the application of VR technologies to solve real commercial and technical problems.

The aim of VRS, initially planned as a 2-year programme of work, is not

Future View

Virtual Reality? It's Just A Clever Arcade Game... *Isn't It?*



Virtual Supermarket system designed for the UK Cooperative Wholesale Society

only to keep British Industry abreast of significant international developments in the field, but also to demonstrate to participating companies (with minimal financial risk) the commercial value of Virtual Reality and Simulation. At the end of the 2-year Programme, VRS will provide the participating companies with sufficient know-how to introduce the technologies into their own businesses with minimal technical and financial risk. Members of the 13-strong VRS Collaborative Group include: the Cooperative Wholesale Society (supermarket space planning, exploiting related developments in electronic point-of-sale systems, electronic shelf-edge pricing, customer tracking systems and intelligent packaging), Rolls-Royce plc (Trent 800 aero engine design and maintenance evaluation), United Kingdom Nirex Limited (nuclear repository design and operational training), Vickers Shipbuilding and Engineering Limited (submarine design, compartment visualisation and refit planning), and ICI Chemicals & Polymers Limited (computational fluid dynamics).

The Future?

One gratifying aspect of leading a team closely involved with the application of VR technologies to real industrial problems is that one regularly gets invited to speak at conferences and meetings across the globe. Not only does one come away from such events truly convinced that the UK currently leads Europe and, in some cases, the world in terms of VR computing developments and applications, but one also gains an otherwise expensive insight into new and exciting concepts and projects attempting to achieve the ultimate interface between human and computer. Whilst a minority of the projects are, to put it mildly, outrageous (being led by a fringe element desperate for an excuse to resurrect the cultures of the 1960s), many are of such a quality that they will undoubtedly shape the future face of VR.

> ***...being able to handle complex graphical images, approaching the quality of those used in Jurassic Park and Terminator 2 in the laboratories of VR researchers, is not the end of the story.***

However, any attempt now to predict the near-to-mid-term future of VR with a high degree of certainty must surely be classed as foolhardy. Incredible developments in the real-time computer graphics field over the past 18 months or so were as unpredictable in 1992 as were the two multi-million pound flotations by British VR companies in 1993, selling products based essentially around a couple of electromagnets, a pair of pocket televisions and a cannibalised PC joystick!

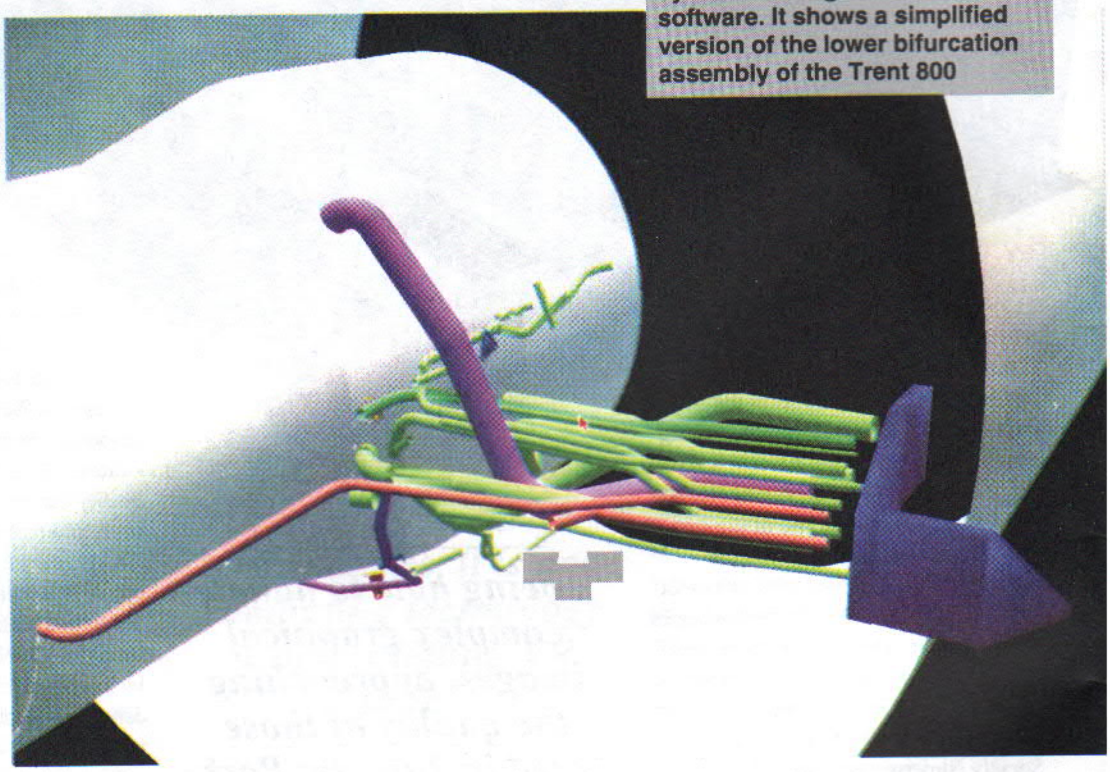
Seriously, being able to handle complex geometries and graphical images, effectively bringing images approaching the quality of those used in Jurassic Park and Terminator 2 into the laboratories of VR researchers, is not the end of the story. Contrary to early expectations, it is not computing technology which is letting VR down. Nor is it virtual environment modelling and run-time software which, despite worldwide sales of, frankly, beta-release quality products, is evolving slowly but surely. It's the peripheral devices - the headsets, the gloves or hand controllers, the body tracking systems - the very means by which immersion is achieved.

For immersive VR to become the norm rather than the exception, a lot has to happen in a short space of time, especially if the technology is to offer a commercially viable and professional tool for industrial applications, not to mention a means for training physicians, helping the handicapped to enjoy new experiences or in finding widespread use in civil engineering and architecture. Head-mounted displays, be they in the form of "ski-goggle" visors, miniature glasses, or laser retinal projectors will have their day - we are just waiting for the "killer" combination of high resolution colour imaging panels with optics which approximate the human's natural field of view. Providing "cable-less" VR - thereby removing one of the technology's frustrating characteristics - has to be addressed seriously. The possibility of direct neural interfacing - linking silicon with human nervous tissue - is a question I am often asked in the lectures I give throughout the UK and Continental Europe. Many scientists and medical practitioners are sceptical about the ability to feed computerised images directly into the optical nerve. Yet I believe the time will come when current developments in neural prostheses will enable direct VR-sensory linkages, albeit initially to enhance the lives of individuals with pathological disorders.

Linked to the improvement of VR peripherals will be a parallel improvement in the sense of presence in a virtual environment and a reduction in the incidence of known psychological and physiological problems associated with immersion. The large number of legal representatives, psychologists and ophthalmologists at the New York VR Expo' in December of 1993 is testament to the current existence of a variety of health and safety problems. Despite the somewhat scare-mongering reports featured in the tabloid press during 1993, claiming that "VR damages your health", there is, sadly, only a handful of respectable studies which have tackled this emotive subject. Human factors issues related to the acceptability and usability of VR peripherals, most notably the resolution and field of view offered by immersive head-mounted displays are only now being addressed in a practical yet academically credible way. In the UK, the recent funding of psychological and ergonomics studies, together with the establishment of professional bodies of "watchdogs" should help establish relevant standards and codes of practice for VR developers and distributors.

If we are to believe international "intelligence", VR is set to invade the homes of ordinary people some time in 1994. What form it will take and, more importantly, what quality of experience it will offer is open to debate. Most likely, going by the mentality of the well-known video console developers, low-resolution, unstable images of violence will secure the greatest expenditure from the gullible general public and their families.

Despite the achievements and false promises of those involved in the VR community, it is fair to say that VR is here to stay. Europe in general is already ramping up to launch a major effort in VR. The Commission of European Communities (CEC) has placed small consultative contracts with a group of key personalities within the Continent to advise the Brussels Coordinators as to developments and trends across the globe, including reviews of hardware, software and applications. This effort will pick up sometime early in 1994 with the likely establishment of a European Advisory Committee in VR, involving representatives from many countries. Within 18 months to 2 years, and if all goes according to plan, the scene will be set for an exciting era in the evolution of VR on this side of the Atlantic. It is therefore encouraging that British Industry has taken, arguably, the first and most difficult step in adopting a radically new technology, helping to establish a national "try-before-you-buy" and risk-sharing project in order to judge the technical and commercial viability of VR before investing further.



Virtual model of part of Rolls Royce Trent 800 aero engine, hosted on Silicon Graphics Onyx system running Division dVS software. It shows a simplified version of the lower bifurcation assembly of the Trent 800

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