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DECEMBER 1990 £1.60

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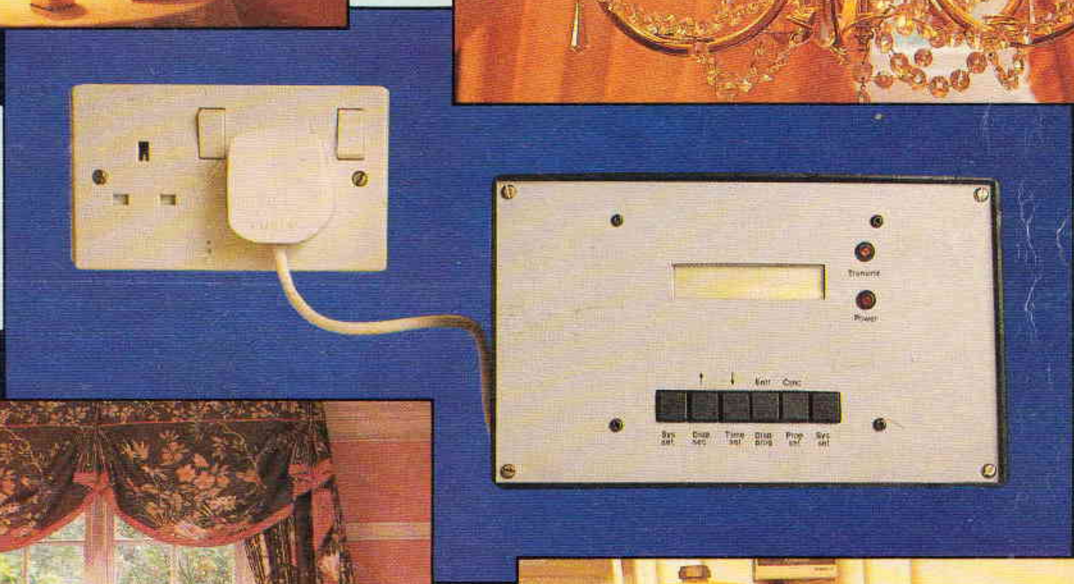
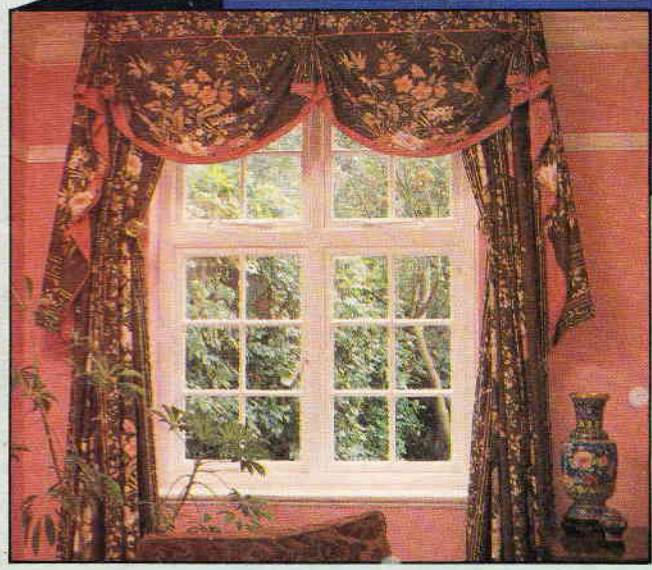
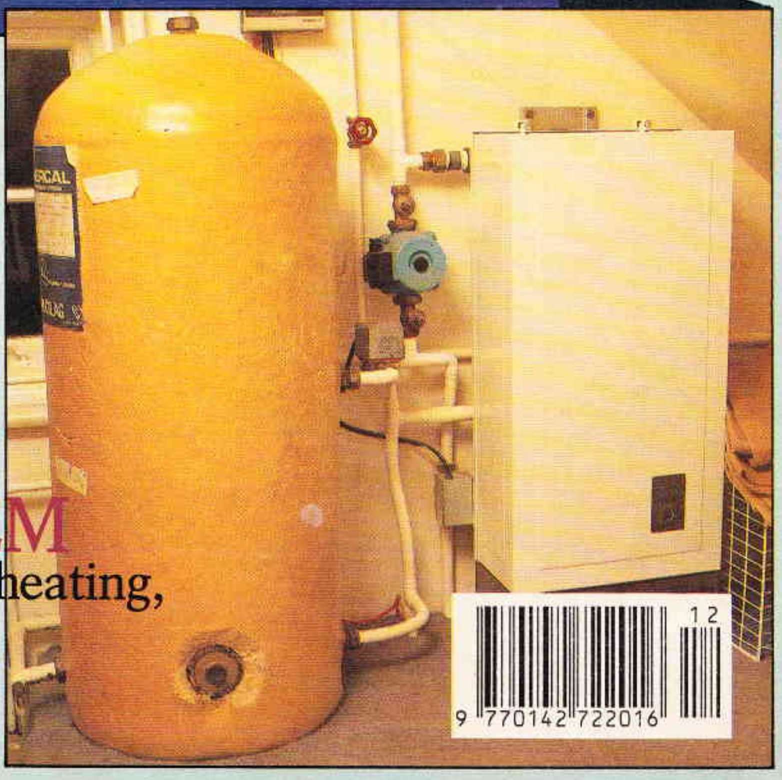
INFRASWITCH Local electrical control







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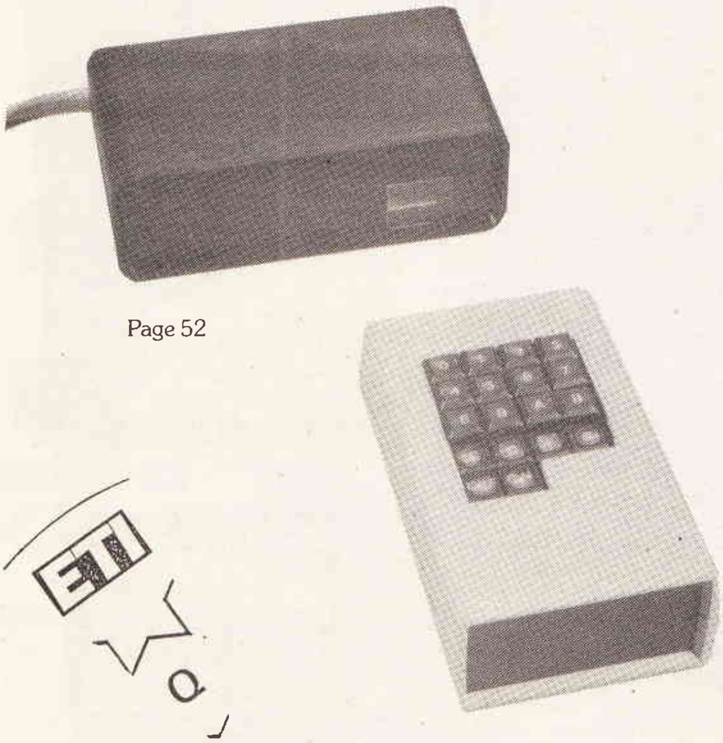

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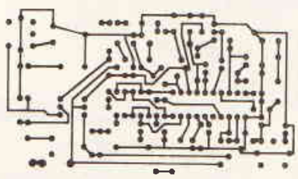

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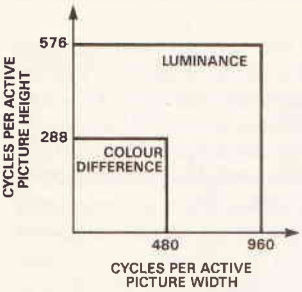
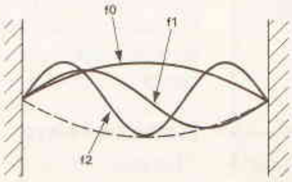
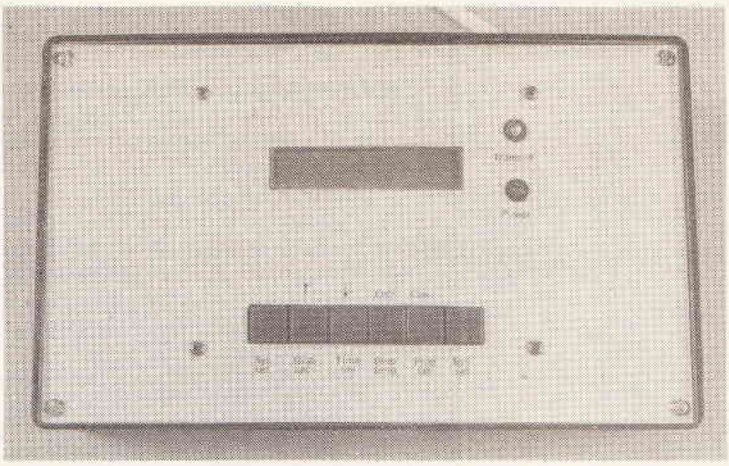




AXIAL MODES – DEVELOPMENT OF HARMONICS



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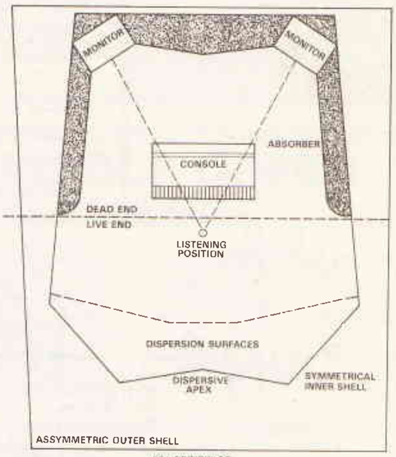

LEDE PRINCIPLES

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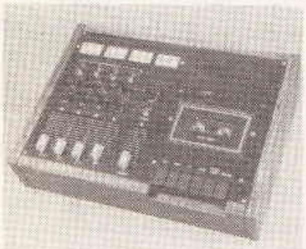

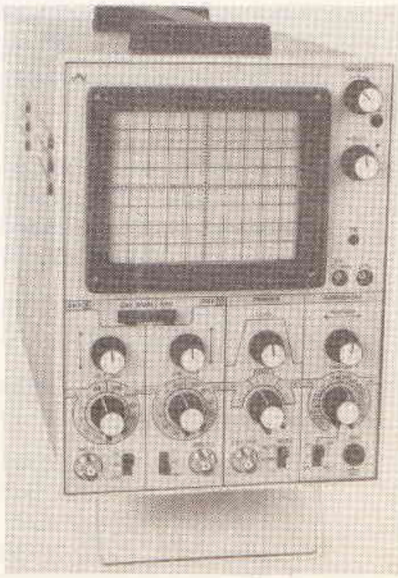

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BLUEPRINT

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

An enquiry from overseas states:

Dear Blueprint,

My hobby is making knife blades using coal, forge, hammer, and anvil. I want to use modern steels which need a much slower rate of cooling than more traditional varieties to permit them to be filed at room temperature. To cool a blade from 900°C to room temperature at 10°C per hour, I intend to use a shoebox sized electric furnace. The power rating of the electric heating element is 2kW, 240V.

I need a circuit to decrease the power to the heater from full to zero over a 12 hour period. I hope that by using a slow enough cooling process I will be able to avoid the need for a much more expensive thermocouple controller.

Yours sincerely, Woodson Gannaway N5KVB/EA.

Taking last things first, a thermocouple control system need not be prohibitively expensive. It would involve more circuitry, but should work better. I will first show a design which simply decreases power over about 12 hours, and in the next Blueprint I will show how to add a thermocouple temperature control loop to improve the performance.

There are several snags to the scheme as it stands. First of all, you have made the implicit assumption that a heater power of 2kW will keep the interior of the furnace at 900°C. This may not be true, if the thermal resistance of the insulation is higher or lower than you imagine. It is true, you will start by dissipating 2kW over the surface of something the size of a shoebox. The surface will become hot enough to radiate and convect 2kW into the surroundings. At best this would make the room too warm in summer, at worst there could be a risk of fire.

I would suggest the use of better thermal insulation, but regardless of the temperature of the outside of the box the maximum heater power must be chosen so that it just keeps the interior of the furnace at 900°C at the start of the cooling run. Under these circumstances it would take a long time for the furnace to reach 900°C, so it would be desirable to have extra power available to heat the furnace quickly, followed by a lower power setting to maintain the required temperature. The start of a cooling run would then, perhaps, see the heater not at full power but at half power.

Burst Firing

There are two obvious ways to control the power of a heater. The first is to phase control it after the manner of a light dimmer, the second is to switch it on and off for varying periods to average the correct power. There are two good reasons for using the latter technique.

First of all, to phase control such a high powered load would generate severe radio interference which would necessitate the use of substantial filtering components. Secondly, varying the triggering phase linearly over a half cycle does not vary the power linearly, but varies it much more rapidly near the peak

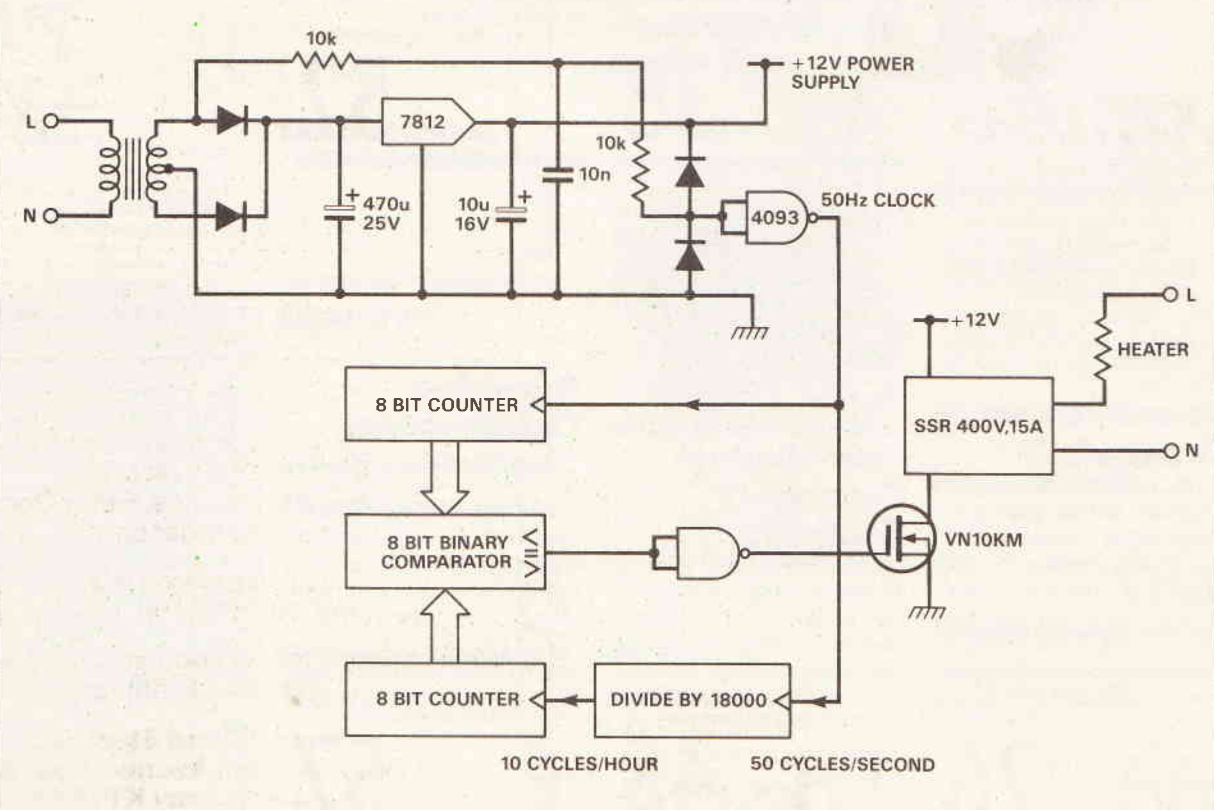


Fig. 1

of voltage. On the other hand, varying power on time over a longer period does vary average power linearly.

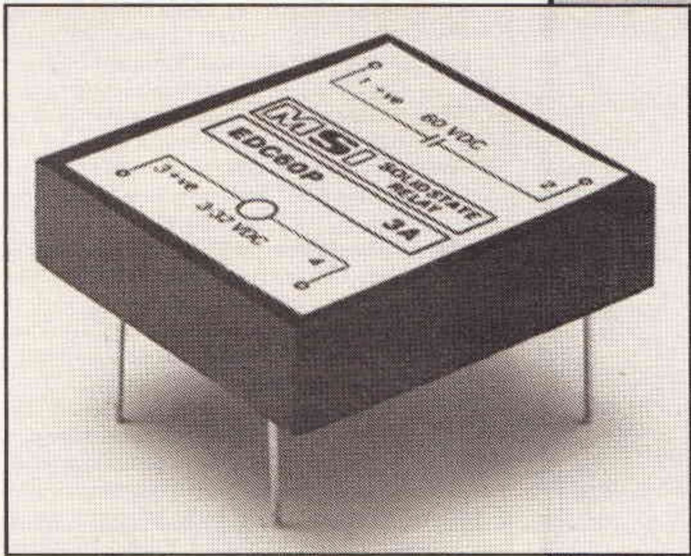
To control the heater, a solid state relay (SSR) is probably the best choice. One could use optotriacs and power triacs with a snubber network to save a little money, but an ssr is more reliable and dissipates less power, so needs a smaller heatsink. The simplest way to control this would be to use a 555 timer to make an astable oscillator with a period of a few seconds. The mark:space ratio could be adjusted by potentiometer, and an alarm watch set every half hour could be used to remind the operator to turn down the power a notch. This could be a useful way to test the thermal characteristics of the furnace before building the complete controller.

Digital Control

One could use an analogue voltage to control the mark:space ratio of an oscillator, and automatically reduce the voltage over the 12 hour period. The voltage would probably need to be controlled by a digital counter and a DAC (digital to analogue converter), so it is better to use digital circuitry throughout.

Figure 1 shows a block diagram of a suitable system. A 50Hz clock derived from the mains is used to count an 8-bit counter round and round continuously. A binary comparator compares the output of this counter with that from another similar counter clocked ten times per hour. Only when the count from the upper counter is less than that from the lower one is the SSR switched off, so that when the lower counter is at 00000000 the SSR is always switched on. When the lower counter reaches 00000010, the SSR is on for 126 mains cycles each 128.

The power reduction continues as the lower counter is counted up, and when the lower counter reaches 11111111 the SSR is only switched on for one cycle each 128. Extra circuitry is needed in a full design to prevent the lower counter from counting round to 00000000 again, and to force the SSR to remain off all the time when the lower counter is at 11111111. The detailed design, including this circuitry will be covered next month.



OPEN CHANNEL

Round about now, that is mid-November, the Department of Trade and Industry is due to release a consultative document which gives detailed plans for the UK telecommunications industry. Although this is merely a consultative document, we can more-or-less take it as gospel. What Government wants, Government normally gets!

In conjunction with UK telecommunications watchdog Oftel, the Department of Trade and Industry has considered the UK market and come up with its plans for the future. At the time of writing, you'll understand, these are not known but it's not too difficult to work out along what lines these plans are likely to look like.

The Government is likely to want to change the current duopoly situation, in which British Telecom (with the lion's share of the market — some 90% of all inland telephone calls) and Mercury (most of the rest) effectively control the UK telecommunications market. As I've argued many times in this column, this is neither fair to potential competitors, nor is it good for the customer. True, we have the option to use Mercury if we want and make use of its cheaper long-distance call system (I've used it for over three years now and calculate it saves me around £100 a year; not a great amount, but enough to make it well worth my while) but customers still have to go out of their way to do it.

How the Government sets about this task is less obvious. A number of contenders have been lobbying Government to allow other telecommunications network providers to sell spare capacity. Several networks already exist around the country — cable television networks, private organisations' communications networks and so on. One of these network providers is British Rail which has a huge telecommunications network of its own, based around its railway communications systems. For a while, BR has been advocating licensing a number of *specialised telecommunications operators* (STOs) of which BR would be one. These would be able to provide, so the argument goes, complementary telecommunications services in the areas where this is most needed, without the massive investment and duplication of services required if more *public telecommunications operators* (PTOs) like BT and Mercury are licensed. BR's network covers every major town and city throughout the UK, so would be in a strong position to apply for such a licence. A question arises though, in that should such network providers be allowed to offload their spare capacities onto an unsuspecting public. Far from making telecommunications industry more competitive, this could simply make it harder for real tecommunications network providers (ratepaying shopkeepers, by the same analogy) to make an honest, taxed, pound. On a personal note, I think it may be better if BR concentrated on getting its railway network in order, before it starts making late telephone calls!

Cable television providers should be aware that if they are allowed to transmit telephone signals, British Telecom should, quite fairly, be allowed to transmit television signals. This will create something of a shake-up. Cable television providers have to invest highly significant sums of money, laying cables means digging up roads and providing lines to each and every potential customer. This cost must, initially at least, be borne by the provider but eventually and inevitably it is passed on to the customer, in the form of network charges.

Cable television providers are already allowed to transmit telephone signals as agents of BT or Mercury, but as you might expect, the telephone companies take the greatest part (around 90%) of the profits. What the cable television providers want of course, is to be able to be allowed to transmit telephone signals as their own agents. This will give British Telecom and Mercury a headache because a television network system that is allowed to piggyback telephone calls is bound to be, (when all costs of providing the network have been recouped), a cheaper method of providing a telephone network. In such instances, it's easy to visualise how some of these network providers will not bother to set-up their own telephone switching systems, instead would allow BT or Mercury to provide services via the television network for a fairer split of the profits — say, 50-50. However, several cable television providers are owned and run by US telephone and entertainments organisations which could well set up their own telephone switching systems.

Although most of British Telecom's local lines aren't capable of allowing transmission of television signals (which require a greater bandwidth than a telephone signal), there is still a proportion that can. BT is currently well into a policy of changing existing local lines to suit. Consequently, it is feasible BT will be prepared to offer television services if it's allowed to. It is feasible that television services will be offered very economically to customers as this will be piggybacked onto its telephone network.

So, this is a vital area in which the Government once and for all, is going to have to make a definite choice. If it decides British Telecom can transmit television signals, cable television providers are going to face an extremely hard time — perhaps facing potential disaster. However, to ban BT from doing so is unfair if a policy of competition is to be desired. I'm only too pleased I don't have to make the decision!

ETI NEWS

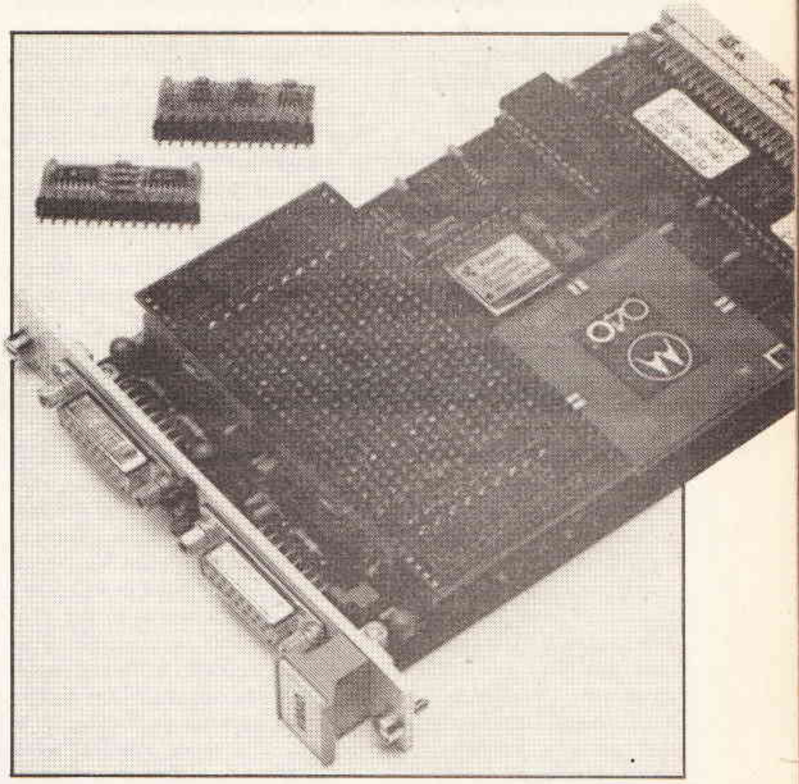
VM40 68040 WITH 20 MIPS ON 3U VME

PEP Modular Computers has introduced a high-performance CPU based on the 25MHz 68040 with 20 MIPS and 3.5 MFLOPS. The VM40 provides full software compatibility to existing 68000/68020/68030 applications, it offers about four times the performance of a 68030. The 25MHz HCMOS 68040, is clocked internally with 50MHz, hosts 4 KByte instruction and 4 KByte data cache as well as an on-chip FPU with 3.5 MFLOPS and a Paged Memory Management Unit. Similar to a RISC processor, the 68040 is capable of executing several instructions with a single cycle and includes bus snooping for cache coherency.

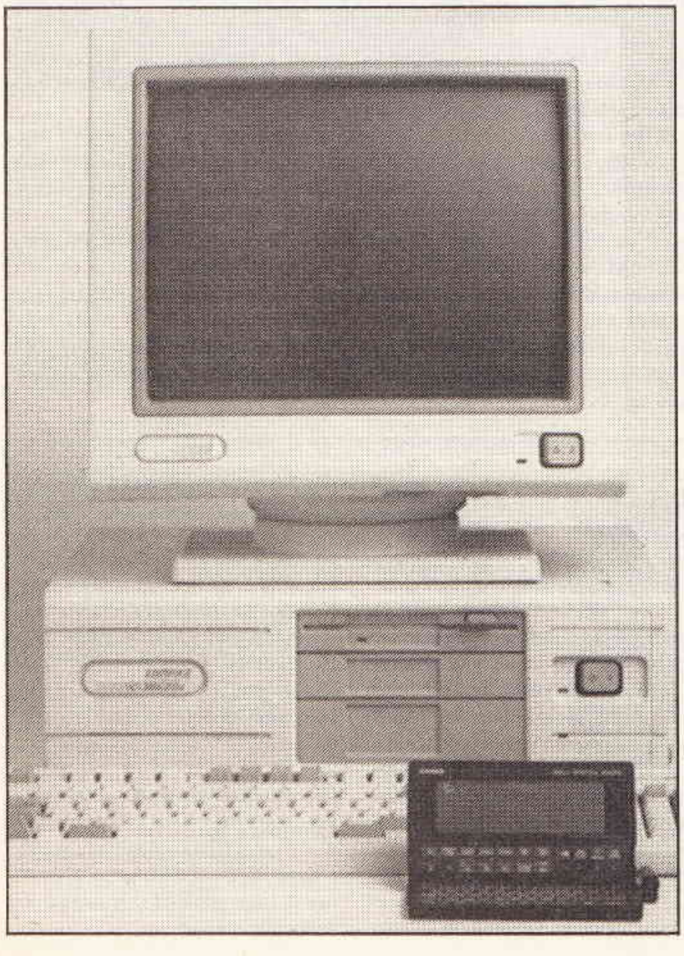
For high-end applications the VM40 is equipped with 4/8/16 MByte of 32-bit wide CMOS-RAM supporting burst fill mode (3/1/1/1). The initial version is planned with DRAM, however local memory modules may be configured for single-ported or dual-ported SRAM with battery back-up. As the memory modules are self-configuring, no PAL change of jumpers are required to upgrade any memory configuration. The two 32-pin sockets for up to 1 MByte ROM are configured with a PEPbug debugging monitor in standard deliveries. In addition, application specific parameters may be stored in an optional EEPROM with 8 KByte capacity.

The complete economic high-performance CPU is implemented in CMOS with less than 7 Watts and occupies only 1 slot (3U) in a VME rack.

Contact: PEP Modular Computers UK Tel: 0273 423915



PC LINK FOR DIGITAL DIARY



Casio Electronics have introduced a new interface package, Datalink 200, which allows their Digital Diary to be hooked up to all IBM-PCs and close compatibles from 512Kb RAM upwards.

Datalink 200, compatible with the IBM PC/XT, PC/AT, PS/2 and close compatibles including all Amstrad PCs, enables the transfer of information stored in the Digital Diary, providing a convenient and fast method of processing large amounts of data.

Using the PC, data can be edited and updated, stored on disk for archiving or back-up security, printed out, converted to other formats and, transferred back to the digital diary.

Datalink 200 is priced at £89.95 and comes as a ready-to-run package, comprising a self-powered, smart communication cable with RS-232 connector, a 9 to 25-pin AT adaptor, software on 5¼" and 3½" disks, and full instructional manual.

Datalink 200 can be used with four out of the five-strong range of Digital Diaries, which includes the top-of-the-range 64Kb SF-9000 with IC card expansion.

For more information contact Tony Manton, Casio Electronics, Tel: 081 450 9131

LONGER LAPTOP LIFE

A new longer lasting battery system specifically designed for the portable laptop computer market has been launched by Gates Energy Products.

Already available in the USA, the C2500mAh battery allows up to four hours of running time — a 25% increase in capacity over previous battery systems used in the field.

The C2500mAh could have a significant impact on the laptop and portable electronic equipment industry.

Further information contact: Gate Energy Products, Tel: 0483 757505

ASTRONOMY WEEK

It is National Astronomy Week between 17th-24th November 1990 and if you have ever wondered what astronomers find so fascinating about the night sky, this will be your chance to find out.

During National Astronomy Week there will be hundreds of locations throughout the UK and Ireland, ranging from small amateur societies; to large professional observations, inviting you to see for yourself the celestial bodies in the night sky. On show will be our near neighbours the Moon with its craters, the 'red planet' Mars, and giant Jupiter with the four moons that Galileo discovered. Farther afield there are nebulae — enormous patches of glowing hydrogen gas — and galaxies containing thousands of millions of stars.

There are also many indoor events organised — exhibitions, talks, and slide shows — in schools and colleges, observatories, leisure centres, museum, and planetaria.

The same week sees the launch of the Dark Skies 2000 campaign. These wonders of the night sky are becoming more difficult to enjoy in urban areas because of light pollution. Astronomers think that by careful design, light can be directed to the place of interest and will need less power. Any light going upwards is wasted energy that we all pay for. The more light directed upwards, the less we all see in the night sky.

For information on National Astronomy Week events in your area contact Linda Simonian, The NAW Coordination Team, The Astronomy Centre, Todmorden, Lancs, OL14 7HW, enclosing an SAE, or telephone 0706 815816.

PC PROTECTED

Anyone who knows how to use a PC can read and copy confidential files, personnel records and commercially sensitive information all too easily, leaving no trace of a breach of security. A new data security system called 'Policeman' prevents this risk. An additional benefit is that as well as protecting PCs it can also be integrated with other security products — to control access to buildings or departments, for example.

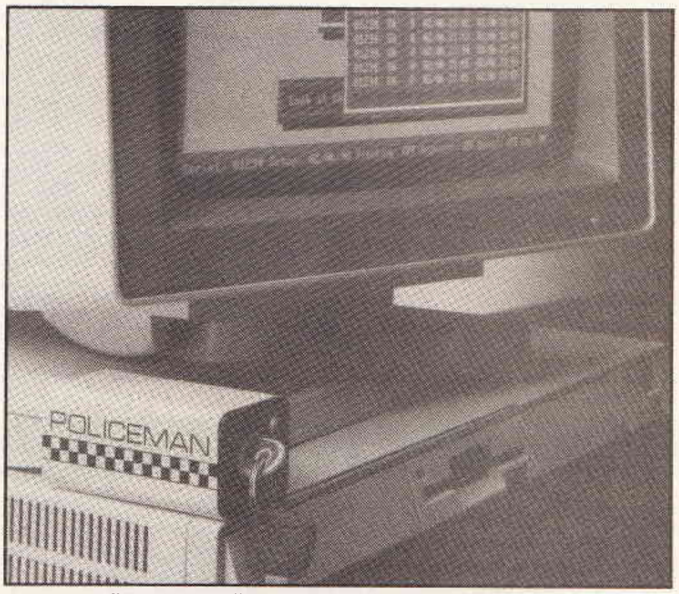
Developed by Plus 5 Engineering Ltd of Crowborough, the system can protect any IBM XT, AT or compatible personal computer. Policeman gives equal protection to all files held on the hard disk. As a result, security classification is not required: all files have maximum security.

Furthermore, management has the assurance that protection does not depend on PC users choosing whether or not to observe a security routine; they have no choice. The system is automatic and there is no 'back door'.

The main part of the hardware is a small external enclosure which is connected to the PC via an internal interface. The enclosure contains a device which can read specific information stored within an electronic tag, and a PIN number and password, allows access to the PC. The 'PlusTag' (as it is called) is small, smooth, light and neat enough to be carried on a keyring or attached to the user by a cord. The outer stainless steel panel can be etched or engraved for identification.

To access the computer and read the files users must insert their PlusTag and enter their PIN number and password. No other form of access is possible. For additional protection every attempt to access the computer is automatically logged. After three successive false attempts an alarm like a police-car siren is sounded. This feature is a strong deterrent against attempted unauthorised access.

Extra security is provided by an option allowing the user to encrypt all data on the hard disk. Before this process can be initiated the system asks the user if a back-up copy of the hard disk has been made. 'Policeman' then

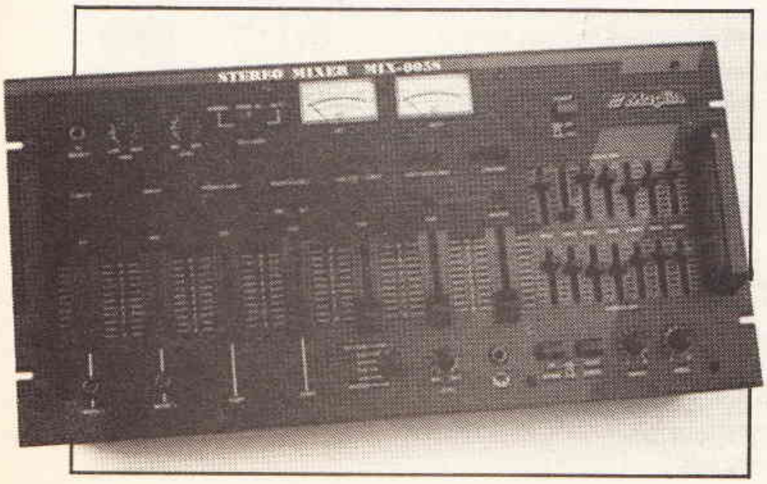


automatically encrypts all the data on the hard disk.

This scrambling process includes COMMAND.COM and the whole boot sector; so the hard disk cannot even be booted without the use of the Policeman PlusTag, PIN number and a valid password. Decrypting is automatic when the authorised PC user reads the file. The back-up file can be in either encrypted or decrypted form.

Another option secures the system for individual users during a work session. If the user wants to leave the PC, even for a moment, removing the PlusTag instantly blanks out the screen and disables the keyboard. Reinserting the PlusTag enables work to be resumed.

Contact: Plus 5 Engineering Ltd, Tel: 0892 663211



STEREO DISCO MIXER

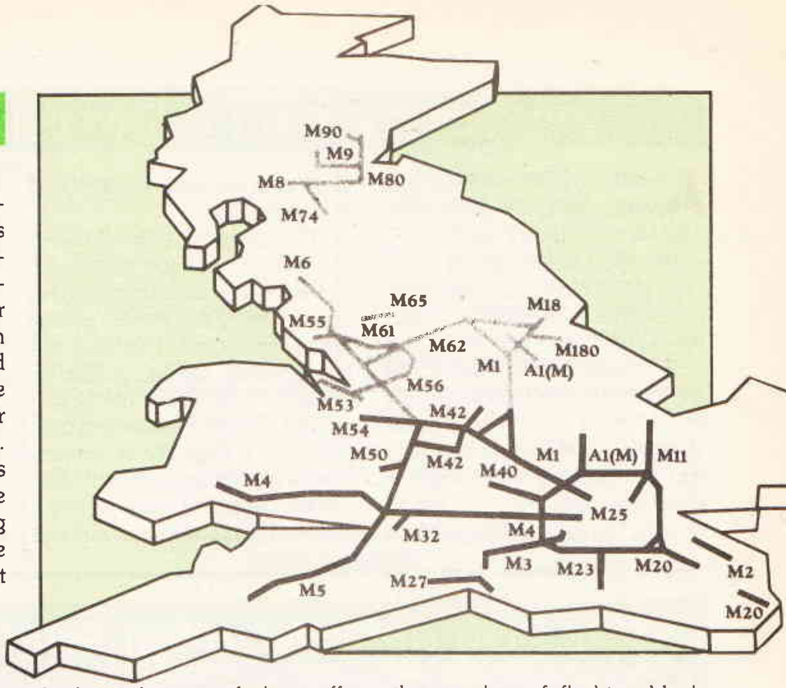
The Maplin 6-Channel audio mixing desk, primary intended for use in disco applications, is guaranteed to raise the roof and amp levels. The red and black stereo mixer has six main input channels, each with preset level and slide fader controls.

Channels one and two are microphone inputs with switches to select low or high level inputs. Channels three and four and turntable/line level inputs are switch selectable. A feature of channels is the provision of auto start outputs for turntable. Channels five and six are CD/line level inputs.

A DJ microphone input with tone, level and talk-over is included and a headphone monitor output with level control is provided.

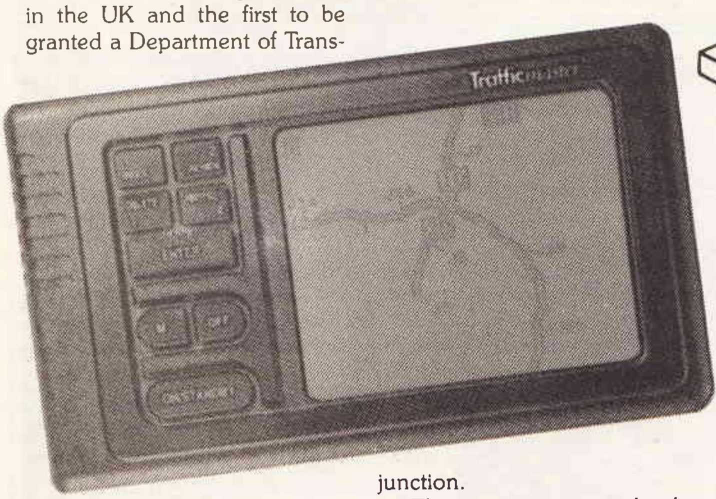
Two seven band equalisers are provided to equalise outputs to suit room acoustics. The mixer also has a BBD echo circuit that can produce effects ranging from rapid 'slapbacks' to reverberation and discrete echoes.

A JAMMY DODGER



On September 3rd the Secretary of State for Transport, the Right Honourable Cecil Parkinson MP, officially launched Trafficmaster, a new system to try and beat the jams developed by General Logistics PLC, a Luton-based company.

Trafficmaster is a real-time traffic information system, developed to provide motorists with up-to-the-minute information on motorway traffic problems. Designed and built in Britain, it is the first in-car information system to become commercially available in the UK and the first to be granted a Department of Transport licence under the Road Traffic (Driver Licensing and Information Systems) Act 1989.



For years motorists have suffered the effects of traffic congestion on our increasingly over-crowded motorways. Apart from the stress and frustration caused by sitting in a jam, motorway traffic congestion costs British business millions of pounds every year.

The problem has been compounded by the fact that drivers have been starved of really accurate motorway traffic information. Radio reports and other forms of traffic information can take between five minutes and half an hour or more to reach the motorist, by which time the driver may already be stuck in a jam. More to the point the driver has no way of knowing how far the tailback stretches or the waiting time — in fact there is no choice but to sit and wait for the next junction.

The new system provides the motorist with accurate information on the speed, direction and length of any tail-back, enabling the driver to assess the situation and take avoiding action before getting stuck in the problem area in theory. As General Logistics Managing Director, David Martell, commented that: Trafficmaster is the first system to provide drivers with a more recent 'birds eye' view of the traffic situation on our motorways.

Trafficmaster works by having over 230 infra-red sensors mounted on motorway bridges at approximately two miles intervals to log the speed of traffic passing below. If the speed drops below a pre-set threshold of 25mph — the sensors relay that information via a radio link to the General Logistics Control Centre at Luton. From there the data is transmitted via the Air-Call Paging radio pager network to a Receiver Unit mounted on the dashboard of the vehicle.

The Receiver Unit displays the information on a screen in map form, giving the driver an audible and a visual signal when updated information is received. Trafficmaster then zooms in to a close-up map of the area where the problem is occurring — a flashing block shows location, speed and direction of the hold-up while the number of flashing blocks denotes the length of the tail-back. Trafficmaster updates information every three minutes.

The Unit can be programmed to begin updating information before the motorist sets off. Selecting the zone of the motorway for which information is required before setting off, the drivers hands need not touch the unit for the rest of the journey. Pre-selection of the zone also prevents the motorist being alerted to problems which are irrelevant to his planned route.

Cynics might say that when the majority of motorists have such a system fitted to their cars the jam will transfer itself somewhere else, the result of motorists taking similar avoiding action. Also the technology could be available to detect maximum speeds from the infra-red sensors as a secondary function in the quieter periods!

LOW COST CAMCORDER

Amstrad intends to complete its 1990 leisure product range with the introduction of a new high spec camcorder. The launch of the under-£500 Amstrad Videomatic VMC200 follows last year's VMC100, which tested the camcorder market with a low price, simple to use model.

The Amstrad Videomatic VMC200 has been designed in the UK and is made in Japan by Amstrad subcontractors. The 3.5kg unit will retail in the UK at £499.00 including VAT, and will be available in the UK, Holland, Italy and Spain in October.

Features include a 6:1 power zoom, a 1/1,000th second fast speed shutter, a back light compensator and an electronic viewfinder with playback facility and automatic focus.

Other features include a long play facility (up to 60 minutes), a macro facility for sharp close ups, a 3 setting white balance control, a date/time feature and a fade-in/fade-out recording facility which gives a soft fade at the beginning and end of each recording to avoid sharp joins on recorded tape.

FINNISH ELECTRIC CAR FINISHED FIRST

An electric car developed by a consortium comprising Imatran Voima, Neste Corporation, and Lokari recently won a European urban road trial competition held in France. Driven by Jouko Ryynanen, the Finnish 'Elcat' prototype covered a total of 270 kilometres and 90 metres during the 12-hour trial. The French Volta 90, which won the competition last year, finished some 4 kilometres behind the Finish winner. The Renault Master came third, over five kilometres behind the winner.

The Elcat is a totally new model and has been developed by the Finnish consortium of the basis of the partnership's earlier Finvan prototype. The Elcat will be unveiled to the public in Finland at the end of the year.

The 12-hour competition took place in La Rochelle in western France last weekend. A total of 20 electric vehicles from France, Belgium, Germany, and Finland took part in the competition. The majority of these were vans designed for carrying freight.

The 2-day competition comprised two 6-hour periods of uninterrupted driving, one on each day, on normal roads of about 8-kilometres in length. Speeds in the congested medieval centre of La Rochelle were low. A number of faster stretches were also included to ensure that the route matched typical urban driving conditions. Competitors were allowed the opportunity of charging their vehicles as needed during the competition.

The successful prototype was powered by a conventional lead-acid battery manufactured by Neste, which proved the most efficient during the competition. The three runners-up were fitted with nickel-cadmium batteries costing some four times the price.

TIME FOR BIRMINGHAM SUPER PRIX

Teams at the Birmingham Super Prix, the annual race around the streets of Birmingham, benefit from a sophisticated timing system incorporating the Concept Keyboard Company's touch sensitive keyboard. Over half the participating teams receive essential information on their own and competitor's lap speeds from the 'ComputeRace' timing system.

An A3 sized Concept Keyboard with touch sensitive keys forms the basis of the ComputeRace which is connected to an IBM PC or compatible and a printer.

The harsh race track environment makes a conventional keyboard unsuitable for this type of data entry. With cars flashing past at up to 180mph, a fast and positive data entry system is essential.

The Concept Keyboard allows a selection of information to be displayed, from numbers of laps and pit stops made to current lap time and the gap between each car and the leading car. The system can time up to 48 cars in a single race. For each race or practice session, an overlay is placed on the keyboard and a segment assigned to a particular car. As the car passes, the operator touches the relevant key and the time is entered into the system. For greater accuracy, an optional timing beam can record the time while the pad identifies the car.

The complete system, housed in a compact unit, can be plugged into a convenient power point or 12 volt car battery.

Further information contact Paul Goddard, Tel: (0962) 843322.

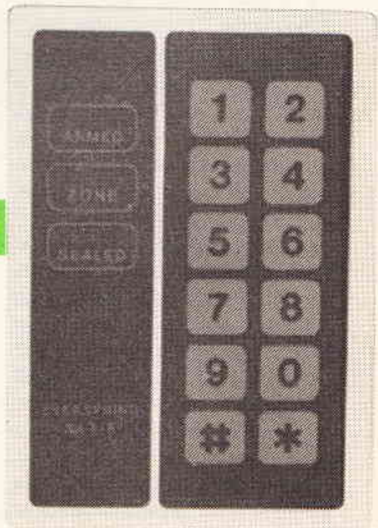
COMBOLOCK

The Maplin intelligent keypad is a high security keypad that will find many applications in security and areas that require restricted access. It can be used in place of a key to control an alarm panel, locks, and access devices like doorphones.

The multi-function pad is even more secure than a key operated system since it can provide up to four user codes controlled from one master code, key time out and wrong code lock out. It allows zoning and can operate a panic alarm. It also has its own tamper alarm.

The unit can be used with either surface or mortice locks and the mechanism is supplied with two strike plates to suit both types of lock. The lock mechanism itself is not supplied. Connection to solenoid coil is via two screw terminals. The unit requires a cavity of 102×21×29mm for mortice locks.

The unit requires a 12V DC 25mA supply

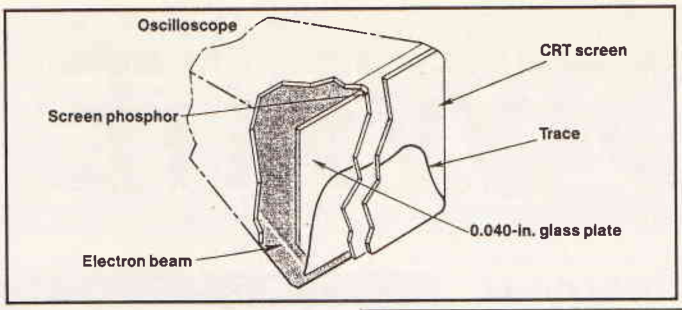


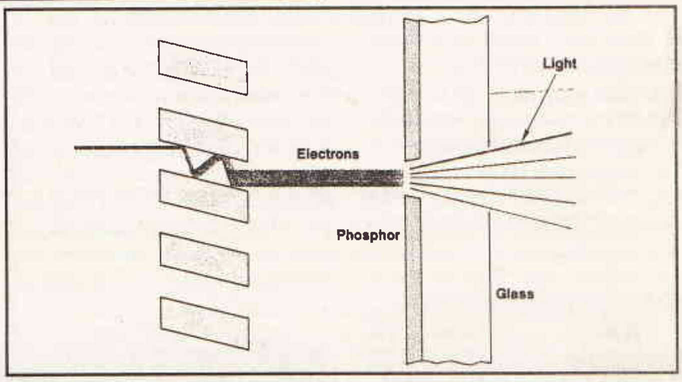
ETI NEWS stateside

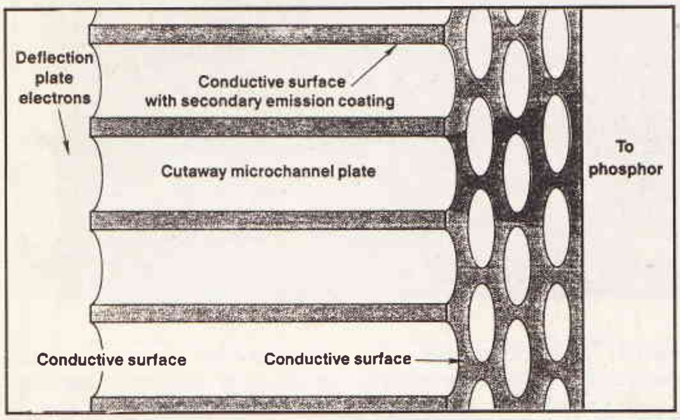
Intensifying Random Signals

High repetitive rate signals occur in laser pulses, radar, and digital and communications data. An oscilloscope can easily miss infrequent spikes that occur in the presence of these signals. Random transients arise from trigger failures, noise spikes, surges, and cross talk.

Because these signals are infrequent, their trace is too dim to be seen against the strong, repetitive signals on the scope screen. It is now possible to intensify such random signals and make them easier to see by adding an electron-multiplying microchannel plate behind the CRT phosphor. This 0.04in. thick glass plate contains closely spaced channels set at an angle to the electron beam axis. Angled channels ensure that electrons must strike interior surfaces before leaving.







Select materials and special processing enable the micro channel plate to generate secondary emission electrons as incident beam electrons bounce through the microchannel. Many more electrons consequently leave than enter the microchannel plate. An easily visible trace results as there are now sufficient electrons to excite the screen phosphor.

With high repetition rates, the same microchannels saturate. Electrical characteristics of the microchannel walls curtail electron multiplication. Thus bright traces are limited to comfortable viewing levels. The combination of beam amplification and output current saturation is known as adaptive intensity.

Called the BrightEye Transient-Intensifying oscilloscope, it uses the microchannel plate to display a 1Hz fault in a 1MHz signal in 2s. The 2467B BrightEye portable has a visual writing speed of 4 div/ns and 400MHz bandwidth. Laboratory BrightEye models 11302A and 7104 offer even higher writing speeds and up to 1GHz bandwidth.
Source: Tektronix Inc., Beaverton, Gregon.

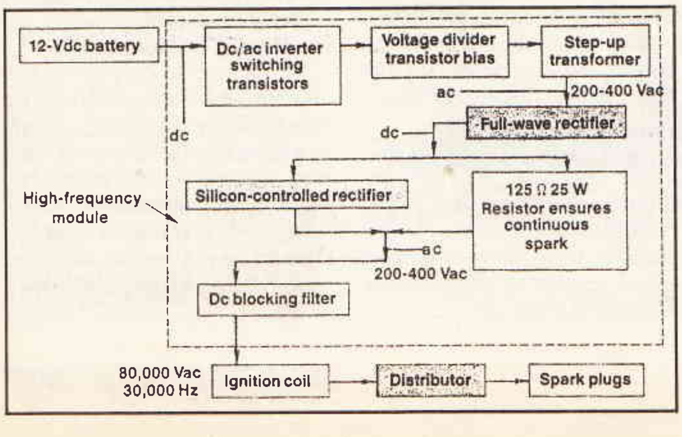
New ignition system

In automatic engines conventional spark ignition starts combustion and dies out early in the power stroke which leaves unburned hydrocarbons and carbon monoxide.

In contrast, a new system called single-spark ignition generates a high-frequency AC arc that remains throughout the power stroke. The result is more complete combustion that makes catalytic converters obsolete.

The Zivkovich ignition system for vehicles consists of a high-frequency module that delivers between 200 to 400V AC at 30Hz to the ignition coil. The coil boosts spark-plug voltage to 80,000V AC. Two switching transistors in the inverter use a voltage divider and step-up transformer to convert 12V DC to 200 to 400V AC. A full-wave rectifier transforms AC to pulsating DC. A resistor in parallel with a silicon-controlled rectifier ensures continuous output to the high-frequency module during spark distribution. The parallel rectifier converts DC to AC, and DC-blocking filter stabilizes the final waveform.

Inventor is Zivkovich Associates, Grantham, New Hampshire. The system operates on both fuel-injected and engines with carburetters.



Melting ice on a windscreen

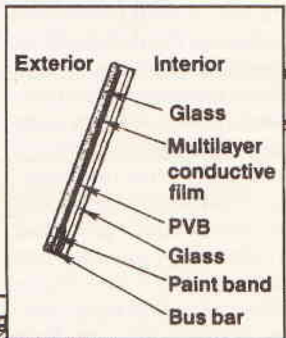
To melt 0.1in of ice on a car windshield takes 1500W and constitutes a severe drain on most car batteries.

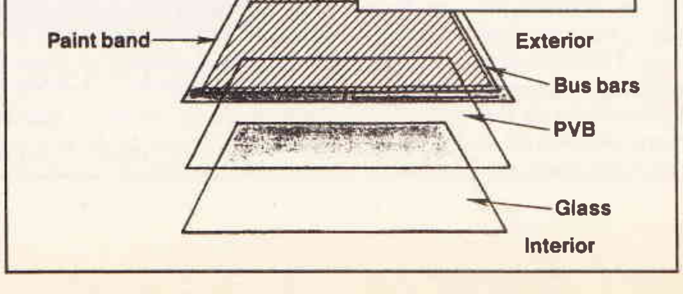
A new dual-output generator avoids the problem by providing a separate three-phase AC outlet for windshield heating. The generator also has a DC terminal supplying the nominal 12V system. At 0°F, the generator can supply 2,200W.

A power module is used to boost three-phase AC input from the generator to a higher voltage, which is then converted to DC for windshield heating. A control module regulates the heating cycle, checks wind shield current, ambient temperature, and DC voltage; and provides automatic turnoff.

But heating bars in the windshield are hidden beneath a paint band.

A thin conductive coating within the plastic-glass laminate distributes heat evenly. The windshield itself has no metallic sheen. The Delcotron generator from Delco Remy works in conjunction with the ElectriClear heated wind shield system from Libby-Owens-Ford Co., Toledo, Ohio.





READ\WRITE

ETI LETTERS

More Amplifier Business

I have been asked by a friend who plays trad jazz on an acoustic guitar with a pick-up to advise him on constructing an improved amplifier. I immediately referred to The Business (ETI March, April, May '90) for guide lines. In this design all the pre-amplification is in a single stage giving of 4.8 or 23 for inputs of 0.5-1.0V or 50-100mV respectively.

However, in your Dec. 1986 issue, "What makes a Classic Instrument Amp" by David Peterson says "The gain requirement is simple: an input sensitivity of 10mV to produce a signal of between 500mV and 2V adequate to drive the power amp. Less apparent is the headroom. The signal whose mean value is 10mV can have a transient maximum up to 500mV". If this is true, we are in deep trouble even at 10mV, since 23 times 500mV is 11.5V RMS = 33V pk. At 50-100mV, assuming the same headroom ratio, the situation appears quite untenable.

Could you please offer some helpful comments on this problem since it is clearly fundamental to get the first stages right.

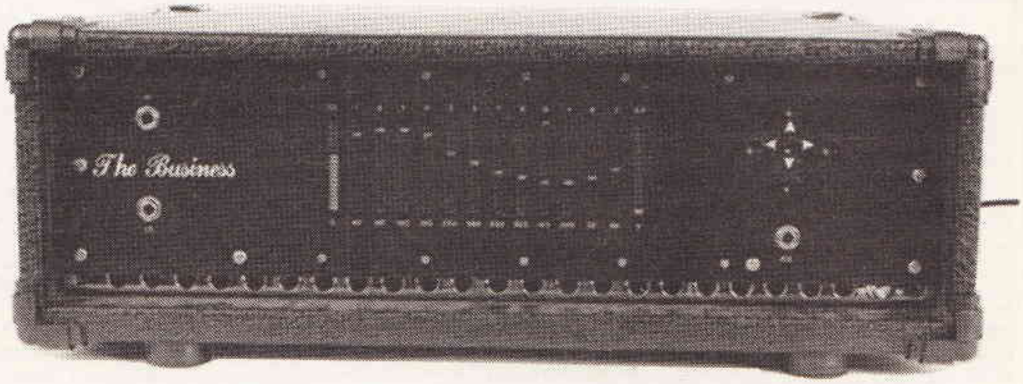
J C Laine, Lymington, Hants.

Bob Whelan, author of the Business Amp replies:

The output from a guitar pick up will depend on many variables, obvious examples being the position and distance from the strings and the gauge of the strings. In deciding the pre-amp gain of the Business Bass amp, I plugged in my bass guitar (a Fender precision with an EMG active pick up) turned the guitar volume up full and observed the output from the pre-amp stage on an oscilloscope. I played normally to obtain the lower output figure and as hard as I possibly could, including slapping the open E string, to obtain the higher output figure. I adjusted the gain allowing a little headroom on the maximum signal produced by the guitar. I repeated this for the high gain input using a Fender Telecaster bass. I have experienced no problems with pre-amp overload. The Business amp was designed for the Bass guitar as it requires a clean powerful sound with good separation at low frequencies.

Six-string guitars requiring are totally different overdrive and distortion, and valve amps rule supreme. Most guitarists turn up until the right amount of distortion is present, giving the sound a nice edge. Solid state amps are too clean sounding for the guitar, and when overdriven into clipping, produce a terrible biting treble sound. Most commercial solid state guitar amplifiers have diode shaping circuits, or secret propriety circuits on the front end in an attempt to emulate the sound of overdriven valves, but with limited success. It would be hard to name a top professional guitar player who does not use a valve amp. In guitar music, such as heavy metal, the Marshal 100 watt valve amplifier dominates the scene. Truly a classic amp. A lot of guitar players also use a compressor pedal to get improved sustain during solo's.

Amplifying an acoustic guitar has its own problems, such as being very sensitive to feedback and a loss of acoustic tone. Acoustic guitar pickups are normally of the piezo-electric type, which have a high output impedance. Attempting to drive an average guitar amp with these pick-ups results in a loss of signal and bass response, producing a sound that can best be described as 'tinny'. Feeding the pickup into a buffer with an input impedance of 1 to 2 Megohms overcomes this problem. One idea to produce good results for an acoustic guitar would be a valve pre-amp with an input impedance of around 1M driving a soft clipping MOS-FET power amp. I wish Mr Laine the best of luck with his improved guitar amplifier project.



Project Ideas

As a keen constructor of the projects in ETI (I am building the superscope at present), and also a keen caravanner, I was very interested in the caravan hot water control unit a while back, which I intend to build. What I was wondering is whether it would be possible to use the circuit given and make adjustment automatic so that the unit would 'look to see what the current was being used for' by other devices and then adjust the water heater accordingly. I thought of this as being useful in a space heater using a thermostat so that when the thermostat was off (or TV/lights) the water heater would increase the current not exceeding 10 amps.

Another possibility for a project would be a complete charger control unit for caravanners and campers, similar to the ZIG units, possibly in modular form, with a 'smart' charger which could charge up the battery but would know whether to use boost or trickle charge. Other suggestions include a battery monitoring system using tricolour leds, a 'night' switch to switch on a 12volt outside light at dusk, and monitoring of water levels in hot water tanks. I'm sure there would be interest in such devices and it could be done as a series although I haven't the ability to design any of this stuff!

Another valuable project would be a good quality mixing desk in modular form that could be built to whatever size was required, with separate mixing channels and a main unit with monitoring and full off-air talkback facilities. Idealy the unit should be 12/24/140 volt operated so that it can be used for outside broadcast away from the mains.

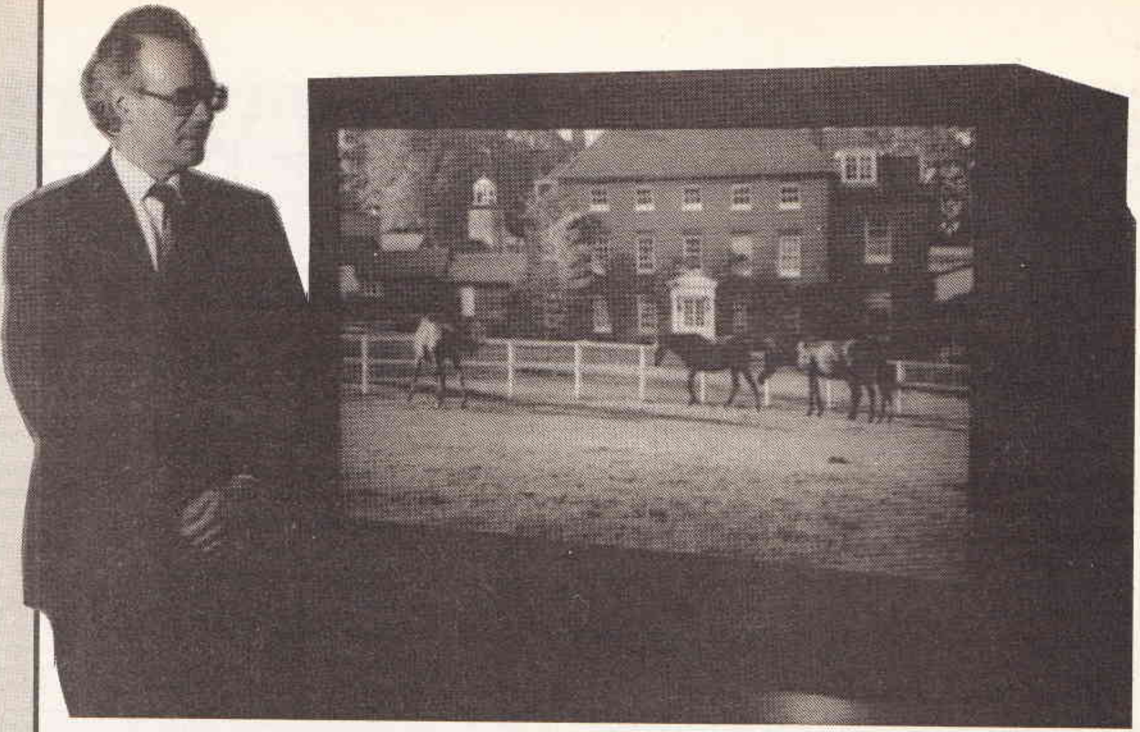
How about a fairly hefty 12V power amp with 100 volt line output, or alternatively a 12DC to 240AC invertor with enough power to drive 300 watts or so of mains equipment. Hope these ideas are of some use.

The magazine is very good but seems to be getting a little short of advanced assembly projects recently, and please don't follow the craze of reviewing tons of high priced MIDI instruments, not all your readers even LIKE music!

Keep up the good work.

Ian Beeby, Bolton, Lancs.

You ask a lot, particularly on the demands of a 12V battery. Don't be surprised if your car will not start after using your creations. Anyway, you suggest lots of interesting ideas and indeed food for thought for our readers to come up with the goods for publication. — Ed.



3

HIGH DEFINITION TELEVISION

Compatible Approaches to HDTV

James Archer now looks at a new TV system for Europe.

There is now a general assumption throughout the television industry that one day in the indeterminate future HDTV will have replaced present day television systems. In the first part of this series we discussed whether or not it was likely that viewers could be persuaded to spend money on higher definition television receiving equipment, especially since there is currently very little evidence that television picture quality plays a major part in a typical viewers choice of programme. The industry is now convinced, however, that the arguments against HDTV are very much short-term ones, since the average life of a colour television receiver is well under ten years, so that between now and the end of the century, which is when HDTV will be becoming widely available, almost all existing viewers will have had to replace their existing television receivers. This means that the decision to buy an HDTV receiver will actually become a decision between buying a conventional receiver and an HDTV set, a marginal decision that may well depend to a large extent upon the price at which HDTV receivers are available.

We have seen already, that there are several major considerations, both technical and commercial, which make it unlikely that there will suddenly be a technological revolution which persuades all the peop.e to throw away their existing equipment and rush around to the local shop to buy brand new HDTV receivers. It is therefore very important to give the strongest consideration to the various ways in which HDTV might be introduced, assuming that in the longer term HDTV will become the normal method of watching television.

In the studies of HDTV that have been going on around the world, three main approaches to its implementation have been prominent. The first approach, typified by the Japanese 1125-line/60 FPS system, is to produce a format with a completely new transmission, that is not compatible with any existing system such as PAL,SECAM, or NTSC. The general idea is that such signals would be radiated via satellite or cable systems, although there is no reason why, in principle,such a system could not also be adopted for terrestrial transmission. New receivers specially designed for the HDTV system would be required to provide the higher quality pictures and sound. Conventional receivers would only be able to make use of these signals if they were to be provided with complex transcoding standards conversion equipment, which would only see the new programmes at a quality determined by the existing receiver.

The second approach, which has proved of particular interest to American broadcasters, is to produce a so-called compatible emission system format. This consists of a signal is compatible with a conventional television system plus an added signal to provide additional information required to produce an HDTV picture. Such systems enable conventional receivers to pick up the compatible part of the programme material from HDTV emissions at the same quality as their normal pictures, whilst viewers with special HDTV receivers can make use of the full quality of the HDTV signal. This type of system can be considered as truly compatible, since an existing viewer needs no adaptor to receive the HDTV programmes, although they are only receiving at the same level of quality as before.

The step-by-step or multi-step systems are those using an improved quality TV system a step towards HDTV, this first step not being compatible with an existing standard. The introduction of MAC systems for satellite broadcasting in Europe can be considered as an example of a first step. Once scene is set for the later introduction of HDTV which is fully-compatible with the new system introduced at stage one.

TVs receiving first-step signals would automatically be able to receive the second-step HDTV pictures, but at a reduced quality, and HDTV receivers would be able to pick-up full-quality HDTV step-two transmissions including first step transmissions.

In this arrangement, conventional receivers would not be able to receive the HDTV transmissions. They could only receive the first step transmissions if a fairly complex adaptor is used, and even then the receivers using such adaptors may not be able to make use of all the technical advantages of the new transmissions. The HDTV set would not be able to receive conventional transmissions unless it was fitted with extra circuitry, but some people feel that this will not be a significant disadvantage since it may take so long for this stage to be reached that conventional transmissions will have come to an end of their natural life. This writer tends to feel that conventional transmissions still have a great deal of life left in them, and the extra cost of including conventional decoding circuitry for PAL signals would perhaps make little difference to the total cost of an already expensive large screen HDTV receiver.

Using this step by step approach it seems that at least three different generations of receiver hardware would be involved:

Step 1 Conventional receivers: Existing 525/60 and 625/50 NTSC, PAL, SECAM receivers.
Step 2 Improved system that retain 525/60 and 625/50 displays (MAC systems, for example).
Step 3 Full HDTV receivers.

There may also be several other intermediate steps introduced, allowing developments such as wide screen enhanced receivers which are capable of improved 525 or 625 line displays, without providing full HDTV quality.

Figure 1, which is based on a drawing from Professor Krivosheev of the CCIR study group which is examining possible routes towards HDTV, gives a broad overview of the various options which will become available as the change from conventional services to HDTV takes place. It illustrates the various linkages that must be taken into consideration between the different elements of the television system of the future, from studio, via the transmission channel, to home.

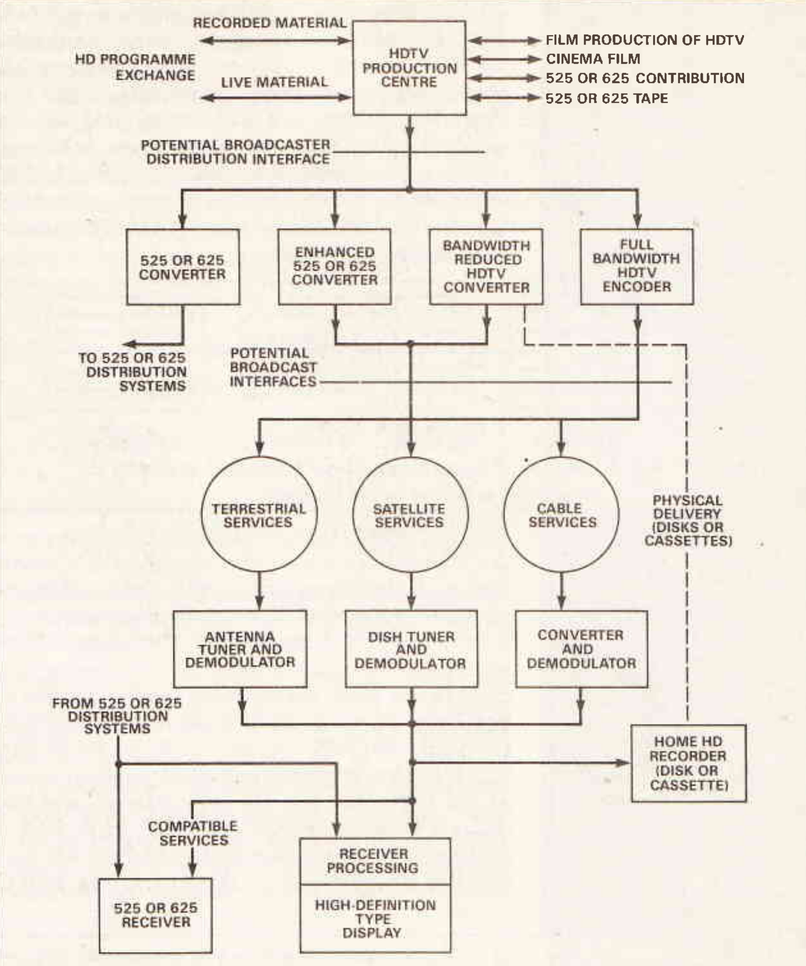


Fig. 1 HDTV Delivery — The future environment (CCIR Report 801-3).

The key part of the future broadcasting environment will be the HDTV production centre which is shown at the top of the diagram. Whilst most of the productions will be made in the HDTV format, it will, not for the foreseeable future, be necessary to use other contribution formats as well, since archival material in 525 and 625 line formats, analogue and digital, as well as films in various formats, will provide much of the necessary programme material.

From the production centre the HDTV programme material will pass to the broadcasting network

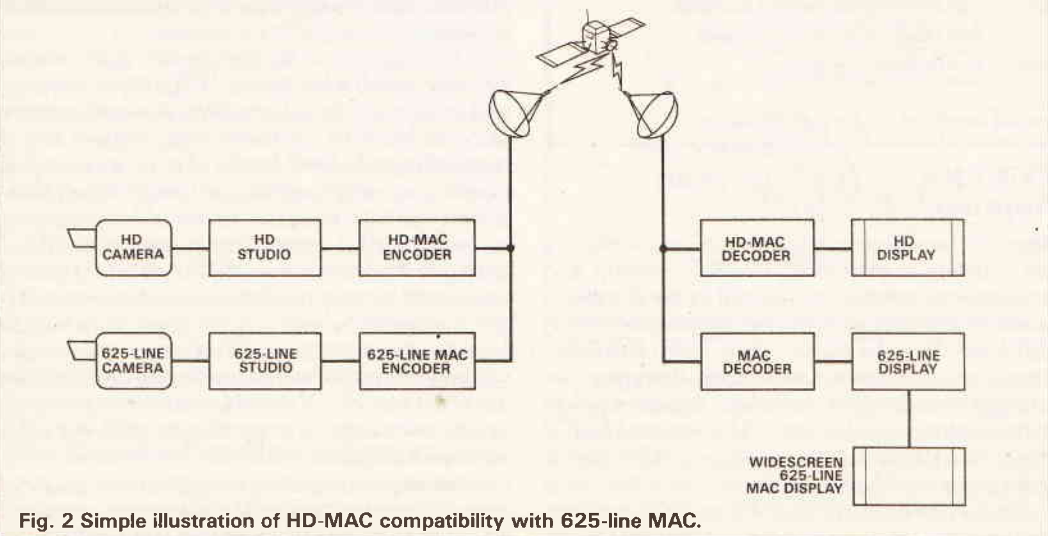


Fig. 2 Simple illustration of HD-MAC compatibility with 625-line MAC.

via a multi-purpose distribution interface, at which point there will be a number of convertors to change the HDTV source signals into the various forms that are necessary for the various broadcast systems. The convertors will provide outputs suitable for the standard 525 or 625-line transmissions, enhanced television transmissions, bandwidth reduced HDTV transmissions, for use over satellites perhaps, and the full bandwidth HDTV signals which may be passed over fibre optic networks.

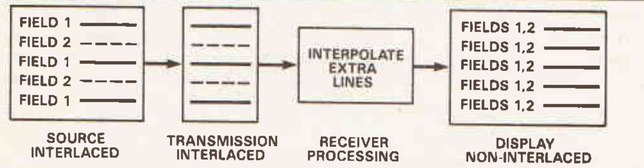


Fig. 3 Principle of unconverting from interlaced scanning to sequential scanning in the receiver.

The outputs from the different delivery systems are then sent to the viewers, and here it is worth noticing that the diagram also offers the possibility of physical delivery of HDTV programme cassettes to the home as one of its alternatives. The quality of the picture that the viewer actually sees will depend to a great extent upon the receiving equipment that is installed in the home. Signal quality could range from full-bandwidth HDTV through reduced bandwidth HDTV to various levels of enhanced television as well as the basic 525 and 625-line services, and the diagram shows that it will be necessary for an HDTV receiver to be able to receive the normal 525 and 625-line transmissions in addition to the HDTV signals.

	SCANNING PARAMETERS	ASPECT RATIO	SAMPLING PARAMETERS		GROSS BIT RATE (Mbit/s) (Y+2C) x 8 BITS/SAMPLE
			LUMINANCE Y	COLOUR DIFFERENCE C	
HDP (1)	1250/50/1	16:9	144MHz ORTHOGONAL (1920 s/apw)	36MHz ORTHOGONAL (960 s/apw)	1728
HDQ (2)	1250/50/1	16:9	72MHz QUINCUNX (960 s/apw)	36MHz ORTHOGONAL (960 s/apw)	1152
HDI (3)	1250/50/2	16:9	72MHz ORTHOGONAL (1920 s/apw)	36MHz ORTHOGONAL (960 s/apw)	1152
EDTV (4)	625/50/1	16:9	36MHz ORTHOGONAL (600 s/apw)	9MHz ORTHOGONAL (480 s/apw)	432
REC601 (5)	625/50/2	4:3	13.5MHz ORTHOGONAL (720 s/apw)	6.75MHz ORTHOGONAL (360 s/apw)	216

(1) HDP = HIGH DEFINITION PROGRESSIVE SCANNING
(2) HDQ = HIGH DEFINITION PROGRESSIVE SCANNING AND QUINCUNX SAMPLING PATTERN
(3) HDI = HIGH DEFINITION INTERLACE SCANNING
(4) EDTV = ENHANCED DEFINITION TELEVISION
(5) REC601 = CCIR RECOMMENDATION 601
s/apw = SAMPLES PER ACTIVE PICTURE WIDTH

Fig. 4 The proposed family of studio standards.

EUREKA — The European Approach To HDTV

After the Japanese proposals in the early 1980s for the adoption of their 1125/60 HDTV system as a worldwide standard were rejected by the European broadcasters, the EBU Technical Committee, which had been studying HDTV since 1981, suggested various ways in which a world-wide agreement on HDTV standards might be reached. A major plank of their proposals was that an 80Hz interlaced HDTV studio standard should be introduced, 80Hz having merit that it would allow relatively simple standards conversion to and from both 50Hz and 60Hz systems. Unfortunately, this idea was not accepted by the rest of the world's broadcasters, and the goal of reaching a common standard seemed to be getting no nearer, as those countries using 60Hz field rates felt that it would be a backward step to adopt 50Hz, and those using 50Hz felt that it would be too much of an upheaval to have to make the change to 60Hz. Even some of the members of the European Broadcasting Union disagreed as to the field rate to be used.

All this gave rise to the formation of a European multi-national research and development project aimed at bringing together interested parties to combine their research efforts in the field of HDTV; the project was named Eureka EU95. The project was the joint initiative of Bosch (West Germany), Philips (Netherlands), Thomson (France), and Thorn EMI (U.K.), but many other European industrial companies and public and private sector organisations also joined, so that there are now over thirty participants.

The main aim of the projects were to propose a compatible HDTV studio standard of the highest quality, suitable for use in 50Hz countries and designed in such a way that the HDTV signals can, in future, be transmitted, but can also be used as the source from which lower quality signals may be derived, which can be carried by present-day satellites, terrestrial transmitters, or cable systems and displayed and recorded with existing receiving equipment.

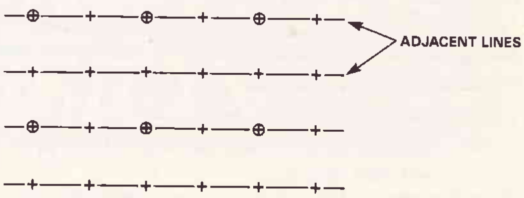


Fig. 5 Luminance (+) and colour-difference (0) sampling pattern for the HDP system.

Another well understood aim was to have this system, rather than the Japanese 1125/60 system accepted as *the* world standard, but as has already been indicated, this aim was much less likely to succeed.

The project did succeed in its aim of submitting a proposed standard, or more properly, a detailed specification of such a standard, to the CCIR plenary assembly in 1990, and of building a full range of equipment to demonstrate that the system really does work. This standard can provide pictures which are a significant improvement on anything seen so far in the HDTV field, and it has also been designed to be readily compatible with film, since it is felt that 50Hz systems are superior to 59.94Hz or 60Hz systems when it comes to transfer to and from film, and to make possible the exchange of programme material between 50Hz and 60Hz countries.

The system is of the step-by-step type detailed above, in which a full-quality HDTV signal is generated in the studio, whilst a specially processed version, know as HD-MAC, is transmitted, a signal that is compatible with MAC family of standards, so that people who have bought the first generation of MAC satellite receiving equipment will be able to make use of the HD-MAC transmissions at lower than HDTV quality. In this sense, compatibility means that existing equipment is not immediately made obsolete as the new transmissions begin; 'old' receivers, (only back as far as the first generation of MAC receivers, though, which in 1990 is not very far back!) will be able to make use of the new HDTV signals, and new receivers will also be able to pick up straightforward 625-line MAC signals. This also means that existing video recorders will not need to be made obsolete, although once again the initial compatibility will be limited, as current video recorders can only record PAL/SECAM/NTSC signals. It is worth noting however that some work has been done to investigate whether domestic video recorders could be made to record MAC signals, and the outcome was that this should present few problems for the manufacturers.

The Eureka HD-Mac approach to HDTV is a genuinely evolutionary approach that will allow viewers to change up to better standards of display as they wish. The key to all this is the realisation that no longer do receiver standards have to be the same as the production studio standards; it is possible to have a very high quality production studio source, and to derive from this a less–good version of the studio signal which may be transmitted over a standard bandwidth transmission channel. Once this signal is received in the home, it can be displayed on an ordinary MAC receiver, or it can also be displayed on a receiver that is fitted with advanced signal processing equipment, which can provide enhanced quality pictures. Readers who have difficulty in understanding how studio and transmission path may have different standards should think what happens in a studio today, when 35mm film is being used as the programme source. The 35mm film is capable of producing pictures of a much higher technical standard than the 625-line PAL network can transmit,but a picture of somewhat lower quality than could have been produced from the original film is transmitted via the transmitting network and is received in the viewer's home.

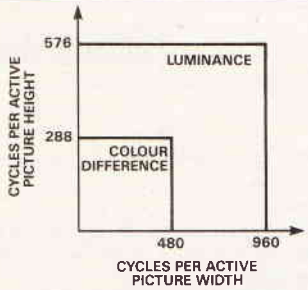


Fig. 6 Limiting resolutions for luminance and colour difference components of High Definition Progressive Scanning system.

In the same way, it is clear that pictures could be transmitted at a field rate of 50Hz and yet displayed with a field rate of 100Hz if suitable storage and processing circuitry was built into the receiver. The simplest way of achieving this field rate upconversion would be to repeat each field of the incoming picture to produce 100 field/sec, but if this method is to be used with 100Hz interlaced displays it is necessary to interpolate between the lines of the incoming fields to ensure that the lines appear in their correct places. To produce a display with a 100Hz refresh rate it is estimated that perhaps an extra 3 Mbytes of storage must be included in the receiver, and although this may seem a lot, it is expected that a full HD-MAC receiver will need at least 9 Mbytes for all its picture processing circuitry. This technology can only be transferred to the domestic marketplace if memory costs fall, and it is fortunate that memory chips are expected to fall in price until the cost of all this storage becomes an acceptable percentage of the cost of the receiver, the 'ten-dollar frame store' being something that manufacturers regard as a goal which can eventually be achieved.

The Eureka Family Of Systems

As well as being based on the MAC family of systems, the various steps of the EUREKA EU95 project have also been arranged so that each one bears a simple relationship, when expressed in digital form, to the international digital studio standard defined in CCIR Recommendation 601.

The long-term target for the studio standard of the European HDTV system, which has been submitted to the CCIR as a proposed *world* HDTV studio standard, has the following characteristics:

Total number of lines per picture	1250
Number of active lines per picture	1152
Scanning method	Progressive 1:1 (non-interlaced)

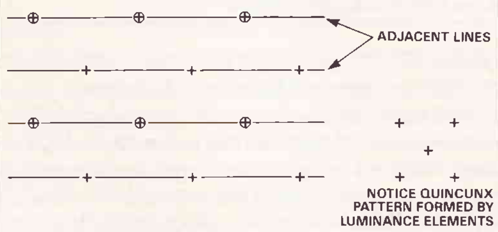


Fig. 7 The luminance (+) and colour difference (0) sampling pattern for the HDQ system.

Aspect ratio	16:9
Field frequency	50Hz
Line frequency	62.5KHz
Normal line period	16μsec.

The analogue picture signal is in the form of three, parallel, time-coincident component signals,consisting either of red, green, and blue signals or of a luminance signal and two colour–difference signals. When expressed in digital form the signals have the following characteristics:

Number of samples per active line:	
luminance signal	1920
colour-difference signals	960
Number of samples per full line:	
luminance signal	2304
colour-difference signals	1152
Sampling frequency:	
luminance signal	144MHz
colour-difference signals	72MHz

Since CCIR Recommendation 601 assumes interlaced scanning, it was originally thought that the HDTV studio standard might be based upon interlaced scanning, but better performance, with a greater apparent vertical resolution and an absence of interline flicker, can be obtained from continuous (progressive) scanning, although this performance is only obtained at the cost of an increased video bandwidth.

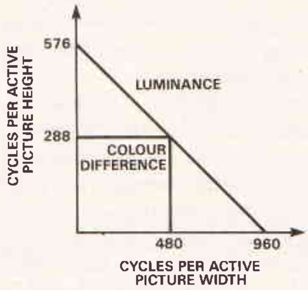


Fig. 8 Limiting resolutions for luminance and colour difference components of HDQ system.

It was therefore decided to base the hierarchical family of studio standards on a 50Hz progressive standard. The various evolutionary steps as far as studio production is concerned are detailed in figure 4, and it can be seen how each step upwards is based upon the original Recommendation 601 standard; there are three levels of HDTV defined, together with

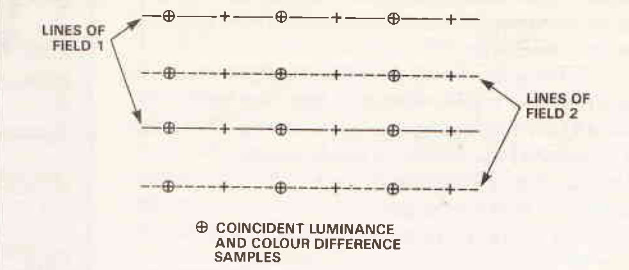


Fig. 9 Luminance (+) and colour-difference (0) sampling patterns for HDI interlaced system.

an enhanced 625-line system which has a 16:9 aspect ratio and non-interlaced sequential scanning.

The high-definition progressive standard (HDP) thus represents the ultimate in the European HDTV system, but requires a large amount of data processing and storage to cope with its data rate of 1728 Mbit/s. 1920 luminance samples are taken for each active line, but colour difference samples are taken at half this rate, and only on alternate lines, giving the sampling pattern shown in Figure 5.

Figure 6 is drawn to illustrate the limiting resolutions, horizontally and vertically, that a system of this type gives, we can see that the vertical resolution for the luminance part of the picture is 576 cycles per active picture height, and if we say that we can carry two bits of information per cycle this is equivalent to 2 × 576 = 1152 active lines. For the colour difference part of the picture signal, since we have only 288 cycles per picture height. In the horizontal direction there are 1920 samples per active picture width for luminance and half this number for the colour difference signals.

The next level down in the hierarchy shown in figure 4 is known as HDQ (High Definition Progressive Scanning and Quincunx sampling), and this system manages to preserve the benefits of progressive scanning whilst reducing the data rate and signal bandwidth required, making it a practical way to provide progressive scan HDTV pictures. This is achieved by sampling the signal 'quincunxially', so that the resulting samples appear in sets of five, like the arrangement of five dots on the sides of poker dice, as shown in Figure 7. In order to do this the picture must first be diagonally filtered, but as we saw when we were considering the MUSE system, the eye is happy with the results of this, since it is not very sensitive to lack of detail in diagonal directions, and the effective horizontal and vertical resolutions for both luminance and colour stay the same as for the HDP system.

The limiting resolutions for the HDQ system are shown in Figure 8, from which the effect of the diagonal filtering can be seen.

The sampling frequency of the luminance signal can be reduced to 72 MHz by this technique, but the colour-difference signals are sampled at the same 36MHz rate as for the HDP signals. The total data rate for the luminance signal and the two colour difference signals of the HDQ system is therefore reduced to: (72 + 2 X 36) x 8 bits per sample = 1152 Mbit/s

The third level of the hierarchy, and the lowest level of HDTV, has 1250 lines per frame and 1920 samples per active line, but uses 2:1 interlaced scanning. This is called the interlaced studio standard,HDI, and the sampling pattern for luminance and chrominance components can be seen in Figure 9.

Notice that there are still 1250 lines per frame, but that each frame is now made up of two sets of interlaced 625 line fields. Although the luminance can now be sampled at only 72MHz, compared with the 144MHz needed for the HDP system, we still get 1920 samples per active picture width. The interlace makes it unavoidable that there will be colour difference signals on every line, as shown in Figure 9, and this results in greater colour difference resolution in the vertical direction,, as is shown in the resolution diagram for the HDI system, Figure 10.

You never quite get something for nothing, however, and an interlaced display requires about 1.5 times as many lines as a progressive, sequentially scanning display in order to subjectively give the same resolution. This means that although the vertical resolution on the diagram appears to be a full 576 cycles per picture height, equivalent to 1152 lines, in practice this will be reduced by a factor of about 1/1.5, approximately 0.6.

The World Production Standard, Or Just One Of Them?

The 1250/50/1:1 HDP proposal gives excellent pictures and it is felt that this system has enough extra quality in hand to cope with any processing which it is likely to undergo in a studio environment; the Eureka EU95 team would like this to become the eventual world HDTV production standard, and it certainly seems that it will definitely become the standard for Europe. To try to persuade the 525-line countries that a 1250/50 HDTV system would be suitable for them, much work has been carried out on standards conversion techniques. The aim is to show that HDP signals can form an excellent basis for conversion to a 1050-line/59.94Hz system and then can be further downconverted to provide 525-line NTSC compatible pictures. It seems that most of the technical problems of this type of conversion can now be overcome, but political consideration still make it most unlikely that 60Hz countries will adopt HDP.

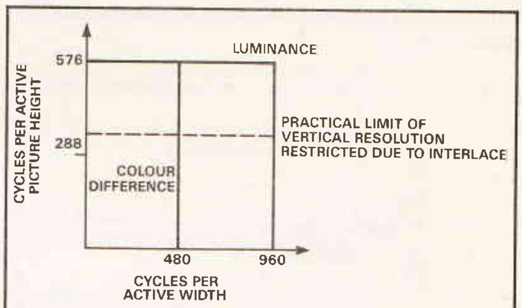


Fig. 10 Limiting resolutions for luminance and colour-difference components of HDI interlaced system.

Very good progress has been made with the production of equipment for the Eureka EU95 project, and as long ago as September 1988 the team were able to demonstrate a 1250-line sequential scan camera and a complete HDTV chain sending signals over satellite links, with displays from projectors and cathode ray tubes showing the high-definition MAC signals in may different formats.

Transmitting compatible HDTV Signals

So far we have discussed in detail only the production standards part of the European HDTV initiative, but we must remember that one of the key factors in undertaking this work was to be able to define a transmission standard which would provide step-by-step evolution from today's 625-line MAC pictures to full-quality HDTV.

The starting point, and the sticking point, for anyone wanting to transmit HDTV pictures, is that CCIR Report 801 gives the definition of HDTV

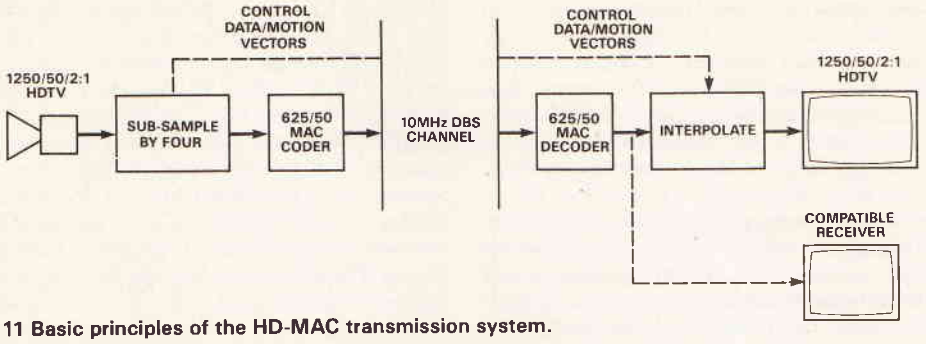


Fig. 11 Basic principles of the HD-MAC transmission system.

pictures as pictures having approximately twice the horizontal and vertical resolution of normal television pictures; this means that they must contain around four times the information of a normal television picture, and will require about four times the bandwidth to transmit. Although it might be feasible in the future to provide enough bandwidth over fibre optic cable networks and satellites in the bands from 20 — 80GHz, at the present time, and for the foreseeable future, we just don't have the radio frequency spectrum available to allow us to transmit HDTV, without first of all processing it in some way which will reduce the bandwidth of the signals. Effectively, then, we need some means of taking an 1250 line/50 f.p.s. source picture and compressing it so that it will pass over a normal 625-line MAC satellite channel and produce a usable picture on a standard 625-line MAC receiver. In addition we need the owner of an HDTV receiver to be able to use the same 625-line signals, plus perhaps some data transmitted in the frame blanking intervals , to be able to obtain a high-definition picture on his display.

The Eureka EU95 HDTV project aims to overcome these problems, and to use the MAC/packet transmission system to provide a step by step route to full HDTV in a manner which ensures compatibility with all receivers using MAC system. The basic principles of the HD-MAC transmission system are shown in Figure 11.

Perhaps the first point of interest in this diagram is its similarity to the diagram in the previous article which illustrates the principles of MUS; the same types of technology are being used to provide better quality at the receiver than could normally be expected if the transmissions are sent via a relatively narrow-band channel. The big difference between the two systems is that the HD-MAC system can be introduced in a compatible manner, providing all the commercial advantages.

The production standard 1250-line HDTV picture provided by the camera in the studio needs to have some or the information which it contains removed before the picture can be passed through a standard satellite broadcasting channel, which can cope with a baseband signal bandwidth of about 10MHz. Note that the diagram shows the source as 1250/50 interlaced, since that was the standard used for the EUREKA HD-MAC demonstrations in 1988, but further developments in this project will probably see the 'top – quality' source eventually providing 1250/50 non-interlaced pictures.

Characteristics Of The Working HD-MAC Transmission system

It is important to remember that HD-MAC is still very much under development, and that changes to the original system are almost certain to be made before regular transmission begin. The HD-MAC studio production standard described in the previous section as the target system is somewhat different from the working system which is actually being used for tests and demonstrations of the HD-MAC transmission system at the present time. This utilises the 1250 lines, 50 fields per second and 2:1 interlace, and differs from the system that we have described mainly in that the basic sampling frequency is 54MHz, rather than the 72MHz that we have used so far, giving 1440 luminance samples per active picture line (rather than 1920), and 720 colour-difference samples per line (compared with 960). Note that these numbers of samples are twice as many as the samples per line defined for the CCIR 601 digital standard, so that we are still transmitting a true HDTV picture according to the definition given in CCIR Report 801, since we have twice the horizontal and vertical resolutions of the basic 625-line standard.

From Figure 11 we see that the pictures from the source are first subsampled by a factor of four, which effectively compresses the 1250-line interlaced signal which has 1440 samples per line and produces a 625-line interlaced signal with 720 picture elements per line. This lower bandwidth signal is then sent to a MAC coder for encoding as a standard MAC/packet signal, which may be transmitted over a standard direct broadcasting satellite channel.

Although the pictures seen by the viewer with the conventional 625-line MAC receiver who is watching images derived from a 1250 line HD-MAC source will be very good, critical viewing may well show some aliasing artifacts, taking the form of slight patterning in some picture areas. This is an inevitable result of the subsampling of the HDTV signals that has taken place, but is not generally regarded as seriously degrading the pictures, and its effect is probably even less than that which was suffered by viewers of black and white receivers when the colour television subcarrier was added to the transmitted monochrome signals in the 1960s.

Fig. 12 MAC decoder expansion ratios with 4:3 aspect ratio source and 4:3 aspect ratio display.

Digital Assistance

Subsampling inevitably leads to some loss of information from the transmitted signal, whereas the job of the HD-MAC receiver is to build an HDTV picture which is as close as possible to the original. It is possible, at the source, to analyse what has happened to the original picture in the subsampling process, and to transmit information about this to the receiver. This will enable an HDTV receiver to control various complex processing circuits, which will allow an

HDTV picture to be displayed. This extra control information, sometimes called digital assistance, can be transmitted during frame blanking intervals, in a similar way to which teletext is carried on normal terrestrial transmissions, so that the control information is carried as an integral part of the HD-MAC signal. The capacity of the digital assistance channel when a standard 625-line MAC signal is being transmitted over a satellite is about 1 to 1.5 Mbit/s.

Much of the information which we shall want to transmit as digital assistance will be to do with picture movement, and information about the movement of various areas of the picture may be sent to the receiver in various ways. There are two major methods of dealing with motion, the processing systems being known as 'motion adaptive' and 'motion compensation', the latter being a more complex and more powerful technique. In motion adaptive systems control information sent merely tells the receiver to switch between two or more processing methods for different parts of the picture, whereas when the motion compensation technique is used the data takes the form of motion vectors which can used by the processing circuits in the receiver to accurately calculate where each group of picture elements should be displayed. In a perfect world it might be desirable to send information about the speed and direction of motion of every moving picture element, but the available vertical blanking interval data channel is much too small for this, so the picture has to be analysed as blocks of pixels, but this works well in practice.

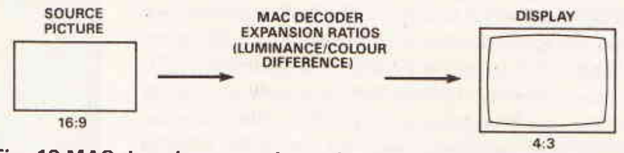


Fig. 13 MAC decoder expansion ratios with 16:9 source and 4:3 display.

The Motion Adaptive Technique

The first technique uses an approach similar to that which was discussed when considering the MUSE system, in that each picture is divided into two different types of information, corresponding to areas where there is no movement of the image, and areas which are moving. The processing mode that is utilised then depends upon whether or not the particular part of the picture is static or moving, and switching takes place between the two modes, so as to make the best use of the available bandwidth. It is systems in which this type of switching takes place that are called 'motion adaptive'.

Whether or not a particular group of pixels is moving or static can usually be determined fairly simply by comparing the pixels in adjacent pictures. Having divided the areas of the picture in this way, the information from the static areas of the picture is temporally filtered and the subsampled by a factor of two, which effectively throws away every other pair of fields. The remaining pair of fields is treated as four standard MAC fields of 288 lines by 720 pixels, and these are transmitted over a four-field period. Pixels are interleaved using a line-shuffling technique, which improves the effective horizontal resolution. At the receiver, each incoming picture is stored and then displayed twice, which, since the picture elements involved have not moved, provides a satisfactory display. The information from the moving parts of the picture is again filtered and then subsampled by a further factor of two, and then transmitted every field period. The result is a loss of detail in the moving parts of the picture, but as we saw before, this generally proves acceptable to the eye, which is not very sensitive in these circumstances. Motion adaptive techniques need not be limited to just two classes of picture movement.

Motion Compensation

The motion compensation technique allows for much better results than using motion adaptive techniques when trying to transmit fine detail in moving areas, but this improvement comes only at the expense of considerably more complexity in the coder. Basically, the position of small blocks of picture elements is compared from one field to another, and the centre of the block is seen to have moved in a particular direction at a certain speed. The speed and the direction of movement are then conveyed to the receiver by means of the digital assistance channel in the form of a motion vector, and the position of the displayed pixels is adjusted accordingly. As was mentioned earlier, the amount of data which the DATV channel can carry is limited to somewhere around 1.5 Mbit/s, which means that the number of motion vectors that can be sent is insufficient to cope with very complex movements.

Perfect processing of all pictures is still a long way away, however, and several different schemes are being investigated by the Eureka EU95 team, including a system which uses both of the above techniques, automatically deciding which technique to use according to the type of motion involved. One interesting trick that can be used in the coder, although it is very complex in terms of information processing, is to try each of the available techniques for dealing with motion on each block of pixels, and then to test the results in the coder, prior to transmission, by rebuilding the block in the coder, in just the same way as it would be treated by the receiver's decoder. The result of the test is then compared with the original information presented to the coder, which is, of course, still available at that point. The technique which provides the best result from these tests is then used for transmission of that particular block.

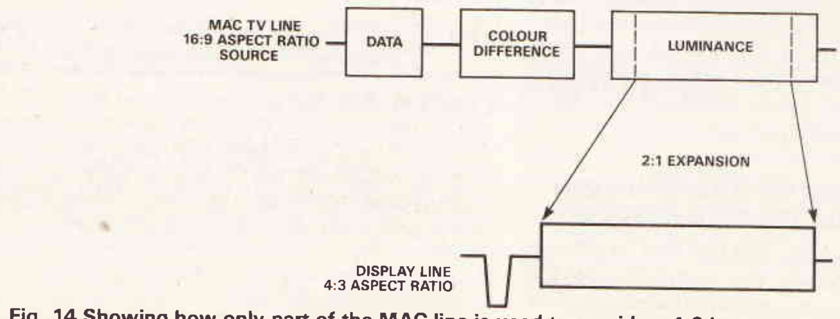


Fig. 14 Showing how only part of the MAC line is used to provide a 4:3 image when the source has a 16:9 aspect ratio.

HDTV

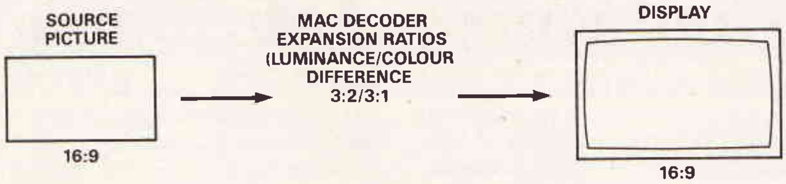


Fig. 15 MAC decoder expansion ratios with 16:9 source and display.

Widescreen HD-MAC

There are various methods which can be used to achieve compatible widescreen pictures using MAC. Of the various approaches that were considered, HD-MAC makes use of a system in which the decoder can be switched between two different sets of compression ratios in order to cope with pictures having either the standard 4:3 wideband 16:9 aspect ratios. To understand how this happens, let us consider three different scenarios, and see what happens at both source and display ends of the broadcasting chain.

Figure 12 shows the simplest case, when the source is a 4:3 aspect radio picture and the display has the same aspect ratio. This is the situation with the normal standard MAC pictures, and the decoder will therefore need to expand the received picture signals by the standard ratios of the MAC system, 3:2 for luminance and 3:1 for the colour difference signals.

The second case is shown in Fig 13, where the source is using a widescreen 16:9 aspect ratio whereas the display is a conventional 4:3 receiver.

In this case using the standard MAC expansion ratio would lead to the decoded picture being distorted, since the original picture s have been compressed by the usual 3:2 luminance and 3:1 colour difference ratios. It is therefore necessary in the decoder to use the alternative expansion ratios of 2:1 and 4:1 if the picture on the 4:3 display is to maintain the same relative proportions as the original. Unfortunately this leads to the decoded picture being wider than the display screen, and so in this case we have to arrange that the 4:3 receiver only takes in and expands a part of each line, as shown in figure 14. Effectively, this method discards the sides of the original 16:9 picture, but keeps the remaining 4:3 picture undistorted.

The third case to be considered is that where both source and display have the widescreen 16:9 aspect ratio. In this case the standard MAC expansion ratios of 3:2 and 3:1 produce the correct display, as shown in Figure 15.

We thus have a system that allows for different aspect ratio receivers to be provided with pictures of the correct aspect ratio, irrespective of the source aspect ratio, in a very compatible manner. There remains, the problem that the person who buys an expensive widescreen receiver will have to put up with the pictures that do not fill the screen for much of the time, since this seems unlikely that broadcasters will be able to provide continuous 16:9 programming for some years to come, and the vast amount of archival material shot with 4:3 aspect ratio will always present this problem. It has been suggested that the areas at the side could be filled with other information, ranging from electronically generated 'curtain' patterns to small pictures showing what is on the other channels, but another option that is likely to be offered by manufacturers is to allow for the screen to be over-scanned top and bottom, making for a picture that actually fills the visible screen area, but in which the top and bottom of the original display is lost. To television professionals who have been trying for years to ensure that their carefully composed pictures are seen in the home as closely as possible to the originals this may be anathema, but to receiver marketing men it may well be a way of persuading potential customers to purchase a widescreen receiver. The French company, Thomson is promising that its widescreen receivers will give the viewer the capability of varying the picture geometry at will, they call it 'format control', so as to provide the choice between filling the screen or having an undistorted picture with blank edges. Thomson's advanced television receiver, expected to be on sale towards the end of 1990, which, as well as 'format control', has internal circuitry which provides a doubling of the lines from the standard 625-line MAC picture to provide a 1250-line display.

This is to be a multi-standard PAL/MAC/RGB/YC receiver with all the inputs and outputs that you could think of, including something with the marketing man's dream name of a "golden SCART" socket, which will allow HD-MAC signals to be plugged in once they become available. The receiver is not strictly an HDTV receiver. since the tube has less resolution than that required for HDTV, but it will let viewers take full advantage of any extended signals that become available, and will allow them to make use of the widescreen display, even with transmitted 4:3 pictures. It is likely to cost around £3000 initially, according to manufacturers estimates.

Progress With The 1250/60 System

Except for the system's being unlikely to be accepted as *the* world production standard, work on the 1250/50 studio standard is going according to plan. The HD-MAC transmission project is also progressing well, with equipment rapidly being developed for both studio and home use. The target date for domestic receiving equipment to be available is 1992, and the various members of the EUREKA EU95 team are working hard to meet this target. The 1992 Olympics, which are to be held in Barcelona, Spain, will be covered by HD-MAC cameras, and the aim of the EUREKA manufacturers is to have HD-MAC receivers on sale in the shops by that time. Most market estimates suggest that the cost of such receivers will initially put them out of the reach of the average domestic viewer, but, as we have seen, there are good reasons for thinking that these costs can eventually come down.

ETI

TECH TIPS

High Voltage Lab Supply

Being one of these freaks who still find it amusing to design with, and look at valves, I have long felt the need for a variable power-supply other than my home-designed all singing all dancing 0-30V 0-10A just like any other lab-supply. For quite some time my eyes have dwelled on an application's circuit from a certain supplier of semiconductors, utilizing an LM 117 as the regulating part, and (oh, — joy!) an EL 84 output-pentode as the main series-dropper. Recently I even noticed a circuit-idea following exactly the same scheme.

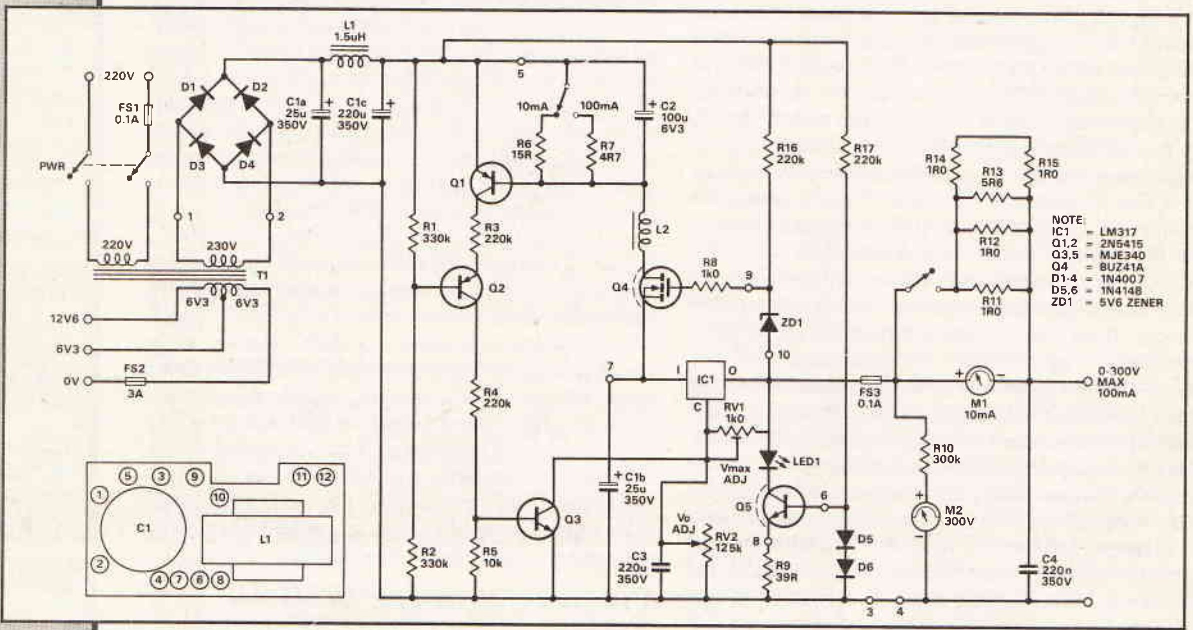
Observing the amount of current available from an EL 84, it struck my mind that the power-MOS transistor actually has been invented. No sooner thought than done. Here is a circuit of a high-voltage lab-supply capable of delivering a lot more current than you can ever expect from an EL 84.

Shunt resistors R13-R16 are found by experiment, in spite of calculations giving 0R37. R12 was delivered with its associated Voltmeter. The voltage across the LM 317 never exceeds 8V2 (due to ZD1) minus the threshold voltage of Q4. Furthermore, an LM 317 needs to idle a few mA's to be stable, so why not utilize that as driving current for an LED control lamp? Constant current sink Q5 supplies about 15 mA, enough to supply the max 1.45 mA needed for the zener. Output current sense is incorporated via R6 or R7, Q1, Q2 and Q3, to protect the meter movement rather than the semiconductors. If a higher-voltage PNP than 2N5415 can be found for Q1, then Q2 can be omitted. L2 is not strictly necessary, though it does add to the stability of the circuit. Q4 dissipates 33 W maximum. It can easily be paralleled, so as to achieve very high output power indeed. (Separate gate-resistors, please!). Remember then to alter the values of current sensing resistors R6 and R7 — AND the transformer, AND D1-D4, AND —-

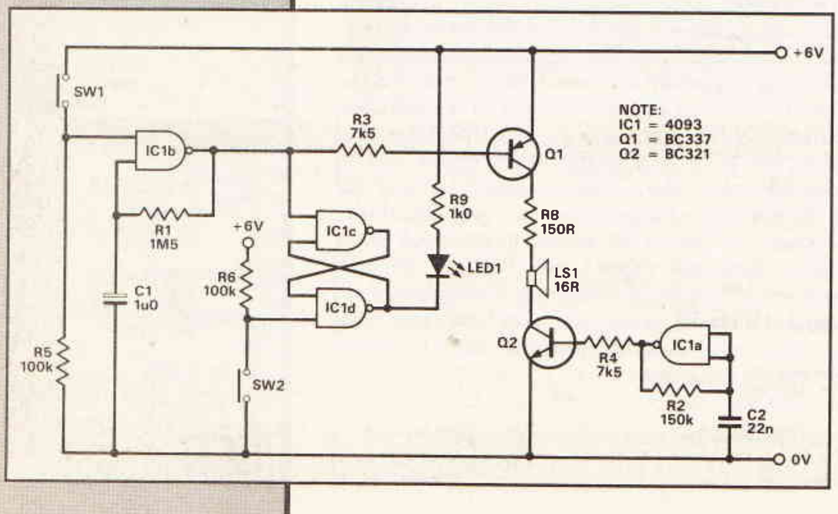
Output is short-circuit proof, but definitely NOT shock-proof to moist fingers.

Finally, it should be noticed that R10, the V0 adjustment potentiometer, must be able to dissipate at least 0.8 W.

Michael G Lyngsie, Denmark.



Door Bell With Memory



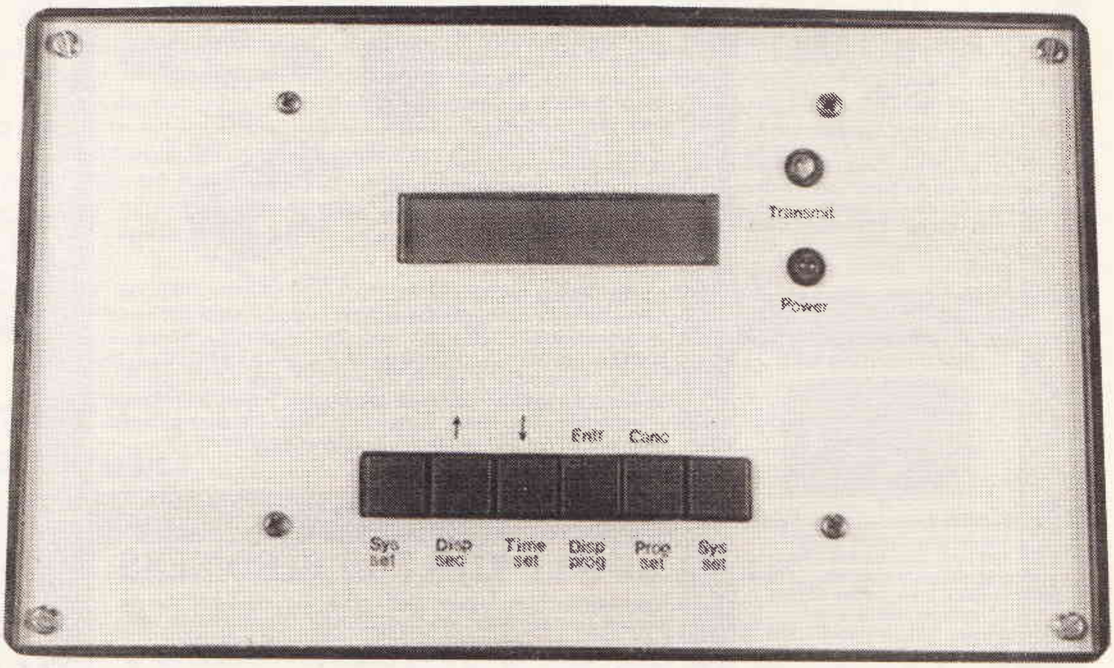
This circuit was devised not only to provide an ordinary door bell but also to indicate whether any one had paid a call when the householder was out.

ICa is a free-running audio signal generator, the output of which is fed to Q2 base via R4. In the normal condition, the output of ICb is at high voltage, and Q1 is cut off so no current flows through the loudspeaker. On pressing SW1, a low frequency signal is generated by ICb. This drives Q1 via R3. Now, the loudspeaker gives a modulated audio sound.

ICc and ICd comprise an RS latch with ICd output being high at normal condition. Pressing on SW1, the low voltage of ICd output triggers the RS latch. The output of ICd goes low and the led lights. This state will remain after pressing the Reset button SW2.

Hong Yu Qing
Tongling, Peoples Republic of China.

1 REMOTE CONTR



A microprocessor controlled universal timeswitch system by Kevin Browne

Many homes these days employ timeswitches to control appliances, such as the central heating, the security lighting, the immersion heater and the greenhouse heating system This particular timeswitch is designed however, to replace all of these individual units. Its central control unit transmits coded control signals through the mains wiring system of the house, and is able to control up to 100 remote switching units, at any give time.

Facilities

- Independent control of up to 100 remote switches.
- 7 hardwired outputs available.
- One-shot or repeating programs.
- Programs selectable on an individual day, weekdays only, weekend only or an every day basis
- Fixed switching periods.
- Pseudo random period generation within preset times.

System Overview

Figure 1 shows a block diagram of the overall system. The main control unit may be plugged into the mains at any convenient location. The remote switches may be plugged in wherever they are required including the garage and greenhouse.

The Central Control Unit.

The block diagram in Figure 2 shows the main functions of the control unit. The CPU (central processing unit) is a CMOS version of the popular Z80 8 bit microprocessor. This is connected to the ROM, RAM, display unit, key switches and output latch via a common 8 bit data bus.

The ROM (read only memory) contains the software program, enabling the CPU to perform the timeswitch operations. This IC is a CMOS version of the more common 2764 64K EPROM (8K x 8bit). The software program would actually fit in the smaller 2732 32K EPROM (4K x 8bit). At the time of writing, this IC was not available in a CMOS version, at a reasonable cost.

The RAM (random access memory) is a 2K byte CMOS memory chip which is used to store the switching program, the current time and other system variables. Only one bit of the output latch is actually used for the remote timeswitch system. This bit, (bit 7) is used to control the tone transmit circuit. The remaining 7 unused bits of the latch can be utilized to provide 7 hardwired timeswitch outputs, if required.

Two signals are provided for the CPU by the timing section of the circuit. A 3.125 kHz signal is used by the CPU to format the transmitted code. The second signal, of 50 Hz, is used by the CPU for timekeeping purposes.

The PSU (Power supply unit) provides a stabilized 5V supply for all the circuits. This supply is either derived from the mains supply, or in the event of a mains failure, from a standby battery source. The battery can be of the rechargeable type, since the PSU also supplies a charging current. A 50 Hz synchronization signal is extracted from the mains supply, which is used in conjunction with the timing circuitry, for timekeeping purposes.

The key switches and display unit are mounted on a separate PCB. The 6 keys interface with the data bus via diodes. These keys perform multiple functions

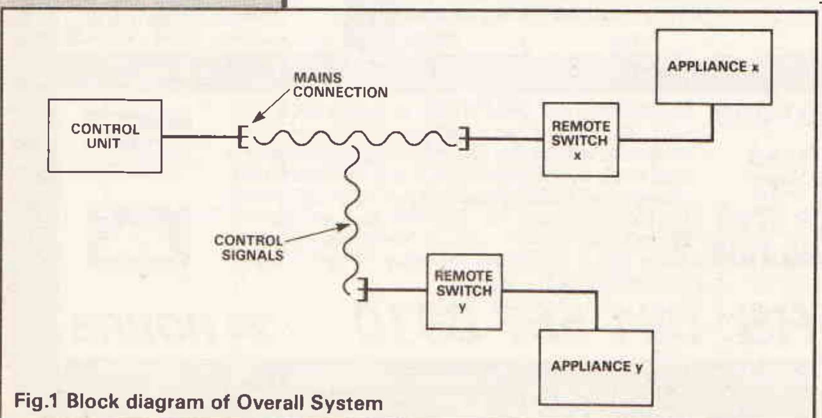


Fig.1 Block diagram of Overall System

OL TIMESWITCH

to enable the user to program the timeswitch.

The display unit is a 1 line x 16 character LCD (liquid crystal display) module. It is one of a range of self contained LCD modules manufactured by EPSOM. It contains its own ROM character generator and display RAM. Care should be taken when handling this unit as they are quite expensive and easily damaged.

The tone transmit module is again on a separate PCB. In response to control signals from the CPU, via the output latch, it generates a series of 180 kHz tones which are superimposed on the mains wiring via a tuned coil and isolating capacitors. These tones can be detected by all the remote switching units, and decoded as required.

Remote Switch Unit.

The block diagram in Figure 3 shows the principal functions of a remote switch unit. A filter is used to extract the 180kHz control tones, sent by the main control unit. The tone signals are first amplified, then decoded and compared with preset switch settings. If the received code agrees with the preset code the switching action is enabled. The signal is further decoded to determine if an ON or OFF command is being received. The output relay is then switched as required.

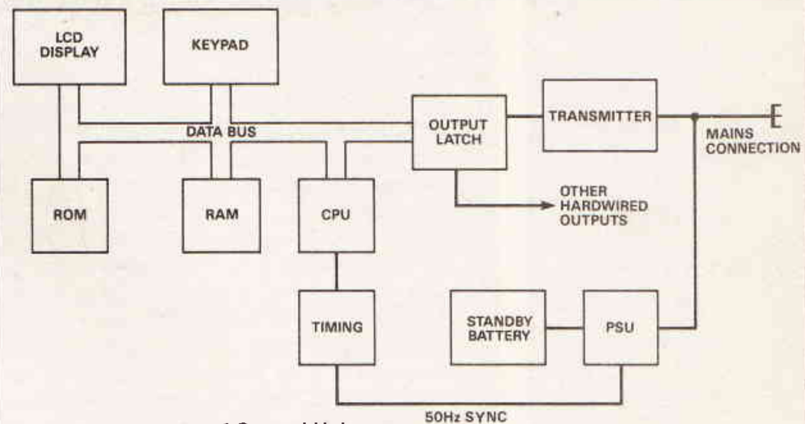
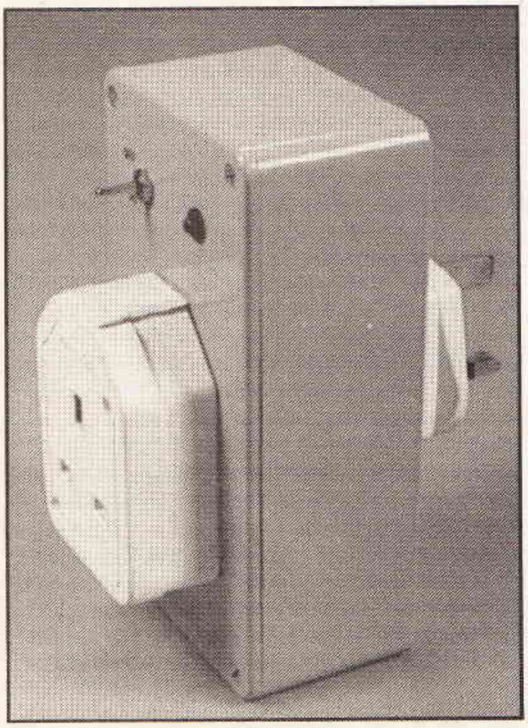


Fig.2 Block diagram of Control Unit



HOW IT WORKS

Main Control Circuit

The Power supply

In Figure 4 transformer T1 reduced the 250V mains to 9V. This is rectified by diodes D1 to D4 and smoothed by capacitor C2 to provide approximately 12V DC. This voltage is used, via resistor R4 and diode D7 to charge the standby battery, if required. The 12 volt supply is also fed, via diode D8 to the regulator circuit (formed around IC1 and Q1) where the voltage is stabilized at 5V.

Resistor R1 feeds positive half cycles of the mains frequency to the opto-isolator IC10. The output is fed to the pulse shaping circuit, formed by C1 and R12. The resulting short duration positive pulses are inverted by IC4e. These pulses are used as a reference by the CPU to synchronize the timekeeping clock.

Transistor Q2, Diode D6 and Resistor R3 form a monitor circuit for the 12V supply. Q2 is normally in the ON state. In the event of a mains failure, R2 discharges the smoothing capacitor C2. When the voltage across C2 falls to approximately 8V Q2 is turned off, providing a power fail signal to the rest of the circuit.

The Timing Section

The CPU requires two timing or interrupt signals, at 50Hz and 3.125kHz. The normal supply of the 50Hz signal is from IC10 in the PSU circuit. These pulses are applied to one interrupt input of the CPU. In the event of a mains failure these pulses would be lost, so a second source of 50Hz pulses is required. This is provided by oscillator circuit around IC2. The frequency of oscillation is set by resistors R8, R9 and C4. Variable resistor RV8 allows fine tuning of the frequency to exactly 50Hz. The power fail indication from transistor Q2 in the PSU circuit is connected to the oscillator circuit by diode D11, the result being, IC2 only provides an output when a mains failure occurs.

The second interrupt signal required by the CPU (3.125 Khz) is used for code transmission timing. This signal is provided by another 555 oscillator circuit (IC3). The frequency is set by R10, R11 and C5. The fine tuning is provided by RV10. Since the remote switch units are mains powered, there is no point in transmitting control codes during periods of mains failure. IC3 is turned off during these periods, again by the power failure indication from Q2, now inverted by IC4f before being applied to the oscillator circuit via D12.

The CPU Circuit.

A clock supply for the CPU (Figure 6) is generated by the circuit around IC4c. The crystal in the circuit is 1.842MHz. This frequency is lower than the maximum operating frequency of the CPU, but the LCD display unit used in this project can only operate with signals below 3MHz. The 8 bit data bus is connected to the ROM (IC6), the RAM (IC7) and the output latch (IC8). Twelve of the address lines (A0-A11) are also connected to both the ROM and the RAM IC's. The remaining address lines (A12-A15) are used to select one of the various IC's connected to the common data bus. Various gates on IC9 are used to 'AND' these address lines with the MRQ (Memory Required) output from the CPU, to provide the correct timing. A truth table of the address decoding is shown in Table 1.

Display Module and Key Switches

The 8 bit data bus from the CPU, along with two of the address lines (A0-A1) are extended through to the display PCB (Figure 7). Four of the key switches, (SW32-SW35) are connected directly to individual lines of the data bus. Pressing a key has no effect, unless the IORQ (Input/Output Required) lead from the CPU is low. This lead is normally high, and only taken low by the CPU when it requires to read the key switches. It does this periodically. When a key is pressed during a CPU read cycle the appropriate data line is pulled low via one of the diodes.

(D32-D35). If two or more switches are pressed at once, this problem is sorted out by the software program.

The two other switches (SW31 and SW36) are wired in series to the data lead D1. Both switches, have to be operated together before an input is registered by the CPU to prevent accidental operation of these switches.

The CPU writes data to, or reads data from, either the control or data registers in the display module. Access to the registers is controlled by the two lower address leads A0 and A1 and by address lead A15 (see Table 2). A summary of the control codes and character set available within the display module is detailed in Table 3.

Variable resistor RV30 to adjusts the contrast of the display.

Two LED indicators are also provided on the display PCB. LED30 flashes to indicate that code transmission is in progress. LED 31 indicates that mains power is present to the unit.

Transmitters Module

The transmitter is a 555 oscillator circuit (IC 20). R21 and C23 set the frequency of oscillation to around 180kHz. The square wave output from IC 20 is fed to Q20 which acts as a driver for the tuned circuit, formed by the coil transformer T20 and capacitor C22. This circuit rounds off the waveform to nearer a sine wave, before superimposing it on to the 240V supply via the two isolating capacitors C20 and C21. The voltage dependent resistor (VDR) across the 240V supply suppresses noise spikes.

The transmitter circuit is controlled from the output latch of the CPU. The CPU is responsible for coding the transmitted tone. Figure 9 shows the waveform of part of the transmitted signal. The logic 1 level is sent as a burst of tone, and the 0 level as silence.

The 'ON' or 'OFF' control signal is determined by the number of identical, complete control frames sent within a given time period. An 'ON' command requires 16 complete signals within 400 milliseconds, whereas an 'OFF' signal only requires 8 within the same time period.

The F register is known as the FLAG register, and is not used for general data storage. The contents of the F register are affected by the results of operations such as ADD or logical operations such as AND. These operations set individual bits, or flags in the F register. The only two flags or real interest in the timeswitch program are the ZERO flag, set when the result of an operation is zero, and the CARRY flag, set when the result of an operation overflows (ie exceeds 255). These flags can be used to determine a program operation in a similar way to the BASIC IF– THEN statement.

The CPU also has four 16 bit data registers called IX,IY,SP and PC. The PC register is the program counter, and stores the point in the program, where the CPU is at the moment. The programmer has no direct access to this register. The SP register is the stack pointer. IX and IY registers are index registers, mainly used for accessing tables of data information.

There are two other 8 bit registers, I and R. These last two registers have specialist uses, and in the timeswitch program are not used at all.

The Stack

The stack is an area of RAM memory set aside by the programmer. It is used to store temporarily, the contents of a register pair, perhaps because that register is required for another job. The contents are PUSHed onto the stack. In a similar way, you might make notes or jottings, each written on a separate piece of paper, then 'stack' them on a table. The data may be recovered by POPing off the stack, in reverse order (ie first on, last off). The SP register is used to point to the top of the stack. In reality the stack is upside down, and grows downwards in memory.

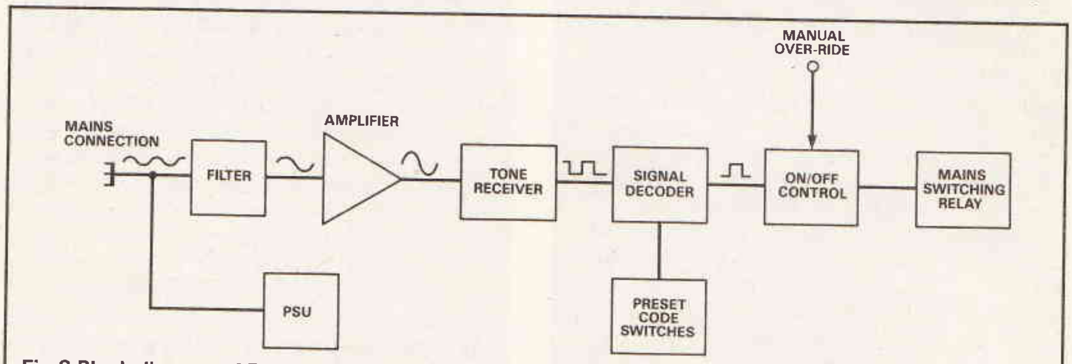


Fig.3 Block diagram of Remote Switch Unit

THE SOFTWARE PROGRAM

The Z80 CPU Registers

The Z80 CPU has 16 general purpose 8 bit data registers or stores. There are 8 'main registers' called A,B,C,D,E,F,H and L, and a further set of 'alternate registers' also called A,B,C,D,E,F,H and L. Each register can hold an 8 bit binary number (ie a number between 0 and 255). These registers can be grouped together in pairs, AF,BC,DE and HL to form a store for 16 bit binary numbers (ie a number between 0 and 65535). The two sets of registers, 'main' and 'alternate', are interchangeable, so with a single instruction the main registers become the alternate registers and vice versa.

Some of the Z80 registers have prefered uses. The A register, for example, is always used in 8 bit arithmetic operations. For instance, instructions are available to add B register to A register (ADD A,B) or subtract the D register from the A register (SUB A,D) but, there is no instruction available to add the B register to the D register. Similarly the B and C registers are prefered for counting and loops, whereas the HL register pair is prefered for storing 16 bit memory addresses.

Timeswitch System Memory Map.

Table 4 shows how the available RAM memory has been allocated in the timeswitch system. The first 64 bytes are allocated to system variables. This is data such as the current time, the date and so on, the state of the system and the number of items currently awaiting attention.

The next 32 bytes are the transmit data queue. Transmitting a control signal to one of the remote switch units can take up to 400 milliseconds. This is a long time to keep the CPU waiting, especially if a number of control signals have to be sent one after another. So, the data to be transmitted is queued until time is available to send it. The transmit queue can hold up to 16 control signals pending transmission.

Once every minute, the CPU has to check the entire stored switching program for any program that requires action at that time. As the current time changes every 20 milliseconds, the entire operation has to be completed within this time. Any stored programs, which require action to be taken are queued in the job queue, to be dealt with at leisure. The job queue can hold up to 16 items.

The output state bit map holds the current state

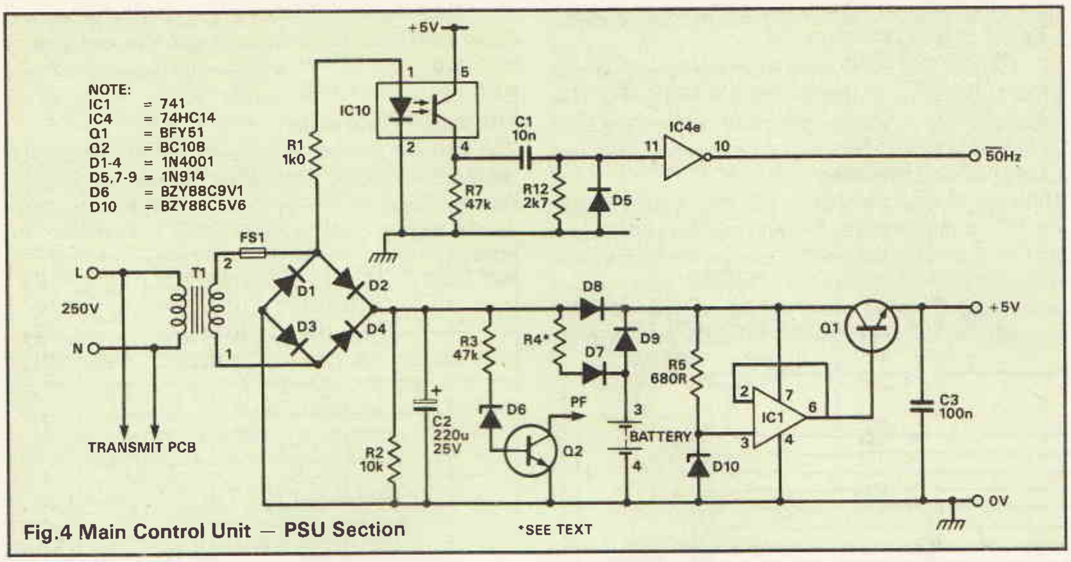


Fig.4 Main Control Unit — PSU Section

of all 100 remote switching units. This store is used after a mains power failure to return all the remote switching units to their correct states.

The largest slice of RAM memory is allocated to the user program store. This is where the instructions you input, such as 'switch 5 ON Monday at 10.30', is stored. There is sufficient store for upto 255 program steps.

The final 64 byte is used for the stack, explained previously.

The Program Flowchart

The flowchart shown in Figure 12 shows an overall view of how the program operates. The first section deals with initialising the system from a cold start ie. the first time it is powered up. Since the system has a battery backup, the initialisation would only take place again if the battery was removed and the system powered down. After initialisation the program continues into the main program loop, where it continues looping the loop for evermore.

A separate section of the flowchart shows the timekeeping interrupt sequence. The CPU is diverted from the main program loop to the interrupt subroutine every 20 milliseconds by the 50Hz synchronizing signal. This is derived from the mains supply frequency. After completing the interrupt

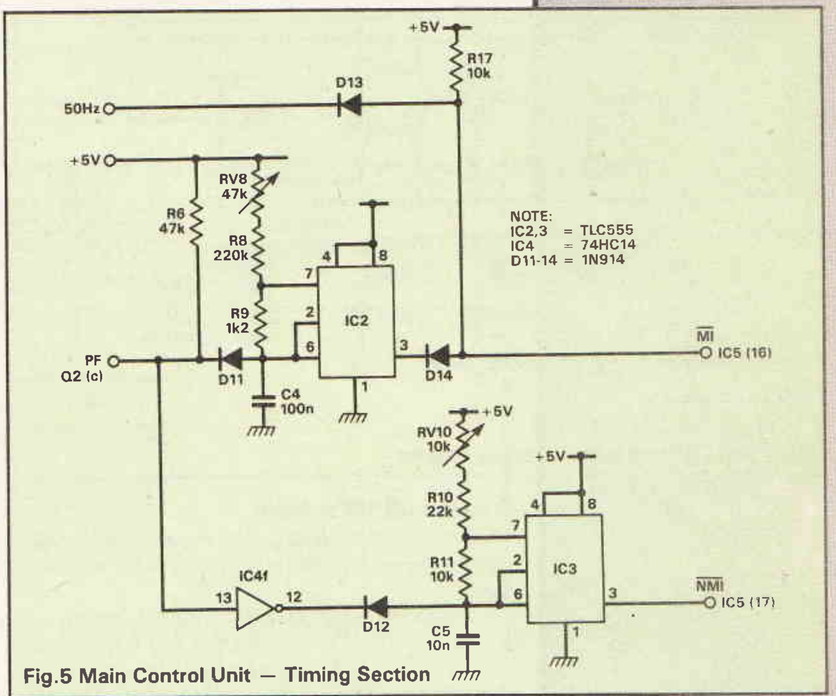


Fig.5 Main Control Unit — Timing Section

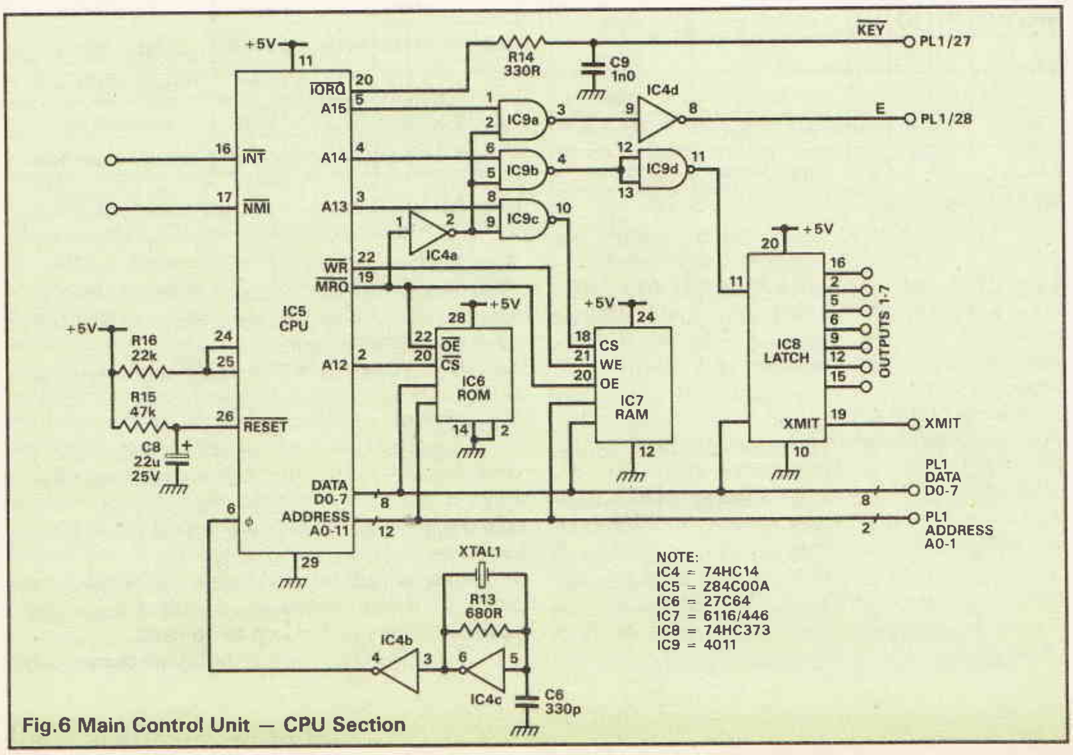


Fig.6 Main Control Unit — CPU Section

subroutine, the CPU returns to where it left off in the main program loop.

Each box on the flowchart represents at least one small subroutine in the timeswitch program. The flowchart is by no means complete as there are over 90 separate subroutines in the timeswitch program.

Example Subroutines

It is beyond the scope of this article to give a full insight into the programming techniques of microprocessors, but I have selected three of the many subroutines used in the timeswitch program to illustrate some of the basic steps in programming. All numbers in the examples below are written in Hexadecimal format.

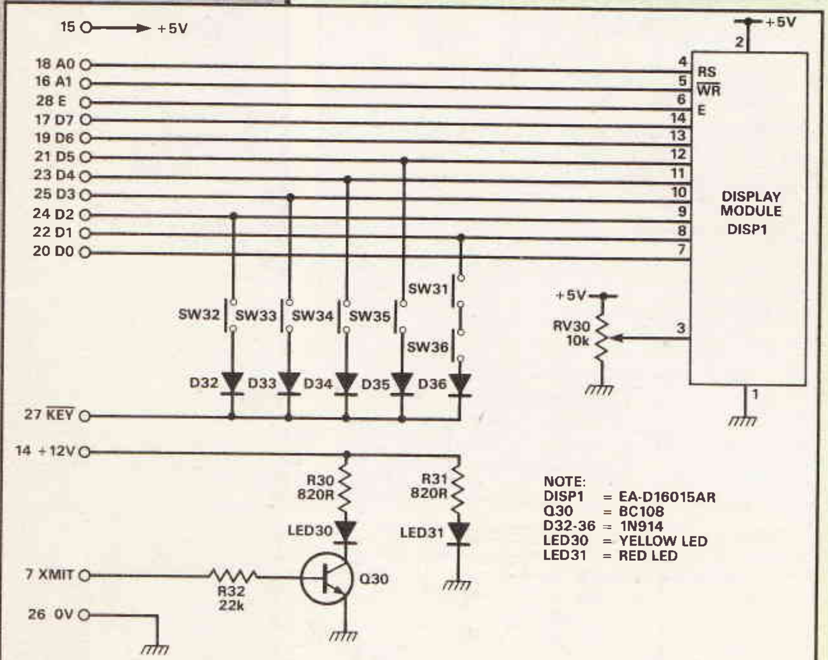


Fig.7 Main Control Unit — Display Section

The Zero RAM routine.

This routine is used as part of the initialisation of the system, to set all 2048 bytes of the RAM memory to zero.

	LD HL, #3000	loads the HL register pair with the first RAM address. (see Table 1)

Address leads					IC Selected	Base Address
MRQ	A15	A14	A13	A12		(in hex)
0	0	0	0	0	ROM	0000
0	0	0	1	1	RAM	3000
0	0	1	0	1	Output Latch	5000
0	1	0	0	1	Display Module	9000

TABLE 1 Address Decoding

	LD BC, #0800	Loads the BC register pair with 2048. (the count)
loop	LD A, #0	Load A register with zero.
	LD (HL), A	Load the RAM address pointed to by HL with the contents of A (zero).
	INC HL	Increase the HL register pair by one.
	DEC BC	Decrease the BC register pair.
	LD A,B	Load A register with contents of B.
	OR C	'OR' the contents of A register with C and leave result in A. (ie check if both B and C are zero.
	JR NZ, loop	Jump if the result of the check is not zero, to a point called 'loop'. (ie test Zero flag)
	RET	Finish the subroutine and return.

Display A Character

This routine is used extensively in the timeswitch program to display a character pattern on the LCD display. On entry to this routine A register contains a valid display code from Table 3c.

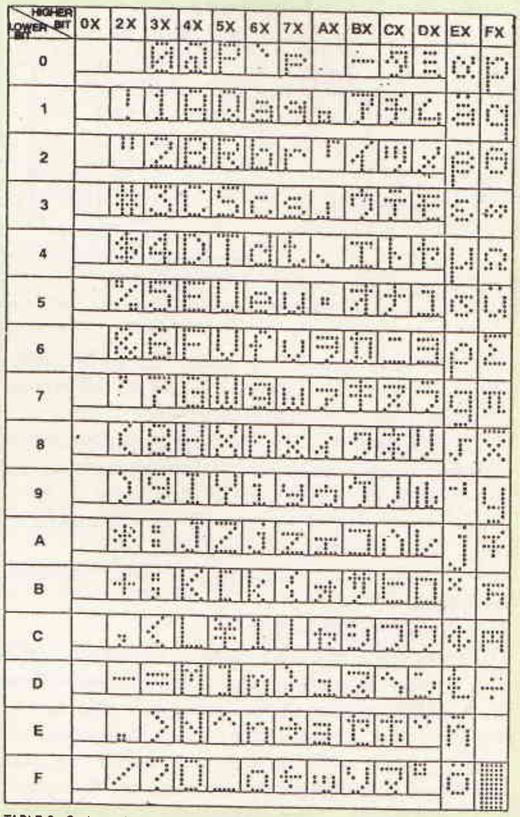


TABLE 3c Codes written to Data Register for Display Pattern

CALL busy	Call the 'busy' subroutine. (see below)
LD (#9001),A	Load the LCD data register with contents of A register. (see Table 2)
RET	Finish subroutine and return.

Address leads							Address	Display Module
MRQ	A15	A14	A13	A12	A1	A0	(in hex)	Resister Selected
0	1	0	0	1	0	0	9000	Instruction Resister (write)
0	1	0	0	1	0	1	9001	Data Register (write)
0	1	0	0	1	1	0	9002	Instruction Register (Read)
0	1	0	0	1	1	1	9003	Data Register (Read)

TABLE 2 Display Module Register Selection

The Busy routine

This routine checks that the LCD display module is ready to receive an instruction. The program will wait until the display module is ready.

busy	PUSH AF	The busy subroutine, save 'AF' registers on the stack.
wait	LD A, (#9002)	Load 'A' with contents of the LCD instruction register. (see Table 2 and 3b)
	BIT 7,A	Test bit 7 of the 'A' register. (the busy bit)
	JR NZ, wait	Jump to a point in the program called 'wait' if bit 7 was not zero. (ie wait until the LCD display is ready for data.

TABLE 3a Codes Written to the Instruction Register.

Code (in binary) Data line	Instruction
7 6 5 4 3 2 1 0	
0 0 0 0 0 0 0 1	Clear display and home cursor.
0 0 0 0 0 0 1 *	Home cursor and return shift.
0 0 0 0 0 1 i s	Entry mode set.
0 0 0 0 1 m c b	Display on/off.
0 0 0 1 0 d * *	Shift cursor position.
0 0 0 1 1 d * *	Shift entire display
0 0 1 z 1 0 * *	Function set (used once to initialise)
0 1 a a a a a a	Set the user defined character RAM address.
1 a a a a a a a	Set the display RAM address.

Notes.
* Bit has no effect.
a. Address character generator (range 00 to 3F hex) display RAM (range 00 to 4F hex)
b. Cursor character flashes. (0=no flash 1=flash)
c. Cursor. (0=off 1=on)
d. Direction (0=left 1=right)
i. Increase or decrease address (0=decrease 1=increase)
m. Display mode. (0=off 1=on)
s. Shift display on entry. (0=no shift 1=shift)
z. Set number of data bits. (0=4 bits 1=8 bits)

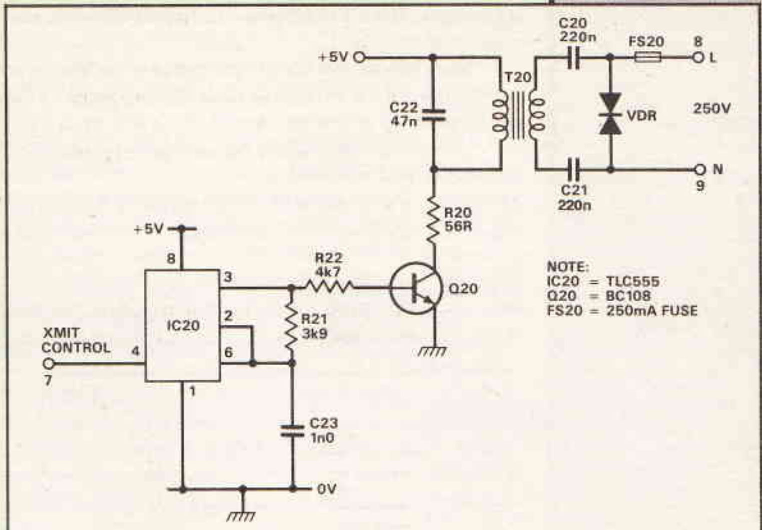


Fig.8 Main Control Unit — Transmit Section

TABLE 3b Codes Read from the Instruction Register.

Code read (in binary) Data line	Instruction
7 6 5 4 3 2 1 0	
f a a a a a a a	Read busy flag and address

Notes.
a. Current address in either character generator or display ram, depending upon previous set instruction.
f. Busy flag (1=busy 0=ready)

TABLE 4 RAM Memory Allocation.

Address (in hex)	Number of bytes	Use
3000 – 303F	64	System variables.
3040 – 305F	32	Transmitt data queue. (16 items)
3060 – 309F	64	Processing job queue. (16 items)
30A0 – 30BF	32	Output state bit map.
30C0 – 37BF	1792	User program store. (256 items)
37C0 – 37FF	64	Stack. (32 items)

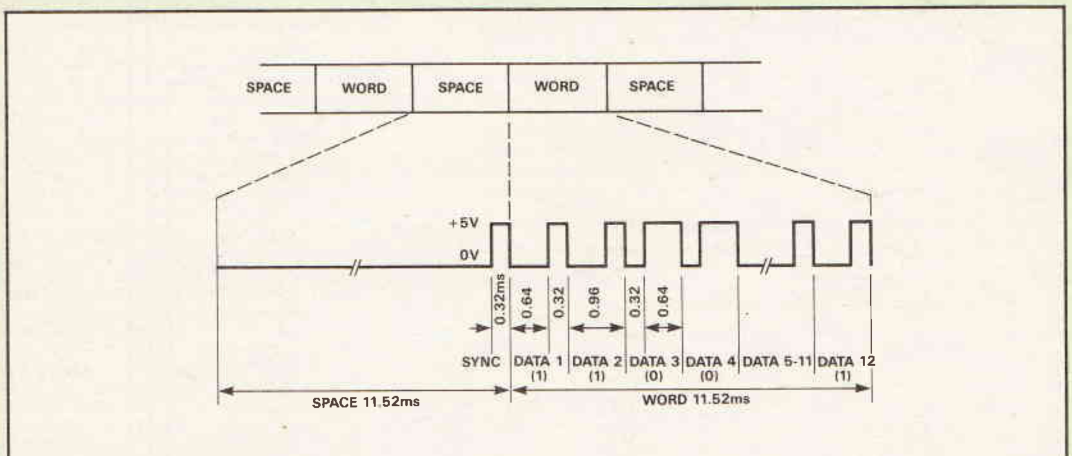


Fig.9 Data Transmission

POP AF	Restore the AF registers.
RET	Finish subroutine and return to the display a character routine.

The Program Code.
The example sub routines given earlier are written in mnemonic format. ie. LD A,B is the mnemonic form of the expression. Load the A register with the contents of the B register. Mnemonic form is a way of writing a program, which we humans can understand. The Z80 processor, however, requires all its instructions in binary. It has no knowledge of mnemonics at all. To overcome this problem there are two alternatives. The first, is to write the program directly in binary, but this would be almost impossible with a program of any size due to the sheer scale of work involved. For the timeswitch program, this would involve over 4000 eight bit binary words. A single one or nought in the wrong place and the program would not work.

The second alternative is to use an assembler program. This is a computer program which converts

TABLE 5 Binary — Hex Conversion.

Binary	Hex	Decimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7
1000	8	8
1001	9	9
1010	A	10
1011	B	11
1100	C	12
1101	D	13
1110	E	14
1111	F	15

Example Binary 0101 1101 converts to Hex 5D
Hex 5D converts to decimal $(5 \times 16) + 13 = 93$.

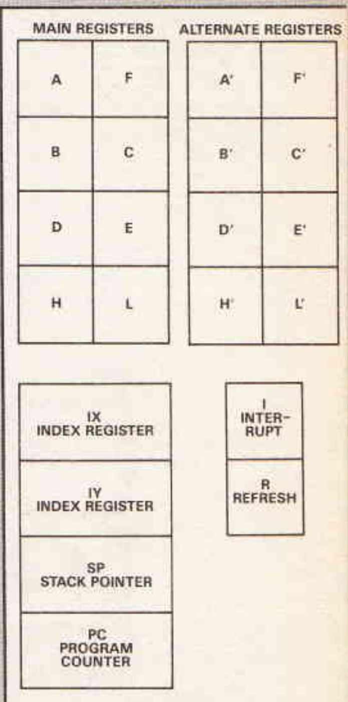


Fig.10 Z80 Register Set

the mnemonic instructions such as LD A,B into their binary equivalent — 01111000 (hex 78). Binary numbers are usually written in hexadecimal format for convenience. See Table 5. for a quick binary — hex conversion.

The mnemonic listing for the timeswitch program runs to over 22,000 characters or 187 lines of program. This is crunched down to just over 400 bytes of Z80 program. Thank goodness for computers!

Finally on Software

For anyone interested in further details on microprocessor programming, I have included at the end of the article, a list of suggested reading material. As to the timeswitch project, constructors who are familiar with programming EPROM chips can use the Hex listing. The alternative is to buy a pre-programmed EPROM, details of which will be given at the end of the article along with the availability of the Hex listing.

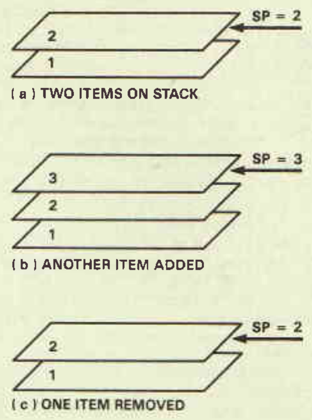


Fig.11 Stack Operation

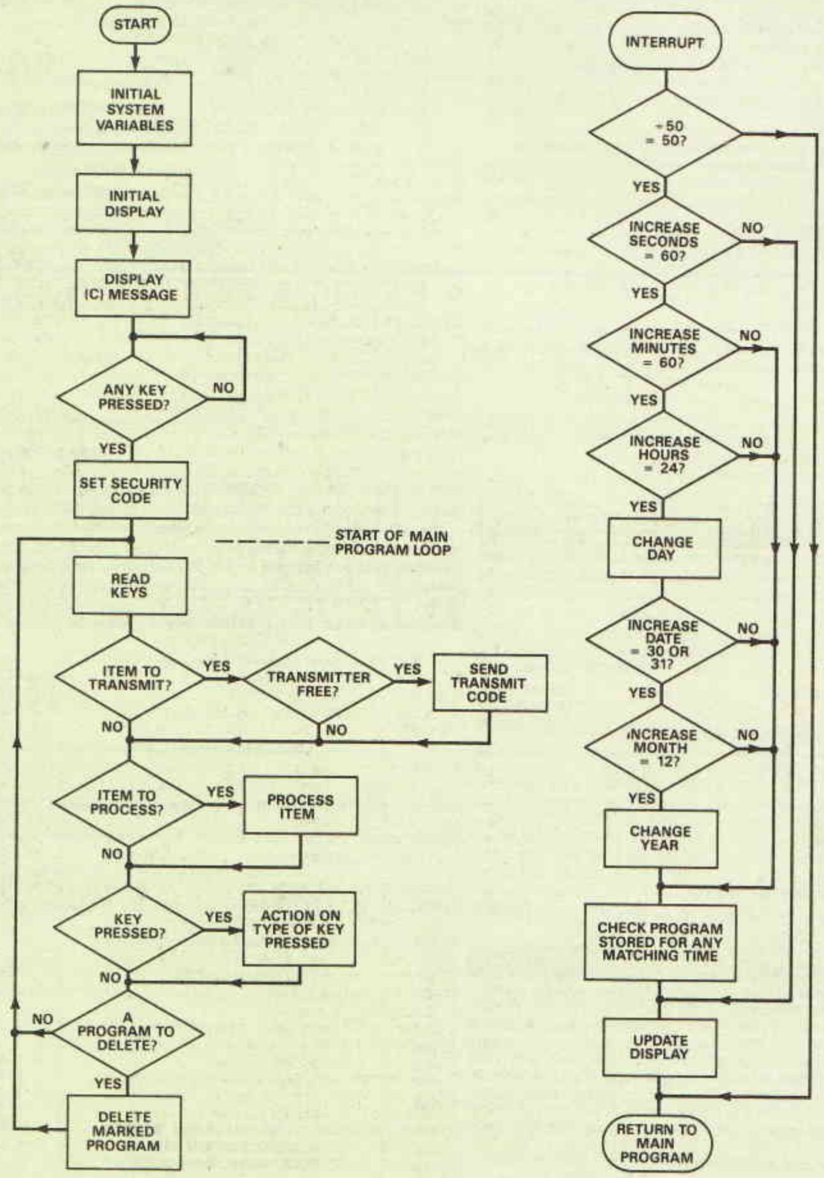


Fig.12 Program Flowchart

TO BE CONTINUED

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BD49	5	Neon valves, with series resistors, these make good night lights
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through on pole
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BD149	6	Safety cover for 13A sockets — prevent those inquisitive little fingers getting nasty shocks
BD180	6	Neon indicators in panel mounting holders with lens
BD193	6	5 amp 3 pin flush mounting sockets makes a low cost disco panel — need cable clips
BD199	1	Mains solenoid very powerful has 1" pull or could push if modified
BD201	8	Keyboard switches — made for computers but have many other applications
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BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor
BD305	1	Tubular dynamic mic with optional table rest
BD653	2	Miniature driver transformers. Ref LT44. 20k to 1k, centre tapped
BD548	2	3.5 volt relays, each with two pairs changeover contacts
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PERSONAL STEREOS Again customer returns but complete and with stereo head phones. A bargain at only £3 each. Our ref 3P83.

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EQUIPMENT WALL MOUNT. Multi-adjustable metal bracket for speak, etc. 2 for £5. Our ref 5P152.

STABILISED POWER SUPPLY KIT. +—+/V 2.0A. Contains PCB, transformer and all components excluding case, etc. Our price is £20. Ref 20P25.

KEYBOARDS. Brand new uncased with 84 keys plus PCB with several ICs. Only £3. Ref 3P89.

SUB-MIN TOGGLE SWITCH. Body size 8mm×4mm×7mm SBDT with chrome dolly fixing nuts. 3 for £1. Order ref BD649.

COPPER CLAD PANEL. For making PCB. Size approx 12in long×8½in wide. Double-sided on fibreglass middle which is quite thick (about 1/16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD633.

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Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder — a complete mains operated kit, case included. **£18.** Our ref 18P2.

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REAL POWER CAR SPEAKERS. Stereo pair output 100w each. 4-Ohm impedance and consisting of 6½" woofer, 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00. Order ref: 30P7.

TV SOUND DECODER. Nicely cased, mains powered with 8 channels. Will drive a small speaker directly or could be fed into HI FI system etc. £12.00 each. Ref: 12P22.

VIDEO TAPES These are three hour tapes of superior quality, made under licence from the famous JVC Company. Offered at only £3 each. Our ref 3P63. Or 5 for £11. Our ref 11P3. Or for the really big user 10 for £20. Our ref 20P20.

ELECTRONIC SPACESHIP. Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kit with really detailed instructions. Ideal present for budding young electrician. A youngster should be able to assemble but you may have to help with the soldering of the components on the pcb. Complete kit £10. Our ref 10P81.

2KV 500 WATT MAINS TRANSFORMERS. Suitable for high voltage experiments or as a spare for a microwave oven etc. £10.00. Ref: 10P93.

12" HIGH RESOLUTION MONITOR. Amber screen, beautifully cased for free standing, needs only a 12v 1.5 amp supply. Technical data is on its way but we understand these are TTL input. Brand new in maker's cartons. Price: £22. Order ref 22P2.

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COMPOSITE VIDEO KITS. These convert composite video into separate h-sync, v-sync and video. Price £8. Our ref 8P39

BUSH RADIO MIDI SPEAKERS. Stereo pair. BASS reflex system, using a full range 4in driver of 4 ohms impedance. Mounted in very nicely made black fronted walnut finish cabinets. Cabinet size approx 8½in wide, 14in high and 3½in deep. Fitted with a good length of speaker flex and terminating with a normal audio plug. Price £5 the pair. Our ref 5P141.

3½in FLOPPY DRIVES. We still have two models in stock: Single sided, 80 track, by Chinon. This is in the manufacturers metal case with leads and IDC connectors. Price £40, reference 40P1. Also a double sided, 80 track, by NEC. This is uncased. Price £60, reference 60P2. Both are brand new.

YUASHA SEALED LEAD ACID BATTERIES 6V 10AH only £9.00 each or 2 for £15.00. Ref: 15P37.

SINCLAIR C5 WHEELS

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

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

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

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This is helium-neon and has a power rating of 2mW. Completely safe so long as you do not look directly into the beam when eye damage could result. Brand new, full spec, £35. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

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

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

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape 4 1/2in x 4 1/2in x 13/4in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each.** Our ref 8P26.

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

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

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

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

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

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YUASA LEAD ACID RECHARGEABLE BATTERIES. 1.9AH 12v, £6.00 each.

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

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

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

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

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

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

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

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

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

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

EX EQUIPMENT SWITCHED MODE POWER SUPPLIES. Various makes and specs but generally ±5, ±12v, ideal bench supply. Only £8. Our ref 8P36.

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

PTFE COATED SILVER PLATED CABLE. 19 strands of .45mm copper, will carry up to 30A and is virtually indestructable. Available in red or black. Regular price is over £120 per reel, our price only £20 for 100m reel. Ref 20P21 or 1 of each for £35. Ref 35P2. Makes absolutely superb speaker cable!

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

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

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

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

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

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

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

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

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

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

C5 GEARED MOTORS. Please phone for Price and Availability.

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

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

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

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

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

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

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

2 AN INTRODUCTION TO RECORDING STUDIO DESIGN

Acoustic Design

In this second article, James Roberts analyses the problem of sound reflection

Control of reverberation is one of the prime objectives and tasks in acoustic design, since it primarily determines the sound and feel of the space. If a short sharp sound impulse is made in an enclosed space, with the resultant reflections measured, a whole series will be found,commencing with simple reflections from the principle surfaces of the space, rapidly multiplying until it is not possible to distinguish separate reflections. At each reflection, some energy will be absorbed by the reflecting surfaces so that over time, the acoustic energy will be absorbed and the sound field dies away. The whole of this is known as reverberation (see Figure 9). The precise control of it can be broken down into the early phase and later multiple reflections.

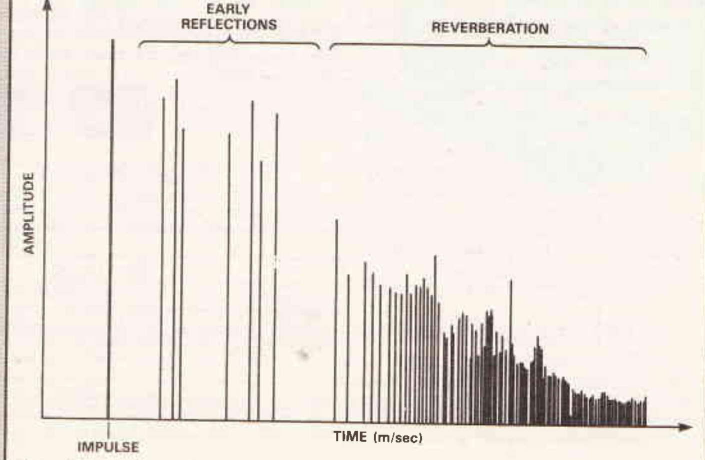


Fig. 9 Reverberation.

Eigentones

Eigentones (German for 'Own tones') or 'modes' are fundamental resonant characteristics of space. The distance between surfaces establishes a path time for sound travelling between them, and the path time establishes a frequency. There are several possible modes — axial, where the waves fall between plane parallel surfaces, tangential, those between two pairs of surfaces, and oblique, which involves all three sets of surfaces. Research has shown that the axial modes are normally predominant since they carry the bulk of the energy (see Figure 10).

There is no way of avoiding eigentones, so the art of the process is to adjust the room dimensions in such a way that they are spread as evenly as possible, with no clustering to add colouration. Imagine a cubical room, with all dimensions the same. The eigentones will be identical for all three sets, giving the most marked colouration (Figure 11).

Much research has been done into satisfactory ratios of dimensions for eigentone distribution. One set of relationships was derived by Bolt, in 1936 (Figure 12). This can be used as an initial guideline. Some practical room dimension ratios proved to work are 1:1.14:1.39, 1.00:1.28:1.54 and 1.00:1.60:2.33.

The eigentones can be calculated from the following formulae:

For axial modes $F_m = X \times (C/(2 \times \text{distance}))$

For all modes $F_m = (C/2)\sqrt{(x/L)^2 + (y/W)^2 + (z/H)^2}$

where C = velocity of sound 344 m/sec

F_m = modal frequency

distance = length, width, height respectively

L = length

W = width

H = height

x, y, z, are integers 0, 1, 2, 3...etc.

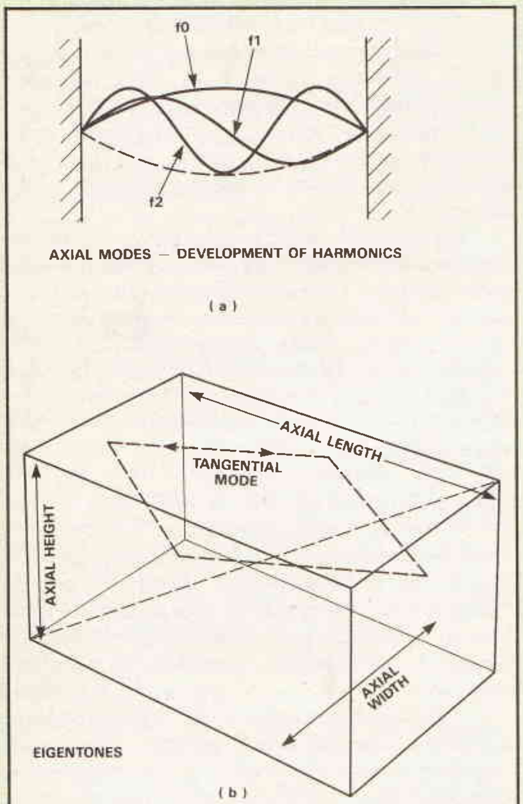


Fig. 10 Eigentones

A particular and undesirable example of an eigentone is the flutter echo, which is an un-damped eigentone between two parallel plane surfaces. You often hear this in a subway or public toilet, and you don't want it in your recording space. The usual cure is to angle or damp one of the surfaces involved. Angling walls and ceilings is a very effective stratagem, and most Control rooms and studio exhibit an alien-landscape lack of squareness for this reason!

One of the main difficulties of designing small rooms is obtaining sufficient density of eigentones. It is generally agreed (not much is) that a room requires at least 10 modes per ⅓ octave for reasonable balance, which is very difficult to achieve in small rooms. Eigentone calculations are only really relevant below 300Hz. Above that, they usually become so closely spaced as not to present a problem.

The later phase

The decay of a sound field was first studied by Sabine, at the beginning of the century. He decided that the decay time was proportional to the volume of the space and the absorptivity of the surfaces and contents. The relationship derived was:

$R_t = 0.161 \times V/A$

where R_t = reverberation time at a particular frequency

V = room volume in cubic metres

A = total absorption in room

A can be substituted by α S where

S = total surface area m^2

α = average absorption coefficient

The average absorption coefficient can be calculated from $\alpha = 1/S\ \{\alpha_1 S_1 + \alpha_2 S_2 + ...\}$

where α_1...are individual absorption coefficients and S_1...are the individual areas.

The reverberation time was defined as the time for the sound to die away to -60dB or one millionth of the original level, so the standard measurement is known as R_{t60}. Several people have come up with variations and extensions of Sabine's original work, all of which are more or less accurate in different situations. The topic is complex, and none of the equations really deal satisfactorily with small rooms, as for example many control rooms. Sabine is as good a place to start as any.

Absorption

The basic physical measurements of a space having been chosen with the acoustic consequences in mind, it is then necessary to adjust the decay of the reverberant field to suit the application of the space. The reverberation time chosen will be totally different for orchestral music or for speech, for example. There has been much discussion and research over the years as to the ideal reverberation times for different

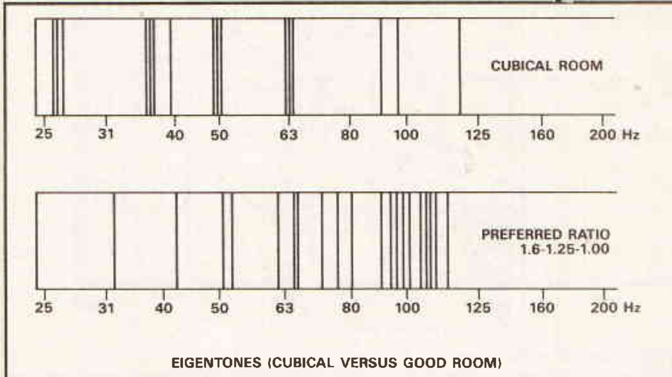


Fig. 11 More Eigentones.

purposes. Tastes vary between countries, in the same way as taste for musical balances vary. Also there was a tendency some years ago to build rooms with very short reverberation times indeed for multi-track recording, the idea being to minimize the room ambience recorded so as to ease the processing and mixing of the various tracks. Fortunately this has been

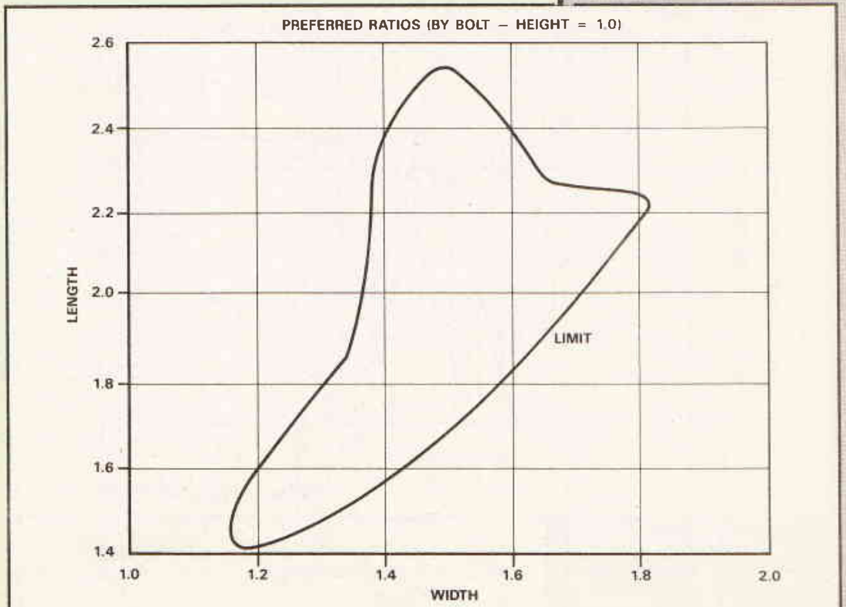


Fig. 12 Bolt's diagram — Preferred Ratios.

largely abandoned — I say fortunately because it made it very difficult for the musicians to play their instruments properly. Figure 13 shows some curves for one set of widely accepted recommendations for reverberation times. The methods available for control of the reverberation are essentially absorptive. The absorbers can be either wide band or narrow band.

Absorbers

Absorption at high and high-mid frequencies is not difficult. Most common materials such as carpet and curtains or hangings (and people!) are HF absorbent, since their thickness compares with the wavelength of the impinging sound ($f = V/\lambda$). The problems arises at LF, since about a quarter wavelength is required in a passive absorber. For 100Hz that adds up to about 2m. Therefore deafened techniques are required, such as membrane absorbers or Helmholtz resonators. Let's look at HF and MF first.

Some of the materials available are:

Acoustic tiles, which are the traditional tiles with holes in them, often mistaken for pegboard. Recent production has more interesting surface finishes. They are a useful standby for killing high frequency reflections from plane surfaces.

Acoustic foam, which is a relatively recent arrival on the scene. It is a very useful material, being available in rolls or tiles. The thickness of the tiles is such that they offer a better spectrum of absorption than acoustic tiles. They do look rather womblike though, and usually are covered by trim cloth. It is quite an expensive material.

Carpets, draperies and so on are good HF absorbers but too thin to have much effect at mf. They can effectively kill HF reflections.

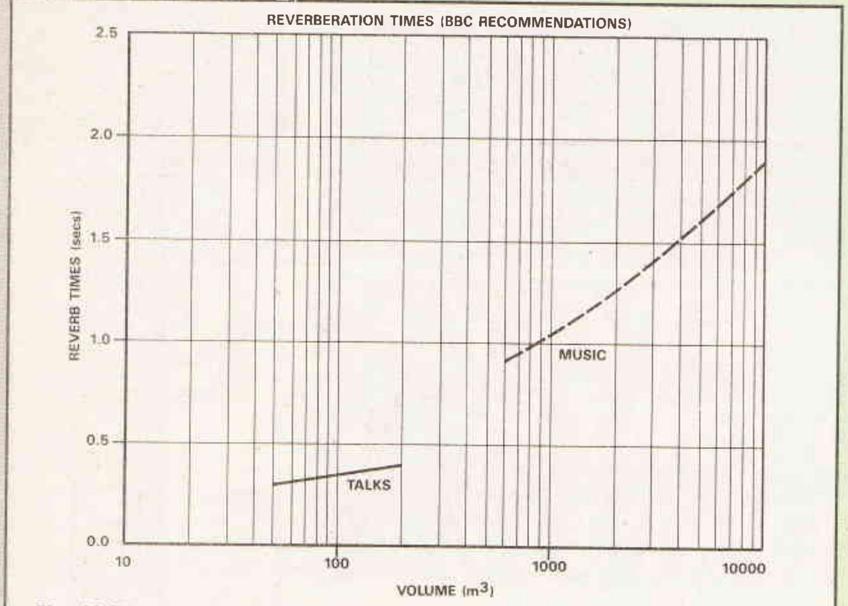


Fig. 13 Recommended reverberation.

A list of common materials and their absorbency versus frequency is given in Table 2, while characteristics of porous absorbers are shown in Figure 14. In this diagram you can see that adding air space behind the absorber works just as well in terms of increasing absorbency as adding thickness to the absorber.

For low MF and LF absorption, membrane absorbers are commonly used. They are often referred to as 'bass traps'. The essential feature of a membrane absorber is the use of a sheet of non-resonant material over an air space, ideally damped with Rockwool or fibreglass wool. Roofing felt has been used very successfully as the membrane. The formula for frequency of absorption (non-critical to ½octave either way) is:

$F_{abs} = 600/(\sqrt{M}D)$

where M = mass of panel in kg/m^2

D = depth of air space in cm.

If the cavity is filled with absorber the frequency will drop by up to 50% and the absorbency can be doubled. A typical construction is shown in Figure 17a, and the absorption characteristics can be seen in Figure 15. An alternative approach is the Helmholtz resonator.

A Helmholtz resonator works on the principle of a critically damped tuned resonator. The tuned resonator can be understood by considering a bottle. Blow across the neck of the bottle and it will ring at a fundamental frequency and harmonics. Since one node of the system is fixed, maximum velocity is at the neck of the bottle, so if you stuff some cotton wool in the neck, energy can be effectively absorbed. The types used in the studios don't make use of the bottle, but the principle is identical. Helmholtz resonators are usually employed to absorb a specific troublesome resonant frequency, or band of frequencies. This particularly applied at the low frequency end of the spectrum. A typical construction is shown in Figure 17b, with the absorption characteristics in Figure 16. I haven't given a formula, as I have never found one that predicts the actual result!

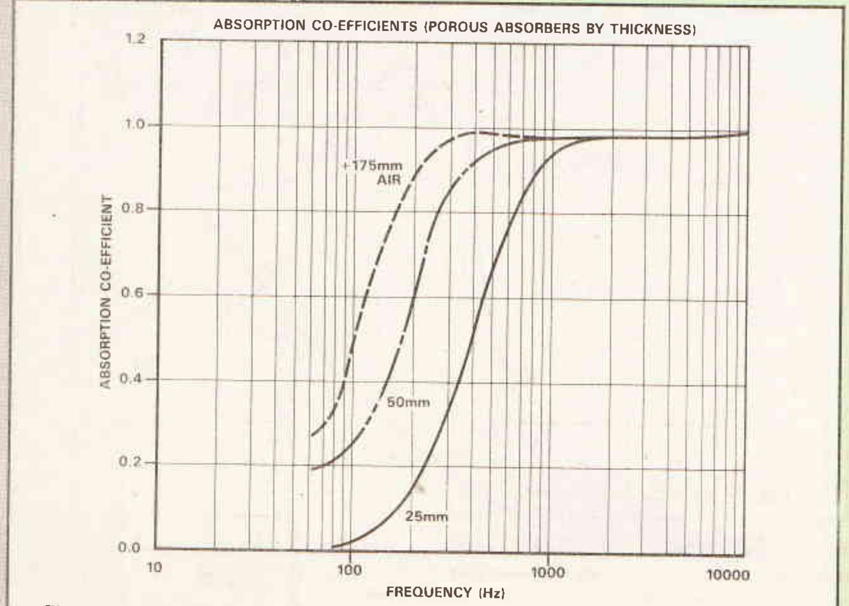


Fig. 14 Porous absorbers.

Dispersion

Apart from control of eigentones, good dispersion of sound where it reflects from walls is required. A flat surface will act acoustically rather like a mirror, sending beams of sound whizzing round the room. Much worse, a concave surface will act as a concentrator, focusing incident sound to a point. A convex surface will, on the other hand, disperse any incident sound. This can be seen in Figure 18. Apart from convex surfaces, many other materials can be used for dispersion, The main ones are natural stone (for the slick look), strips of timber rough mounted (for the sauna feeling), rough finished concrete (the car park style) and brick (garage studios). If you wish to avoid snide remarks, it is possible to gain good dispersion by spreading the sound treatment you are using around the studio, rather than keeping it in one place, without the use of exotic materials.

TABLE 2
ABSORPTION COEEFICIENTS for Various Materials and frequencies

MATERIAL	HERTZ 63	125	250	500	1K	2K	4K
Heavy curtains	0.010	0.070	0.370	0.490	0.810	0.650	0.540
Foam-back carpet on concrete	0.007	0.020	0.060	0.140	0.370	0.600	0.650
Coarse Concrete	0.200	0.360	0.440	0.310	0.290	0.390	0.250
Solid wood floor	0.140	0.150	0.110	0.100	0.700	0.060	0.070
4 mm glass	0.380	0.350	0.250	0.180	0.120	0.070	0.040
6.3 mm glass	0.360	0.350	0.250	0.180	0.120	0.070	0.040
Plaster on brick	0.010	0.013	0.015	0.020	0.030	0.040	0.050
Membrane absorber 300mm gap	0.800	1.100	0.900	0.400	0.150	0.100	0.100
Helmholtz absorber 5% perf.	0.100	0.200	0.800	1.100	0.900	0.500	0.300
Porous absorber 50mm	0.200	0.300	0.750	0.930	0.950	0.950	0.960
Acoustic foam 110mm	0.150	0.280	0.800	0.980	0.800	0.980	0.980
Acoustic foam 75mm	0.050	0.120	0.250	0.600	0.950	0.800	0.950
Deep-cushioned chair (each)	0.700	0.850	1.200	2.000	1.700	1.500	1.300
One human (average) (each)	3.300	3.900	4.300	4.700	5.000	5.100	5.200

Anti-carpet

Anti-carpet is a term derived, I believe, from the BBC. It expresses a simple problem. The largest flat untreatable surface in the control room or studio is likely to be the floor. It is often covered with carpet, which absorbed well at high frequencies, but leaves you with problems at the bass end. One solution is to make the ceiling into a bass trap, which absorbs the mid and low frequencies reflected by the floor. A typical design for a small control room is shown in Figure 19a. This does however lead to an acoustic asymmetry which may be unsatisfactory.

Overall Design

Traditionally, a sound studio has been divided essentially into two areas the control room and the studio. The control room was where the control equipment was installed, the studio where you could put the musicians, and never the twain shall meet. The recording staff would have been recognisable by their white laboratory coats and test meters. This changed in the Sixties. Most studios still do have a division into two areas, but now it is very common for musicians to work in the control room, particularly with the increasing use of electronic instruments, the studio being used where there are problems of isolation or scale — for example, vocals or acoustic drums (anyone remember acoustic drums?)

Control room

The control room is still the usual location of the mixing console and multitrack recorders, complete with all the effects units, patching facilities, monitor loudspeakers and video monitors, engineers, producer and musicians (plus friends).

The primary function of the control room is to provide a balanced acoustic response that can be relied on for monitoring the quality and balance of the recording, and so that the final output will sound good when reproduced in its intended setting, with no unexpected colorations.

The secondary function is to provide a good working environment, house all the necessary working equipment and personnel, look good and be capable of 24 hours a day usage, 365 days a year. These two functions are generally in conflict. Such is life!

There is an increasing tendency to remove as much of the equipment as possible to a separate equipment room, made possible by the enhanced automation of the essential items. Almost all multitrack recorders can be run entirely 'hands off once the tape is threaded, being under microprocessor control. Getting them out of the way removes a lot of noise, heat dispersion and awkward reflective acoustic surfaces from the equation.

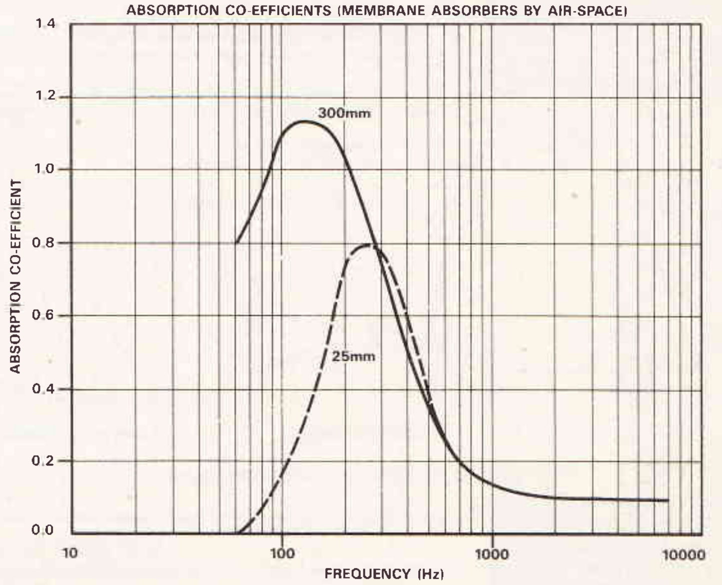


Fig. 15 Membrane absorbers.

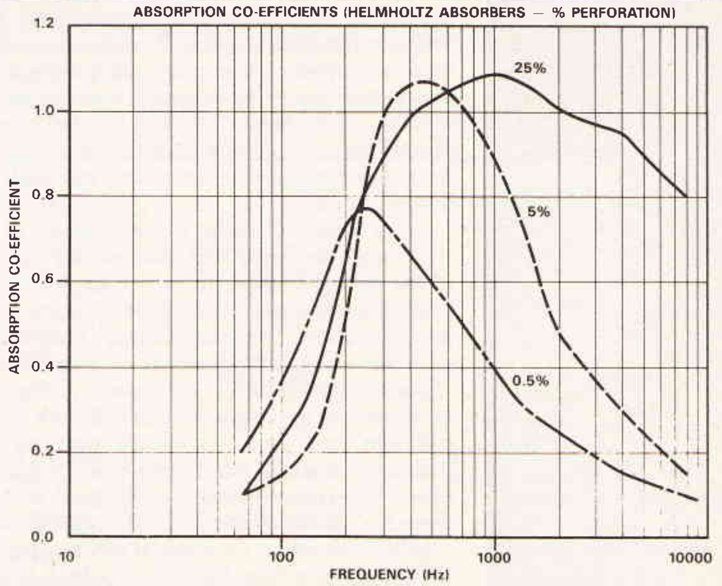


Fig. 16 Helmholtz absorbers.

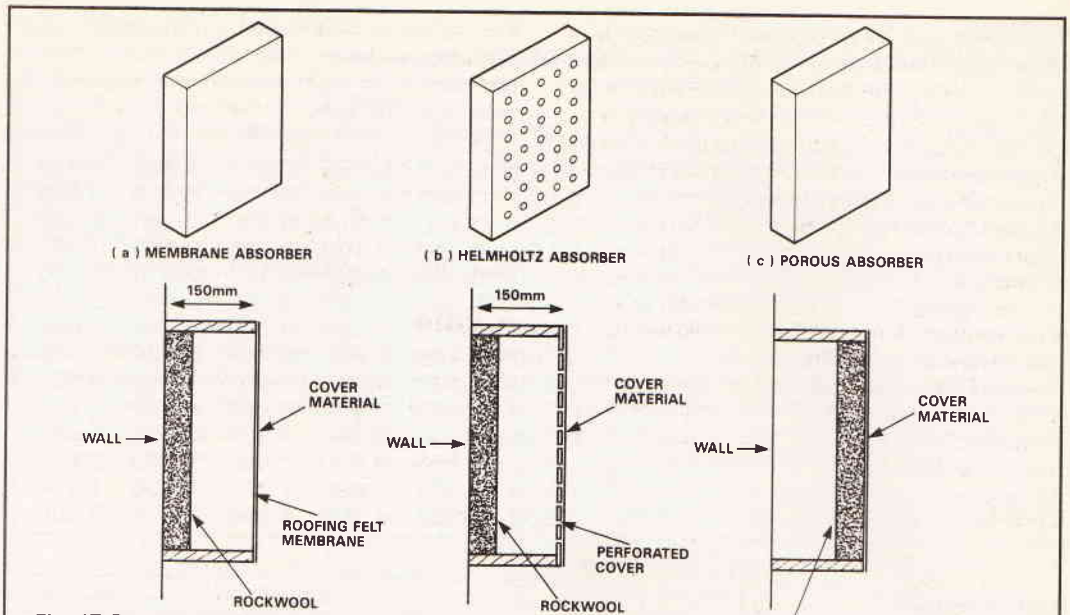


Fig. 17 Construction of absorbers.

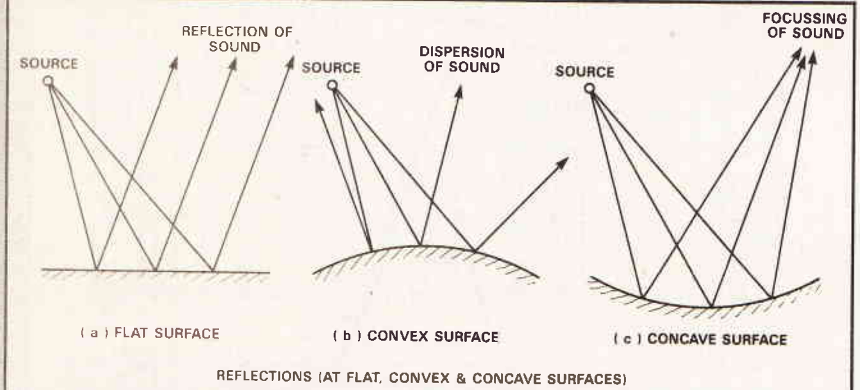


Fig. 18 Reflection of dispersion.

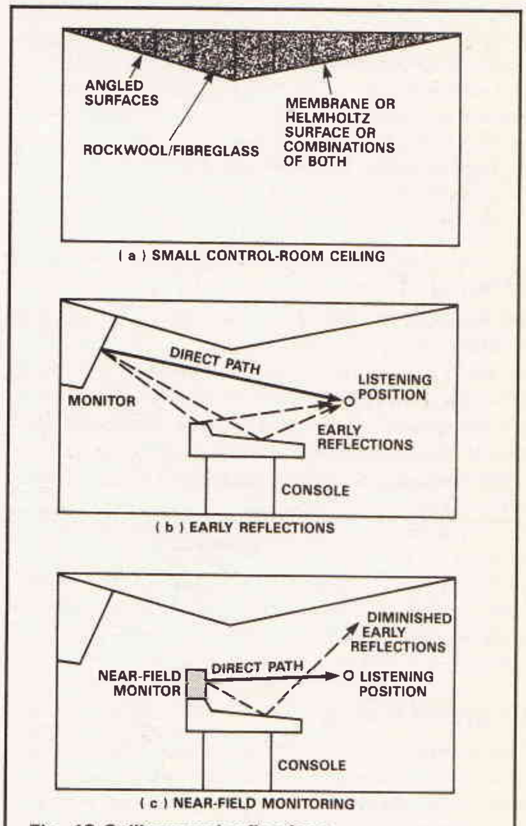


Fig. 19 Ceilings and reflections.

Although there have been various attempts at getting the bulk of the audio pathway into racks, with all the signal control handled by remote interface, this has not on the whole been taken up. Fully digital processing of signals from microphone inputs onwards has been possible for some time, but the ergonomics of the process (or possibly the egos of the people involved — 'egonomics'?) makes it necessary to retain a very large control surface in the control room. This usually is an acoustic disaster area due to the reflections and resonances and invariably leads to compromise.

For example, there is the problem of 'early reflections' (see Figure 19b). Because of the presence of the mixing console, there is a large flat surface providing reflections which arrive at the ear just after the direct sound. These together with the direct path, give rise to what is known as a 'comb filter', the characteristics of which are shown in Figure 20. Movement of the listener's head adds and subtracts sufficient time delay to slightly shift the comb frequency. Now this affect is very useful in those little effects boxes called 'phasers' or 'flangers', but it is not desirable in the monitoring path, though we are usually stuck with it. One partial solution is to adopt what is known as 'Near Field' monitoring, in which the speakers (usually miniatures) are mounted very close to the listener, so that the ratio between direct path and reflected path is enhanced (see Figure 19c). There are other advantages to Near Field monitoring as well, not least the diminishing monitoring levels used...

Another problem is 'mirroring' which ruins any stereo placement. This occurs if surface near to the speakers are reflective (see Figure 21). One cure for this is to make the adjacent walls very absorbent at the relevant frequencies.

Another issue to be considered is the speaker mounting. Sound travels at approximately 344 m/s in air, very much faster in wood, metal, brick and so on.If the speaker box is rigidly attached to a solid surface, sound waves travel through the conducting medium radiating from any suitable flat thin surface they encounter (like the mixing console). This 'Early Early Sound' arrives before the direct sound from the speaker, causing a characteristic 'smearing' of the sound.

Then there is the problem of the radiant angle of the speakers. A point source of the sound in free space radiates into 4π radians (see Figure 22). On an infinite plane, the radiation angle halves to 2π radians. This increases the effective sound preserved level and bass coupling, but depends on the practical size of the theoretically infinite flat surface. The angle is halved again when corner mounted. As most studio speakers approximate to the π radian condition when mounted, special consideration has to be given to this in the speaker design. This is why standard domestic speakers, which nowadays are often designed for stand mounting and loading into something like 2π radians are usually not suitable for studio use, despite their often superior quality.

All of this has been taken into account in addition to the already-discussed acoustic problems, philosophy of design, physical placement and accommodation of personnel.

LEDE

LEDE stands for Live End - Dead End, and is a principle of design largely evolved some ten years ago by a company called Syn-Aud-Con in America, whose registered trade mark is duly acknowledged. It is an attempt to solve some of the problems we have uncovered. There are seven basic principles to LEDE design as follows.

- There is a non-resonant asymmetrical low-frequency outer shell, large enough to allow LF to be developed.
- There is a symmetrical inner shell.
- The path between the speakers and the engineers ear should be anechoic.
- The sound field should be highly diffused during the initial Haas effect period.
  The speakers, console etc should not affect the anechoic path from the speakers to the ear.
- No Early early sound.
- The reflective rear wall should provide a smooth high density sound field.

A typical LEDE construction is shown in Figure 23. It has had its adherents, and also its detractors. The theory followed exactly can give rise to very good

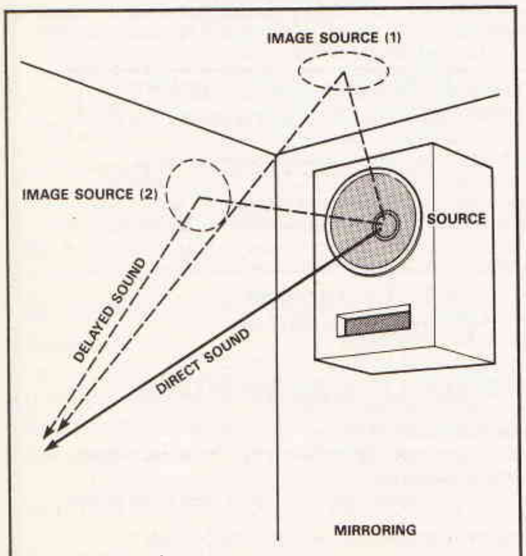


Fig. 21 Mirroring.

rooms, but in practise there is such a lot of junk around and the practical difficulties of building sufficiently absorbent surfaces at one end and sufficiently dispersive at the other usually leads to partial success.

Brave attempts

One or two studios have tried something quite different. This is partly derived from the observation that almost all work is done in the control room nowadays, and partly in an effort to break down the communication and role barriers between the musicians in the studio and the producer and engineer in the control room. It's simple — have one room only, with the recording and monitoring being done in the same space. This is just how most engineers and musicians start off, anyway, and it certainly could have its advantages. At other times the lack of a separate monitoring space could be a real pain in the . . . ear!

Studio

With a sigh of relief we can turn to studios. They are usually a bit easier to design. What we want is a nice balanced acoustic, ideally with some 'brighter' more reflective areas for brass and string players, pianos, and drums, and some 'dead' non-reflective areas for vocals and guitars. This given a decent size space, is not too difficult to arrange. The usual general principles of non parallel walls and an anti-carpet ceiling are adopted, with some of the walls being dispersive reflective finishes across which curtains can be drawn. Often the floor will be in wood, with the carpet removable in sections for increased brightness. Some studios provide separate 'vocal ' and 'drum' booths, so as to reduce spillage from and to other

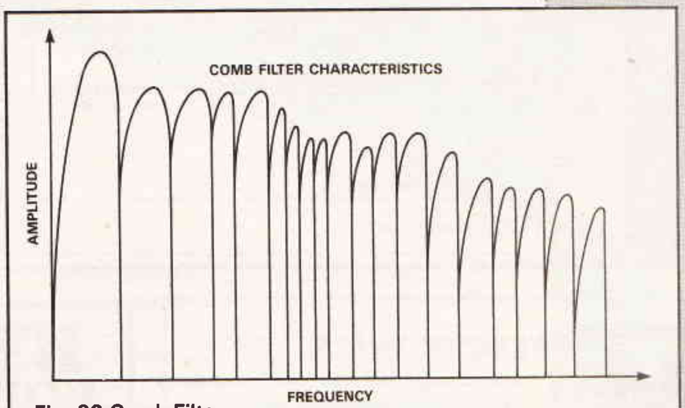


Fig. 20 Comb Filter.

instruments whilst recording simultaneously, but it is more common now to just use screens. These are often arranged with a reflective and non-reflective side, so they can give a locally brighter acoustic or increase separation between instruments. While studios often present interesting design problems, especially in the smaller sizes, there are no new principles to consider.

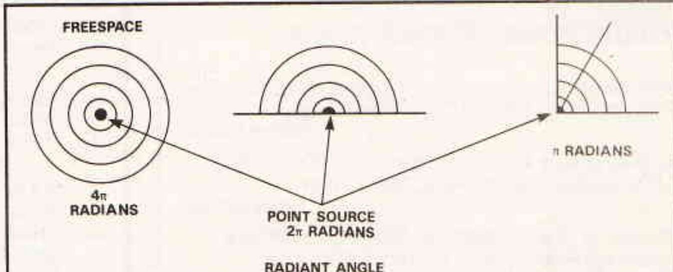


Fig. 22 Radiant Angles.

How important is all this, anyway?

It is important to maintain a sense of perspective. Because recording studios are technically sophisticated and impressive places, and often visually overwhelming, it is easy to take it all over-seriously.

A recording studio serves a similar role to a sewing machine — in goes the raw material (cloth or musical compositions), it is assembled according to a plan (designer or producer), by an expert (machinist or desk engineer) and out comes the final product which may have monetary or aesthetic value or both. If neither, it was probably a waste of time. The skills of the individuals concerned and the quality of the raw material limit the final output more than the idiosyncrasies of the room or equipment. And remember, Tamla Motown music depended for its character on being recorded in an acoustically horrific hall, while world-wide hit records have been recorded in front rooms barges and gentlemen's toilets.

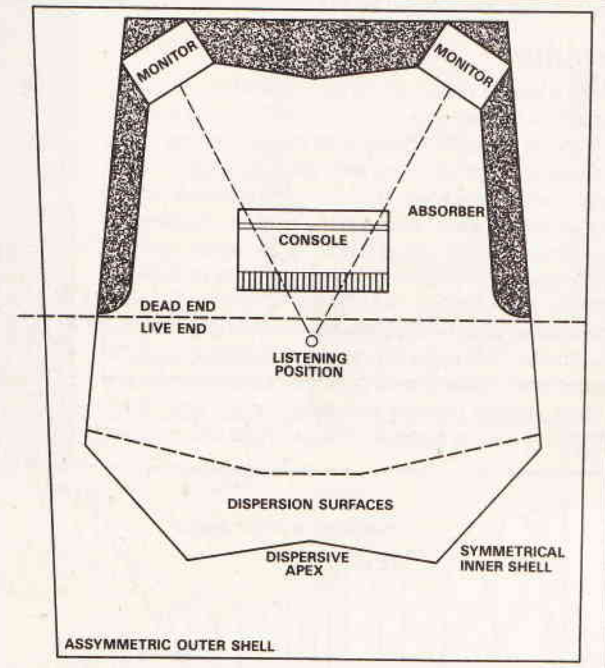
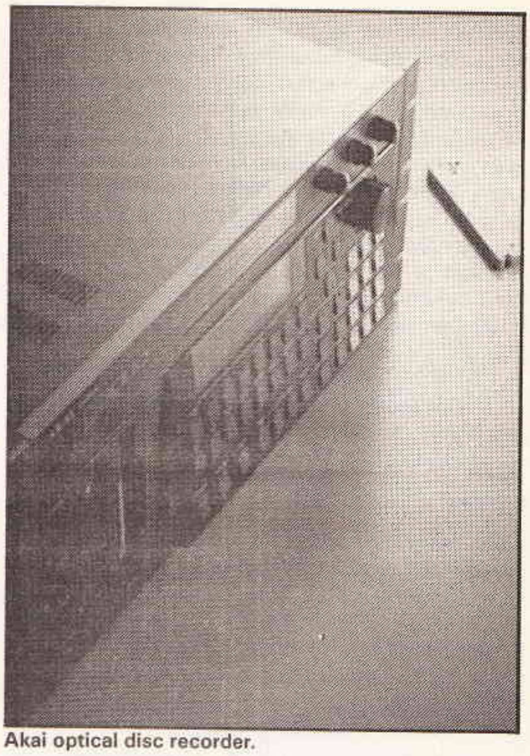


Fig. 23 LEDE principals.


Akai optical disc recorder.

Sources, reference and further reading:

Sound Recording Practise, ed. John Borwick: OUP
The Technique of the Sound Studio, Alec Nisbett: Focal.

FOUR TRACK CASETTE RECORDER

Tom Scarff builds a four channel recording system

2

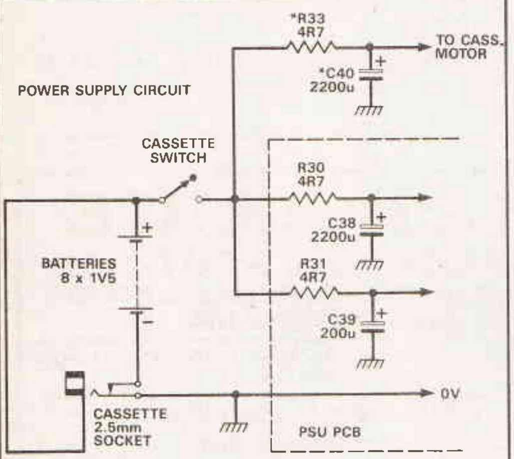
Last month, the article featured details of the Record/Playback amplifier and the Bias/Erase oscillator board.

This month we look at the adjustments, measurements, construction and testing. A full components list appears at the end of this article.

MONITORING

The signals to the stereo headphone amplifiers IC5, Left and Right, are fed from a DPDT switch which switches between a Mono Cue and Stereo Remix sources. Cue feed is a mix of the signals across the four channel faders which monitors the channels in both record and playback, before the faders are opened. Stereo Remix feed is taken from across the Left and Right line-outputs. The headphone amplifiers have a gain set by (1+R42/R40) and (1+R43/R41) for the left and right channels respectively.

The output resistors R38, R39 are 470R and are suitable for 8R headphones, but they can be reduced in value if higher impedance headphones are used.



* NOTE: R33, C40 should be mounted on the cassette motor in order to reduce noise originating from the pulsating current demand from the DC motor.

Fig. 5 Power Supply circuit

Adjustments and Measurements

• Playback

a) Azimuth: Using a test-tape or a commercially pre-recorded cassette, the record/playback head azimuth screw is adjusted for maximum high frequency output as measured on the VU meters or by listening.

b) The VU meters can be adjusted initially to the mid-point of their range for a pre-recorded cassette.

• Record

The adjustments in the record mode are to set:

a) Bias levels,
b) Bias traps,
c) Bias oscillator dummy loads,
d) VU meter presets.

a) Bias level is a compromise for optimum recording to obtain the maximum output level, least harmonic distortion and modulation noise and the best high frequency response. In general, for cassette recorders, the best compromise is achieved by setting the bias to give maximum output at 330Hz and the reduction at higher frequencies is compensated for by modifications to the record re-emphasis curve.

Relative Bias levels can be measured by including a low value resistor in series with the record head. This could be 10R.

The optimum bias level can vary for different cassette tapes and so once adjusted the same tape type should be used. For Sony HF 90 tape the optimum bias level was between 35Vp-p for tracks 1 and 4 ; 40Vp-p for tracks 2 and 3.

b) Bias traps are required in each of the playback channels to reduce the bias crosstalk breaking through via the record/playback head, from adjacent channels which are in the record mode. In Channel 1 the bias trap is the series combination of L1 and C2, and at the output of the playback preamplifier the combination of L2, R19, C25 and C26 further reduce the bias breakthrough.

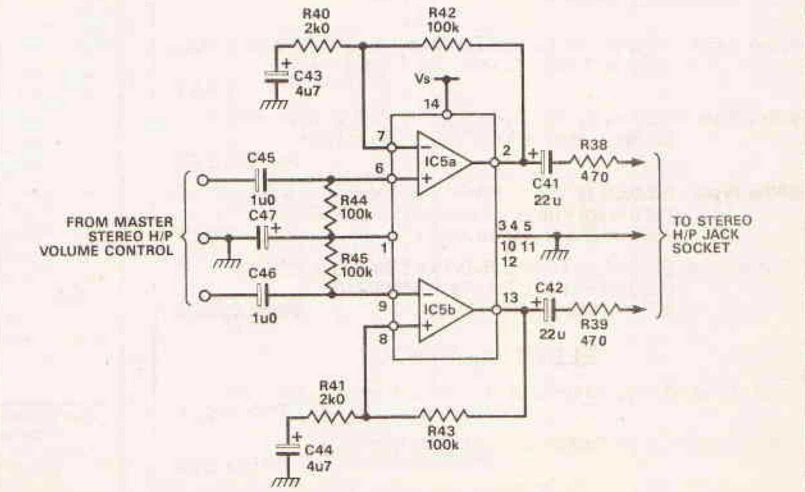


Fig. 6 Stereo Headphone Amplifier

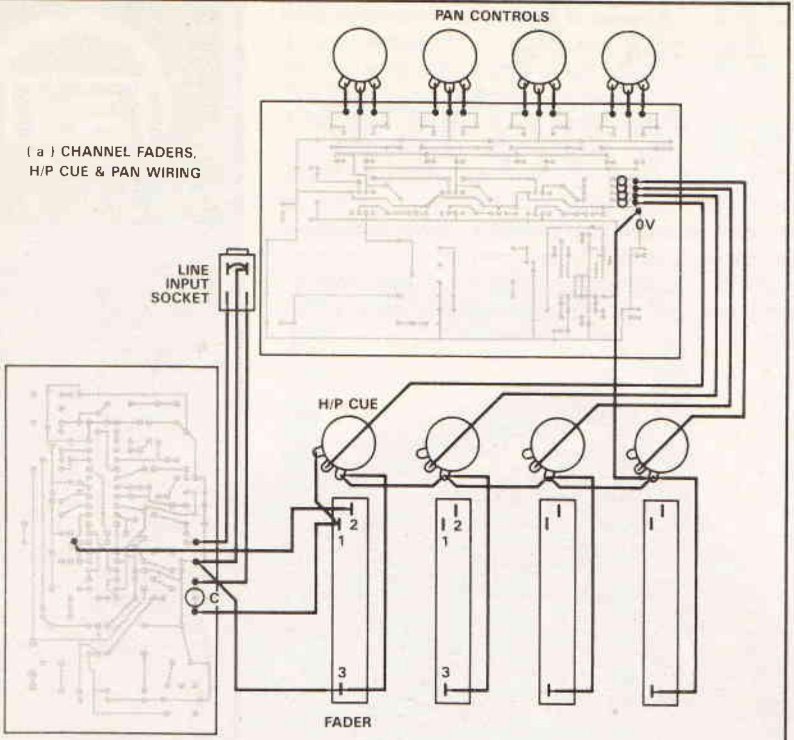


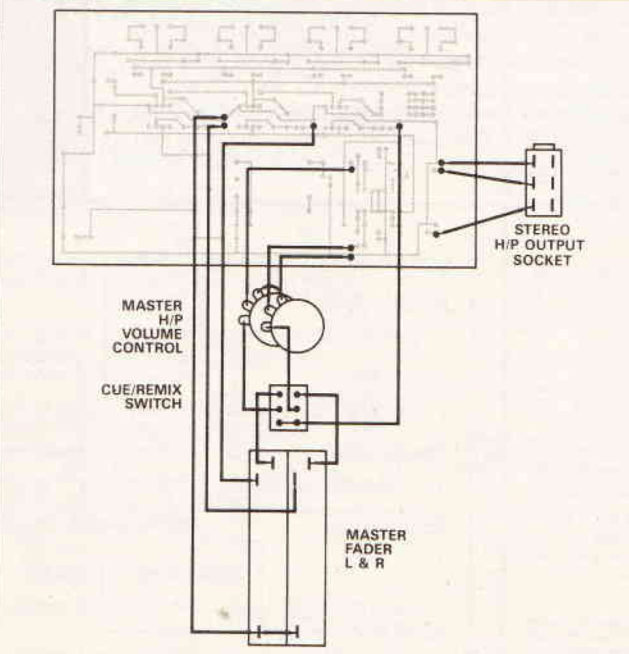
Fig. 7 Interwiring of channel faders and pan controls

c) Bias oscillator dummy loads are required to maintain a constant load and thus a constant output level from the bias oscillator.

The dummy load is a variable inductor L3 and series preset resistor RV3 used to match the parallel combination of the erase head and AC coupled record head.

The inductor is adjusted first to obtain the same frequency between channel heads and dummy loads. Then the series resistor is adjusted to get the correct level.

c) The VU meters can be finally adjusted to set the level recorded onto tape for a given harmonic distortion.



(b) MASTER FADER & H/P VOLUME CONTROL

Fig. 8 Wiring of master fader, Headphone control, meter and record switching

Measurements

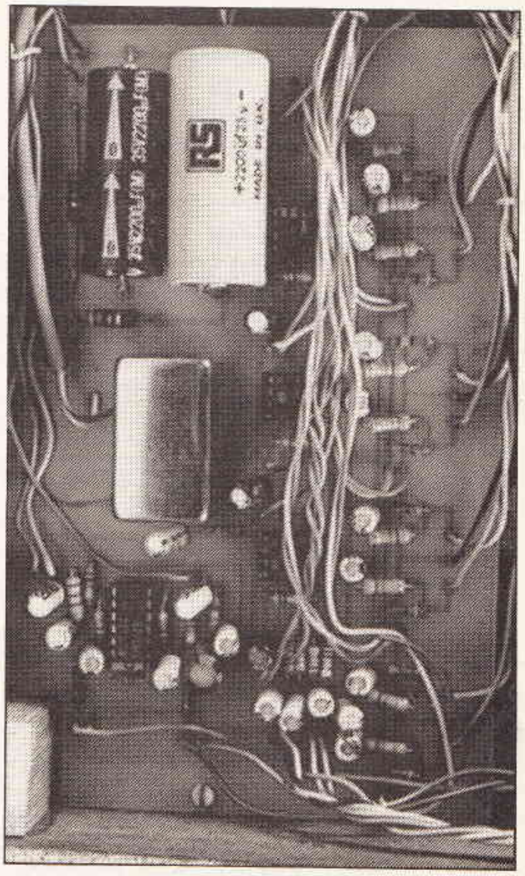
Exact measurements can be taken if a sinewave generator and oscilloscope are available, however the presets can be adjusted using the internal VU meters as follows:

- Adjust bias for maximum output at 330Hz (approximately the note E4 that is the E below middle C) using a synthesiser playing a basic sinewave type sound like a flute sound.
- Adjust bias traps in adjacent channels for minimum output on VU meter. So with channel 1 in record mode adjust the bias trap in Channel 2 in playback mode and so on for all four channels.
- Adjust the 'dummy' load for minimum breakthrough in adjacent channels. With Channel 3 in record mode and while Channel 2 is switched between record and playback set up the 'dummy' load on Channel 1 to maintain the same minimum breakthrough which will occur when the bias frequency and level is the same both on and off-load. The 'dummy' load in Channel 2 can be set up in a similar manner.

Operation

It is possible to record individual instruments or voices onto individual tracks and to record up to 10 tracks on the four track cassette without re-recording any track more than once. (See Figure 13)

Also a number of sources can be mixed together via an external mixer and recorded onto a single track. It is possible for the four tracks can be mixed-down and recorded in stereo onto another machine allowing you to keep the original tracks.



Erase oscillator, PSU and headphone amp board.

It is also possible to insert a piece, or over-record to correct a mistake, using the remote punch in/out jack record socket.

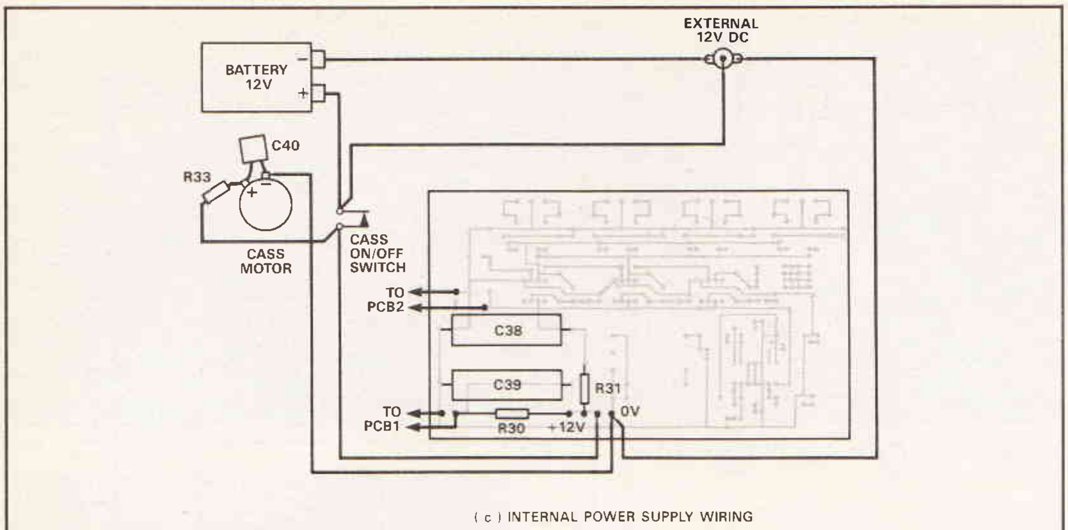


Fig. 9 Internal power supply wiring

PARTS LIST

RESISTORS (all ¼W Metal film)

R1,6,9	10k
R2	220
R3	430k
R4	18k
R5	330
R7	100
R8	1k
R10,23,27,28	47k
R11,12,14	100k
R13	15k
R15,16	1M
R17	3M3
R18	680k
R19	470
R20	4R7
R21	15k
R22	2k7
R24	560
R25,26	5k6

4 off of the above are required for 4 channels

R29,32,35	100k
R30,31,33,34	4R7
R36,37	47k
R38,39	470
R40,41	2k
R42,43,44,45	100k
RV1	47k Horiz Preset 4 off
RV2	22k Horiz Preset 4 off
RV3	4k7 Horiz Preset 4 off
RV4	10k Slider Log Single gang 4 off
RV5	50k Rotary Log 4 off
RV6	50k Rotary Lin 4 off
RV7	10k Slider Log Dual gang
RV8	100k Rotary log Dual gang

CAPACITORS

C1,8,9,10,12,14, 15,16,18,21,24	1µ/100v
C2	470p Ceramic
C3,11,13	10µ/35V
C4,22	1n Ceramic
C5	6n8
C6	220µ/16V
C7,19	100µ/25V
C17	10n High Voltage Ceramic (500DC)
C20	1n
C23	3n3 Ceramic
C25,26	4n7

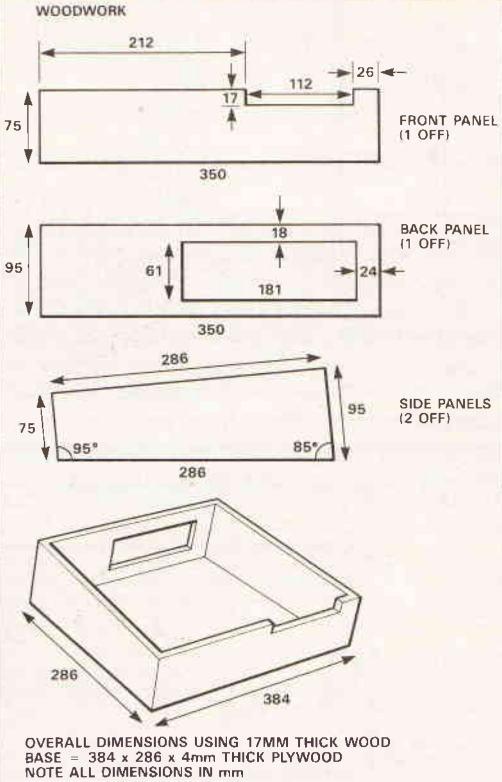


Fig. 10 Constructional details of woodwork

4 off of the above for 4 channels

C27	100µ/25V
C28,29,34	1µ/100V
C30,31,32	1µ/100V 4 off
C33,36,37	82p Ceramic
C35	22µ/16V
C38,39	2200µ/35V
C40	2200µ/25V
C41,42	22µ/63V
C43,44	4µ7/63V
C45,46	1µ/100V
C47	100µ/25V

SEMICONDUCTORS

IC1	LM1818 4 off
IC2,3,4	741
IC5	LM377
D1,2,3,4	1N4001 4 off
D5,6,7,8	1N4148 4 off

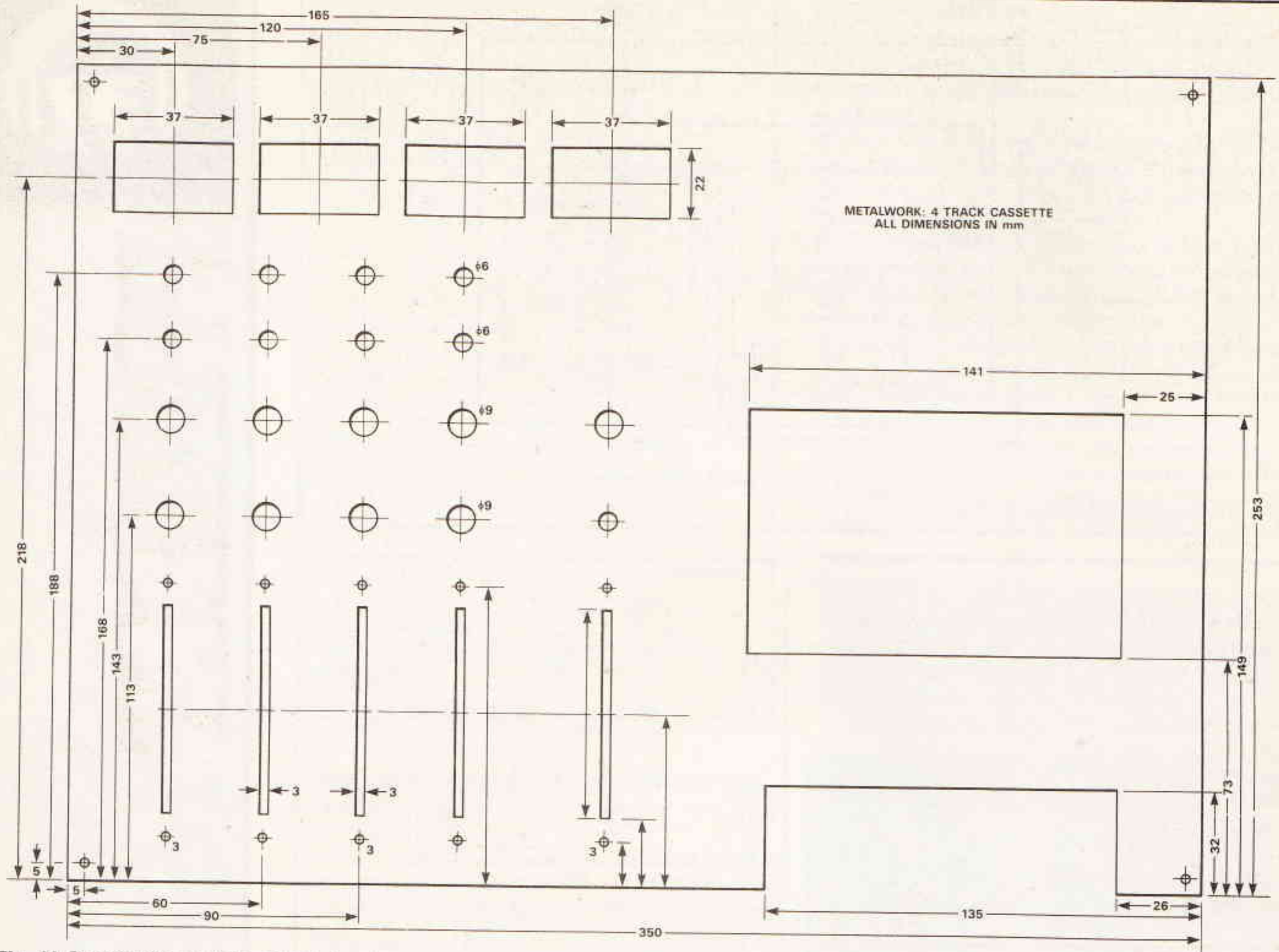


Fig. 11 Construction details of metalwork

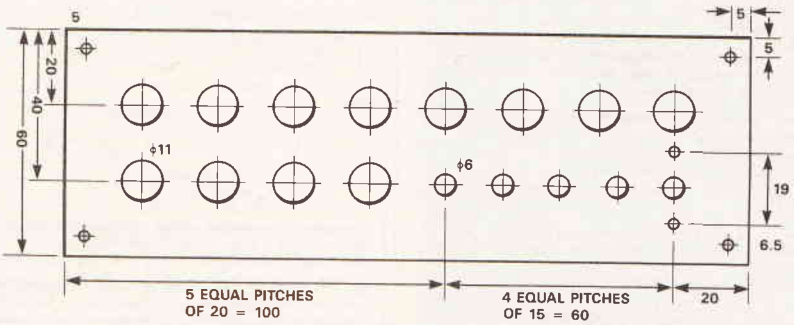


Fig. 12 Back panel drilling details

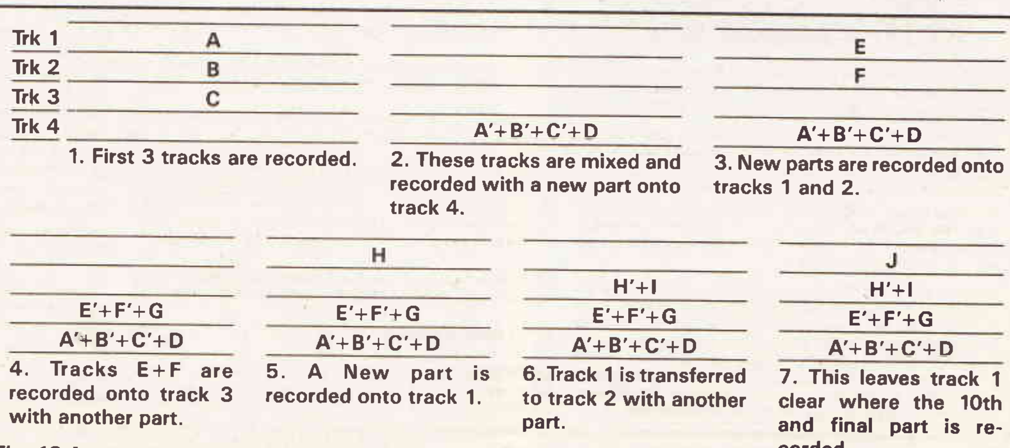
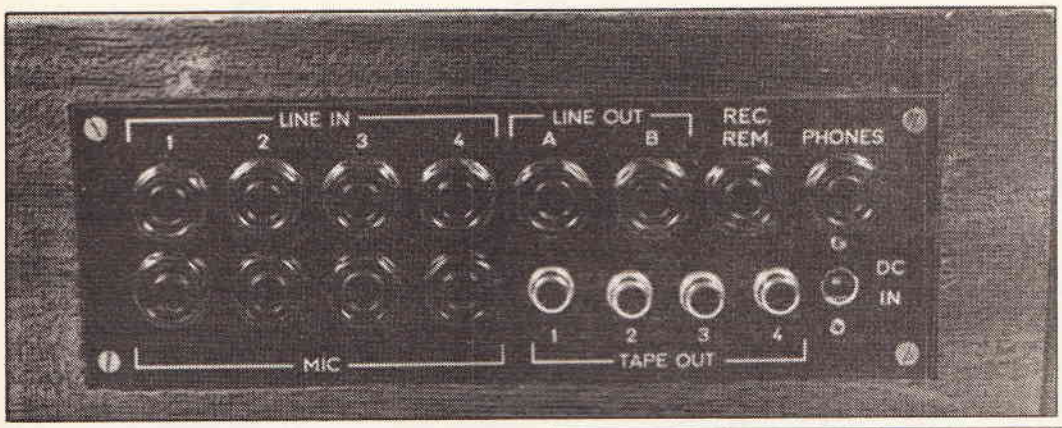


Fig. 13 Arrangement for ten-track recording



Rear of 4-channel recorder

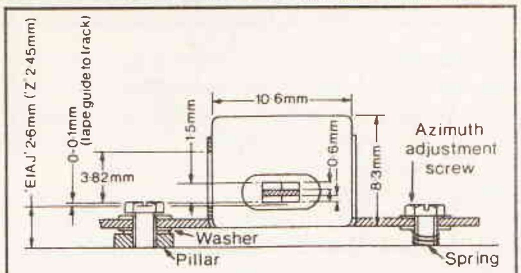


Fig. 14 Dimensions for cassette Record/Replay heads

MISCELLANEOUS

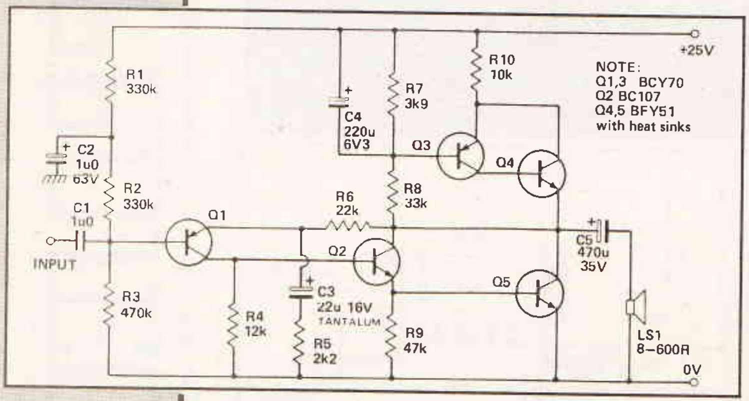
Bias/Erase Oscillator Toko 724 BOR 1078N
L1,3 Toko 87 BNS 135BX 6 off
L2 10mH choke 4 off
VU Meter type V41 4 off
Relays 12V Miniature DPDT 4 off
LEDs Standard red 4 off
SW1,2,3,4 Sub-Min toggle DPCO 4 off
SW5 Sub-Min toggle SPCO
Microswitch for Record On/Off
Cassette 2.5mm switched power socket
Cassette 2.5mm Power plug
Phono chassis sockets 4 off
¼ inch Jack sockets mono 11 off
¼ inch Jack sockets stereo
Cassette deck with 12V motor
Record/Playback Head Type HQ551
Erase Head Teac

BUYLINES

Most components are standard and available from Maplin. The four-track cassette heads are available from Hart Electronic Kits Ltd., 4 Penylan Mill, Oswestry, Shropshire, SY10 9AF. However it is also possible to obtain them as "replacement" heads from some of the Portastudio manufacturers.

AUDIO TIPS

High Quality Headphone Amplifier



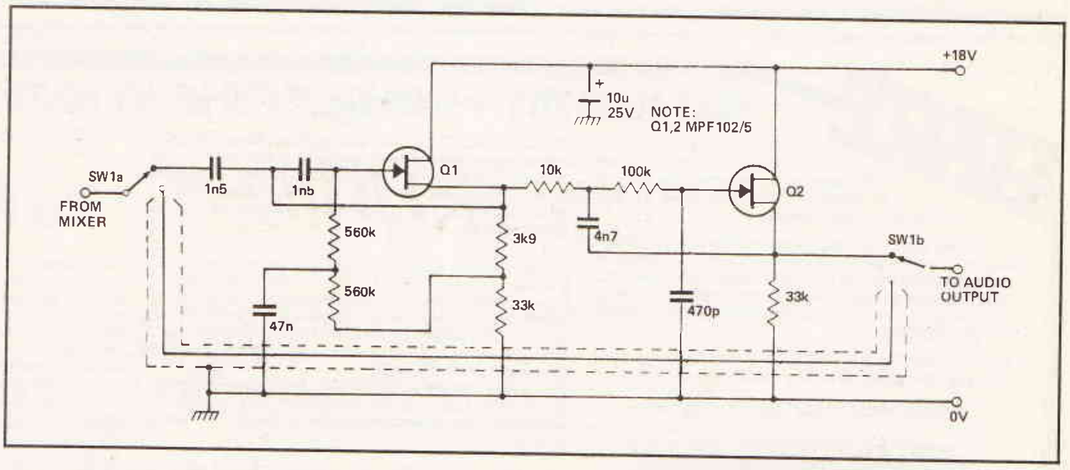
This circuit is capable of high performance using low cost, readily available components. The class A amplifier is designed to drive efficient, high impedance headphones of 150R and above, although it will drive 8R headphones with reduced performance.

Feedback is applied by R1,2 and gain with the specified components is 11. For maximum output the input sensitivity is 0dB. Q3,4 and C4 form a gyrator circuit and present a high impedence to AC signals. This gives the circuit a high open-loop gain. Quiescent current is set by R9 (approximately 60mA).

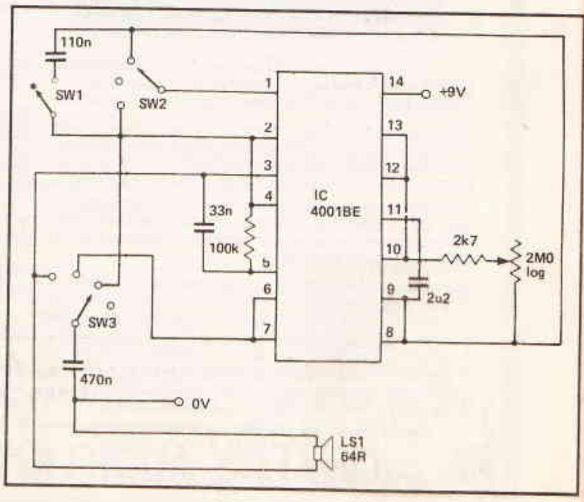
Performance is good with distortion and noise measured on Radford test kit at less than 0.01% for maximum output. Noise is less than −80dB unweighted. Power bandwidth is less than 10Hz to over 50kHz. Slew rate is greater than 5V/us.

Active Audio Filter

The main drawback of passive IF filters is their insertion loss when using inductors, necessitating the use of a two or three stage high-gain preamp to compensate for this loss. With an active audio filter the insertion loss can be low, non-existent or even provide gain. In this FET filter there is virtually no insertion loss. When this filter is incorporated in a receiver and switched in, there is an apparent improvement in the signal-to-noise ratio and readability of signals. High and low frequency heterodynes and audio chatter outside the filter passband are quite noticeably attenuated, making listening pleasant.



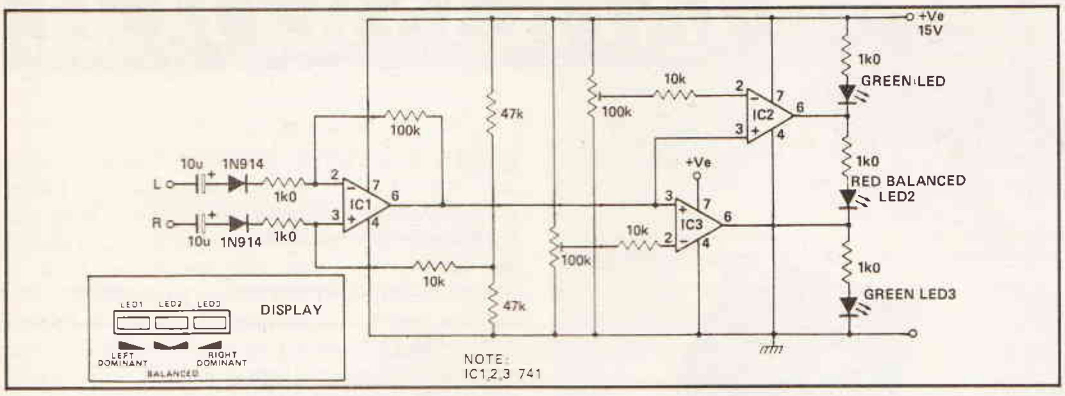
Simple Sound Effects



This circuit will generate 24 different sound effects including two-tone sirens, rising tones, seagulls etc. It operates from a 9V battery and uses only one CMOS IC. Most of the components are not critical, but the speaker must have an impedance 64-100R. Note that the negative supply from the battery does not go to the negative supply pin on the IC, which must be the buffered version of the 4001.

Altering the 33n capacitor or 100k resistor changes the basic frequency, and the 2M0 pot adjusts the speed of the rise and fall of the tones. A PP6 battery was used to drive the circuit and has been in regular operation for six months without replacement.

Stereo Balance Meter



Balance on a stereo amplifier is usually set by ear, but this of course can be very difficult to judge. If an amplifier has a balance meter at all, it is usually of the centre-zero moving coil type — bulky, old-fashioned looking and expensive. This circuit is designed to overcome all of these problems.

The outputs from each channel are fed to the two inputs of IC1, this being connected as a differential amplifier. If the left and right channels are of equal levels, the output of IC1 will have its output at about halfway between the supply rails. If the left channel gets above the level of the right channel, the output of IC1 will approach the 0V rail. If the right channel is loudest, the output becomes positive.

IC2 and 3 are also differential amplifiers, but in this case they are driven by the output of IC1. LEDs form a display at the outputs of the two ICs. Pin 2 of ICs 2 and 3 each go to a preset across the supply. In practice, the preset in conjunction with IC2 is set to hold pin 2 slightly above 0V and the preset connected to IC3 is set to hold pin 2 just below supply voltage. These settings, however, must be set by trial and error so that the circuit works accurately.

The output of IC1 is connected to the non-inverting inputs of IC2 and 3. If the output of IC1 approaches the supply rail, the outputs of ICs 2 and 3 will also go high, thus illuminating LED 3. This would happen if the right channel were dominating. If the left channel were dominant, the outputs of ICs 2 and 3 would be low, thus illuminating LED 1. If the two channels were equal in amplitude, the outputs of ICs 2 and 3 would be high and low respectively, lighting up LED 2.

The circuit can easily be added on to a ready constructed unit without using up large amounts of panel space, or used as an add-on unit for a high-fi system. The unit draws about 20mA, so battery operation is practical.

INFRASWITCH

Dom Banham develops his remote control from last month to operate electrical appliances within a room

This project follows on from last month's Infra-lock article. In this I mentioned the fact that most remote control links work on much the same principle, so one basic system can have a large number of possible applications. The present project uses the same basic system for simple on/off remote control. Up to 16 receivers can be used, each having a different address. The receiver is a compact unit which connects between the mains and the controlled device. Unlike last month's Infra-Lock project, security is not necessary so the receiver can be housed in its own separate box if desired. A power relay is used as the switching element, which allows trouble-free control of large loads (up to 2kW) such as heaters. I will also describe an alternative switching system which enables the system to be used with such things as power-operated doors and home or stage curtains. Some extra switches will need to be added to the transmitter (see photo).

Construction

All the circuitry is contained on the single small PCB, the construction of which is straightforward if a fine-tipped soldering iron is used. Do not forget the single wire link near IC1. In the prototype, the mains connections were soldered direct to the PCB, as was the photodiode. The latter must obviously be able to receive radiation from the transmitter, so it is positioned behind a piece of clear plastic sheet — the red filter from an LED display would also do the job nicely. The PCB should, in the interest of electrical safety, be secured to the bottom of the plastic case with nylon nuts and countersunk screws. If this procedure is followed the whole assembly is effectively double insulated and an earth connection is only needed if required by the load, which is connected via a terminal block attached to the inside of the casing.

Alignment of the unit should be carried out using a 15V power supply connected to the supply rails of the circuit and NOT using the mains!!! With the aid of an oscilloscope and a x10 probe, the period of the oscillator in IC2 (as measured at pin 1) should be adjusted by means of RV1 until it is equal to 1/40 of the '0' interval of the transmitter (see last month's article for further details of the timing). The desired address is set up on SW1-4: SW1 is the LSD and SW4 the MSD. By pressing the corresponding switch on the transmitter and then the 'on' or 'off' position when the circuit is first switched on. If not, switch off and check your construction and timing alignment. There is really not much to go wrong with this circuit! If and when you have success, the unit can be connected up to the load and is ready for use.

HOW IT WORKS

The receiver circuit, as shown in Fig. 1, is fairly simple. The circuitry around IC1 is the infra-red receiver. Pulses of current passing through D1 as a result of incident infra-red radiation are amplified by IC1a. The network R4-R5-C2 rolls off the gain at low frequencies to prevent interference from mains lighting and reduce the effects of varying ambient light level. The output of IC1a is in the form of negative-going pulses which are fed to the non inverting input of IC1b, and also to its inverting input through the R6-R7-C3 network. Normally the potential divider action of R6 and R7 keeps the inverting input at a slightly lower level than the non-inverting input, but due to the decoupling effect of C3, sharp-edged negative going pulses from IC1a will reverse this situation and produce negative-going pulses at about 10V at the output of IC1b. These pulses are inverted and level-shifted by Q1 and fed to IC2, the decoder circuit. This IC is wired to operate in its addressed mode, whereby any code received which has its MSB (bit E) reset is treated as an address. The IC will only respond to the

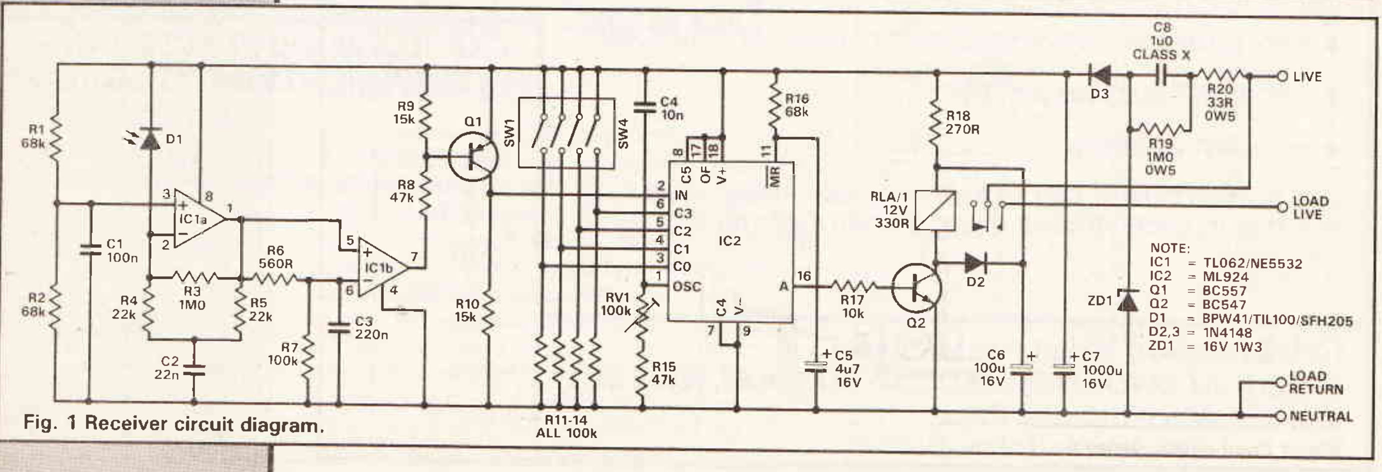


Fig. 1 Receiver circuit diagram.

address set by SW1-4. Once addressed, received codes which have their MSB set will be treated as data and latched on outputs A-D. In this circuit only output A is used, set and reset by the codes 10001 and 10000 respectively. These codes are sent when the 'on' and 'off' switches on the transmitter are operated. Output A of IC2 drives the relay RLA1 via Q2. The relay coil current is limited by R18 to keep it within the capabilities of the reactive power supply, while C6 provides a switch-on 'kick' to ensure that the relay pulls in smartly. The power supply is formed by C7, D3, ZD1, and C8. R19 serves to discharge C8 when the unit is unplugged. R20 acts as an inrush current limiter and fuse(!). For this reason it should be left as the type specified.

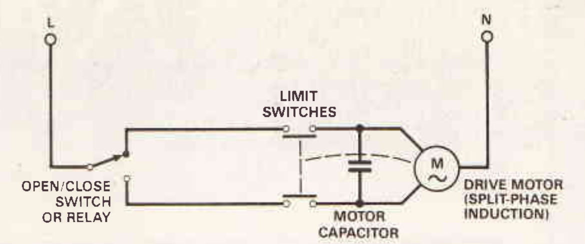


Fig. 2 Power operated door or curtain wiring.

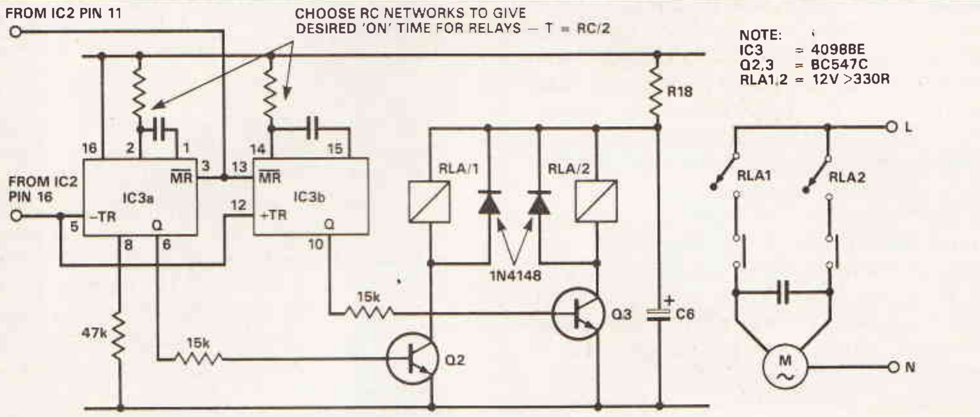


Fig. 3 Modification to receiver circuit for dual relay operation.

PARTS LIST

RESISTORS (all ¼W carbon unless specified)	
R1,2,16	68k
R3	1M
R4,5	22k
R6	560R
R7	100k
R8,15	47k
R9,10	15k
R11-14	100k SIL resistor pack
R17	10k
R18	270R
R19	1M ½w
R20	33R ½w
RV1	100k enclosed sub-min. cermet horizontal preset
CAPACITORS (all polyester unless specified)	
C1	100n
C2	22n
C3	220n
C4	10n
C5	4µ7 16v radial electrolytic
C6	100µ 16v radial electrolytic
C7	1000µ 16v radial electrolytic
C8	1µ 250V AC class X mixed dielectric
SEMICONDUCTORS	
D1	BPW41 or TIL100 or SFH205
D2,3	1N4148
ZD1	16V 1w3
Q1	BC557
Q2	BC547
IC1	TL062 or NE5532
IC2	ML924
MISCELLANEOUS	
RLA1	12V 330R coil, 8A 250V N.O. contact
SW1-4	4 way DIP switch
Case, PCB, wire etc.	

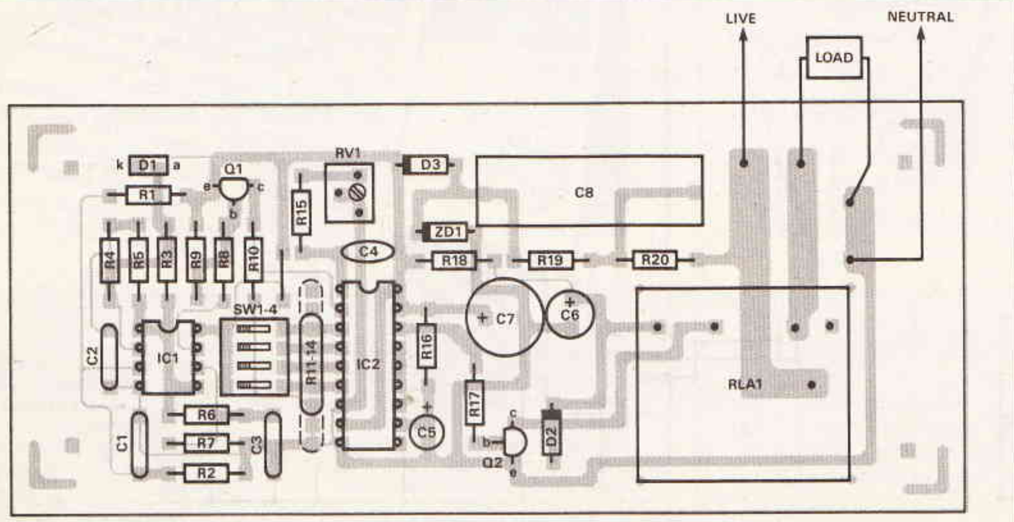
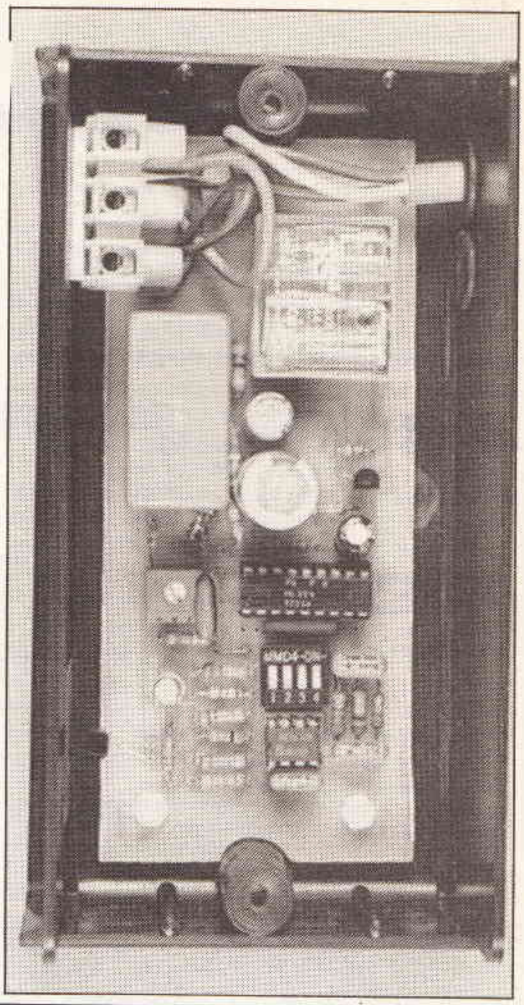


Fig. 4 Component overlay for receiver.

BUYLINES

Most of the parts for this project are standard and should not cause problems. The ML924 was obtained from Watford Electronics (phone 0923 37774). The relay can be obtained from Maplin as order code HY20W or from RS/Electromail as 344-467.



Conclusion

As mentioned earlier, this receiver can be modified to control curtains or automatic doors. These are usually wired as in Figure 2. As it stands the relay in the receiver has changeover contacts which could be used to replace the open/close switch. However, this means that in one state or the other the relay has to remain energised. Whilst this is little disadvantage with doors, which usually remain open for only a short time, with curtains the relay would have to remain energised for hours or days, and bizzare behaviour could result if the power was momentarily interrupted. To solve this problem the circuit in Figure 3 is suggested. Here an extra relay is added, and thus when not actually moving, both relays can be de-energised. The on/off commands generate a rising or falling edge on output A of IC2, and this will trigger one or other of the monostables and its associated relay for just long enough for the mechanism to reach the end of its travel. The connections to the mechanism are shown in Figure 3 but no PCB layout is given as the dimensions of suitable relays can be quite variable, and the remaining circuitry can easily be built on a small piece of veroboard.

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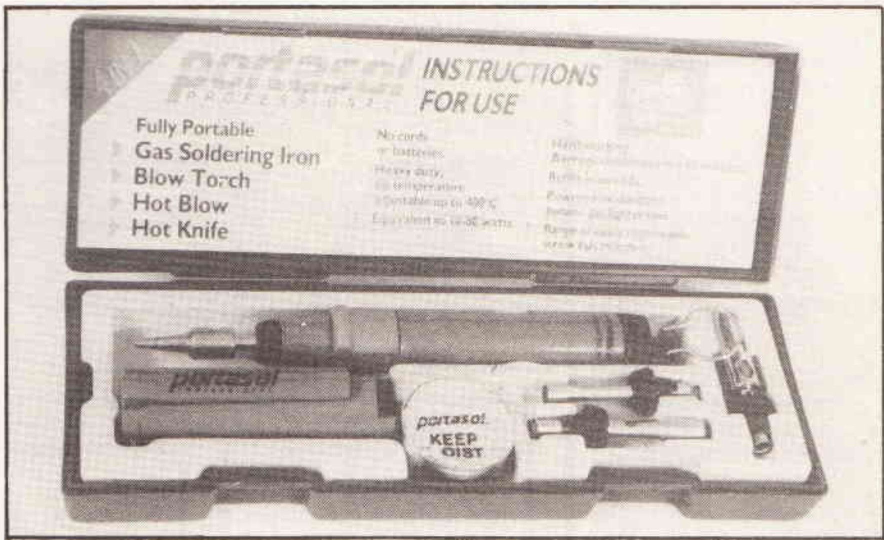

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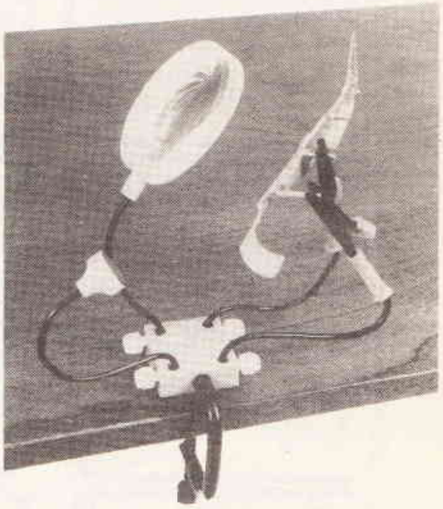

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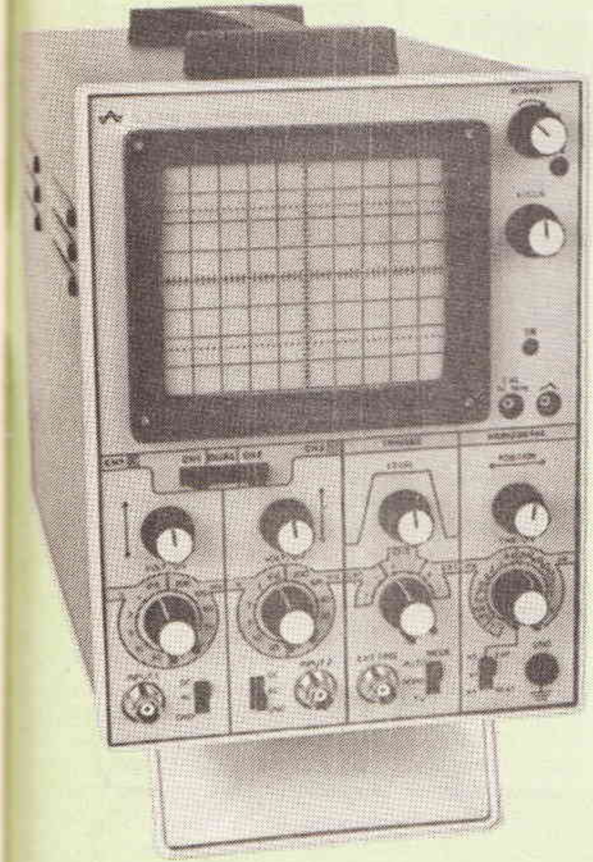
REPAIRING OSCILLOSCOPES

REPAIR

1

Simon Russell takes us through the jungle of buying an old 'scope and bringing it to life.



If you go to a lot of amateur radio rallies of junk sales you might have noticed that there are a lot of old scopes about. By old I mean more than twenty years or so. There might be a little note tacked on the top saying something like 'Timebase faulty', and the whole thing might look quite tatty and dirty. This may not look very promising but many people fail to realize that often there is very little wrong with the equipment, at least nothing that can't be put right with a few hours attention. It is most likely that the equipment will use valve technology and many people know little about circuits that use those glowing glass tubes. This article aims to give a few words of advice to anyone who happens to see a 'scope for sale and fancies their chances at getting it working.

You will need a DMM or an accurate analogue multimeter with a maximum operating voltage of at least 1000V. Another 'scope can also come in handy if you can borrow one. If you have a manual or circuit diagram then you can increase your chances of success by about 5000%.

For the purposes of this article I have assumed that you know about the principles behind the operation of CRO's, if you don't then there's no way you'll be able to repair one.

It is most likely that the equipment you get hold of will use valves. Bear in mind at all times that these circuits operate at supply voltages generally in excess of 250V. These voltage are potentially fatal and you should observe a few safety precautions when working on them. Firstly, never touch an assembly or board when it is switched on. These are not TTL circuits and you will almost certainly get bitten. Secondly, always make sure that any capacitors in the circuitry that you are working on are discharged after you switch off but before you touch the circuit, they can hold their voltage for a long time. Lastly, always use your meter correctly. It is almost impossible to blow up a meter whilst working on low voltage circuits but it is extremely easy to blow up one when working on high voltage equipment.

Always treat a live circuit with the same respect that you would a live mains circuit.

What To Look For When Buying A Scope

The worst single thing that can happen to a 'scope is for the CRT to fail. Don't buy equipment that has an obvious problem in this department. Quite often the tube has been taken out but you can use the rest as spares. Sometimes a CRT appears with a large ion burn on it's face. Again, this is extremely undesirable.

Sometimes there is a note on the thing stating that there is a problem in a particular part of the circuitry. Occasionally these are inaccurate and the person who wrote the note simply drew the wrong conclusions from the symptoms. Always try to get a manual or a circuit diagram with it. This will save you a lot of time and trouble later.

You might come across a 'scope that has two brilliance and focus controls. This sort of equipment uses a tube that has two electron guns to produce two traces. These tend to be more trouble than they're worth despite their novelty value.

Sometimes a scope will have been stored in a garage or outhouse of some description. The equipment will probably have been exposed to the damp so most of the capacitors will need replacing. Avoid this.

Look at the mains cable at the plug end. Is the insulation in poor repair? If so then the equipment has probably not been plugged in for a long time. There might well be a calibration sticker on the equipment that is usually a pretty good indication of when it was last in service.

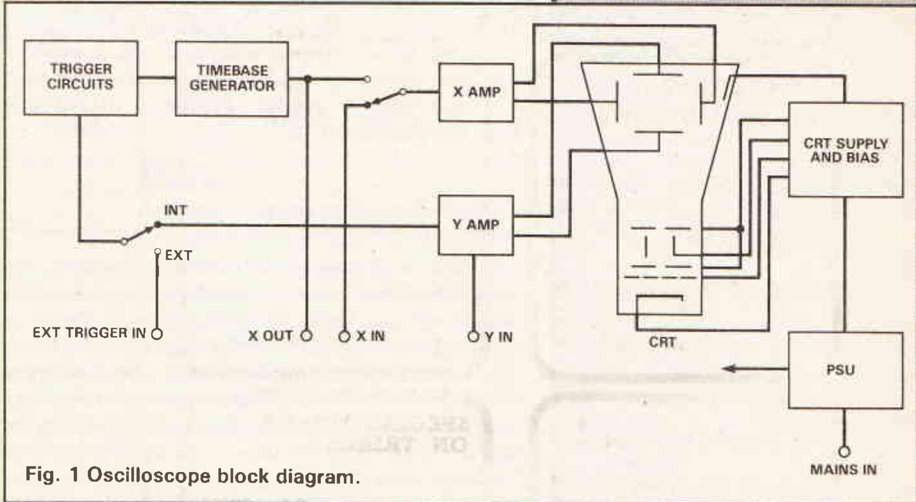


Fig. 1 Oscilloscope block diagram.

Initial Tests

So, you've got the 'scope home and on the bench and are about to plug it in for the first time. First of all you should have a quick peek inside, just to see that everything is there and in place. Just for interest, check the date on the capacitors, this will give the approximate year of manufacture. For instance, 'JUN 65' means June 1965 or '5732' which means week 32 of 1957. Check for components that are blackened and crispy, this is a dead giveaway that something serious is wrong. Assuming that everything looks okay, if a bit dusty, you should measure the resistance between case and Live of the mains input lead. With the instrument switched on there should be an infinite reading on the ohmmeter. This is not a conclusive test but should show if a fatal condition could exist.

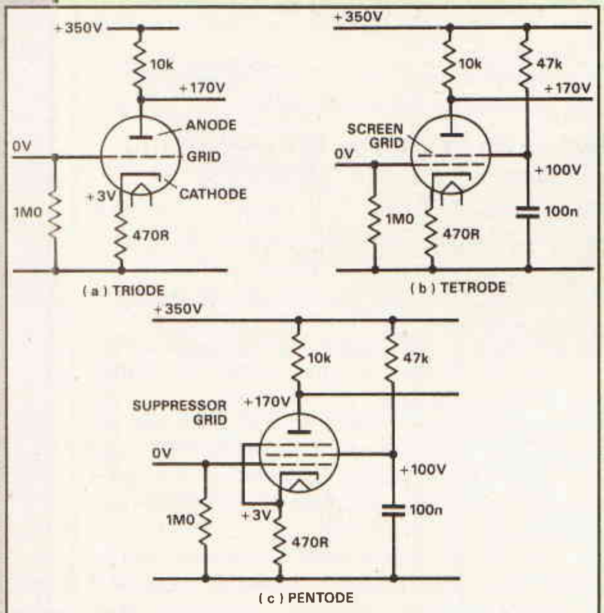
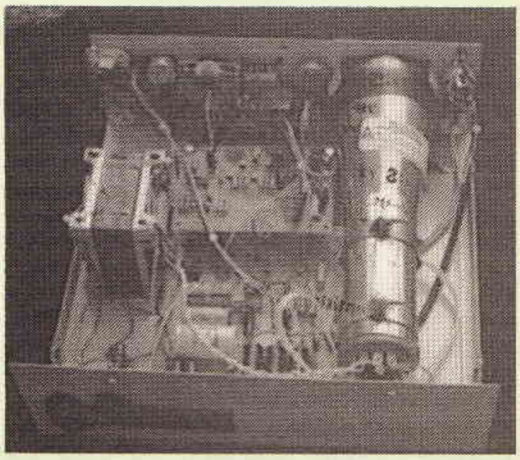


Fig. 2a Typical valve biasing techniques.

Before you do that it's always a good idea to check the input voltage setting. You will probably have no idea where the equipment has come from and it may be set up for American mains at 120V. Putting 240V in could be a costly but easily avoidable mistake. Having made sure all is well you can apply power. This is a rather tense moment as the thing could explode



in your face. your most useful sense is that of hearing, you will hear something go wrong before you see it or smell it. I usually work with a radio playing in the background but would never plug in a piece of kit for the first time without being able to hear exactly what's going on.

Let's assume that there is no immediate sheet of flame and that your house is not plunged into complete darkness (don't laugh — it happens). Your next task is to find out what the 'scope can't do. A typical symptom might be on trace on the CRT, or a spot but no horizontal trace, or inability to focus, or no vertical deflection or a combination of these. Before you

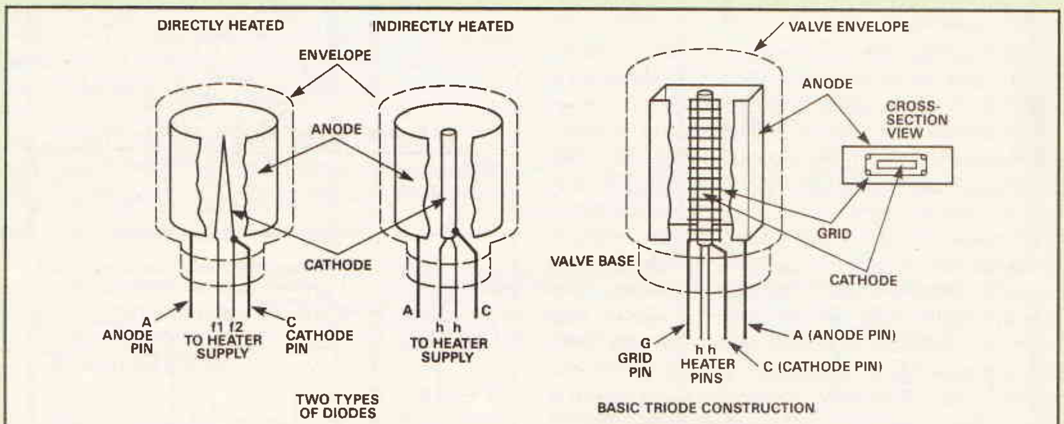


Fig. 2b Basic valve construction.

This is an opportune moment to remind the reader to take all necessary safety precautions. The testing of any piece of electronic equipment is potentially dangerous, and the older the equipment the more this is so. Anybody working on this sort of thing should never become complacent about the hazards involved. Always, when making a measurement on a live circuit, put your free hand in a pocket or behind your back. **Never** lean on a earthed chassis whilst working 'live'. Oscilloscopes are particularly dangerous as all CRTs require high voltages that, although not always fatal, are extremely unpleasant to experience at first hand. For obvious reasons it is extremely unwise to wear metal watchstraps, identity bracelets etc whilst working on live circuits.

Now I've made my point it's time to plug in the 'scope.

decide where to start looking you must be aware of all the symptoms. If no trace is visible then turn the brilliance control fully clockwise, the trigger control to 'AUTO' and play with the X any Y shift controls for a few minutes. If nothing appears then that's as far as you can go until you get that sorted out.

Assuming that something appears on the face of the CRT, check that it can have it's brilliance altered and that it can be focused to give a sharp display. Next check that a horizontal trace can be produced in all positions of the timebase 'SPEED' switch. Check that the X and Y shift controls do their thing. With a finger on the Y input, check that vertical deflection occurs with the Y 'SENSITIVITY' switch fully clockwise. You should get something that approximates to sinewave at mains frequency. If the timebase appears to be present then try to get a stable display by manipulating the trigger controls. If there is a calibration output then check that this is present. The foregoing is a basic functional test and should show up any major problems.

The art of a good trouble shooter lies in his (or her) ability to tell where, approximately, the fault might lie by simply observing the symptoms. Refer to the block diagram of a 'scope (Figure 1). If the operation of oscilloscopes is well understood then the reader should have no trouble determining where to look. If, on the other hand, you are not familiar with the idea of flyback suppression, synchronisation, and deflection techniques, then these notes might be of some use.

No trace or spot on the CRT indicates a problem in the CRT supply and biasing circuits. Inability to focus or poor brilliance are also indicative of a problem here.

No horizontal trace or an offset trace means a fault in the timebase and/or X deflection amplifier. No vertical deflection means that something is wrong in the Y amplifier. Inability to trigger or no calibration signal are self explanatory in their location.

The foregoing is by no means an exhaustive list of faults that you may encounter but, by using similar logic it should be possible to pin them down to a general area.

Having decided where to start looking you will now need to fault find at component level. If you have no experience of valve technology then you might find 'A crash course in valves' useful.

A Crash Course In Valves

If you have never had to work on valve equipment and only heard about valves you might be forgiven for thinking that they are extremely unreliable and dangerous to use. This is only partially true. There are an almost infinite variety of valves, many types are still in production because semi-conductors cannot do the job. I will confine my description to the type of low power receiving valves normally found in instruments and that have now been totally replaced by semi-conductors. All valves rely on movement of electrons within a vacuum. This is why valves are always encased in glass or metal. If you look at a glass cased valve you will notice a rather beautiful silvery mirrored effect. This is the result of an incomplete chemical reaction that was started the day the valve was made. The practical up-shot of this is that if any gas enters the valve, due to a crack or a broken seal, the silvering starts to turn white as the reaction completes. Thus a 'gassy', and hence useless, valve is indicated by a white deposit within it. Just like tyres, valves can have a slow leak and the change in the silvering could take several days. There are four main types, diodes, triodes, tetrodes and pentodes. The first and simplest of these is the diode (see Figure 2b). The original diode had two electrodes (hence di-ode). The cathode consisted of fine wire, similar to an incandescent lamp. The anode was simply a plate of metal. When the cathode was heated, electrons could leave it and would be attracted towards the anode if it was positive with respect to the cathode. By this means a current could flow from anode to cathode (remember conventional current flow). If the anode was negative then any electrons that left the cathode would be repelled from the anode and no current would flow. As you can see, a valve diode behaves in a very similar way to a semiconductor diode, the main difference being that a valve diode may drop several volts in it's forward mode, whereas a semiconductor diode will only drop 0.6-1V. Most diode valves have a slightly different electrode arrangement. Instead of the cathode being a single wire, it is a small cylinder coated with oxide. This, itself, does not produce heat but the centre is packed with a heating element. This gives improved performance and valve life. The two types of cathode are known as directly and indirectly heated respectively (Figure 2b). The anode is almost always of a tubular construction (though the Americans persisted to call it a 'plate' for decades after it stopped being so).

A triode is very similar in construction to a diode except that the cathode is surrounded by a spiral of wire called a 'grid'. Electrons that travel from the cathode to the anode must pass through the grid. As this grid is much closer to the cathode than it is to the anode, it can have much greater control over anode current than the anode can itself. If the grid is at the same potential as the cathode then current will pass unhindered to the anode. If the grid is taken negative of the cathode then electrons will be repelled from the grid and return to the cathode, never reaching the anode. The more negative the grid, the less anode current flows until the valve is completely cut off. The grid is never taken positive of the cathode so no grid current passes. By this means a small signal on the grid will cause a larger signal to appear on the anode if a suitable anode resistance is supplied. The change in anode current for a given change in grid voltage is called the mutual conductance and is measured in mA/V. Some readers may have spotted a similarity in behaviour between the triode valve and the n-channel JUGFET. This is a perfectly good comparison as they behave in almost exactly the same way. Despite this, the triode was replaced by NPN and PNP bipolar transistors.

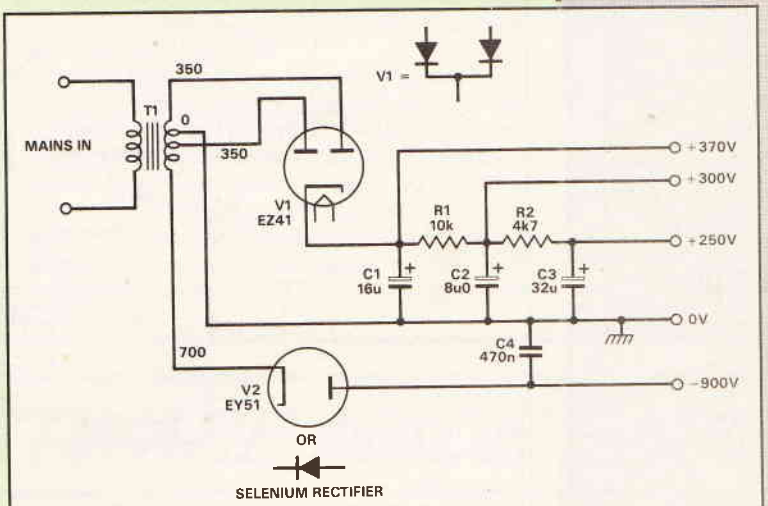


Fig. 3a Power supply found in older units.

A development of the triode was the tetrode. This has a second grid, called a screen grid, between the control grid and the anode. This is at a similar or slightly lower voltage than the anode. It purpose is to reduce the Miller capacitance between the control grid and anode. This means that much higher gains can be achieved without the valve oscillating. An unfortunate side effect of this is the introduction of a 'kink' in the transfer curve of the valve called the negative resistance region. This can give rise to distortion. To combat this a further grid was added between the screen grid and the anode called the suppressor grid. This was always kept at cathode potential or simply earthed. This device was called a pentode. The symbols for all these valves are shown along with typical biasing arrangements in Figure 2a. If you think that these look similar to transistor biasing circuits you'd be right, except that these circuits were around long before transistors were invented.

A few points are common to all these valves. Firstly, the cathode must always be hot for the valve to work (=1000°C). This should be evident by a bright yellow glow in the centre of the valve. If this does not occur then the heater may be open circuit (a common fault). Secondly, valves are extremely tolerant to overloads and over voltages (except heater voltages which should always be within 5% of their stated value). Unlike semiconductors which blow instantly, valves will stand instantaneous overloads of many times before finally expiring.

Another advantage of valves is their ease of replacement. If a transistor blows you generally have to desolder it, valves simply fit into sockets.

The final, and most important, point is one of safety. If you have bothered to read this section then you have probably never worked on valve equipment. Most valve circuits work in positive supply lines of about ±350 volts. If you are used to ±12V supplies you might be in the habit of poking around the circuit whilst it is switched on. If you should continue this practice when working on high voltage stuff you will not stay breathing long. Valve equipment requires a healthy respect and you should never feel completely happy about making measurements on a live circuit, though you will always need to. I find it helpful to keep in mind the fact that only 100mA flowing across ones chest will easily kill. There is also nothing more disconcerting than realizing that the black and crispy object hanging from the light fitting used to be a colleague.

Power Supply Faults

If, upon switching on, absolutely nothing happens then you may have a fault in the power supplies. If you have a circuit diagram then there will be obvious supply lines. Check the voltages on these lines using your meter. As a general rule they should be within 5-10% of their nominal value. If you have no diagram then measure the voltage on the collectors of a few transistors or the anodes of a few valves. There will almost always be voltage test points marked in obvious places, these should be checked. If all supplies appear to be present and up to strength then you may have a fault in the CRT supply/biasing circuits. Assuming that one or more of the supplies appears so be low or missing you must find out why. A few typical PSU circuits are shown in Figure 3. If your 'scope is of the early valve type then Figure 3a will be of the same type. If yours is of the more up-market valve type then the supplies will be electronically controlled, (Figure 3b).

If the scope is of the transistor variety then Figure 3c might be similar to it. These circuits, like all others in this article (unless otherwise stated), should not be taken as gospel and are for illustration purposes.

Figure 3a shows a classic un-regulated linear power supply. Mains is applied to the primary of T1 by the usual means of fuses and switches (not shown for clarity). V1 is a double anode diode and works in exactly the same way as a normal diode except that there are two anodes. This full wave rectified DC is smoothed by C1, C2, C3, R1 and R2. A further tapping on T1 is half wave rectified by V2 to provide a high negative voltage that is smoothed by C4. In later 'scopes V2 was replaced by selenium rectifiers. These behave in a similar way to diodes except that the can carry an almost infinite instantaneous current. If any of the positive supplies are missing then V1 could be faulty, any of the resistors could be open circuit or even the primary or secondary of T1 could be open. If any of the supplies appears to be low then there could one or two causes. A large amount of ripple on the supply lines will appear to be a reduced voltage so you must first check the ripple content with either another scope or the AC range of your voltmeter in series with a 0.1μF/400V capacitor. If the ripple is more than a few volts peak to peak then you might have a leaky or open circuit capacitor (a very common fault). The rectifier valve may have gone low emission, the only cure for which is a new valve. If all looks okay so far then measure the AC coming out of the transformer. If this is low then it is likely that it has a few shorted turns due to dampness or just breakdown of insulation, a new transformer is needed.

The negative supply follows similar rules except that where a selenium rectifier is used this might well be faulty. What ever you do with a selenium rectifier, after twenty years or so, they go high resistance. If your supply lines are low this will almost certainly be contributing to the problem. The only remedy is replacement. Do not try and replace with another selenium device as this will probably have similar defects. You must use a high voltage silicon diode (1N4007, BY126 and 127 etc) in series with a suitable resistor. The resistor is very important. Selenium rectifiers, even when new, had a very high forward resistance. The circuit designer will have taken this into account when the circuit was originally produced. The only way to determine the value of this resistor is by trial and error. Start off with 10k and check the supply line voltage. If this is too low then reduce the resistance, if too high then increase it. I normally find a few k adequate. Do not be tempted to leave out the resistor even though the circuit appears to work perfectly well.

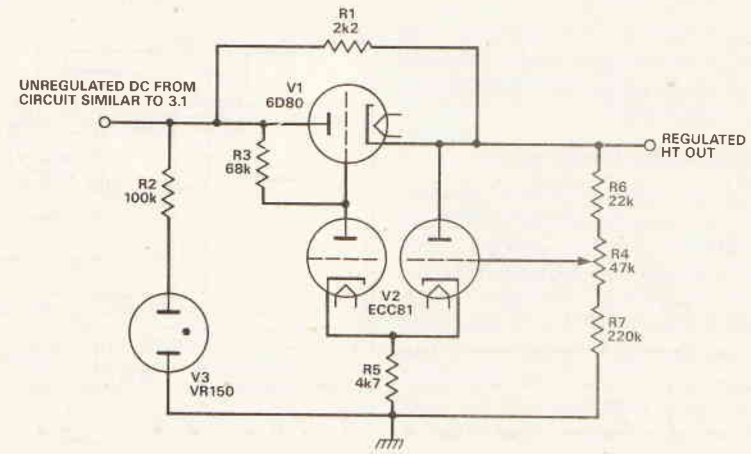


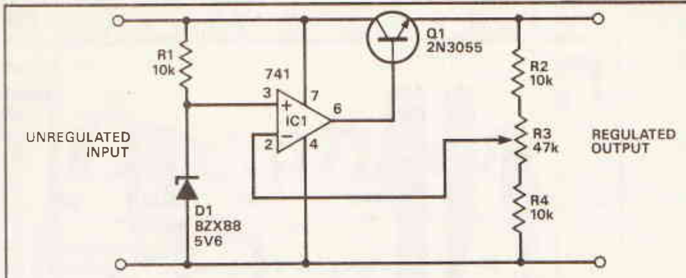
Fig. 3b A regulated HT supply.

You will be putting a big strain on the smoothing capacitors and they will eventually explode!

If all the components seem okay but your supply lines are still low then it's likely that something is drawing too much current. This is a extremely difficult fault to find as almost everything draws current from the supply. The only way to find this is to isolate each bit of circuitry in turn until the supply returns to full strength.

The circuit of Figure 3b uses negative feedback to provide a stabilised supply. All the preceding comments about unregulated supplies apply equally well here, there are also some extra points to consider. V3 is used to provide a stable reference voltage (usually about 150V). V3 is a gas filled device, similar to a neon, that will drop a constant voltage. This sort of thing was often known as a stabiliser tube and was used in any application that we might use a zener diode or diac in nowadays. This reference is compared to a potted down version of the output voltage by V2, a double triode connected as a long tailed pair. The error signal is used to drive the grid of the main pass triode. Note the use of R1. This is to reduce dissipation in V1 and thus allow a smaller valve to be used. If any of this feedback circuitry stops working then an incorrect output voltage will be produced. Note that R4 allows adjustment of this voltage. An interesting and misleading fault can appear if a similar configuration to R1 is used. You might find that the output voltage is unusually high. This could well be due to insufficient current being drawn from the circuit. This sort of configuration relies on current being drawn through R1 to pull the output voltage down below the desired value, at which point V1 starts conducting and the voltage will rise. If insufficient current is being drawn then V1 will be completely cut off and output voltage will be totally dependant on the reduced current drawn through R1. This can be a real red herring.

Figure 3c is the sort of PSU that might be found in older solid state equipment. It's really nothing more than a discrete voltage regulator, the sort of thing you ought to be familiar with. Newer scopes use IC regulators such as the 78 and 79 series, in which case you should have no trouble at all. It's possible (though extremely unlikely) that you might come across a unit that has a switch mode PSU in it. In this case you really need the help of someone with experience of these as they can be a real pain.



NOTE: HT FOR THE TUBE IS NORMALLY GENERATED BY AN INVERTER

Fig. 3c Solid state discrete regulator.

Once more, a word about safety. Regulated high voltage supplies are just as dangerous as mains, they can easily deliver the current that is required to kill and will happily do so if given half a chance. Bear in mind that the capacitors in such a circuit (or any that operates off of high voltages) will retain their charge after switching off. It's always a good idea to have a flying lead connected to the chassis to touch on each capacitor after switching off but before putting your hands inside.

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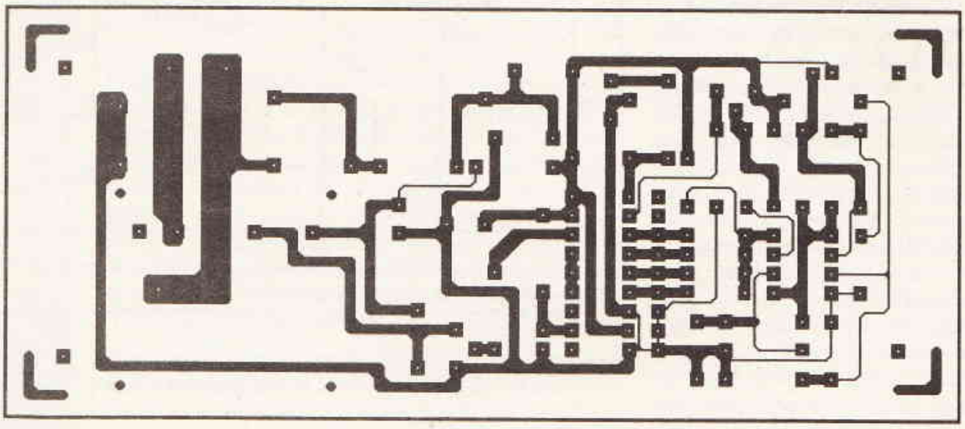

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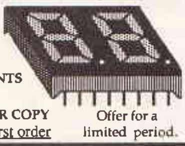

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NEXT MONTH

We continue with our home management system, the system that puts your mind at rest over keeping the lights off in areas you don't want and on in the areas you do and it will open the wrought-iron entrance gates ready for you to drive the Rolls in after a hard day mixing cement on the building site. What it can do for you is only limited by your ideas.

We have a Five-in-one device to remotely sense the start or flow of any current in a conductor be it visible or hidden from view like electric cables in a wall. Again we provide you with five ideas but the usage is limited only to your creativity.

There's more on our regular series of HDTV, Tech Tips and Testing Testing and also the second part on Repairing Oscilloscopes which could prove extremely useful.

January sees the start of a mini computer series, building a general purpose micro-controller, an EPROM Emulator and an EPROM Eraser to keep all computer freaks quiet through the long hard winter.

Make sure of ordering your copy for the festive season and collecting it on 7th December.

The above articles are in preparation but circumstances may prevent publication

LAST MONTH

The HDTV series covered the only operating Japanese system of high definition television. We started the series on Recording Studio design to help you on you way with building your own acoustic enclosure. Projects included a 4-channel cassette tape recorder, an Autocue — a digital timer to give perfectly timed speeches, Infra-lock — a remotely controlled security device to lock up your computer, TV or electronic safe and a host of Musical circuits under our Tech Tips heading. Back copies are available from Select Subscriptions.

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