ETI

ELECTRONICS TODAY INTERNATIONAL

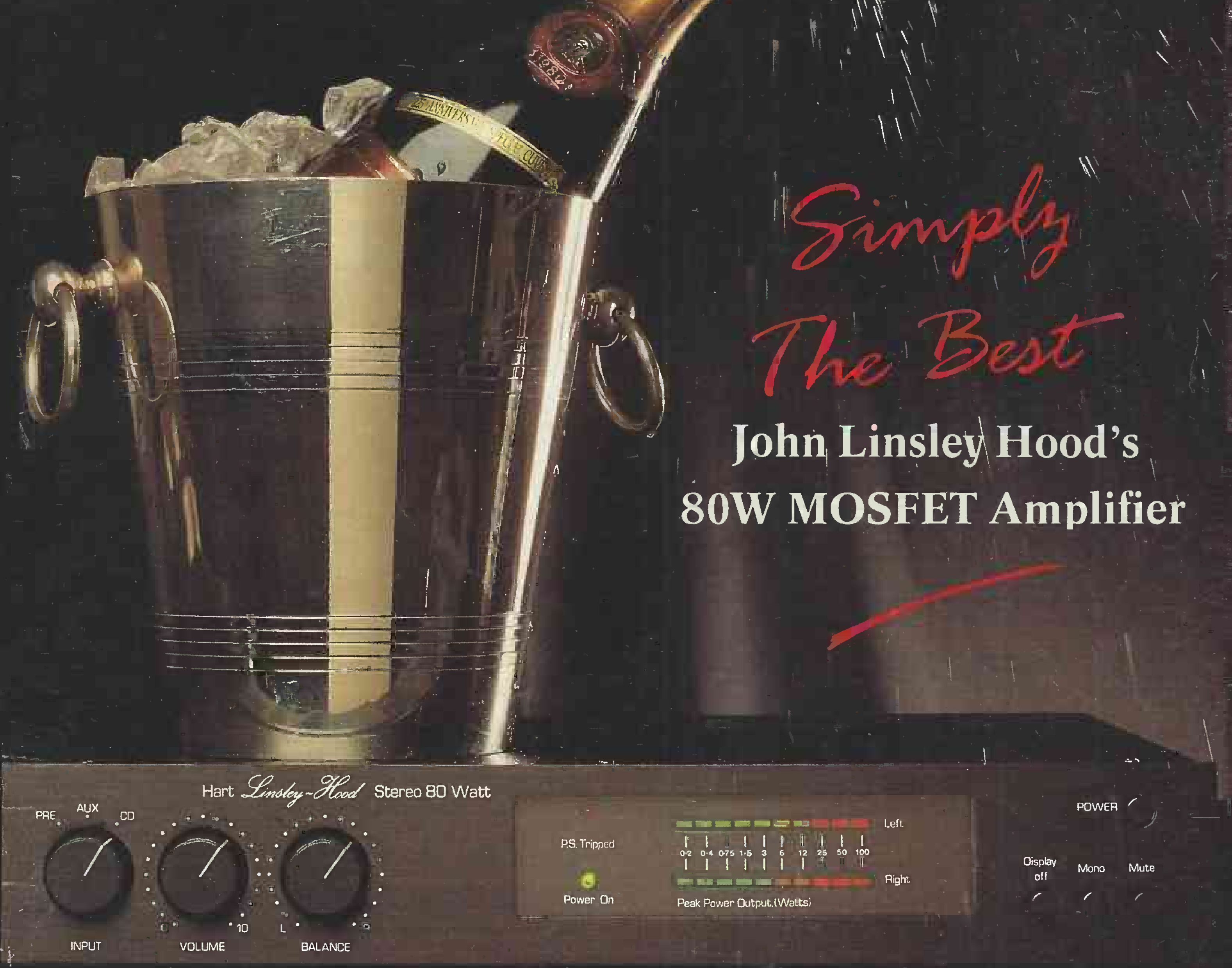
THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

MAY 1989 £1.50

WORKBENCH WORKHORSE
Power Supply Project

PERFECT PITCH
Guitar Tuner Project

DIY PCB EQUIPMENT
UV/Light Box & Etching Tank



Simply The Best

John Linsley Hood's 80W MOSFET Amplifier

AUDIO•COMPUTING•MUSIC•DOMESTIC

ETI ELECTRONICS TODAY INTERNATIONAL IS MOVING!

TO: ARGUS HOUSE, BOUNDARY WAY, HEMEL HEMPSTEAD HP2 7ST

We're off! We've packed the ETI suitcases and departed the hallowed halls of Golden Square for the wide open spaces of Hemel Hempstead.

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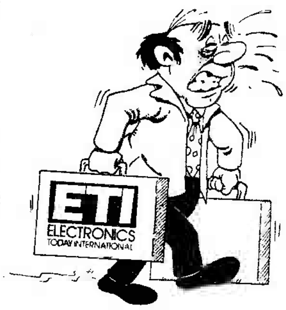

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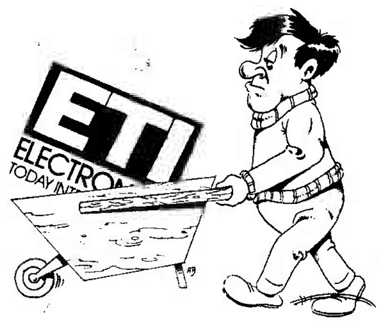

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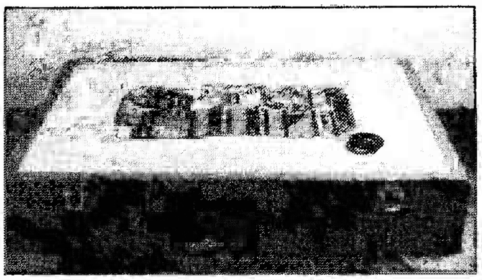

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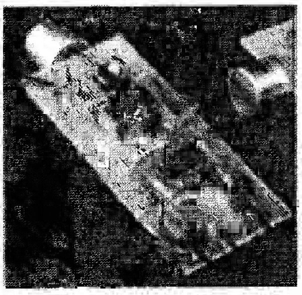

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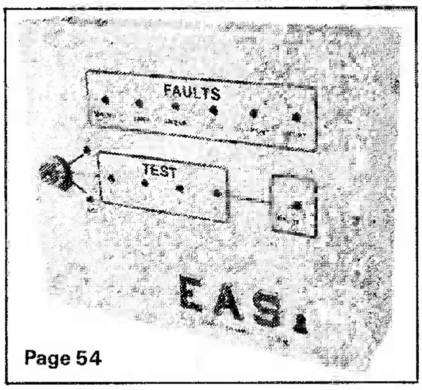

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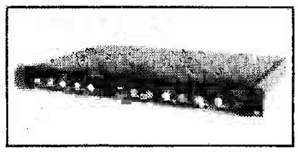

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ELECTRONICS TODAY INTERNATIONAL

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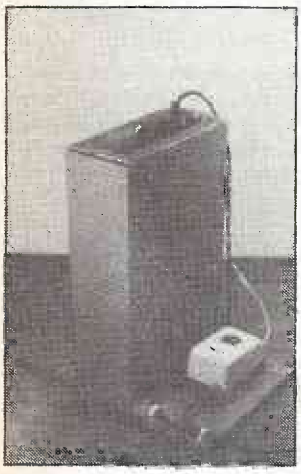

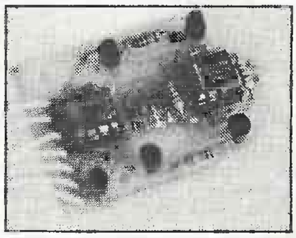

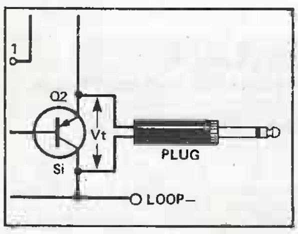

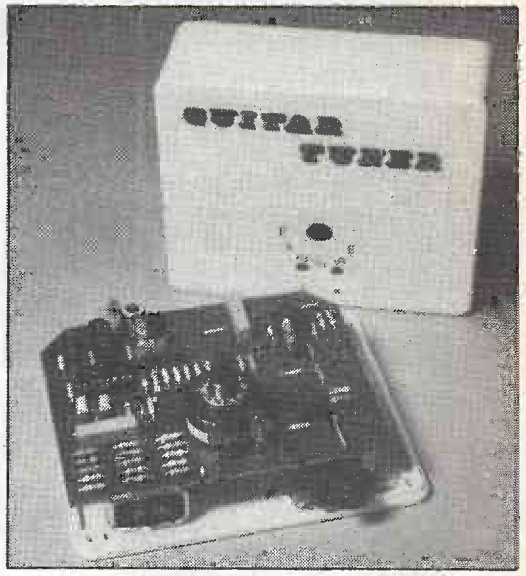

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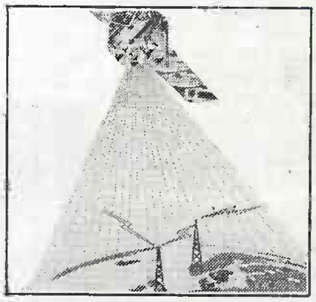

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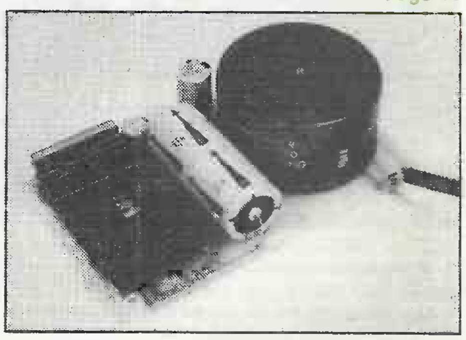
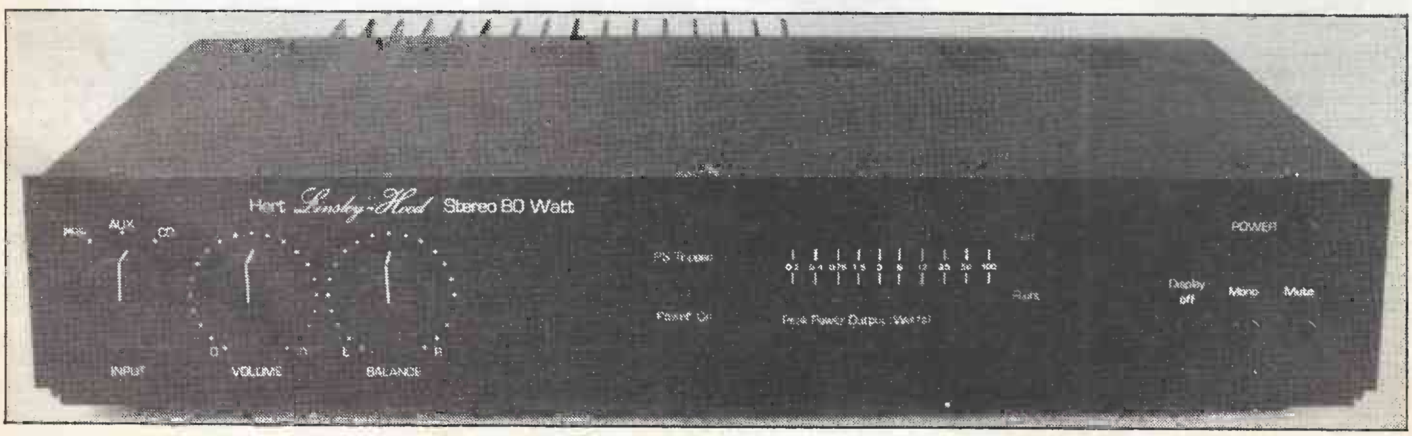




NEWS

SEMICONDUCTOR DEVELOPMENTS

Intel has announced its new 860 microprocessor, a 64-bit RISC operated chip using one million transistors. Although not yet tested in a full system, its speed in instructions/sec is double that of the most advanced RISC processors at present and only about a third that of today's supercomputers.

Microsoft is working on software for the new chip and the news that IBM and Olivetti have adopted the chip means that Intel should take a leap-frog forward to the front of the RISC workstation market.

You can be sure that Intel's 860 will have a very clear copyright marking. The company has just lost a serious 2½-year legal battle with NEC who it claims has been infringing copyright by marketing clones of Intel's nine year old 8086 and 8088 microprocessors.

By failing to clearly mark all its chips with copyright notices, Intel was ruled to have lost its copyright protection.

Although the case does provide a valuable precedent in defining that microcode can be copyrighted, it fails to clearly determine the situation regarding other existing microprocessors.

Intel is considering appealing against the decision.

The biCMOS microprocessor has arrived. Although Texas Instruments has been using biCMOS technology to raise the density of its memory chips, Hitachi is the first company to apply it to microprocessor design. The chip is a 32-bit device that cycles at 70MHz, faster than any other similar unit.

Bi-CMOS combines the speed of bipolar switching with the reasonable power levels of CMOS transistors to yield a low power and so low temperature device.

The reduction in size of heatsinking and cooling apparatus produces smaller lighter computers, the reduction in power consumption keeps down power supply or battery size.

The laboratories of AT&T's Bell in the US are poised to announce the successful development of a truly optical computer processor.

The development, reported in the *Financial Times*, would be a first step towards the much-vaunted possibilities of large-scale optical computing where the possibilities of parallel data handling on a monumental scale could revolutionise computing speeds. A simple lens for instance puts an infinite number of points through a quite complex transformation at the speed of light.

However, the technology of optical computing is currently at the development level that digital computing had reached at around the end of the forties. Bell's processor is of a complexity about capable of operating a tumbledryer.

The immediate future of optical computing will almost certainly lie in hybrid systems using the best of optical developments together with conventional electronics.

It has been a busy time for Bell Labs. It has also just achieved a switching time for a bipolar transistor of 140GHz.

The speed, an improvement of some twelve times on transistors in existing equipment, is achieved by gas-source molecular beam epitaxy, a technique developed by Bell Labs at the beginning of the decade.

The constructed device uses a sandwich of indium phosphide and indium arsenide applied just a few molecular layers thick so collisions in the depletion layer are reduced and electron travel across the device is accelerated by about 500%.

Mass production is obviously a long time distant but there are hopes that such devices could help in the development of lightwave communications and computing.

BAD APPLE

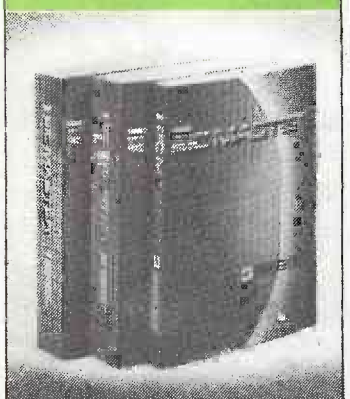
The Beatles' company Apple Corps is taking legal action against Apple Computers, claiming the Apple Corps trademarks are infringed by computer equipment designed for making music.

It is not the first time the two companies have had to resolve a dispute. In 1981 it was agreed that Apple Computer could use the Apple name and trademarks provided it did not badge any equipment used as music synthesising apparatus.

Apple Corps is now claiming that many Apple Computer products, including the Apple Mac personal computers, constitute just such apparatus — even through they may not be music specific.

If the action were to be entirely successful it would result in damages to Apple Corps plus the rebadging or withdrawal of all offending machines.

MASTERWORKS



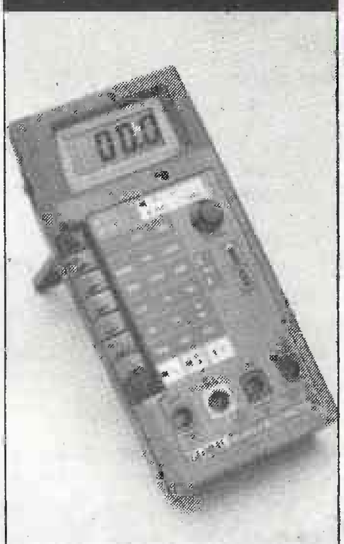
The 1989 edition of that valuable reference work 'IC Master' is now available from JB Tratsart of Basingstoke.

The 3-volume set is the most comprehensive guide to IC design specs available. The new set includes over 12000 new ICs and some 150000 alternative source devices. It has also been expanded to include second information on obsolete devices. The third volume contains a guide to custom and semicustom devices — gate arrays, ASICs and programmable logic, as well as specs for μcomputer boards and add-ons.

The autumn and spring updates are included in the price for the set of £98.00 including postage.

For more details contact JB Tratsart Ltd, 154a Greenford Road, Harrow, Middlesex HA1 3QT. Tel: 01-422 8295.

METER



A versatile budget multimeter, the 6022A, is now available from Global Specialities in Bedford.

The meter has a 3½-digit liquid crystal display with seven measuring functions: DC volts, AC volts, DC current, AC current, resistance, HFE and a diode test.

The 6022A costs £39.95.

Contact Global, 2-10 St John's Street, Bedford MK42 0DH. Tel: (0234) 217856.

TINY — MINI EASY

The manufacturer of EASY-PC, the PCB artwork package for PC-compatibles, has introduced a budget version aimed at home constructors and hobbyists. TINY-PC is less than a third of the price of its big brother and requires only 256K minimum memory.

EASY-PC has just been given a British Design Award by the Design Council for its outstanding versatility, speed and ease of use. Although TINY-PC has only half the capacity and a tenth of the speed of EASY, it still represents excellent power at a reasonable price of £95 + VAT.

For full details contact Number One Systems, Harding Way, Somersham Road, St. Ives, Huntingdon, Cambridgeshire PE17 4WR. Tel: (0480) 61778.

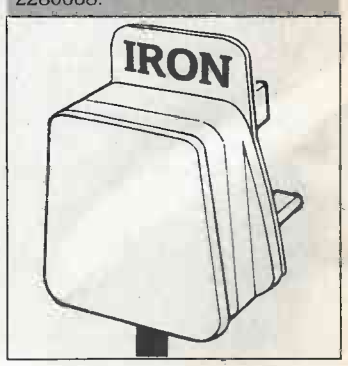
NAME PLUGS

Silly innovation of the month comes from Identiplugs of Newcastle — identiplug labels to slot over the pins of 13A plugs. An overhanging tab (see diagram) then informs you that this is the plug for the fridge or the vacuum or kettle.

Some 38 titles are available ranging from the interestingly spelled 'vidio' and 'sterio' through to 'iron' and 'fishtank'. Blank tags are also available.

Three variations of colouring are available including a genuinely useful braille labelled selection. They cost 33p each or 20 for £5, prices inclusive of VAT and postage.

Interested parties that do not own a Dymo-type printer should contact Identiplugs, 39 Whitehouse Enterprise Centre, Whitehouse Road, Newcastle upon Tyne NE15 6EP. Tel: (091) 2280068.



MEET THE MENTOR

A portable Z80 trouble-shooter has been produced by Technology Interface of Luton.

The Mentor80 is priced specifically to appeal to the one-per-engineer market at around £200. Operation is designed to be simple and clear. Tests can be made without the removal of the test microprocessors. The Mentor80 steps through the program and with the facility of the external trigger can monitor data into and out of peripheral ports, memory and so on.

Static testing allows the identification of bus shorts and chip failures.

For full details contact Technology Interface, 15a Hazelbury Crescent, Luton, Bedfordshire LU1 1DF. Tel: (0582) 458935.

SUPPORT FOR BSB GROWS

Philips has announced its intention to support British Satellite Broadcasting in their September launch of three satellite TV channels and will be manufacturing one million decoders over the next three years.

Philips has always favoured BSB's STV plans over those of Astra and Sky TV, although BSB and Philips have differed over MAC formats. Astra continues to use the PAL standard.

Philips claim its hesitation (Ferguson, Salora and Tatung all announced production plans last year) was in the hope of a single STV standard being agreed throughout Europe. It also stresses that its committment to BSB does not preclude the company from manufacturing PAL receivers.

Meanwhile BSB's Squariel seems to be running into problems. Despite starting its 'Be Smart Be Square' TV campaign, by the start of March there were only three existing working prototypes, none of which used the plastic construction proposed for mass production. It could prove disastrous for BSB if its September launch was hampered by the same non-availability of hardware for which the February launch of Sky was widely ridiculed.

ONE-CHIP NICAM

A single chip NICAM demultiplexing device has been successfully produced in a joint development between Texas Instruments and Ferguson.

The device (not yet available to we humble home constructors) is being adopted by European and Japanese TV manufacturers for use in stereo TVs under design and construction to meet the anticipated demand for NICAM in such countries as Spain, New Zealand, Scandinavia and the UK.

For more details contact TI, Manton Lane, Bedford MK41 7PA. Tel: (0234) 270111.

PROCESSORS NOT YET ON THE CARDS

Microprocessor-based smart cards are dismally failing to make an impact on the credit card market in the US.

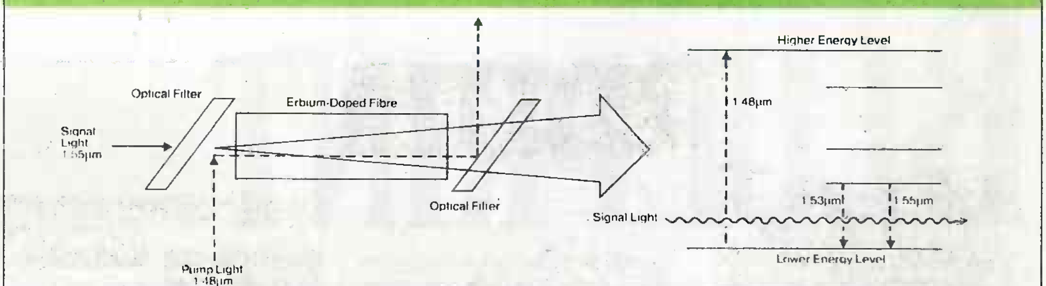
A couple of years back it was widely predicated that the 'portable databank' would replace everything from charge cards to medical records. The added security factor of smart cards (it would take a silicon plant to forge one) makes it reliable to update account information removing the need for telecommunication links to central clearing houses for authorisation.

The reasons for the non-emergence of clever plastic in the US are two-fold. Firstly the cost of the cards is only justified if telecommunications links are an expensive alternative. In the US such links are established and operate fairly cheaply.

The second hitch is the problem of standardisation. It was originally envisaged that many accounts could be held on the same card, reducing the mass of plastic in the pocket of the average American. However the two major credit organisations, Mastercard and Visa, seem unable to agree a common card format.

In Europe smart cards have fared somewhat better, particularly in Norway (where communications are expensive) and France where Carte Bleue is currently implementing the cards in its credit network.

MORE LIGHT AT THE END OF THE TUNNEL



Erbium doping of optical fibres has succeeding in doubling the possible transmission distances without the use of repeater stations.

The experiments have been carried out by the Nippon Telegraph and Telephone Corporation (NTT).

Erbium doping amplifies the signal light as it travels along the fibre. The erbium ions are excited to high-energy states by pump light — the signal light is joined by stimulated emission thus raising its power.

For practical use the doping levels are very low. Best results were obtained using signal light wavelengths of 1.55μm and a pump light wavelength of 1.48μm.

For further information contact NTT, Level 9, City Tower, 40 Basinghall Street, London EC2V 5DE.

KEEPING THE TONE UP

A reasonable priced audio frequency signal generator is available from Masterswitch of Tottenham.

The G3 generator produces sine, triangular or square waves over a range of 20-20kHz. The sinewave has a maximum distortion level of 0.04%.

The maximum voltage output is 6V pk-to-pk from a 50R source — attenuation is continually variable using the level pot and a low-high selector.

The G3 costs £98+VAT. For full details contact Masterswitch Ltd., 8 Dorset Road, Tottenham, London N15 5AJ. Tel: 01-802 1423.

PLAYBACK

The decision to set the peak output level of all commercial CD players at or above a nominal 0dB=2V has had some interesting (and quite unforeseen) repercussions.

Most obvious of these was the need for some subsequent attenuation before feeding the line inputs of 'pre-digital' amplifiers, these older designs often possessing a very limited headroom above the normal 500mV line levels.

Consequently the input stage could be driven into clipping by the peak output of a CD player, resulting in huge and subjectively unpleasant distortions arising at the final output.

This is all pretty obvious stuff of course and has been cured by the use of in-line attenuators where appropriate. For the more modern amplifier possessing far higher input overload margins another train of thought has emerged.

In particular it occured to to several designers that the high 2V output of a CD player was already more than sufficient to drive the power amp stage directly. In effect there was no need for any further preamplification.

In the pre/power amp market this concept surfaced in the form of in-line potentiometers or 'passive pots' as they have become known. Many enthusiasts swear by the use of QED, RJT or some such other passive pot, adjusting the output level of the CD player prior to the input of the power amp.

Many listeners have commented on the sweeter, smoother sound that results from having removed an active preamp from the signal path. The claims for a smoother and less fatiguing sound are often borne out but this usually has less to do with obviating the preamp than the low-pass filter formed by the interaction of the high and non-linear (unbuffered) output impedance of the pot with the parallel capacitance of the interconnect!

This concept has also found its way into the design of new integrated amplifiers. Participating manufacturers equip the amp with a so-called 'CD Direct' facility which routes the high level CD input directly to the volume control, prior to the integrated power amp.

CD Direct has audiophile credibility because the re-routed CD input also bypasses any proprietary tone controls, loudness or low/high cut filters, balance and input select pots. Once more the rationale is based on the fact that removing these superfluous facilities from the signal path can only help preserve its fidelity.

Unfortunately I have become less convinced of the efficency of this technique in recent months, having reviewed some 40 or 50 different amplifiers during this period. Now I find it more and more common for the DC Direct option to sound either worse or different but certainly not better than the standard line inputs.

The explanation is actually quite simple but serves as a salutary reminder of how the best of intentions can get screwed-up by the ideals of marketing.

In some instances it seems the manufacturer has implemented the wrong type of switch, a single-pole rather than double-pole for example. In this case the input to the tone circuitry is left unterminated, thereby generating a higher white noise floor that is dependent on the source impedance of the line amp that drives the volume control. In such cases I have measured an increase in the random noise floor of 10dB or so, all other parameters being equal.

Furthermore, the wiring to and from the CD Direct switch to the volume control will naturally influence the hum levels within the signal path. It may simply reduce or increase the level of 50Hz hum, 100Hz rectifier and harmonic products measured at the output of the amp.

Both these contributions to the amplifier's noise characteristics will influence the sound of the product to a degree, hence introducing a element of subjective uncertainty.

As a result I would urge you not to expect a beneficial change in sound quality as a matter of course when utilising the CD Direct facility on an amplifier. Most are wired correctly but in those that are not you will be trading the subjective benefits of a simpler signal path against the degradation caused by an increase in hum and noise. As they say on TV, take nobody's word for it!

Paul Miller

BLUEPRINT

This column is a service to readers, providing electronic designs. Send your requirements, with as much detail as possible, to ETI Blueprint, Argus House, Boundary Way, Hemel Hempstead HP2 7ST.

This month's problem is from D L Beaumont of Rochester in Kent.

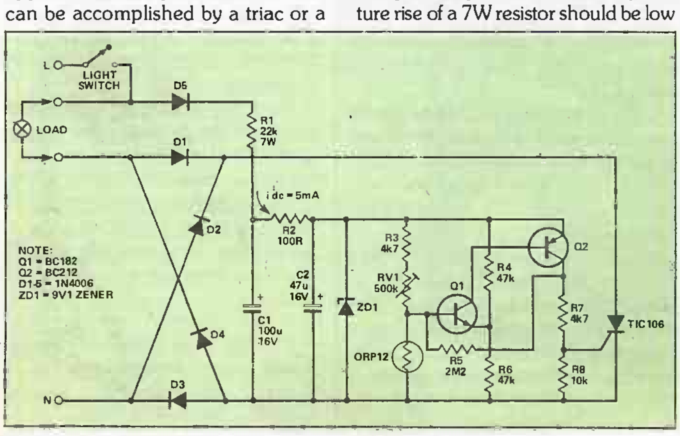
I would like the circuit for a controller to switch a 60W lamp on at dusk and off at dawn. Is it possible to do this without using transformers or relays, triggering a triac or SCR using an ORP12 light dependent resistor?

In answer to your question, yes. I am not sure why you are keen to use an ORP12 rather than a phototransistor, perhaps you happen to have one available.

There is more than one possible approach to this problem. The task can be accomplished by a triac or a thyristor. In the latter case, the thyristor must be supplied via a bridge rectifier so that it can switch on both half cycles of the mains.

I have chosen to use a thyristor because thyristors need less triggering current than triacs, and my design obtains its power via a mains dropper resistor. The less current required by the circuit, the less heat will be dissipated in the dropper resistor.

In the circuit shown here, a 7W resistor is chosen to keep the temperature rise down. The resistor will dissipate only 1.3W so the temperature rise of a 7W resistor should be low enough that there is no fire risk in a domestic installation, nor any risk of melting a plastic case.



The thyristor switches the DC side of a bridge rectifier, with the load connected on the AC side. Note that as drawn this circuit switches the neutral side of the lamp, and the fact that the lamp is not illuminated should not be taken as evidence that it is safe to tamper with. On the other hand, it would not make it much safer to connect the circuit in the live side, because a shadow cast over the ORP12 could switch the circuit on.

The power for the control electronics cannot be drawn from the DC output of the bridge rectifier because this source of supply disappears as soon as the thyristor switches on. A separate diode feeds the dropper resistor to give a DC supply of approximately 5mA. Using half wave rectification, the DC available is VCR × π) where V is the peak of the mains sinewave, approximately 340V.

The emitter of Q1 is held at half the supply voltage by R4 and R6. When the ORP12 is in darkness, the base voltage will try to rise well above this level, switching on Q1. This in turn switches on Q2, which triggers the thyristor. Positive feedback is provided via R5 to make sure that the circuit switches cleanly. The switching light level is adjusted by RV1 and is variable over a wide range.

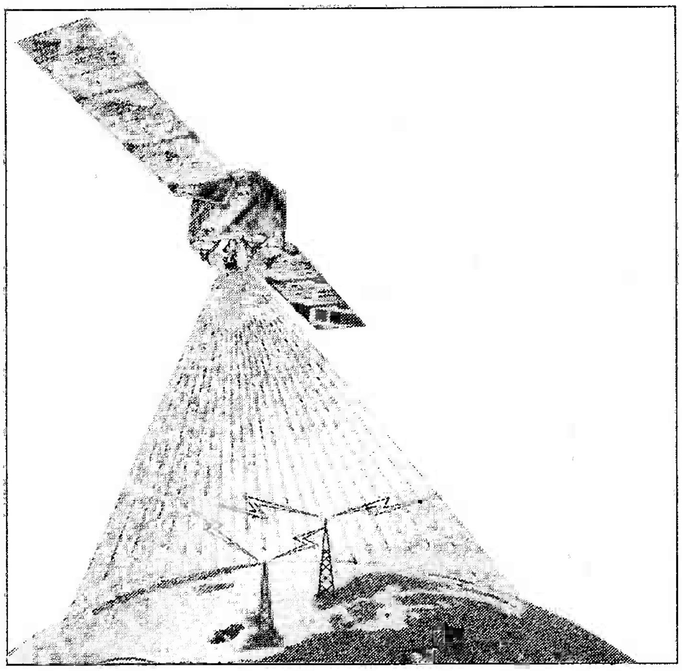
A triggering current of approximately 2mA is provided to the gate of the thyristor. This is more than enough to trigger the TIC106 but the circuit will work with other types of thyristor. Almost any small mains rated device will do, so long as it will trigger on 2mA.

If it is necessary to use a type which needs more triggering current, the value of R7 (and R1) could be lowered to provide more.

This circuit is at mains potential while the lamp is switched on at the light switch, whether or not the lamp is illuminated. It should be mounted in a plastic case or an earthed metal box. This consideration also applies to the ORP12, which may need to be mounted remotely from the control board. Wiring to the ORP12 should be done using low current cable rated for mains voltage, for example twin lamp flex. Ideally the ORP12 and its terminations should be mounted in a small plastic case where it can see daylight but is shielded from the lamp which it controls.

Andrew Armstrong

OPEN CHANNEL



In the 1950s, when the IBA was originally allocated the task of coordinating the independent television companies, it's a good bet that many people were against the idea, saying the greater choice could only mean poorer quality would be the result. You know the argument — more air time will mean quality being spread around, more slices of bread, each with thinner jam. I don't know for sure, I wasn't around when the argument started (believe me, believe me!) but it's certain that the opposite was true in practice.

The greater competition for audience time resulted in better quality programmes and better quality programme production. Compare the single BBC television channel available then, with the four high quality channels (BBC and IBA) now and you'll see a vast improvement. Not only are the much criticised (yet much-watched) soaps of a high production value but the overall range of programmes is generally of a much higher content. There are, naturally, one or two exceptions to this.

So, can we assume the current revolution in television we are witnessing is going to have the same effect? On the face of it, the increase in the number of channels from four to around sixteen or so by the beginning of next year is no greater in percentage terms than the increase noted earlier. Yet the argument still exists that poorer quality overall is going to be the result. You have only to watch the existing satellite channels to see, in the short term at least, that programme content is not as good as current terrestrial channels. But content should improve as numbers of viewers increase. If estimates of new viewers are only partially realised this won't be too long.

Exact numbers of viewers turning to satellite television are obviously difficult to ascertain, so providers have based their figures on the closest modern example of similar equipment — the videocassette recorder, the sales figures of which had a phenomenal growth earlier this decade. After all, it's a similar product in that it gives the viewer greater television viewing choice, for around the same sort of price.

Somewhere over 60% of homes in the UK have videocassette recorders so why shouldn't figures for satellite receivers reach the same sort of level? In the UK alone this will represent sales of over 12,000,000 units by 1996. From this, you'll see why big players like Alan Sugar of Amstrad and Rupert Murdoch of Sky want to get into the game early. Hopefully the big players' presence in the game will help to ensure that programme content *does* rapidly improve.

One reason (and in my view the biggest reason) why programme content improved after the 1950s expansion of television services was that the BBC maintained and improved its own programme content and range because the television licence fee always ensured a regular and increasing income.

This may not be the case in the future as the Government seems to be about to phase out the licence. If this is the case, the BBC will need to derive its income from other sources — probably on a subscription basis. This may be the killer for any future high quality television service.

The Government's argument for replacing the television licence will be that when there are so many channels — 10, 16, 20, 30? — how can they justify charging everyone who owns a television receiver £62.50 (or its equivalent) regardless of whether they watch the two BBC channels or not? With only four terrestrial channels, half of which are BBC, the licence fee can still be more-or-less justified. With so many coming on air over the next couple of years, can the fee be justified at all? The Government will think not.

Yet if the licence fee will ensure that BBC programmes remain of a sufficiently high content to guide the level of content of all other current and future television channels, then surely it *is* worth it. £62.50 is a mere pittance when you consider the alternative charges proposed by subscription-based channels like the satellite movie channels (around £12 a month!). And remember, each subscription-based channel you want to watch will charge you a similar fee.

Television is not the only medium about to be affected by the coming change. The licence, as it stands, allows the BBC to provide not only television services but all its radio services, too. Subscription-based BBC television cannot be expected to fund radio as well — so what happens to it?

There's no simple solution. The real problem is that people only have a limited amount of time in which they can watch television. So, with the much greater choice which television technology is about to give us, how will the much greater number of channels be able to finance themselves?

On a personal note, I know I won't be able to watch any more television than I do now. Videocassette recording is used to time-shift the programmes I want to watch to a time which suits me. Even then I occasionally have to erase and record over programmes I haven't got around to watching before I need the cassette to record another programme. If most people think seriously about it, I am sure they do the same. How am I (and the rest of the television viewing public) going to cope with another twelve channels?

If the high quality programmes currently produced by the BBC and the IBA disappear for one reason or another, what will be left? Will I want to watch television at all? Will anyone? Taking the USA as a lead (and, after all, the USA television system is often quoted by Ministers as an example) public service television (equivalent to our BBC) claims viewing figures as low as only five percent.

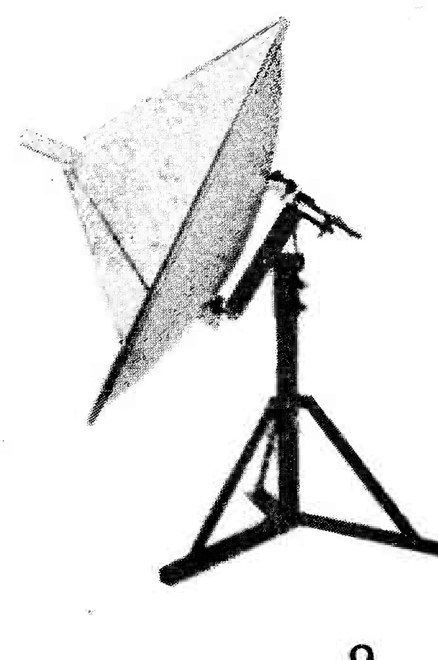
Going back to my opening argument — that the greater competition in the 1950s for audience time only resulted in better quality programmes and better quality programme production — this was true simply because people wanted that greater choice which was the result of the competition. Looking at the future of television, however, it doesn't appear to be in the same context. The results of greater competition due to the greater number of television channels may not have the same effect as before — particularly if the licence fee is discontinued!

A Rose By Any Other Name

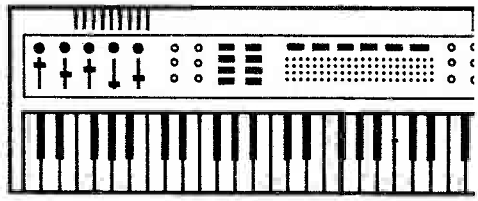
Television is about to change. That change, unless we are very careful, may not be a good one. Justifying a licence fee over the coming expansion in television services may prove impossible but there is surely a case for a public service television system funding arrangement which is not subscription-based.

Still, nothing will change the Government's collective mind until we, you, everyone does something about it. If you feel the BBC (and, for that matter, existing independent television) is worth something better than subscriptions, write to your MP and the Home Office.

Keith Brindley



FRANKFURT



Every trade exhibition has its main theme and its brightest stars. However when you're dealing with a market as complex as music, where bassoons are on show alongside digital multi-effect processors, you can appreciate the problems faced covering such an event as the Frankfurt Musik Messe (no insult intended), earlier this year.

The show itself was BIG — four floors, each the size of Earls Court, spread across two interconnected buildings. Not surprisingly all the major hardware manufacturers were there and all had either new products or upgraded versions of existing best-sellers on show.

Roland

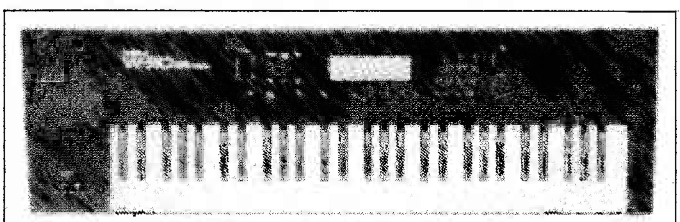
Heading up the Roland line was the W-30 Music Workstation (you're going to hear that word a lot in this article), a five octave aftertouch sensitive keyboard with built-in 16-track sequencer and 16-bit sampler with 3.5in disc drive, all in one box for £1600.

Also launched were two new master keyboards, the A-80 and A-50. Both feature four independent user definable zones which have their own MIDI channel, key range, program change and controller parameters. Traditional modulation and pitch bend wheels are provided as well as Roland's own toggled modulation set up, two MIDI INs (mergable), one MIDI THRU and four MIDI OUTs and 64 patch internal memories which can be dumped down onto RAM card for storage. The A-50 costs £1395 and has a six octave keyboard while the A-80 at £1599 has seven octaves of piano weighted keys.

For guitarists there is the GK-2 synth driver for £110 which fits on to any guitar and allows you to drive the GR-50 guitar synth module (£799). For the guitar purists there's the GS-6 — a digital guitar pre-amp and signal processor all in one box for £560. Also incorporated into this 1U high piece of rack-mounted module is hum canceller and noise suppression so expect to hear some very clean guitar sounds in the future.

For the drummers Roland have two new drum machines — the R-8 Human Rhythm composer (£665) and the cut down R-5 (price to be confirmed). Both feature sampled sounds and combine them with human feel parameters (variations in timing, velocity etc). Extra sounds come on ROM.

Happily those of us on a tight budget have not been forgotten either with the launch of the D-5 — a D-110 sound module and a five octave velocity sensitive keyboard all for just £599.



The Roland W-30 Music Workstation. 16-track sequencer, 16-bit sampler. £1600.

Casio

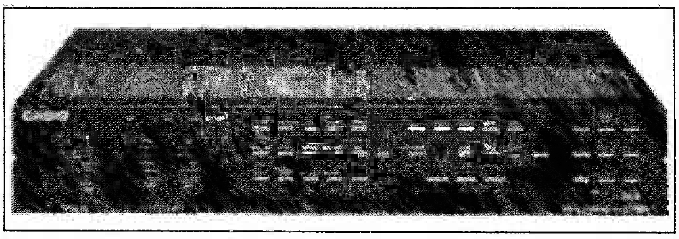
Most significant in Casio's 1989 range is the launch of a series of rack-mounted sound expanders with multi-timbal capabilities.

At one end of the price range we have the CSM-1 which features 16-voice polyphony and four timbres at any one time. The unit features 100 presets (28 instruments, 23 effects and 49 PCM drum sounds), all for just £179. Also available is the CSM-10P which is a touch-sensitive piano module which also features harpsichord, vibraphone, electric piano and pipe organ. Price £299.

Casio is not, however, content producing portable keyboard-style sound units, it is waging war in the pro quality rack synth market as well with the VZ-8M. This unit features eight voice polyphony plus eight timbres at any one time. Sounds familiar so far but this module also features keyboard, guitar and wind modes which alter some of the performance parameters to cater for whichever MIDI controller you happen to be using. RAM cards will be available, the unit is totally programmable and all for less than £500.

For the semi-pros Casio has an upgraded version of its rack-mounted sampler. The FZ-20M features everything the FZ-10M had but also includes a SCSI port so you have the facility to hook up a hard drive thus making life much easier for sample users. Not cheap but certainly good value at £1899.

Not content with the success of the DH-100 Digital Horn, Casio has come up with the DH-800 which will hold ROM packs with auto-accompaniment parameters. If the DH-100 wasn't the ultimate busker's instrument the DH-800 surely must be.



The Casio CSM-1. 4-timbre, 16-note, 100 preset PCM sound module. £179.

Korg

Following on from the success of the M-1 workstation, Korg has the T-1, a refined M-1 featuring more of everything including 88 weighted keys, a 56000 event sequencer and built-in disc drive. At £3700 it'll probably be a few salary checks away from most of us.

A little cheaper is the S-3 production workstation at £1150 — a 16-bit sampled drum machine with built-in digital effects, eight track MIDI sequencer and SMPTE timecode generator. Korg has also come up with a guitar synth system in the shape of the Z-D3 Driver (£179) and the Z-3 synth module (£799).

For the one man bands Korg have resurrected an old idea in the shape of the PSS-60. It's rather like an up-market auto-accompaniment section of a portable keyboard with MIDI as well, at a price of £827. Mind you, judging by the information leaflet that was given to me at the show it either has some dodgy translation or the unit includes a *Pose* key which is 'for making stop for a time'.

Yamaha

Yamaha decided to have its stand in a completely different hall to everyone else. For some reason it felt more at home with the bongo drums and tubas. But the products were good enough.

It's V-50 workstation (It's That Word Again) features 16 voice polyphony, eight timbres at once, a five octave, velocity and pressure-sensitive keyboard plus 61 sampled drum sounds, an eight track sequencer, digital effects and disc drive built in for £1239.

The coupling of synth and sequencer circuitry also comes together in the shape of the budget-priced (£449) TQ-5 FM tone generator. This has 100 internal sounds plus eight track sequencer all in one box.

Generating a fair bit of interest was the Yamaha C-1 music computer. A lap-top 640K MS-DOS compatible with two MIDI INs, eight MIDI OUTs and built-in music software. However, many exhibitors I spoke to seemed to think it was too expensive for amateurs (£2999) and not quite good enough for pros. We shall see!

Kawai

Relative newcomers to the fold, Kawai had quite a few new boxes based on the K-1 architecture. At entry level is the PH-m, 200 K-1 presets, 50 multi-timbral combinations plus rhythm section.

On the programmable side we have the K-1m and the K-1r. Both the same circuitry but in desk-top or rack-mounted versions. Not to be outshone the K-1 also has a bigger brother in the shape of the K-1II which features built-in reverb and improved drums.

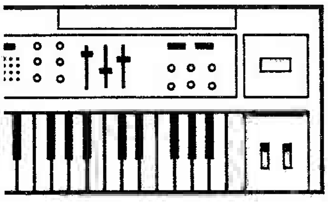
The MX-8SR is a rather nice rack-mounted eight channel 16-input audio mixer with two auxiliary sends and a stereo output, all in a 2U high space. The thinking behind it was that as most synths and drum machines were stereo it made sense to pair up inputs. On the MIDI utilities front Kawai have produced the MAV-8 MIDI patchbay — a four IN eight OUT MIDI matrix with all the sockets round the back for tidiness, with the exception of one IN and one OUT at the front to ease constant replugging pains. And the price of this is a mere £99.

Alesis

Those sages of the signal processing world, Alesis, had on display a new direction (and no it wasn't a workstation), a 16 in, stereo out audio mixer with six auxiliary sends and four stereo returns. Thanks to the newly developed Integrated Monolithic Surface technology, this rack-mountable mixer should be one of the most quiet affordable mixers on the market. Price is to be confirmed but should be under the £800 mark.

The signal processing world has not been forgotten this year. Alesis have come up with the Quadraverb. Much like the enormously successful MIDI-Verb II, it allows up to four effects to be chained together in any order — a snip at £449.

In the Micro series two new units have been added to the range. The Micro EQ — a three band parametric sweepable EQ unit and the Micro Cue Amp which allows two people separate headphone access to a pair of line level inputs. Useful if you have paper walls and less than understanding neighbours.



INSIGHT

Simmons

Not being one to rest on its laurels, leading light in electronic percussion, Simmons, has come up with a new range of trigger interfaces like, for instance, the ADT — a new, improved audio to MIDI interface for £450 plus a workstation (argghhh!!) which looks a little like a MacDonalds cashpoint but costs considerably more (£5645!).

The Portakit — 12-pad triggering unit that's set out in much the same way as a traditional kit — should prove a worthwhile addition to any rhythm purists out there, especially as it's less than £500 which now includes a bracket and stand. In a similar vein are the Drum Huggers — small electronic pads that perch on the edge of conventional drums. The Drum Hugger master unit plus four slave units sells for about £320.

With the current trend in the charts of DJs and producer having hits, Harrison Information Technology (HIT) have produced a sound sampler aimed at DJs that can store and play eight samples, forward or backwards plus or minus one octave. No figures are given on sound quality but I would imagine bandwidth is quite low (as it would generally be used for vocal st-st-stuttering effects) so hopefully the unit will be priced accordingly.

Lake Butler Sound (distributed in the UK by Dixie's Music in Huddersfield) have produced a couple of MIDI foot controllers aimed at guitarists but of equal use to any musician with his hands full. The RFC-1 allows you to send any MIDI information you like across any or all of the 16 MIDI channels at the press of a footswitch. 128 of these can be stored internally and can also be rearranged into three different set lists. Very handy for live use.

The CFC-4 has a slightly different approach. This is a set of four continuous foot pedal controllers that can be assigned to alter MIDI controller information. You can also program in eight different response curves which allow you to blend from one effect to another.

Rane Corporation had a modular rack effect system on show not unlike those marketed by Tantek and Rebis a couple of years ago, the units include input modules, active crossover, parametric and graphic equalisers, compressor / limiters and line driver/transformers. All of these fit into a 4U high rack-mounted cradle.

'Twas a well organised exhibition and a good time was had by all. Watch out for this gear hitting your music stores or, should such distribution efficiency fail, stand by for a hands-on at the BMF.

Kevin Crosby

The future looks good for RISC (Reduced Instruction Set Computing) processors. ***Clive Grace*** *takes a look at advances in microcoding techniques*

Back in the 70s semiconductor memory was replacing core store and was leading to progressively smaller and faster machines. The transition from core store to semiconductors meant that speed performance was increased and that computers were smaller.

Probably one of the most important steps forward at the time was the concept of Control Store (CS) RAM. Microcode was getting very complicated as processor instruction sets got fatter and more complex. This meant that it was very hard to debug microcode — bugs would appear in a processor only after a long time. CS RAM made it possible to load up microcode with no loss in performance (all processors were hard wired at the time) and should a bug occur in the processor, a revision was written and the new microcode loaded up.

Although designers weren't aware of it at the time, the development of cache memory was more revolutionary than anyone expected. A cache was a small area of memory set aside for the processor to act as a buffer for the stack. Generally, a 64K cache was considered a suitable size for minicomputer RAM, it was also able to play a role in the step towards RISC.

Compilers were finding it difficult to generate the complex new functions available and this led to the development of the 'optimising compiler' — a new breed of compiler that was able to simplify the variables, the 'unknowns', at compile time by creating a halfway house between the source code and the processor so much that they rarely needed to access the powerful instructions at run time.

Researchers observed that a microcoded processor could never get any faster than one microcycle per instruction. In reality this figure averaged from around three to four microcycles per instruction.

Microprogramming was the most tedious form of machine programming and researchers started writing compilers, debuggers, trace utilities and relocaters — all the tools we have grown to expect today for the task of microprogramming (amongst these designers was D A Patterson — Mr RISC himself).

Whilst the attempt to improve the quality of microcode went on, computers had since made the jump from physical memory to *virtual* memory. This was because applications were requiring more and more memory and instruction sets were becoming more and more esoteric. Virtual memory was also useful for multiprocessing environments and mainframe operating systems.

Swapping about tasks in a multiprocessing environment resulted in more problems for the microprogrammer. When the end of a process was registered, a new Writable Control Store (WCS) had to be written or reloaded, therefore the time lost could be enormous.

The exponential increase in programming difficulty and dissatisfaction with WCS and VCS memories resulted in a renaissance in processor design. Designers noted that trying to improve processor performance meant that the principles of complex instruction set computers (CISCs) were being undermined. An entirely new approach was needed but the designers still believed that instructions should be faster than microinstructions and that WCS was, in essence, the correct approach.

One good development arose from WCS based CISCs. The development of cache memory meant that caches could access main memory at the same speed as control memory, thus microprogramming was no longer faster than ordinary programming.

From the attempt at improving the quality of microcode, optimising compilers have really come of age. They are able to compile down to instructions running under a complete subset. These developments have led designers to conclude that a simpler approach is needed for the processor.

A criterion was soon set down that any operation that increased cycle time by a factor of, say, 10% should increase efficiency by at least 10% and that microinstructions must never be faster than instructions — thanks to the Pipeline.

A Pipeline is an execution model in which the RISC processor performs at the rate determined by the length of individual instructions rather than by the total length of all pieces. Mr Patterson states quite clearly "that the RISC Pipeline must be elegant in design, all the functions must be simple, unless there is a good reason to do otherwise".

In a Pipeline — such as the one found in the IBM RT processor — the longest instruction determines the width of the pipeline, so ideally each instruction should take the same length of time (even though some will not need it).

In the model, there is a simple set of sequences — *fetch, decode, execute* and *store*. The sequential model requires the completion of all instructions before moving onto the next. The Pipeline however only requires the presence of the first command before determining the next instruction cycle and accordingly moves on, so that an Instruction Fetch (the longest command in terms of cycles) is pipelined as one cycle, followed by a Decode. 'Smaller' commands like the Op(erand) Fetch and Op Store still require the full cycle width of the pipeline, even though they will be executed long before the end of the cycle.

A branch instruction will normally delay the pipeline until the instruction at the branch address is fetched. This is called a pipeline bubble and much work has gone into sorting out these problems. Non-RISC pipelined computers have highly elaborate techniques for fetching the appropriate instruction after the branch but these are too complicated for RISC processors.

Delayed branches allow RISC to always fetch the next instruction during the execution of the current instruction. A similar process cures the problem of data interlock penalties but that is another story.

One such test of a RISC emulation and processor combination was conducted by Michael L Powell at DEC's R&D labs where it was reported that his team constructed two VAX architectures in VLSI. None ever reached the general public as finished bona-fide processors.

The VLSI VAX had no more than nine custom chips and implemented the complete VAX-11 instruction set. However, 20% of the instructions were responsible for only 60% of the microcode and yet only 0.2% of all instructions were executed.

The Micro VAX/32 improved on the VLSI VAX's performance by some 20% but even with its resources it was only five to ten times faster than the conventional VAX processor and the earlier nine chip implementation in VLSI. Although the VLSI VAX and the Micro VAX/32 results were good, they were not significant. Even with the later addition of a FPU to the Micro VAX/32 the speed increase was only marginal.

However some very good results came from Mr Powell's development of a Modula 2 compiler for the Micro VAX/32. Better speed performances were achieved — suggesting that a RISC's power is not in the hardware but rather in the quality of the code generated by the compilers available to it.

Work has been going on to try and improve the generally poor performance all RISC processors exhibit whilst attempting floating point operations — Berkley are working on a FPU for RISC 2, as an internal option. A custom made Berkley FPU Coprocessor is on the drawing board.

The future looks rosy for RISC processors.

Clive Grace is a freelance computer journalist and animal lover.

READ\WRITE

FLAME FAILURE FACTS

With reference to the Read/Write piece Thermostat Threat in your March issue. I am appalled to think of the number of people who now have a totally incorrect conception of a flame failure safety valve after reading the letter and seeing the diagram submitted by T Wright of York. To put the record straight please note:

- The thermocouple output (proportional to temperature) is DC and would never be in series with an AC voltage as shown in the diagram.
- The thermocouple circuit of a flame failure safety valve is totally enclosed. It is not accessible through the terminals of any other component nor is it dependent upon an external supply.
- When heated by the pilot flame the thermocouple output is sufficient to energise a coil within the valve. The energised coil 'holds' the magnet attached to the slide of a 'spring-biased-to-off' valve when the slide is opened manually (by pressing the push button. Full flow is only possible with the button released).
- If the pilot fails the coil de-energises, releasing the magnet and closing the slide. The flame failure safety valve is often a separate device as on a Calor gas heater. On some gas or oil boilers it is included in the same body (but isolated from) the boiler control valve — this may have given rise to T Wright's misconceptions.
- The boiler valve is held closed by supply pressure acting on a diaphragm larger than the valve seat and is opened when the coil (24V or 240V) is energised. It lifts a spring-loaded needle valve which allows the pressure on the diaphragm to reduce by bleeding downstream of the seating. The valve opens when the pressure at the valve exceeds the pressure on the opposite side of the diaphragm.

I hope this clarifies this situation and allows people to understand and safely operate their boiler systems.

Mr N C Lovelock
Senior Quality Assurance Officer
British Aerospace Military Aircraft
Kingston, Surrey

FISHY STORY

I was pleased to see the return of *Tech Tips* in your March edition, it's been so long! Please keep them as a regular feature — often they are the only things I have time to build (being a busy bustling professional electrical engineer as I am).

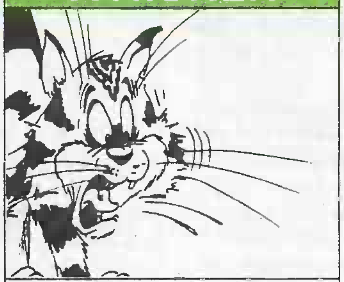
Also I noticed in your April *News* section a somewhat suspicious story concerning the imminent arrival of the edible compact disc (definitely a half-baked idea). The French address ('Rue d'Avril, Foules, Paris-sud') gave your foolish jest away, however I feel duty bound to point out that our continental cousins do not call such pranks April Fools, they refer to them as April Fish, or poissons d'avril as they say over there. I have no idea why, but I thought you should be told.

Stephen Grindberg
Doncaster

Many thanks for pointing out our horrendous mistake. Naturally as soon as the mag came out our switchboard was jammed by readers through the Chunnel putting us right (our thanks to Jean, Paul, Claude, Pierre, Jean-Paul, Jean-Pierre, Claude-Pierre, Jean-Claude, Claude-Jean et tous les autres).

As for the Tech Tips, we've been so full of projects recently. that there simply hasn't been room to fit them in. Keep sending them in, however, and we'll keep printing them. Don't forget we pay for everything we use!

CAT WHISKER



Help! Plagued by wandering strays and pestered by pets from near and far I was most keen to construct the *Ultrasonic Pet Scarer* design of Gary Calland that was published in your February issue.

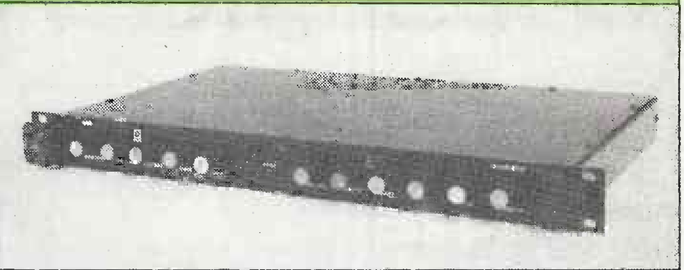
However I cannot find a 23kHz crystal anywhere. The *Buylines* section recommended Cricklewood Electronics but they have sold out and are recommending a 25kHz crytal as a substitute.

Is this okay? Or do you know of another source for 23kHz crystals?

Sam Saddington
Wrexham, Clwyd

Cricklewood contacted us soon after a flood of orders drained stocks of the original crystal. Gary Calland has tested the replacement 25kHz crystal with his original circuit and tells us that it works fine without any alterations being necessary. Good news for project constructors — bad news for pesky pets!

ENCLOSURE EXPOSURE



In the February issue of ETI I was delighted to see an example of our comprehensive range of cases appearing on the cover and inside as the housing for your *Compressor/Limiter/Gate* project. However anyone consulting the Buylines section of the article is referred not to Rackz but to one of our competitors.

May I ask why such an error occurred?

Yours sincerely
David Roberts
Rackz Products
Bristol

Yes, our apologies to Rackz for this case of mistaken identity (groan ...).

The explanation is that the unit shown in the photographs was built here in the ETI workshops using, as you say, a Rackz enclosure while the author's original (referred to in the text) was from TJA. Either is suitable for the project.

Readers who want details of the Rackz range of 19in rack project case kits should write to Rackz at PO Box 1402, Mangotsfield, Bristol BS17 3RY.

DIARY

OS/2 — May 3-4th
Churchill Hotel, London. Seminar on IBM's latest PC operating system. Contact Blenheim Online on 01-868 4466

Graphic Display Devices — May 8th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Advanced ADC And DAC Techniques — May 8th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Automan — May 9-12th
NEC, Birmingham. Automated manufacturing show. Contact Cahners Exhibitions on 01-891 5051

Inspex 89 — May 9-12th
NEC, Birmingham. Quality control exhibition. Contact (0234) 4003.

Packet Video — May 16th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Biotech 89 — May 16-18th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466

Energy 89 — May 16-18
NEC, Birmingham. Contact Emap Maclaren on 01-660 8008

Scitech 89 — May 17-21st
Alexandra Palace, London. Exhibition of all the best British science and technology. Contact British Science And Technology Trust on 01-992 0684

Networks 89 — June 6-8th
NEC, Birmingham. Contact Blenheim Online on 01-868 4466

Electronic Filters — June 9th
IEE, London. Colloquium. Contact IEE on 01-240 1871

Software Tools 89 — June 13-15th
Wembley Conference and Exhibition Centre, London. Contact Blenheim Online on 01-868 4466

Image Processing And Its Applications — July 18-20th
University of Warwick. Third International Conference. Contact IEE on 01-240 1871

Holographic Systems, Components And Applications — July 11-13th September
University of Bath. Second International Conference. Contact IEE on 01-240 1871

Vacuum Microelectronics — July 24-26th
University of Bath. Conference sponsored by The Institute of Physics, IEE and IEEE. Contact The Institute of Physics on 01-235 6111

Circuit Theory And Design — September 5-8th
University of Sussex. Ninth International conference. Contact IEE on 01-240 1871

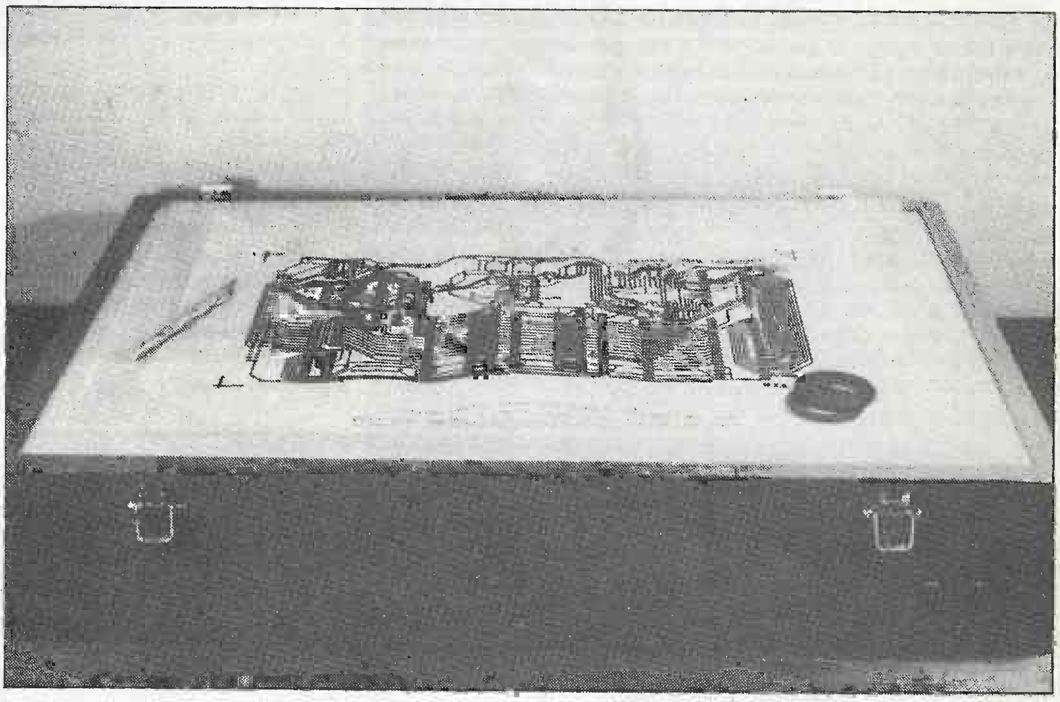
Holographic Systems, Components And Applications — September 11-13th
University of Bath. Second international conference. Contact IEE on 01-240 1871

POS 89 — September 12-14th
Business Design Centre, Islington, London. Point Of Sale technology exhibition. Contact Batiste Exhibitions on (0532) 580033

SKETCH 'N' ETCH

Mike Bedford assembles a UV exposure and light box and a PCB etching tank for pounds less than the commercial units

HOMEMADE PCBs



If you have ever made your own PCBs, the chances are that you messed around in the kitchen sink with all manner of makeshift equipment and the results not only took longer than expected to arrive but were rather below par when they did.

With practice, it is possible to make professional looking PCBs with no more than the kitchen sink and a few dishes. However, the commercial equipment available does speed up, simplify and improve on the boards you produce. The only problem is the high cost of this equipment.

If you can't afford professional equipment then you can still build apparatus which gives the same features as that available commercially. That being the case, this is essentially a constructional article — but for a change the reader can put away the soldering iron and wire cutters in favour of the tenon saw and wood glue!

Having built the equipment it will be possible to take a 1:1 artwork, expose and develop photosensitive copper-clad board and etch it quickly and without mess. This equipment will even ease the design of the original artwork.

The equipment consists of the following:

- A dual purpose light box/UV exposure unit.
- A thermostatically controlled etching tank with agitator.

Exposure/Light Box

It is possible to expose photo-sensitive PCBs without an exposure unit. The author probably isn't the only one with memories of hunting around for a sheet of glass and then balancing it on two blocks of wood or piles of books so that a UV lamp can be accommodated underneath. The two things to be said against such an approach is that it is not the most stable arrangement imaginable and it can be a problem getting all the necessary bits together.

An exposure unit is essentially the same as has just been described but is far more convenient — a box with a glass top containing a couple of UV tubes. It also has a hinged top with pressure pad.

It is quite obvious that another associated piece of equipment is very similar in construction. A light box differs only in that the fluorescent tubes emit visible rather than UV light and that the top surface is a diffuser rather than being transparent (also, of course, the lid serves no purpose). Once again it is possible to cope without a light box but it is so much easier and quicker to use the right equipment.

The unit described here is a dual purpose unit containing both types of tubes and a separate diffuser sheet. It can be used as a light box for sizes up to a little over A2 (630×440mm) and as a UV exposure unit for an area of about 150×250mm. This difference is consistent with the fact that the artwork will often be done at a 2:1 scale.

UV exposure units, even at the prices in the amateur component catalogues, will cost at least £50. Light boxes don't seem to be commonly available to the amateur constructor and will cost well in excess of £100 for the size offered. The combined unit described here can be built for around £50 or considerably less if off-cuts of chipboard, an old fluorescent fitting and so on are available.

Figure 1 shows the mechanical details of the unit. The main body of the box is made from six pieces of ½in chipboard. If chipboard other than ½in is used, some of the following dimensions will require modification (for example the width of the top is the width of the base plus twice the thickness of the board). The first task is to saw these pieces to the following dimensions: Base — 640×450mm, front and back — 640×125mm, the two sides — 475×125mm and lid — 665×475mm. Two lengths of 6mm PSE (timber with 6mm square cross section) are now glued and pinned to the front, back and sides in order to make a channel into which the glass sheet will slide once the box is assembled. It is suggested that the glass sheet is used to ensure correct spacing between these two lengths.

Now lengths of 12mm PSE should be screwed along the four edges of the base. This is used to reinforce the joints between the base and the front, back and sides. 12mm PSE is also used to make the joints between the front/back and the sides. The inside of the box will need painting white and this is probably easiest to do while the box is in pieces. Care should be taken not to paint inside the channel formed by the 6mm PSE as this could stop the glass from fitting.

Now comes the fitting of the electrical components — since everything fits onto the base except for two switches on the front it is probably also easier to do most of this task whilst the box is in pieces. The mechanical positioning of the critical electrical components is shown in Fig. 1 and the wiring in Fig. 2. The diagram is for a couple of tubes so it is doubled up to give the four (two visible and two UV) tubes.

There are two options. In Fig. 2b the tubes are connected in series and driven from a single choke whereas Fig. 2a shows one tube with its own choke. If components are being bought new or if a fluorescent fitting is being bought for the specific purpose of dismantling for this project then the shared choke will almost certainly be the most cost effective solution. If components are being salvaged from old fluorescent fittings, however, it may be that independent wiring is preferred.

If fluorescent fittings are dismantled to obtain components it is useful to know the type of terminals used on the component parts of such luminaries. These tend to be spring loaded and require a miniature screwdriver or sturdy needle pushing inside to get them to release the wire. New wires are attached simply by pushing the stripped end into the aperture. The wire used should be solid core and not the stranded type.

Having fitted and wired up the electrical components (except for the switches) the box can at last be assembled (except for the back) by screwing the sides to the 12mm PSE on the base and making joints between the sides and the front using more 12mm PSE and screws. When this assembly is complete the wiring of the switches can be carried out and the mains inlet lead taken through a hole in the rear of the box. In selecting switches it is recommended that those with integral neon indicators are used, preferably one red and one green so that it is immediately obvious whether UV or visible light has been turned on.

In passing it is also worth saying that a mechanical timer switch could be used for the UV circuit to time the exposure although this would increase the cost of the unit quite significantly.

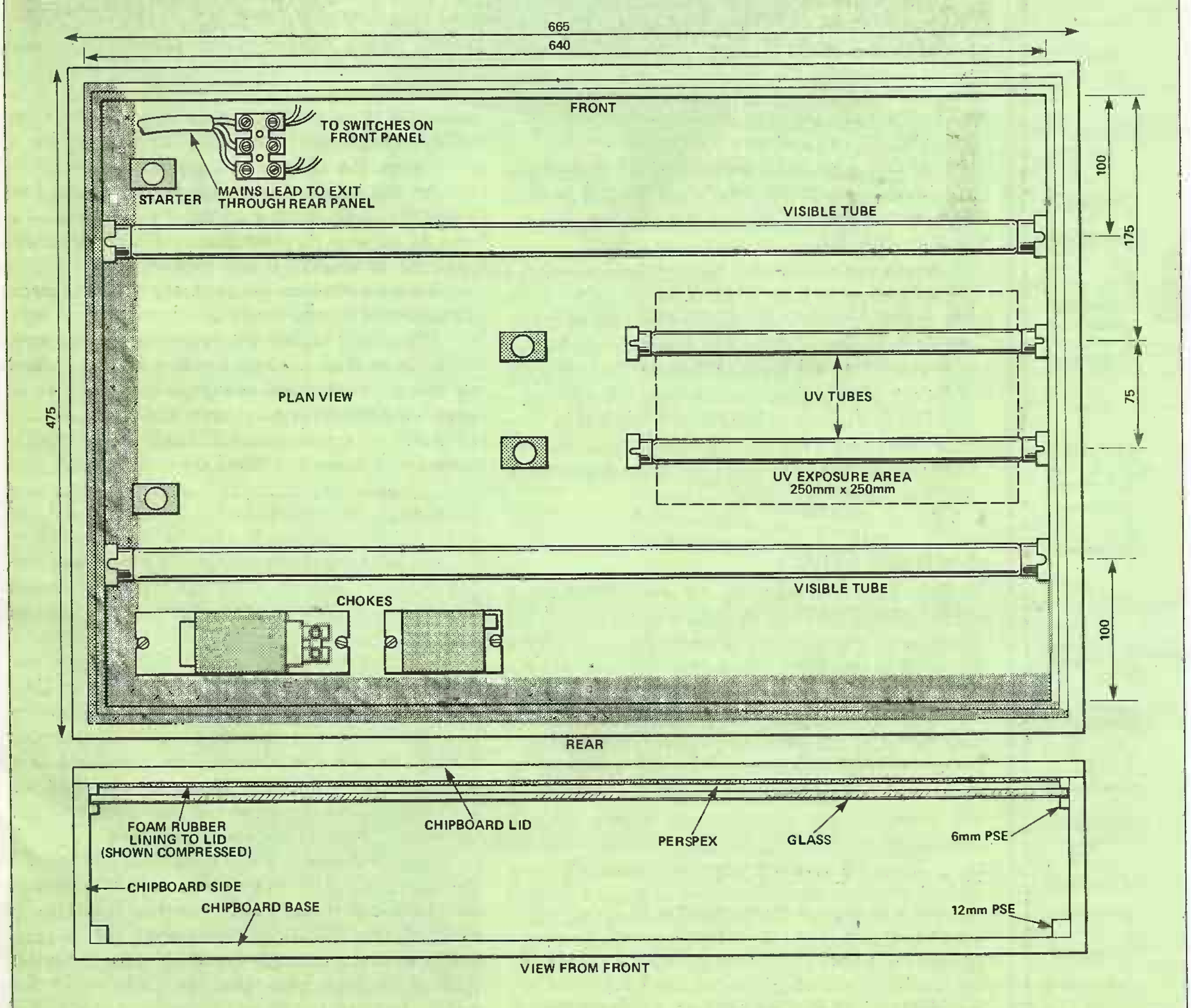


Fig. 1 Dimensions and construction of the UV/light box

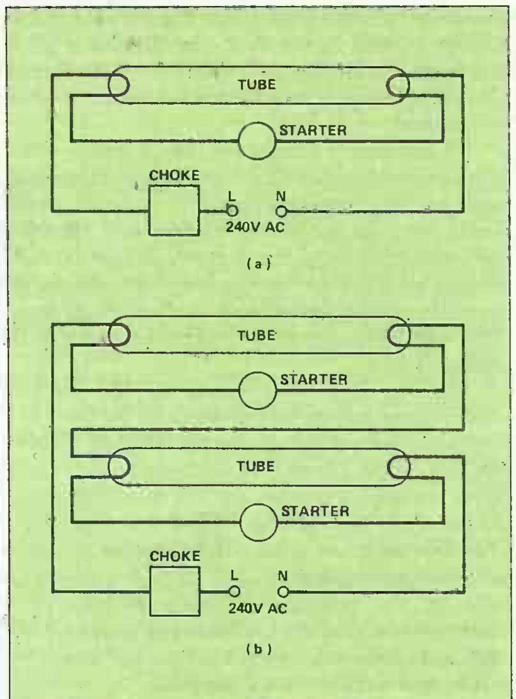


Fig. 2 Fluorescent tube wiring options

The glass top can now be slid in and the back fitted. If glue is used for any of the other joints it should be omitted from the back as the glass top needs to be removable to facilitate tube changing.

Now comes the construction and fitting of the lid. This needs fitting with a pair of hinges at the rear, a pair of catches at the front and a sheet of ¼in foam rubber to cover the UV area on its inside surface. The hinges are of the type which slide apart so the lid may be removed entirely when not in use (when in use as a light box).

To complete the unit it should be checked that the perspex diffuser sheet fits over the glass and can easily be removed — if not it will need filing down somewhat! As a final touch it would also be useful to construct an opaque screen (perhaps from some type of plastic sheet or even black paper could be used) to fit over the enture surface of the glass with a window cut out having the position and dimensions of the UV tube area. This will prevent the user from placing PCBs outside the area of acceptable UV intensity.

The unit is now complete but to rid it of its bare chipboard look the box should be painted or covered. Alternatively it could be built from melamine covered chipboard in the first place.

Etching Tank

Etching tends to be the messy bit of the PCB making process and again it can be done without any special equipment. This process can be carried out in almost any shallow plastic container. One thing common to virtually all containers used is that the board is laid flat — most commonly available receptacles which would take the board upright would be of such dimensions that a very large volume of etching solution would be required. A few words about the chemistry involved will make it clear why this isn't a very efficient arrangement.

Clearly a chemical reaction is involved in etching copper off the copper clad board to make a PCB. It doesn't really affect the argument what the exact details of the reaction are so let's just represent it as follows:

Copper +	Etchant →	By-product 1 +	By-product 2
(Solid)	(Solution)	(Solution)	(Solution)

Normally the etchant is ferric chloride but there are other alternatives. As the reaction takes place the concentration of the by-products builds up in the vicinity of the copper, reducing the local concentration of the etchant and thereby also reducing the reaction speed. If the by-products were evenly distributed throughout the solution then this reduction in reaction speed would be much less pronounced. A horizontal board aggravates this local build up of reaction by-products. Furthermore, it is a general rule that the chemical reaction approximately doubles in speed for each 10°C increase in temperature.

The etching tank described here has a thermostatically controlled immersion heater and a vertical board arrangement (but of such a shape to minimise the volume of etchant required) together with an agitator to ensure good dispersion of the reaction products. Accordingly etching is convenient and quick.

The unit will cost about £30 to build but can be comparable to commercial equipment with a £170 price tag. A further saving will be achieved in the long term (compared to non-agitated room temperature etching) in that a longer lifetime will be obtained from the etchant.

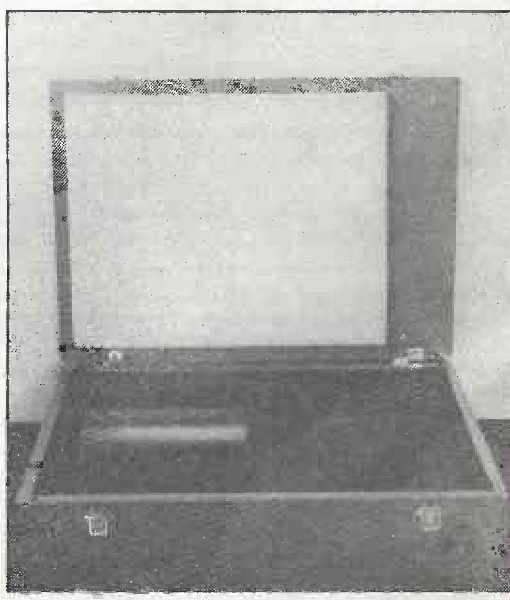
The tank consists of glass fibre re-inforced plastic (GRP) tank, a chipboard cradle and base and an insert to support the heating element and aerator tube.

The tank is constructed by moulding GRP around a pre-constructed mould. Figure 3 shows the required shape and dimensions. The author made the mould out of chipboard but doesn't recommend doing the same as it proved almost impossible to remove once the GRP was cured.

I would suggest using some fairly robust cardboard which could, if necessary, be soaked out afterwards. Nevertheless, as an aid to extracting the mould, it should be coated in wax by painting on molten candles and then polishing with a cloth.

Once the mould has been constructed and waxed, the moulding can begin. This is carried out using fibreglass matting and plastic resin. The resin should be activated by mixing in the prescribed amount of hardener but since it then remains workable for about ten minutes only, smallish portions should be activated at a time.

Moulding begins by painting the surface of the mould with activated resin. Manageable sized strips of fibreglass matting should then be placed on the mould and further activated resin added to these using a brush in stippling action until the matting is completely soaked. Further strips are added, each



HOMEMADE PCBs

PARTS LIST

UV/LIGHT BOX	
½in chipboard	1x 640×450mm
	1x 640×125mm
	2x 475×125mm
	1x [illegible]×475mm
6mm PSE	4x 640mm
	4x 438mm
12mm PSE	2x 640mm
	1x 426mm
	4x 80mm
4mm glass	1x 638×448mm
3mm opal perspex	1x 626×436mm
¼in foam rubber	1x 270×170mm
Fluorescent tubes	2x 24in, 80W
	2x 12in, 8W UVA
Choke	2x 20W or 1x 40W
	2x 8W or 1x 16W
Starter	4
Starter holder	4
Tube connectors	4 to suit
Hinges, Tog[illegible] Screws.	
Glue, Paint	
ETCHING TANK	
½in Chipboard	2x 315×80mm
	2x 315×170mm
	1x 300×195mm
Aquarium heater	[illegible]
Aquarium pump	
Tubing	2m
Fibreglass resin	500ml
Fibreglass hardener	
Fibreglass matting	
Screws, Glue, Cable, Paint	

overlapping the previous one until the entire mould is covered.

Once the tank is dried, further layers of matting may be applied in the same way as the first. It is suggested that three layers are used to give the necessary strength and that particular attention is given to the edges and corners which are potential weak spots. When the tank is complete it should be tested for leaks and if any are found a further liberal coating of activated resin applied. The easiest way of neatly producing the lip of the tank is to mould this oversize and trim with a hacksaw once moulding is complete.

The construction of the chipboard cradle is shown in Fig. 4. The large base is to give the unit stability when full of etching fluid and to produce a mounting position for the pump. It is suggested that this construction is made using woodscrews and wood glue and like the light box, it is made of melamine board or painted or covered.

The immersion heater used is the type intended for aquarium use, having both a heating element and a thermostat in a sealed glass tube. The thermostat should be adjusted to its maximum temperature, normally in the region 30-35°C. This temperature is not as high as in commercial etching tanks but does give a useful increase beyond room temperature and has the advantage of making use of a readily available and low cost heater.

These units are attached to the side of an aquarium tank with a rubber sucker. Since it is not possible to attach it to the inside of the etching tank by the same means, the bracket illustrated in Fig. 5 is used. This is moulded from GRP as described earlier with the top layer of matting applied over the sucker parts of the heater supports.

This bracket also serves to keep the air line at the centre bottom of the tank to correctly agitate the solution. The air line is attached to the bracket by use of cable ties which are threaded through holes, these being drilled after the structure has fully cured. The air line rises 150mm above the top of the tank before attaching to the pump. This is a precaution to prevent etchant from siphoning back into the pump when it is switched off. When fitting the air line to the bracket care should be taken not to bend it through too sharp an angle as this would cause it to collapse at that point.

The unit is now ready to be assembled. The fibreglass tank is placed in the cradle and the bracket together with heater and air line is hooked over one end of the tank and cradle. To complete the unit, the airline is cut to length, attached to the pump and the pump fixed to the base board by use of either sticky pads or long cable ties.

Using The Equipment

This section describes how the equipment is used to make a professional looking printed circuit board. Much has been written on this in the past so the intention is to keep this to a fairly brief summary. The detailed portions will therefore be only those which apply specifically to this equipment.

Using the light box/exposure unit in its light box mode (with the diffuser sheet fitted), the master artwork is prepared on drawing film using black tape, pads and so on. Except for the simplest of boards, this will be carried out at double size.

If the master artwork is double size it will need reducing. Most people will not have the facilities for doing this themselves and should use the services of a professional photographer. A black and white line transparency reduced by a factor of 2:1 should be obtained.

The light box/exposure unit should now be prepared for use as an exposure unit by removing the diffuser and fitting the exposure masking sheet and lid.

The etching tank should also be prepared. If using it for the first time it will clearly need filling with etchant. The suggested etchant is a solution of ferric chloride. This can either be bought as a ready made solution or as crystals which are then dissolved in water according to the instructions on the packet. The tank should be filled to the water mark on the heater

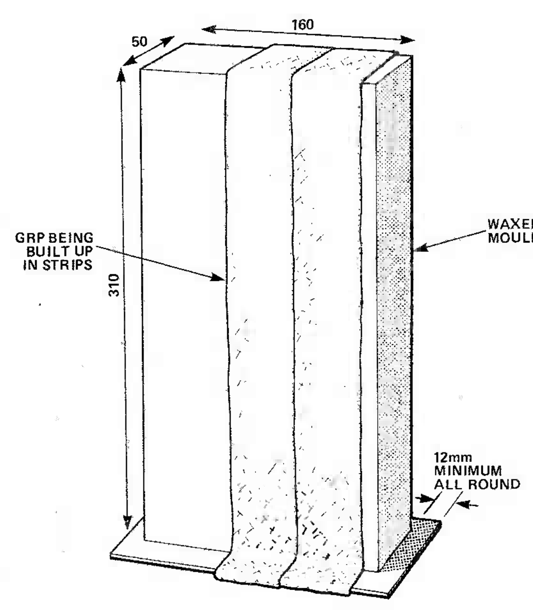


Fig. 3 Building up the GRP tank

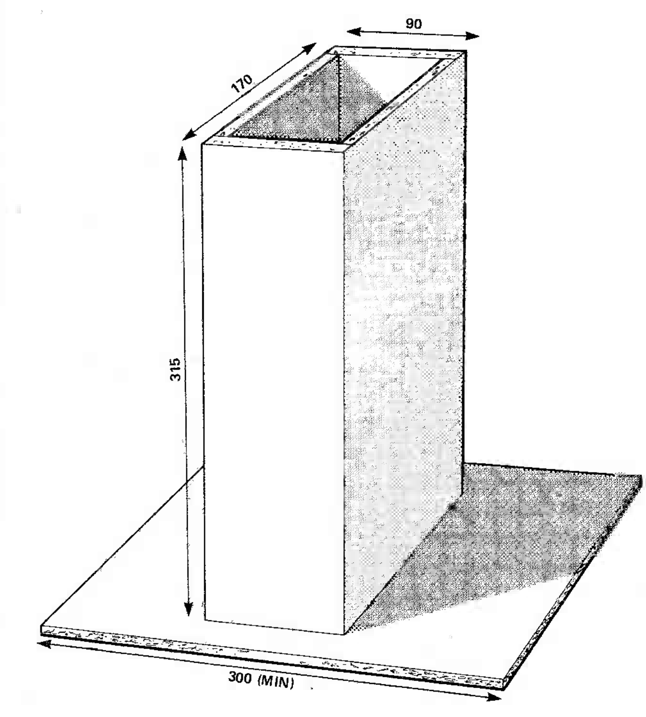


Fig. 4 Construction of the tank cradle

otherwise damage to the heater may result. This will require about 1 litre of solution. The heater and pump should now be switched on and the unit left for a few minutes to warm up.

A piece of photosensitive copper clad laminate is cut to size, the protective black sheet peeled off and the reduced artwork placed in contact with the photosensitive side of the board. Care should be taken to use the artwork the correct way round to avoid making a mirror image of the required PCB.

The board and artwork are now placed artwork down on the glass of the exposure unit and the lid carefully closed and the catches fastened. The UV tubes are now switched on for the exposure period. Since the exposure time can vary with the photo-resist and the age of the tubes, this should be determined by experiment the first time the unit is used and periodically thereafter but is expected to be in the region of eight minutes.

The board is now developed by immersion in developer for a few minutes. A photographic developing dish can be used for this purpose. When developing is complete the pattern of the tracks will be clearly visible and the board can then be removed from the developer and well rinsed in cold water.

Although ready mixed developer can be used this is expensive and a home made solution of sodium hydroxide (caustic soda) is just as effective. Caustic soda is widely available from hardware shops etc. The solution should be made up by adding 20g of sodium hydroxide to one litre of cold water and stirring until dissolved. Care should be taken in making the solution that the water is not added to the sodium hydroxide rather than vice versa as this could cause a rapid rise in temperature (and spitting if it boils). Also remember that sodium hydroxide is a hazardous chemical which should not be allowed to come into contact with the skin.

The board is now ready for etching. It is suggested that a small hole is drilled in a corner, a length of insulated wire tied through this hole and this wire then used to hang the board in the etching tank and facilitate its removal for inspection and when completed. It should only take ten minutes or so to etch a board. When the etching times get very long it is time for the etching solution to be replaced. When the etching is finished the board should be well rinsed in cold water. Care should be taken not to allow ferric chloride solution to come into contact with the skin or clothes.

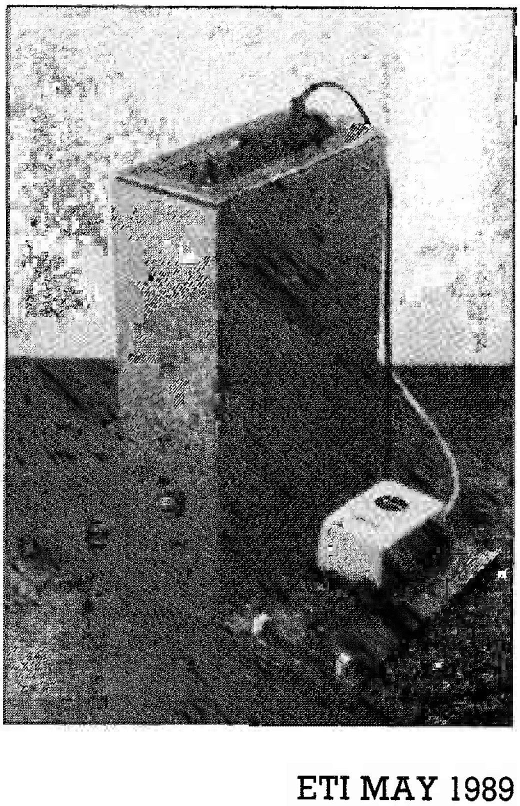
A couple of options are now available. One is to use a solvent such as acetone to remove the remaining etch resist to leave clean copper tracks. However, it is usually pointless doing this since the board can be built up with resist on as it acts as a flux and can be soldered over. The advantage of this is that the resist protects the copper tracks from the corrosion which would inevitably take place over a period of time.

The one reason for removing the resist is to allow the copper tracks to be tin plated hence giving a very professional looking board. A low temperature tinning solution is available from PCB equipment suppliers. This is used by placing the board track down in a small amount of the solution in a photographic developing tray. Over a few minutes the tin coating will build up and the board can then be rinsed and dried.

If attempting tin plating, care should be taken to ensure that the copper is absolutely clean and free from grease. In practice this means carrying out the plating immediately the photo-resist has been removed.

One final option to give that really over-the-top appearance is to screen print the component legend on the top of the board. Without going into details this involves preparing an artwork, exposing and developing photo-stencil film, applying this to the screen frame and finally printing. This may sound all rather involved but can indeed be carried out at home. Suppliers of the materials will normally supply full instructions.

That's all there is too it! With a little bit of practice and without too much mess, professional looking (and of course functional) PCBs can be made at home. Materials such as the photo-resist copper clad board and ferric chloride can be obtained from most electronic suppliers although if a significant amount is to be purchased it will be less expensive to go to a specialist PCB equipment supplier. Such a source will



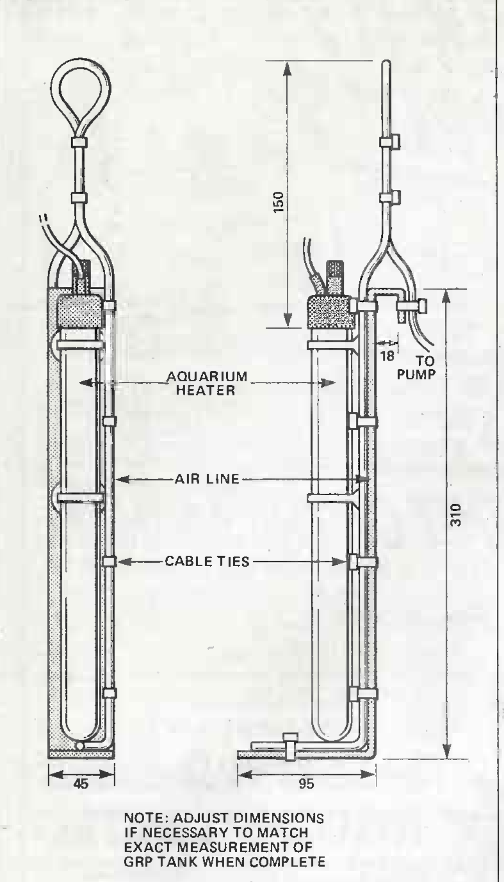


Fig. 5 Construction of the heater/airline bracket

certainly be used to get the more obscure materials such as those for tin plating or screen printing. The following company can supply all PCB making requirements although a £25 minimum order is currently insisted upon:

Instagraphic Products Ltd.,
Ashfield Industrial Estate,
Low Hall Road,
Horsforth,
Leeds LS18 4EF.
Tel: (0532) 589893.

BUYLINES

All the wood and hardware can be obtained from DIY shops and ironmongers. The fluorescent tubes, end connectors, starters and sockets are easily obtainable from electrical shops. Whereas in theory such electrical suppliers can also obtain the UV tubes (which are manufactured by Philips or Thorn) this could be a long process. If ordering from this source make sure to explain that the tubes are not of the filtered 'black light' variety used in discos. Alternatively, many of the electronic suppliers sell these tubes as spares for their UV exposure units but this can be an expensive option. The foam rubber can be obtained from sewing shops or market stalls.

There are two possible sources of the opal diffusing perspex. Most towns have a number of sign makers. Being a constituent part of most illuminated signs, these companies use perspex and may be willing to sell off-cuts. Failing this it may be obtained from industrial plastic suppliers listed in Yellow Pages.

The fibreglass matting, resin and hardener are available from motoring shops, the type used for the prototype was called *David's Fastglass*. The aquarium heater and pump are available from pet shops or tropical fish suppliers. The heater used in the prototype was the Atlantis T150. Other types could certainly be substituted but this may affect the design of the heater support bracket.

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OP-AMPS

Paul Chappell, Delia Smith of the component world, presents a mouthwatering hotpot of op-amp recipes

This month, an op-amp cook book. Figure 1 shows various amplifier configurations — you've met them all before, so I'll dash quickly through them and move on to something new. Figure 1a is the basic inverting amplifier: the output will be 'upside down' with respect to the input. It has a relatively low input resistance (=R1), but has the useful ability to accept several inputs (Fig. 1b), and so can be used to mix audio signals together.

Figure 1c is the basic non-inverting configuration. The output will be a larger version of the input and the input resistance is high (=input resistance of op-amp). One input is your lot on this one.

Next comes the unity gain amplifier (Fig. 1d).

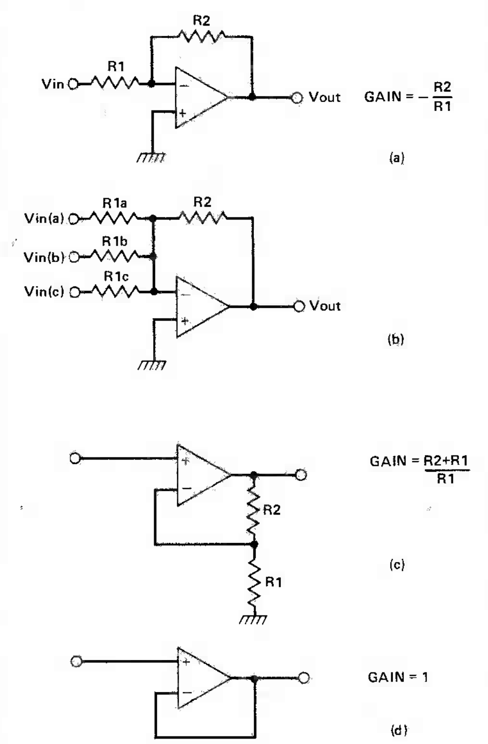

Fig. 1 (a) Inverting amplifier
(b) Basic mixer
(c) Non-inverting amplifier
(d) Unity gain amplifier (Buffer)

This one is often a bit puzzling to beginners — why have a circuit which gives the same voltage at the output as it gets at the input? Why not save the money and use a piece of wire? You can picture it as being a bit like one of those robot arms that follows the motions of your own hand exactly but with a thousand times the strength. The signal that comes in may not have enough oomph to do what you want — the op-amp copies it and supplies the extra power.

Show Me A Sine

Last month I was talking about ways that an amplifier might be made to oscillate. Figure 2a shows one of many possible configurations for a sine wave oscillator. This one is known as a Wien Bridge oscillator, after Wilhelm Wien who invented the frequency selection network used. For reasons which I explained last month, if you want the output sine wave to be as pure as possible the trick is to set the loop gain of the circuit as close as possible to 1. In theory it will be this value when R3 = 2×R4 but in practice it might be necessary to make R3 a touch smaller for the circuit to oscillate reliably. If you only want a roughly sinusoidal output, set R2 to one or two preferred values lower than suggested by the formula. If you're particular about the purity, use a preset and adjust it to the point where the circuit just begins to oscillate.

Figure 2b shows a square wave oscillator. This one has an output which jumps between the two supply rail voltages or as near to them as the output of the op-amp will go, at a rate set by C1 and R1. One nice feature of this circuit is that the output frequency is pretty well independent of the supply voltage: if the voltage increases, the capacitor will have further to charge before the circuit flips over but the rate of charge will also be increased and the two effects neatly cancel each other out. The amplitude won't be independent of the supply voltage of course, but you can't have everything! A version which doesn't require a 0V supply is shown in Fig. 2c.

No cook book would be complete without a selection of filters. Figure 3 shows a low pass, high pass and a bandpass filter. Let me explain how to make them go. Figure 3a is a second order lowpass filter, which means that it has an ultimate roll-off of 12dB per octave. By altering the pole quality factor (q_p) you can effectively trade off a flat passband against a steep initial roll-off.

The starting point is to give the filter a Butterworth characteristic, which means setting q_p to just a touch over 0.7 ($1/\sqrt{2}$ to be exact). R3 = 5k6 and R4 = 10k will do fine. This gives a flat passband but a relatively gentle initial slope. If you need a steeper slope, just increase the value of q_p a little (by increasing the value of R3 or reducing R4). Setting q_p to 0.96 will give a 1dB 'hump' just before cutoff but a significantly steeper slope. A q_p of 1.3 will give a 3dB hump but a still steeper slope. If you want slope without hump, you need a more complicated circuit! The same applies to the high pass filter of Fig. 3b. The slope-and-hump characteristic is known as a Chebyshev characteristic, by the way. With more than one filter section it becomes a slope-and-ripple characteristic: the passband looks like a stormy sea but the roll off is pretty sharp.

For the bandpass filter, altering q_p will vary the sharpness and width of the filter's peak: the higher the value, the narrower and more pointy it becomes.

All the filter circuits are a little more complicated than they need be, but they all have the nice feature that you can vary the tuning and pole independently. All the filters can be tuned by varying R2 and the shape of the frequency response by adjusting R3 or R4. It's not a requirement of the circuits that the two resistors and two caps would be equal by the way, it just makes the sums easier.

Figure 4 is a ragbag of assorted circuits, some of which you may not have seen before even if you've been reading ETI since if first began. Fig. 4a is the op-amp equivalent of one of my favourite transistor circuits: the one that makes a small cap pretend to be a big one. With this circuit you can make up huge time constants without using up the board space (or paying the money) for a huge cap. Can you see how it works?

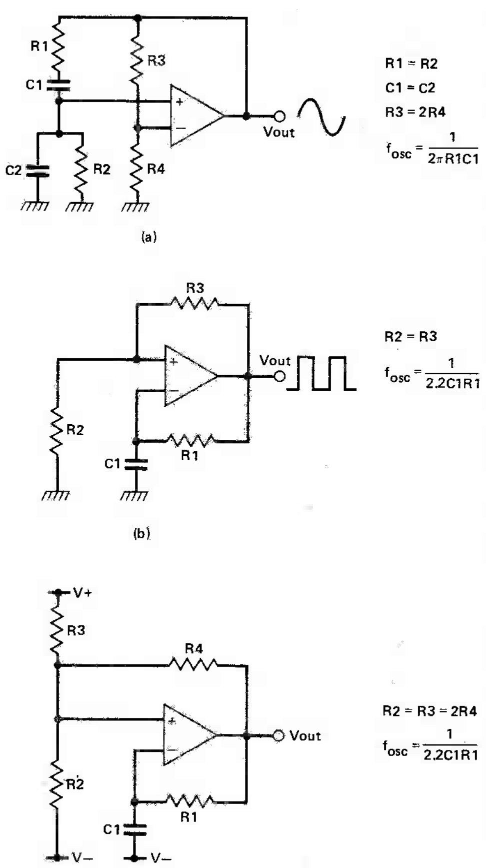

Fig. 2 (a) Sinewave oscillator

(b) Squarewave oscillator

(c) Variation without 0V rail

Figure 4b is a variation on the same theme. This time, C1 looks to the input like a grounded capacitor of a size rather larger than its actual value. If R1 = R2, it will appear to have twice its actual value. This circuit is not suitable for making enormous multiples of the capacitor value because it works by yanking downwards on the other end of the cap and raising the input voltage. To multiply the apparent value by 1000 it would have to drop the voltage by almost 1kV for every volt rise at the input, which is somewhat limiting. On the other hand if R1 and R2 are replaced by a pot, it will make a variable capacitor of a size that would be quite a jaw dropper for any radio ham, who would be more used to those vaned things. Trimming the value of a large cap is not something one would normally try to do but with this circuit you can.

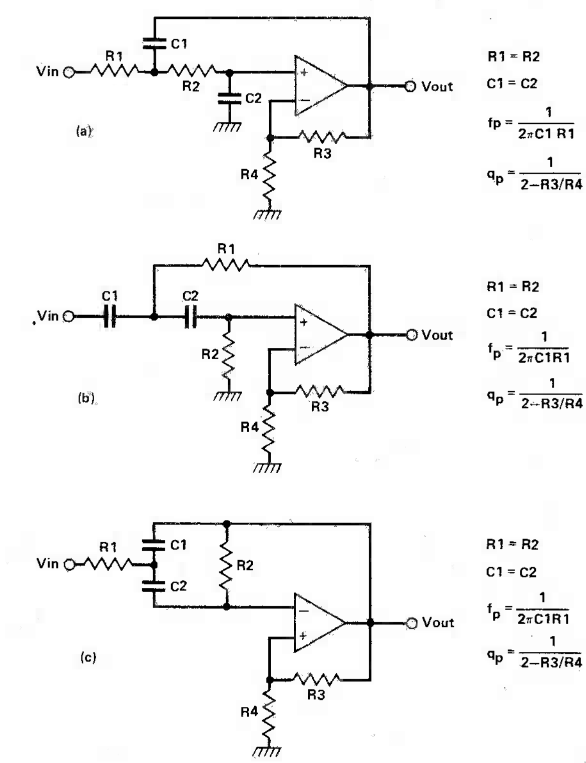

Fig. 3 (a) Low pass filter

(b) High pass filter

(c) Band pass filter

Finally, and still on the theme of things pretending to be what they're not, Fig. 4c shows an op-amp that thinks it's an inductor. The value of R1 should be very much lower than R2 for the circuit to work properly but apart from that you can use whatever values suit your purposes.

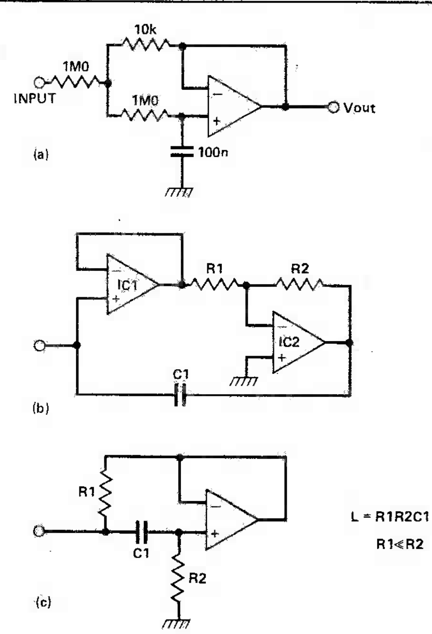

Fig. 4 (a) Long time constant circuit (100s)

(b) Capacitor multiplier

(c) Inductor

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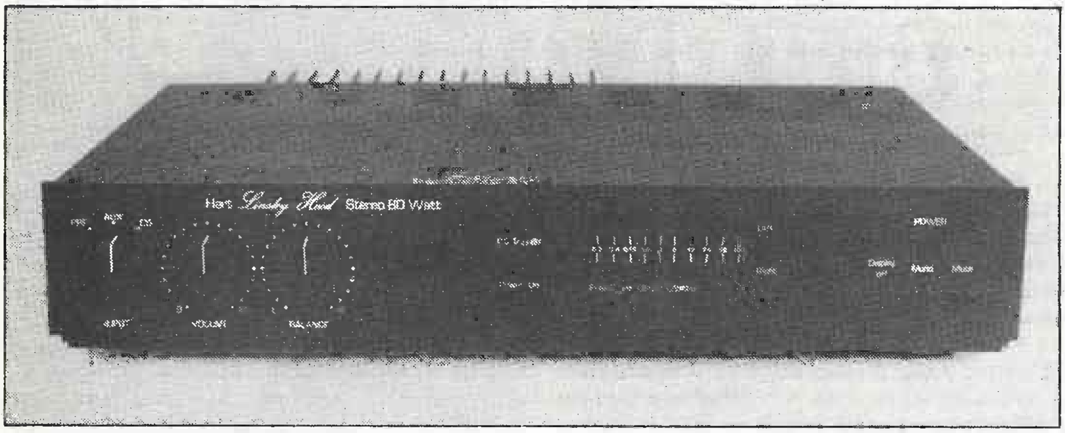


There is an old adage which says that it's nice to be clever but it's a lot more clever to be nice. Translated into audio amplifier terms this could read that it is nice if equipment has an excellent technical specification, but it is even better if it sounds nice.

Of course it is gratifying if gear scores top marks on both counts but the former, sadly, does not guarantee the latter. It is salutary, from time to time, to visit one of the more run-of-the mill High Street 'hi-fi' shops to be reminded that some quite horrible noises can emerge from combinations of reasonably prestigious seeming kit.

This lack of agreement between conventional measurements and perceived sound quality poses a problem for any designer in the audio field. Account must be taken, however reluctantly, of the claims of those who base their judgement of equipment performance on listening trials, and checks made to see whether these claims have foundation in fact.

I admit to reservations about many of the effects attributed to the characteristics of minor amplifier components in amplifier circuitry, particularly where these are clearly peripheral to its function. However in places such as the negative feedback loop (which defines the whole performance of the amplifier) and in the supply line decoupling (which establishes the relationship of the system to the 0V line) there are good technical reasons why component type may affect sound quality and there are small but measurable (and reproducible) effects which can be demonstrated. Having looked at a wide range of these marginal aspects of audio quality, I incorporated those I thought to be sensible into the design of my 80W amplifier featured in ETI from June to September 1984.

In general, I am very well pleased with the performance of this amplifier which is, I think, the best design I have done so far. In the view of some experienced 'audiophiles' whose opinions I respect, it is significantly better than other amplifiers of their acquaintance. It has also attracted some very flattering comment from constructors in the correspondence columns of the 'hi-fi' press.

I share the general regret that a kit of parts for this design did not become available at the time of the original publication. Now that a kit specialist, Hart Electronic Kits, has produced the necessary components, PCBs and metalwork for the power amplifier, I have taken this opportunity to do a little tidying up in areas generally related to convenience rather than performance.

The pre-amplifier has also been given a few amendments, notably the addition of a moving coil head amplifier stage and new tone controls. Hart is

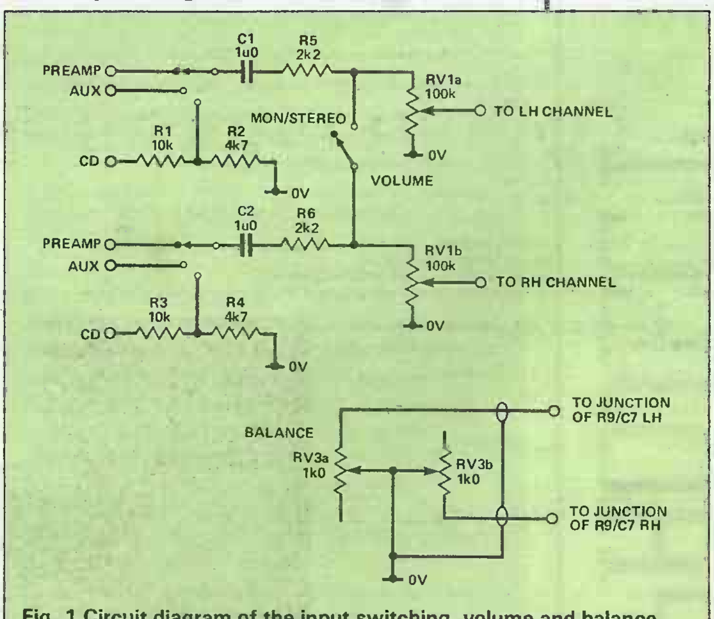


Fig. 1 Circuit diagram of the input switching, volume and balance controls

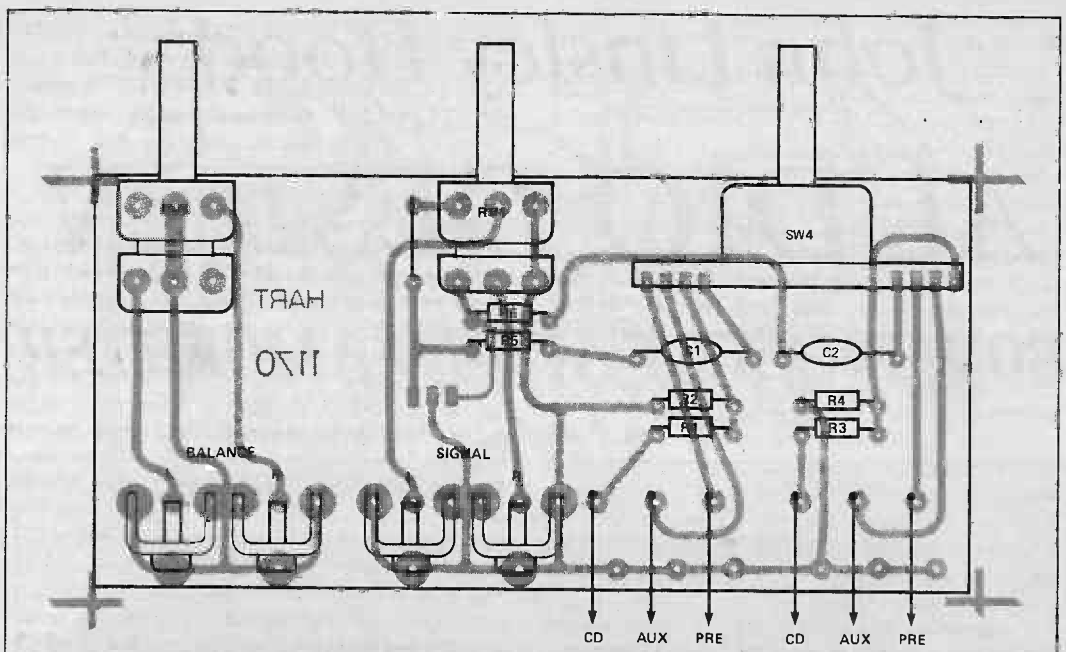


Fig. 2 Component overlay for the input selector circuit

already working on the kit for the pre-amplifier and hopes to have it available later this year. It will be featured in ETI at that time.

In both the power and pre-amplifiers my aim with this revised design remains the same — to provide a system which will be equal to or better than the best of the contemporary market offerings, without making the whole system too expensive for the average potential constructor.

Input Switching

It was an oversight on the original design not to provide an input selector switch to accompany the 'gain' and 'balance' controls on the input of the power amplifier which would have increased the versatility of the power amp. I should have thought of this earlier since I had specifically intended that the power amplifier should be capable of use on its own, by those who were only going to use LS outputs, and whose sources (for example tape, CD or radio) would not need frequency response adjustment.

The small circuit modifications involved are shown in Fig. 1 and the component overlay in Fig. 2.

Output Power Indication

The power output display which I had provided for

COMPONENT CHARACTERISTICS

I have read much, and have been given much advice by some of my experimentally minded friends, on the way in which the nature of a component (as distinct from its actual electrical value) can influence the quality of the sound of an amplifier. I have made a lot of tests to see if I agree with these findings. Mainly the differences are too small for me to be able to say definitely whether there is a change and if so whether it is better or worse.

I do not say that these differences do not exist or that when a lot of very small changes are added together the cumulative effect will not be greater. What I think is that, in most cases, the changes are very small in comparison with those alterations in sound quality which arise from different circuit approaches. I feel that I am better employed in trying to optimise these.

There is one exception to my reluctance here and this concerns capacitors, particularly those in the feedback loop of a feedback amplifier and to a lesser extent those in the signal line.

This is a complex business but there appear to be a few general rules. The extent to which a capacitor will influence the sound depends on the signal voltage which could appear across it, upon its impedance in relation to the other circuit parameters, and upon its dielectric hysteresis and dielectric loss. In a feedback loop, a low leakage aluminium electrolytic is greatly preferable to a tantalum type but must operate with a polarising voltage present across it. Electrolytics will usually benefit from the presence of a parallel connected non-polar type.

Ceramic capacitors can cause some curious effects due to the voltage dependence of their capacitance and should be left to RF circuitry. Silvered mica types seem quite harmless but there is nothing which they can do which polystyrene ones will not do better.

In level low level audio circuitry, such as moving coil head amps, aluminium electrolytics appear to work quite well (which is a good thing since the alternative ways of amassing the necessarily large values of capacitance would be extremely bulky — not to mention the cost).

At higher signal voltage levels, polypropylene, polystyrene, polycarbonate and polyester types, in that order of preference, are better than electrolytics — if one has to use a capacitor at all. If one can rearrange the circuit to avoid or lessen the number of capacitors in the signal line, this is worthwhile.

There is not, I think, much difference between polystyrene and polypropylene types and the latter tend to be more variable in quality — perhaps due to some manufacturers saving pennies by using a packaging grade polypropylene film instead of the more expensive electrical quality material, or perhaps by an inadvertent substitution of film types.

I have tried, therefore, particularly in the revised version of the preamplifier, to recast the circuitry in a form where the capacitors used are the optimum choice for their circuit function in terms of sound quality, practicability and cost. The same considerations apply to the other components used — none of which has escaped scrutiny.

The other major areas in the choice of components are, in order of importance, the switches and connectors (which should have a contact area appropriate to their likely current flow and should be gold plated in low level circuitry) and the integrated circuits such as op amps and voltage regulators. These are now very widely available from a range of sources, but the performance of notionally identical devices from some of the minor manufacturers can sometimes be very poor due to lack of adequate quality control. It pays, therefore, to spend a little extra for a component from a major producer.

the original system used a pair of moving coil microammeters, connected to provide peak-reading linear scale power meters. I thought that the choice of a linear power scale would be useful since it would give the user a good idea of how close he was to the output power overload region — which would, in practice, probably be a bit above 100W per channel.

However, the meter pointers were nearly always at the bottom end of the scale. I know that in my own home, and with my own 'BBC monitor' type LS units, I very seldom use more than about 3W peak, but I had assumed, incorrectly, that there were out there in the great beyond more stalwart audiophiles whose ear-drums and neighbours would allow them to push their amplifiers to much higher power levels.

Since it seems that I had misjudged this, I have opted instead for a fairly conventional twin LED bargraph circuit (Fig. 3). This gives a near instantaneous peak-reading, log-scale display, covering the output power range 0.2-100W. This design provides a module which would be usable as an output power display for other audio amps.

I appreciate that some people like to listen to their music in near darkness, where the flickering bar-graph power display might be tiresome. Others would resent the continuous presence of such a visual intrusion, even in full lighting. I have therefore arranged that the display can be switched off when not needed.

The same LED display panels also carry the power 'on' and power supply overload 'trip' warning LEDs. The overlay is shown in Fig. 4. In order to power this bargraph display circuit, a pair of ±15V lines is also derived from the power supply unit by way of a small additional piece of circuitry, shown later.

Power Supplies

Experience has indicated that a few changes would be useful here. The circuit is shown in Fig. 5. In particular, fault reports from constructors suggest that Q17, an MJ2501 pnp 'Darlington' transistor (in the main ±55V power supply line), is more vulnerable to damage on PSU output short-circuits than I had hoped. In some cases, when this caused the transistor to go open circuit, Q7 and R31 would try to pass the output current instead and this wasn't good for them. I have included two diodes, D23 and D31 (together with D24 and D30 in the −ve channel) to prevent this undesired current flow through the over-current protection circuit.

However, the main improvement in the PSU — principally to ensure that the output lines were truly s/c proof (but which also seems to have given a slight sonic bonus by way of a small lift to the already high level of audio 'transparency') — is that the series 'pass' transistors in both lines are replaced by power MOSFETs, since these are both faster in action and also much more rugged devices. The circuit changes required to allow this substitution are relatively slight, and are shown in the amended PSU circuit diagram (Fig. 5).

The use of MOSFETs here would also allow the HF stabilisation capacitors (C7 and C8) in the loop feedback circuit to be omitted, since with MOSFETs, which have a very good HF response, the feedback loop is quite stable without them. I would however recommend their retention at about the 3n0 value, since this has no ill effect and an increase in stability margin is always useful.

A point I'd like to make here is that there is a current vogue for using greatly oversized mains transformers because it is thought by their users that this modification somehow improves the 'solidity' of the sound. So it might, in a simple transformer-rectifier-reservoir capacitor PSU, provided that the reservoir capacitors were adequately large and the conducting impedance of both the rectifiers and the wiring joining them to the transformer and to the reservoir capacitors was adequately low.

However, a competently designed electronically stabilised PSU can have an output impedance of a small fraction of an ohm, even down to subsonic frequencies and to match this impedance characteristic with conventional capacitors would require values in excess of 1Farad.

I do not recall ever seeing a 1F 80V working capacitor but were such components available they would be both dear and bulky — an inelegant and

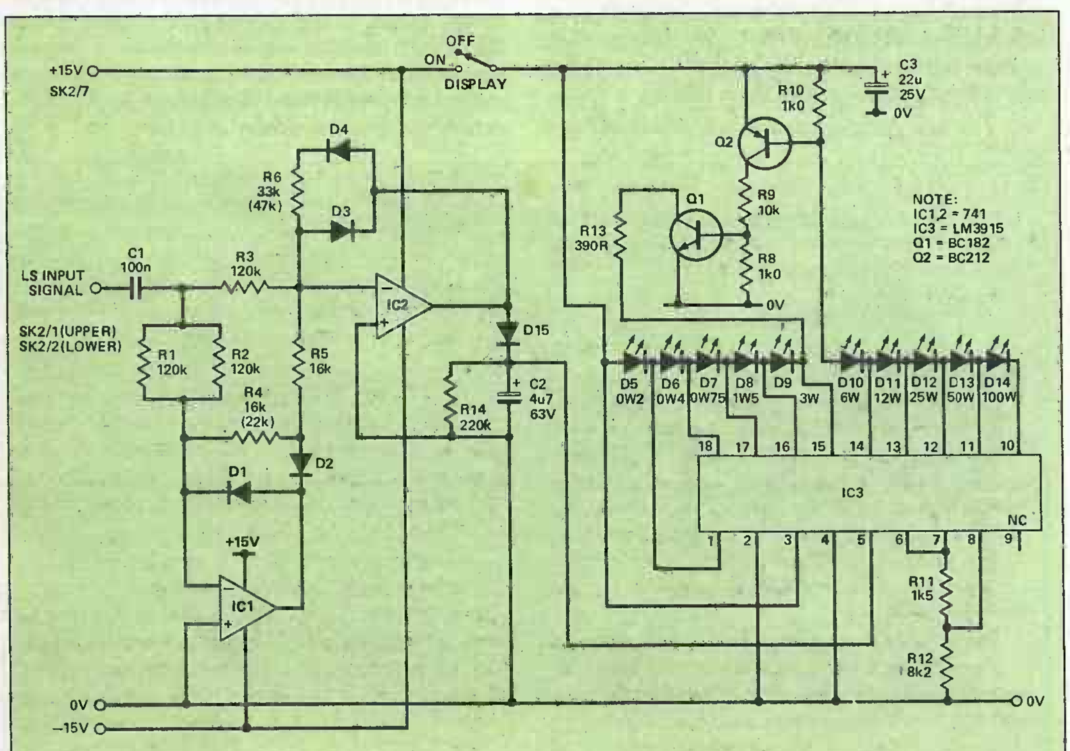


Fig. 3 Circuit diagram for the dot bargraph display

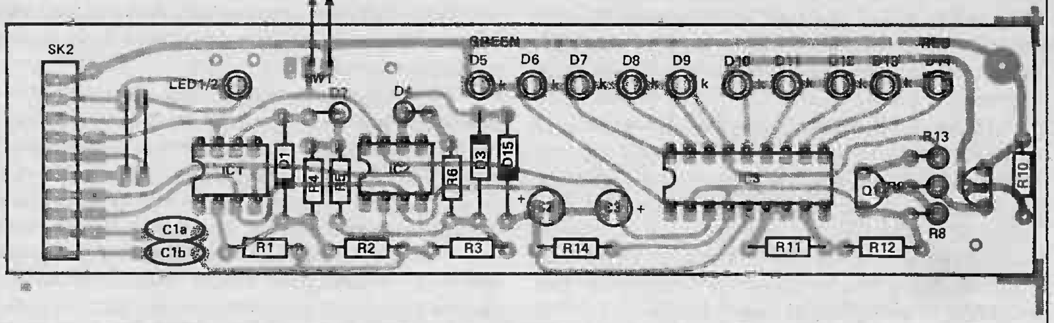


Fig. 4 Component overlay for the bargraph power display

wasteful way of approaching the problem of PSU design. An additional advantage of an electronically stabilised PSU is that it also effectively isolates the power amplifier from the mains transformer, whose characteristics will then be relatively unimportant so long as it is adequately rated to deliver the required input voltage without overheating. Also it doesn't contribute any annoying mechanical 'hum' or unwanted stray magnetic fields.

The power supply for the LED bar-graph display needs only to be stable enough to give a constant LED brightness and to avoid exceeding the voltage or dissipation ratings of the bar-graph IC. The circuit used employs a single transistor emitter follower (Q23 or Q24) whose base is supplied with a ±16V potential from a simple zener diode voltage regulator.

The power supply unit has an output voltage which is capable of adjustment and could stand as a quite versatile independent module, to upgrade other amplifiers designed with rather cruder PSU arrangements. It has therefore been designed as a monoblock unit on a heavy gauge aluminium sub-chassis, with the PCB shaped to fit around the toroidal mains transformer.

In the 80W design, this sub-chassis also carries the LS output connections (via 4mm binding posts), the mains inlet and output sockets and provides heat sinking for the PSU MOSFETs which are mounted in holders and fitted with insulating covers to obviate inadvertent case-to-chassis short circuits.

The new component layout is shown in Fig. 6.

DC Offset Protection

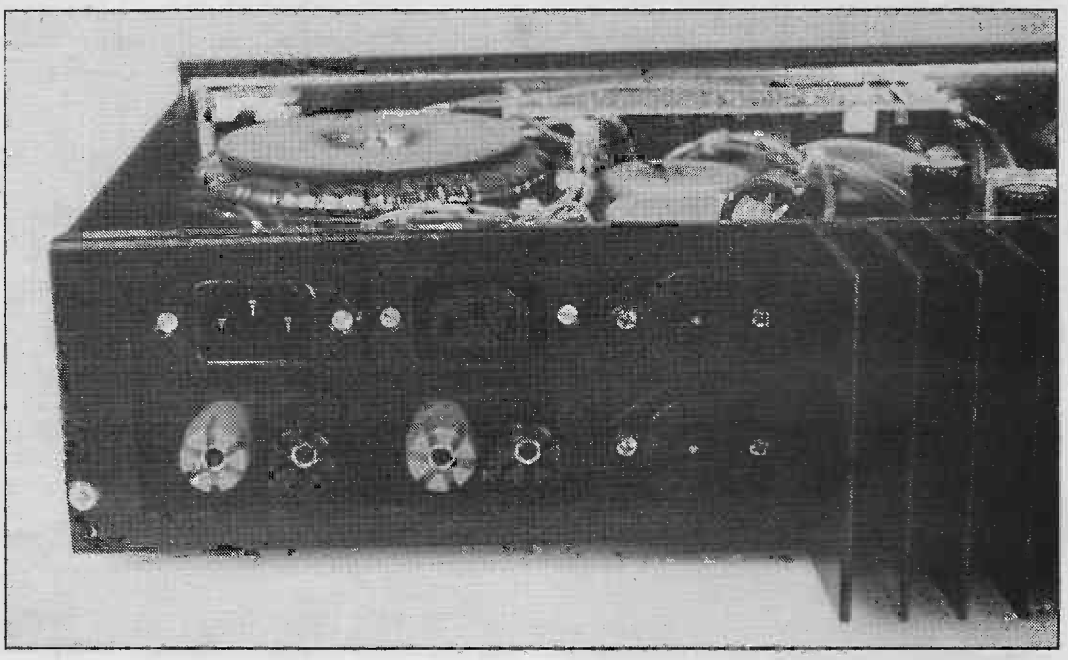
In order to avoid the need for relay contacts in the LS output lines (in the event of a DC offset arising) I had included a protection circuit in the PSU system (Q9,Q11,Q13,Q14 in the +ve line, and Q10,Q12, Q15,Q16 in the −ve line), which would shut down the PSU in the event of an offset.

I had, however, erred on the side of excessive caution, and this could cause the PSU to shut down on quite legal low frequency excursions — especially from compact discs, which have a very good sub-sonic response. I propose therefore that two 470k resistors, R42 and R43, should be added between the bases of Q9 and Q11 to the 0V line, to reduce the 'trip' sensitivity of the circuit.

Please note that there was a misprint on the original diagram which showed D11/D18 joined to the 0V line. Most constructors spotted this but if it was left uncorrected, it rendered inoperative the second shut-down mechanism in the PSU, which is designed to be triggered if an excessive difference occurs between the PSU ± output voltage levels.

The Power Amplifier

The circuit (Fig. 7) of this is unchanged from that shown in ETI in July 1984, except for an amendment to the values of the output gate stopper resistors R18,19,21 and 22, and the inclusion of the small damped inductor L1/R31 in the output line, to ensure complete compatibility with a wider range of LS units or strange speaker cables.



The added input switching arrangements have already been noted but there are also some changes added in the evolution of the 'kit' design which concern the balance and stereo/mono switching. This last facility was included to save difficulty if the amp was driven from a mono input source, such as a TV sound pick-off socket. The recommended PSU component overlay is shown in Fig. 8.

Physical Layout And Kit Evolution

Looking at the efforts of friends and acquaintances who had made their own PCBs and assembled this amplifier from scratch made me aware, not for the first time, just how many things it was possible to do wrong. Even the unwise connection of earth points may destroy the purity of the output signal, let alone the effect of allowing a pair of unscreened input wires to trail across the chasis underneath the power amp and PSU boards.

I was, therefore, very happy to find that Hart was prepared to invest the quite considerable amount of effort needed to work out a neat and fully debugged kit for this design, and I am grateful that they were prepared to make and submit prototypes for me to test and to make layout amendments with very good grace when I felt that some aspect might be improved.

Unfortunately, because their works is some hundreds of miles away from my own lab., the task of evolving a fully 'designer approved' collection of hardware has taken rather longer than either of us had hoped.

I had initially underestimated the amount of space which would be taken up by the PA and PSU boards and the toroidal mains transformer. There is

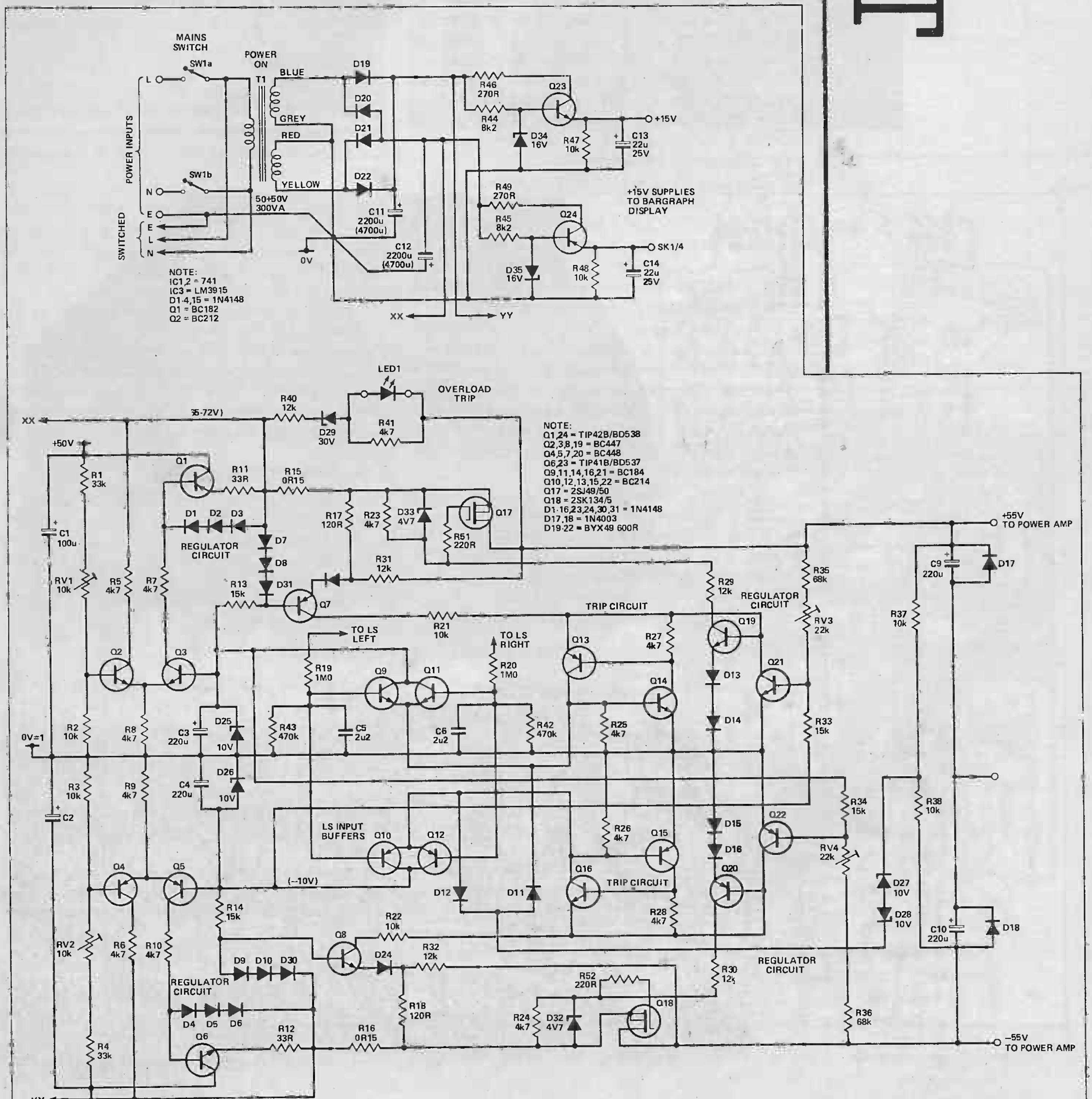
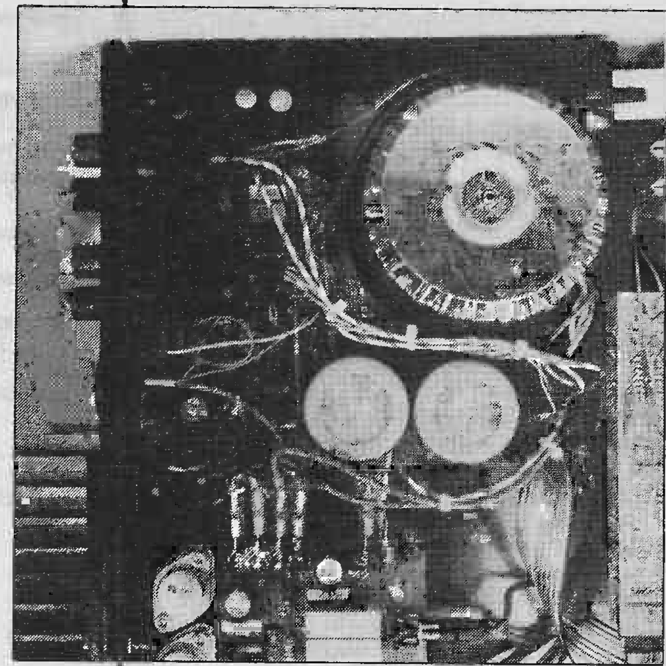


Fig. 5 Circuit diagram for the power supplies



PARTS LIST

Bargraph Power Meter

Parts for one channel only

RESISTORS (all .3W or better. Bracketed values for 4R speakers)

R1-3	120k
R4,5	16k (22k)
R6	33k
R8,10	1k0
R9	10k
R11	1k5
R12	8k2
R13	390R
R14	choice of 220k (slow decay) or 82k (medium decay)

CAPACITORS

C1	100n polyester radial, pitch 7.5mm
C2	4u7 63V electrolytic radial, pitch 2mm
C3	22u 25V electrolytic radial, pitch 2mm

SEMICONDUCTORS

IC1,2	741 or LF351
IC3	LM3915

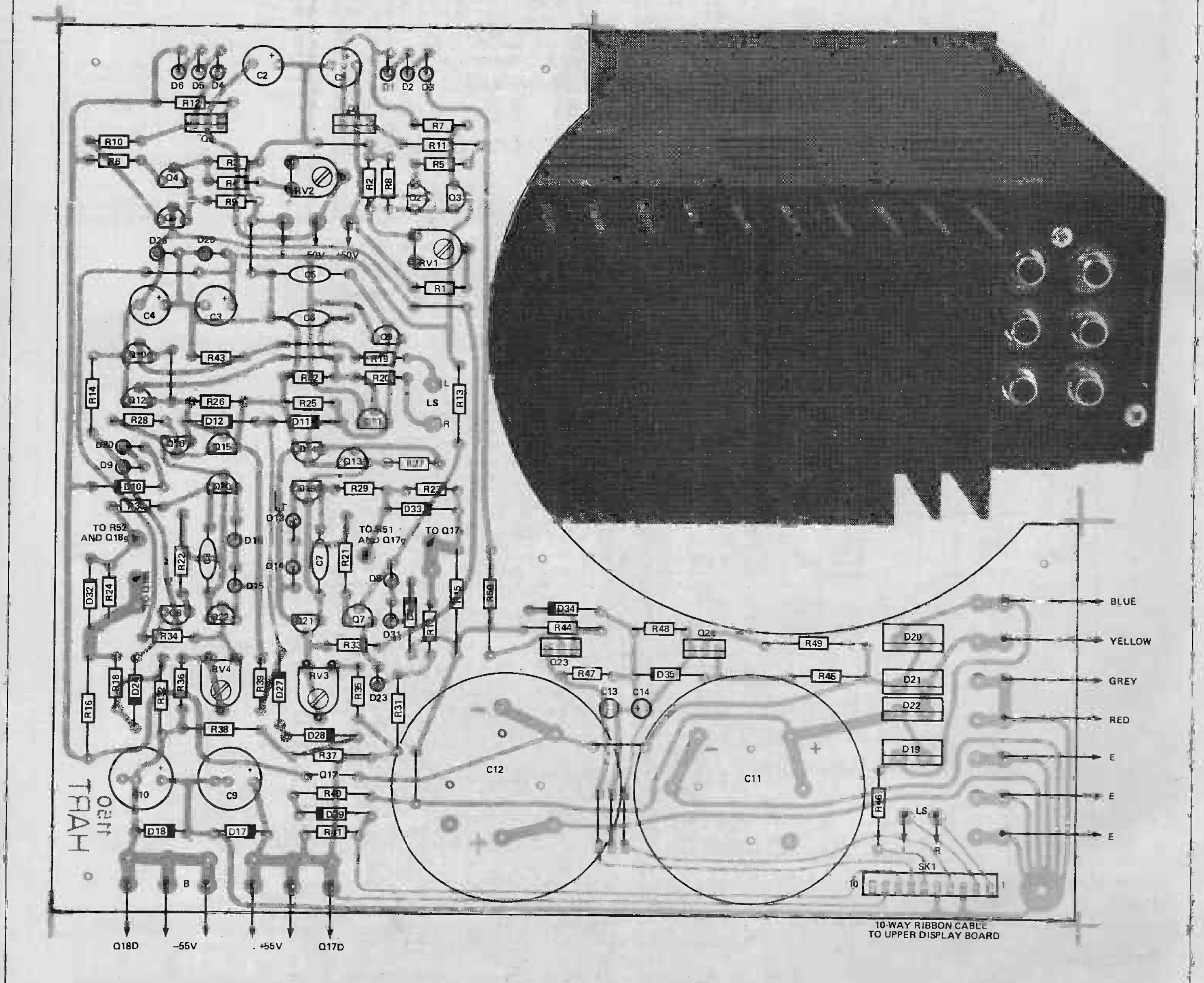


Fig. 6 Component overlay for the power supplies

Q1	BC182 (D pad)
Q2	BC212 (D pad)
D1-4,15	1N4148
D5-14	LED bargraph display assembly
LED1	red LED, upper PCB only
LED2	green LED, lower PCB only

MISCELLANEOUS

SK2	10-way 2.5mm pitch socket (upper PCB only)

PCB. IC sockets. 90° LED mounting. PCB 2-pin header, 2.4mm. Jumper socket. 3-way header and prewired socket for SW1.

Power Amplifier

RESISTORS (all .3W metal film 1% unless specified)

R1,14	150k
R2	4k7
R3	1k2
R4-6	1k0
R7	47k
R8	820R
R9,10	470k
R11	470R
R12	56R
R13	39R
R15	22k
R18,19	330R
R20	8R2 2.5W w/w
R21,22	270R
R23-27	0R22 2.5W w/w
R28	10R
R29	10k
R30	39k
R31	8R2 ½W (matrix for L1)
RV2,4	1k0 lin cermet preset
RV5	2k2 balance preset

CAPACITORS

C1,6,10,12,14,16	470n polycarbonate film radial 15mm
C2	330p polystyrene film axial
C3	100p polystyrene film axial
C4,15	100n polycarbonate 10mm
C5	1n0 polystyrene film axial
C7	2×4u7 polycarbonate film radial 27.5mm
C8	2×10p polystyrene film axial in series
C9,11,17,18	220u 63V electrolytic radial 7.5mm
C13	220n polycarbonate film radial 10mm
C20	1000u 25V radial electrolytic 7.5mm
C21	10n polycarbonate film radial 5mm

SEMICONDUCTORS

Q1,2,6	BC448
Q3,5,7,8	BC184
Q4,11	BC214
Q9	BF870
Q10	VN1210M
Q12,14	2SK135
Q13,15	2SJ50
Q16	2N5459
D1,2	8V2 zener 400mW
D3,4	1N4148

MISCELLANEOUS

L1	6 turns 24swg ECW on R31

PCB. Transistor pads (12). Gold phono sockets (2). Heatsink TO3 angle (4). PCB male tabs .250 horizontal (8). Diode cradles (4). Insulating discs (5).

Power Supply

RESISTORS (all .3W 5% or better)

R1,4	33k
R2,3,47,48	10k
R5-10,23-28,41	4k7
R11,12	33R .5W
R13,14	15k .5W
R15,16	0R22 2.5W w/w
R17,18	120R
R19,20	1M0
R21,22,37,38	10k 0.5W w/w
R29,30	12k
R31,32,40	12k 0.5W
R33,34	15k
R35,36	68k
R39	100k
R42,43	470k
R44,45	8k2 0.5W
R46	3k3 0.5W
R49	2k2 0.5W
R50	270R 2.5W w/w
R51,52	220R
RV1,2	10k preset horiz
RV3,4	22k preset horiz

CAPACITORS

C1,2	100u 63V elec radial 5mm
C3,4	220u 40V elec radial 5mm
C5,6	2u2 63V polyester radial 15mm
C7,8	3n0 polystyrene axial
C9,10	220u 63V elec radial 5/7.5mm
C11,12	4700u 80V PCB mount can type
C13,14	22u 25V elec radial 12mm

SEMICONDUCTORS

Q1,24	TIP42B/BD538 (TO220 heatsink)
Q2,3,8,19	BC447
Q4,5,7,20	BC448
Q6,23	TIP41B/BD537 (TO220 heatsink)
Q9,11,14,16,21	BC184
Q10,12,13,15,22	BC214
Q17	2SJ49/50 fitted with insulated covers and
Q18	2SK134/5 holders on power supply chassis
D1-16,23,24,30,31	1N4148
D17,18	1N4003
D19-22	BYX49 600R
D25-28	10V zener 400mW
D29	24/30V zener 400mW
D32,33	4V7 zener 400mW

MISCELLANEOUS

SK1	10-way 2.5mm pitch vertical
T1	50-0-50 300VA toroidal

PCB. Chassis. PCB tabs. Diode cradles. Heatsinks. Speaker terminals. Mains switch. Mains inlet and outlet sockets + cover boots.

Input selector section

RESISTORS (all .3W 5%)

R1,3	10k
R2,4	3k3 RV1 100k log, 2-gang
R5,6	2k2 RV3 1k0 lin 2-gang

CAPACITORS

C1,2	1u0 polycrbonate rad 15mm

MISCELLANEOUS

SW1,2	SP push switch
SW3	2P push switch
SW4	4P push switch 3W

PCB. Phono plugs and sockets (4). Gold phono sockets (6).

Main chassis. Heatsink 190×75×50mm. 1 chassis cover. Backplate. Frontplate. Dial plate for display. Knobs.

PROJECT

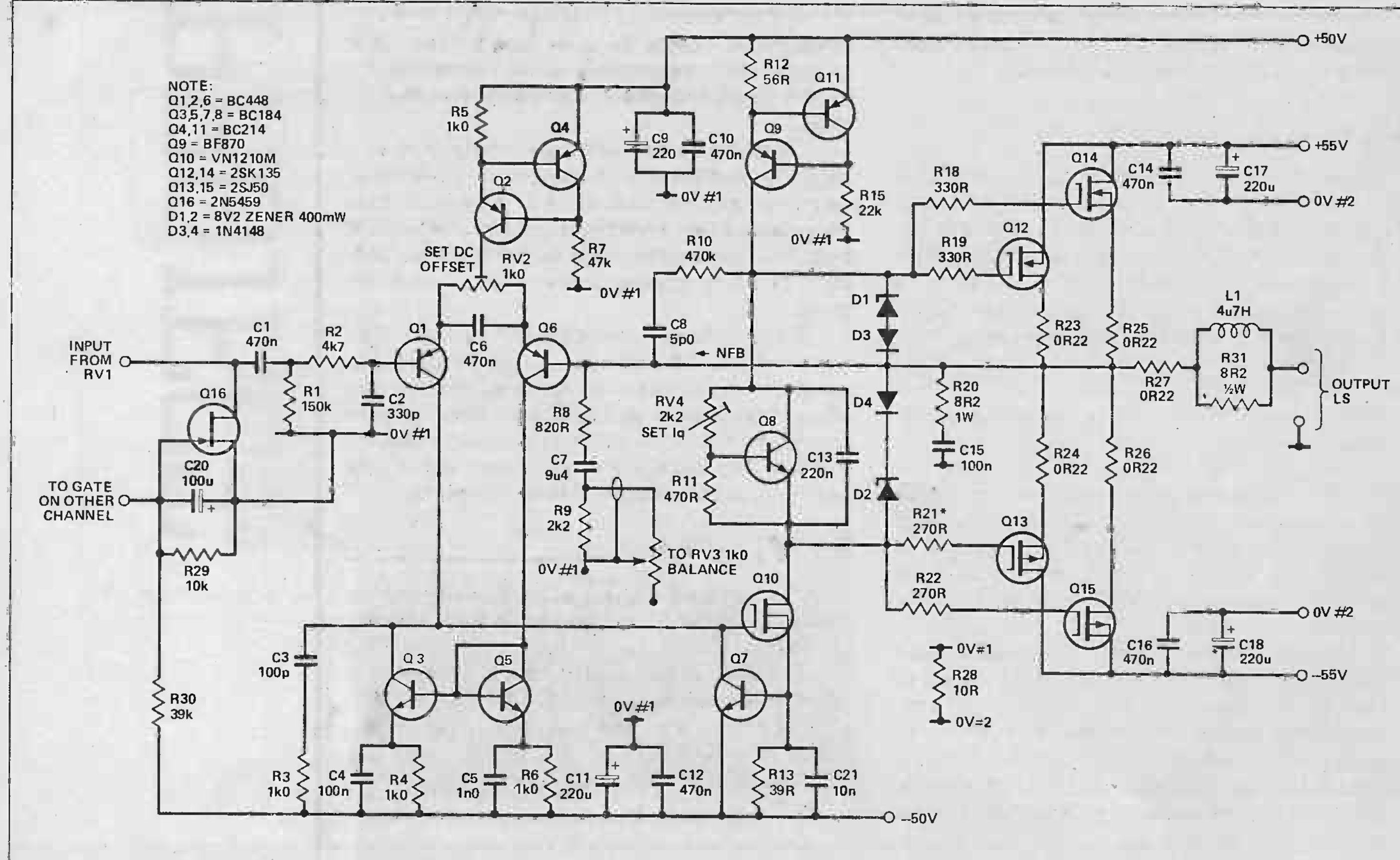
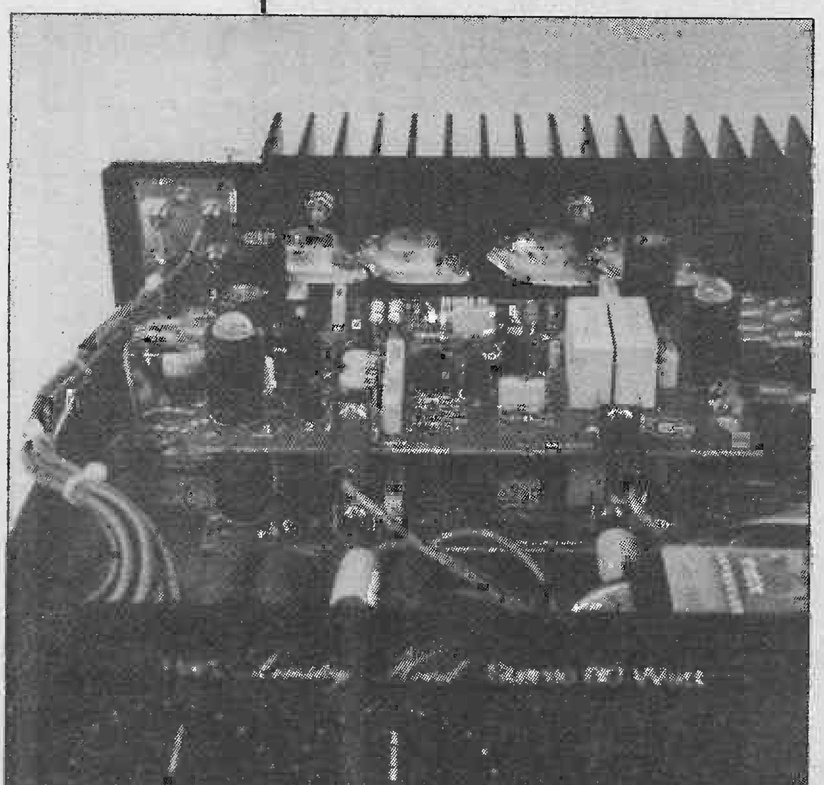


Fig. 7 Circuit diagram of the complete power amplifier

also the electrically desirable, but physically impossible, condition that the two power amp PCBs should occupy the same space, so that there would be no unwanted 'loops' in the wiring between them and the inputs, outputs and power transistors, and so that all the input and output wiring should be of the same length.

A further desirable aspect of the layout is that the connecting leads to the power MOSFETs should be carefully arranged since, with these devices, if one doesn't watch one's step it is very easy to find that one has unwittingly constructed a VHF oscillator.



Hart solved the problem of the MOSFET connections very neatly by attaching an angle bracket (see photo) in thermal contact with the main heat sink to the PCBs and then directly mounting the MOSFETs through this bracket on to the tracks of the PCB. This also solves the problem of accidental mis-connection to the pins.

Their solution to the requirement of identical position of both boards was to mount the two power amp boards flat, one above the other, separated by spacers between the boards. Preset adjustments are made either from above or through access holes in the metal chassis.

In order to make it easy to remove the power amp boards, the input and 'balance' control connections are made via gold plated phono connectors and the heavy current power supply and output connections by means of 63/0.2mm stranded wire and flat tab push-on connectors.

The critical requirements of the earth return connections are satisfied by care in the layout of the PCBs and by joining the two amplifier output 0V lines, 'E2', by identical length, heavy duty cables to a common earth point on the PSU board, together with the lower current 'E1' points. The earthy side of the LS output is then taken directly to the PA PCBs from their respective LS output binding posts.

In order to avoid input earth loops, the six gold-plated phono input sockets (CD, aux. and preamp.) are mounted on a small separate PCB, which commons the earth returns so that this can be taken by one only of the six screened wires to the input selector board. This input socket panel also isolates the input earths from the chassis.

The input selector board has its four outputs via further gold plated phono sockets which take the stereo pairs of signal and balance control connections through screened cables to the two power amp boards via the mono/stereo and mute switches.

Performance

My intention in evolving this design was to offer a circuit which would outperform by a significant margin all but the very best audio amplifiers available today. I do not think that this aim is quite as vain as it might seem, because it is my belief that many apparently near-perfect designs are spoiled by their pursuit of an 'over kill' in aspects where further improvements bring little benefit, while neglecting such things as 'settling time' or loop stability margins, which are very important in terms of sound quality though never specified.

The technical specification for this design, in terms of output power, power bandwidth, harmonic and intermodulation distortion, is fully in line with modern expectations and the transient response is, I believe, a good bit better than average since this is one of the areas which tend to be neglected in commercial hardware.

However, there are aspects of design which affect sound quality but which are not easily related to technical measurements. This is not, I am sure, because they cannot be measured but because we (and I think I speak for most of the designers working in this field) cannot be sure what it is we need to measure. Where I know that one approach in terms of circuit architecture or component choice gives a better sound quality, or even seems better, than another which is electrically apparently identical, I have deliberately opted for that which gives the best sound.

Since the success of the project depends to a large extent on layout and wiring detail, I have been surprised and pleased by the occasional very enthusiastic letters which have appeared in the 'hi-fi' press, from constructors who have overcome the fairly major problems involved in the construction of this circuit.

I am, therefore, very grateful both to Hart Electronic Kits who have put so much effort into making this design a practicable reality rather than just a beguiling chimera, and to ETI for allowing me a second bite at this cherry. It is now my hope that this amplifier may provide the constructor with a unit which will not be outclassed in any company.

BUYLINES

Everything in this amplifier design is available from Hart Electronic Kits Ltd, 4 Penylan Mill, Oswestry, Shropshire SY10 9AF. Tel: (0691) 652894.

A complete price list for each section can be obtained from Hart. The special price for a complete kit is £318.25+VAT, Hart code K1100. A slave version without input selector and bargraph costs £269.07+VAT, code K1100s.

Add £2.00 p+p or £9 for next day delivery.

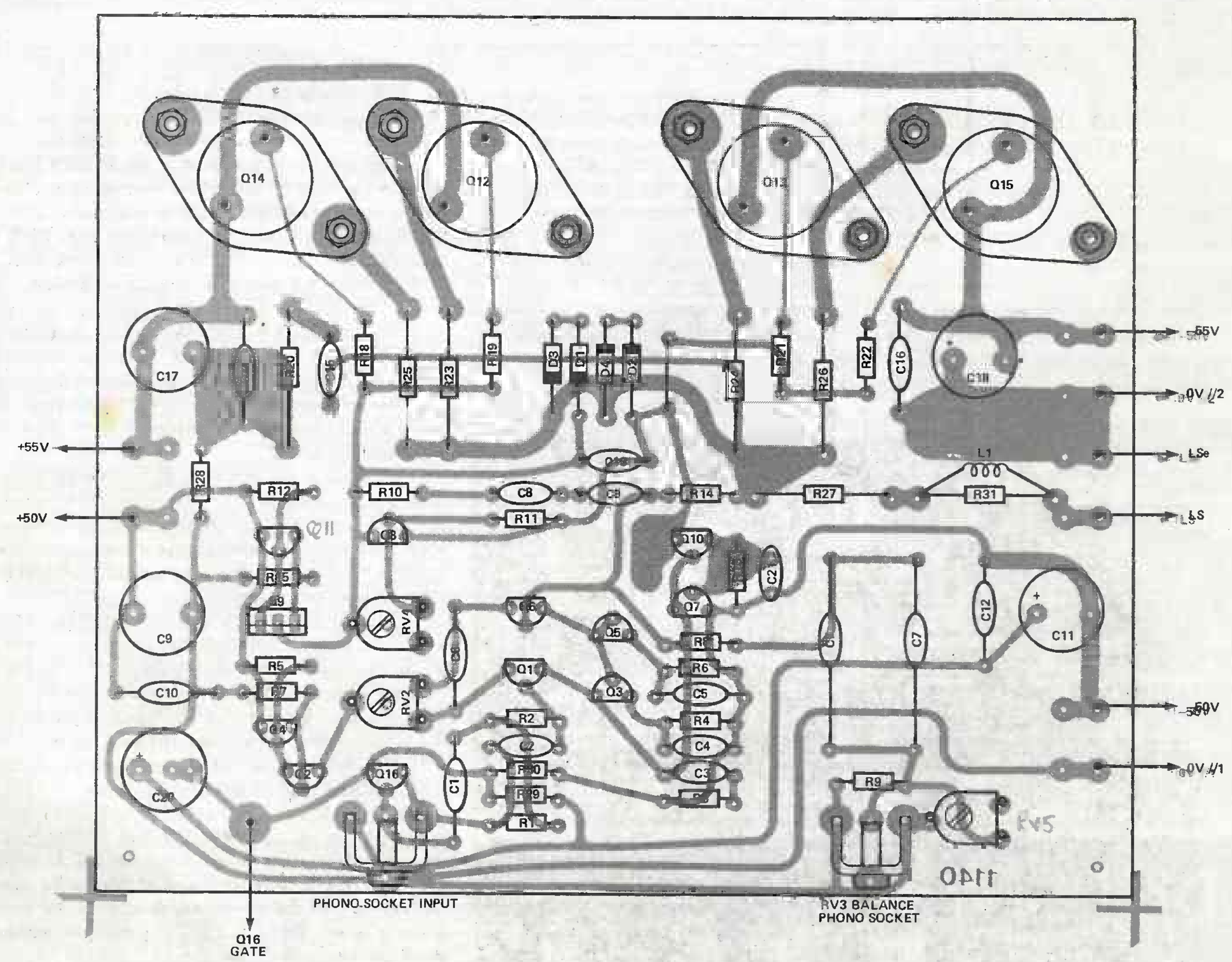


Fig. 8 Component overlay of the complete power amplifier

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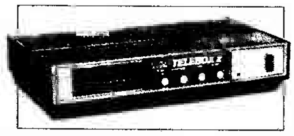

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ULTRASONIC REMOTE CAMERA TRIGGER

Keith Brindley adds ultrasonic remote control to last month's camera trigger

In last month's *1st Class* project — the electronic camera trigger, we promised a number of projects would be in following issues of ETI, each of which would allow your camera to be triggered in a way. This month's *1st Class* is the first of these projects — a remote trigger, allowing you to take photographs at a distance. This could be useful for self-portraits or candid and unsuspected shots of children or animals.

Essentially, the ETI Remote Camera Trigger consists of two separate parts, an ultrasonic transmitter and an ultrasonic receiver. Neither is complicated or difficult to build together they make ideal *1st Class* projects. Although they are specifically designed to work with the ETI Camera Controller of last month's issue, they are more-or-less self-sufficient and can be used to trigger other devices, too.

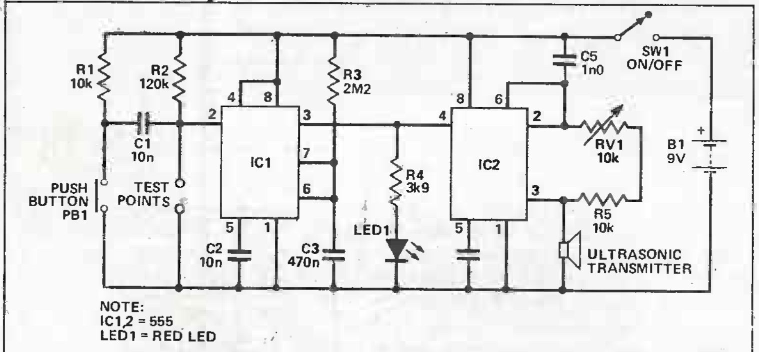


Fig. 1 The circuit diagram of the transmitter

An easy-to-obtain pair of ultrasonic transducers is used to give remote control over a reasonable distance (2-4m), yet this is obtained by an extremely simple transmitter/receiver system.

The ultrasonic transducers operate at a frequency of 40kHz — well above the upper end of the human frequency range (about 20Hz to 20kHz). It shouldn't even annoy your dog!

Power for the receiver is taken from the power supply of the Camera Controller, as this part of the project will be located close to it, anyway. A simple PP3-sized battery powers the transmitter.

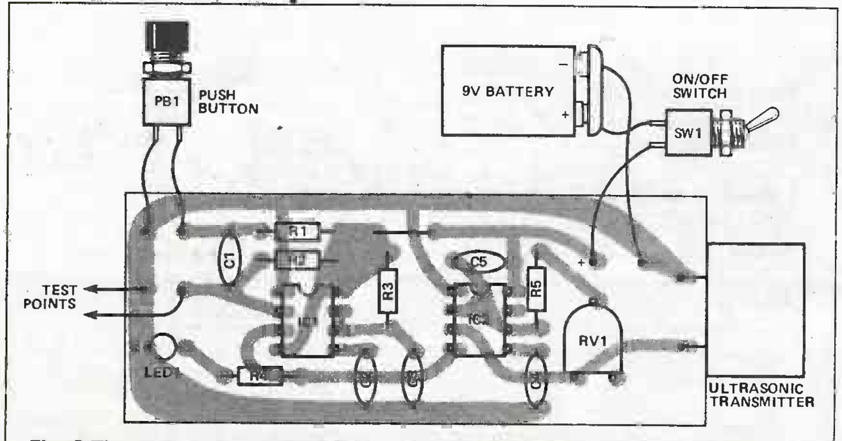
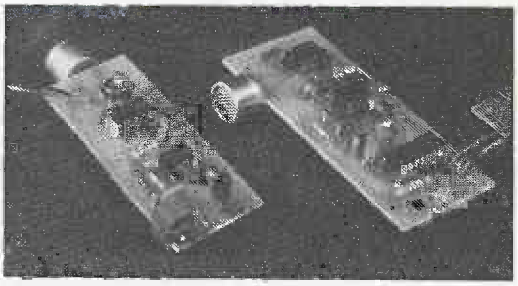


Fig. 2 The component overlay of the transmitter



Construction

Construction is, of course, divided into the parts transmitter and receiver. Both can be built on PCB or stripboard.

The transmitter circuit is shown in Fig. 1, its PCB layout and wiring is shown in Fig. 2, while stripboard layout and wiring is shown in Fig. 4. If you choose PCB construction note the single link required. Use PCB pins for the test points to make life easier when setting up your project. PCB pins for the power supply inputs aren't so critical. Use integrated circuit sockets for IC1 and 2, if you prefer, although 555s aren't expensive. Simply take care you don't overheat either integrated circuit.

For construction on stripboard, the usual rules apply. First make all track breaks where shown, then insert and solder the required links followed by all components. Suggestion for PCB pins and integrated circuit sockets apply here, too. Once built, leave the transmitter aside. Setting it up is best accomplished using a working receiver.

The receiver circuit is shown in Fig. 3 while PCB layout and wiring is shown in Fig. 5 and the stripboard layout and wiring is shown in Fig. 6. All the earlier rules regarding PCB pins and integrated circuit sockets apply here, along with those for constructional order, whether PCB or stripboard construction is your choice.

Housing, or even whether you want to house your project or not, as usual with *1st Class* projects, is left entirely up to you. The transmitter, we reckon, is small enough to fit into just about any of the available small boxes specifically meant for hand-held projects. The receiver is best mounted close to the Camera Controller.

Setting Up

Once both parts of your project are built, it only remains to set them up for peak performance. Initially, connect your receiver to the completed Camera Controller from last month's ETI. If you want to use the Remote Camera Trigger for other purposes, however, you'll need a separate power supply. Once power is supplied, you may find the Camera Controller is triggered — don't worry about that. In fact just leave it in this state as setting up doesn't require it to be reset. Turn preset RV1 of the receiver completely anti-clockwise. Now slowly turn it clockwise, until the LED lights. Now gently turn the preset anti-clockwise again, until the LED just goes out. The receiver is now setup and is at its maximum sensitivity. You'll find that simply

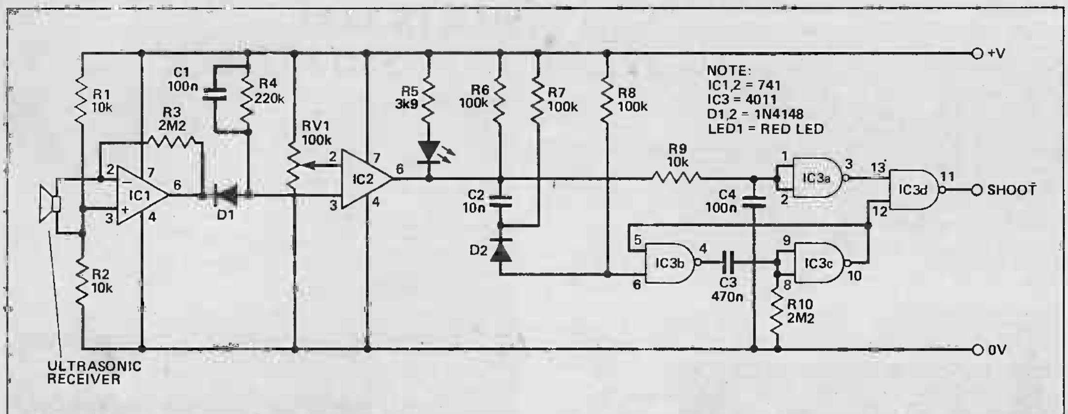
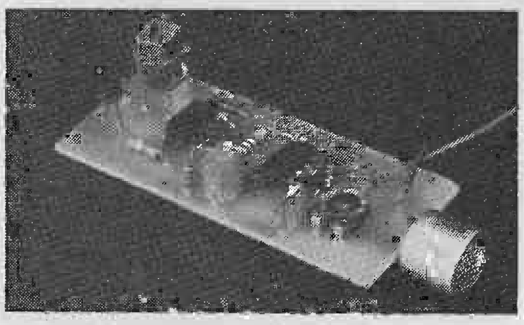


Fig. 3 The circuit diagram of the receiver



clapping your hands close to the ultrasonic transducer will cause the LED to flash, which proves that your project is working (and also proves that hand-claps have a significant high-frequency component which is detected by the transducer).

Setting up the transmitter for maximum output requires that you de-sensitise the receiver, by turning

HOW IT WORKS

A block diagram of the Remote Camera Trigger is shown in Fig. 7. Here the two separate parts, transmitter and receiver, are easily identified.

The transmitter is formed by a monostable multivibrator, followed by an astable multivibrator. The monostable multivibrator is triggered by pressing the push button switch and has an on period of about one second, defined by resistor R3 and capacitor C3. The on period is used to trigger the astable multivibrator, which oscillates at 40kHz and drives the ultrasonic transmitting transducer. Each time the push button is pressed, the ultrasonic transducer emits a 40kHz ultrasonic signal for about a second. Fine tuning of the astable multivibrator frequency is performed by adjustment of preset RV1.

The receiver is a little more complicated. A timing diagram, showing waveforms at various points in the circuit, is given in Fig. 8. Initially, the weak ultrasonic signal received by the ultrasonic transducer is amplified by a straightforward op-amp amplifier formed by integrated circuit IC1. The resultant 40kHz waveform (at point 1 in the block diagram) lasting for one second, can be seen in the timing diagram.

An envelope detector (diode D1, resistor R4, capacitor C1) is next used to generate a negative-going DC voltage (at point 2) from the 40kHz AC signal.

An op-amp comparator (IC2) compares the DC envelope voltage with an adjustable set-point voltage, giving the negative-going switched output voltage at point 3. Preset RV1 of the circuit adjusts the set-point voltage to the comparator and so allows the receiver's sensitivity to be adjusted according to circumstances.

The negative-going edge of the comparator output voltage triggers a monostable multivibrator with an on period of about 0.8 second. Gates IC3cd form the monostable multivibrator, whose on period is set by the components resistor R10 and capacitor C3 according to the approximate relationship:

on period=0.8xR10xC3

The waveform at point 4 in the block diagram (that is, the monostable output) is clearly seen in the timing diagram.

Control logic formed by gates IC1ad ensures a negative-going short pulse is only obtained at point 5, when the output from the monostable multivibrator has gone positive *after* the on period *and* while the 40kHz input signal is still being received. This ensures that spurious 40kHz input signals (jangling money, rattling keys, passing boats and so on) don't affect receiver operation and trigger your camera. Joking aside, spurious signals always *were* a problem with odd-type ultrasonic television remote controllers. The ETI Remote Camera Trigger neatly sidesteps the problem by ensuring that unless the received 40kHz signal is in the form of a pulse of at least 0.8 sin duration, it is simply ignored. We hope not many bats will have read this, so won't trigger the camera spuriously.

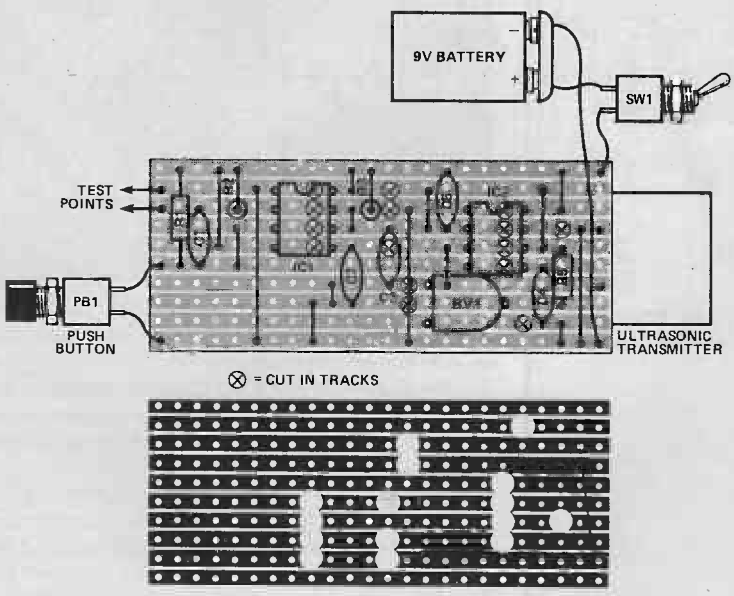


Fig. 4 Stripboard track cuts and component overlay for the transmitter

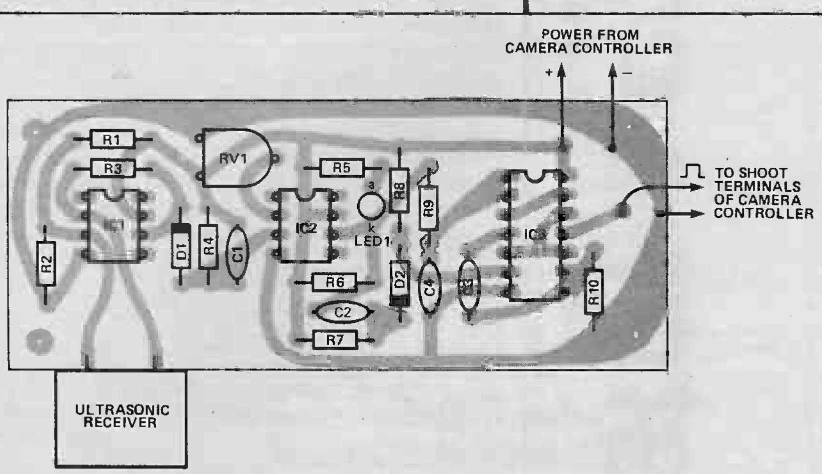


Fig. 5 The component overlay for the receiver

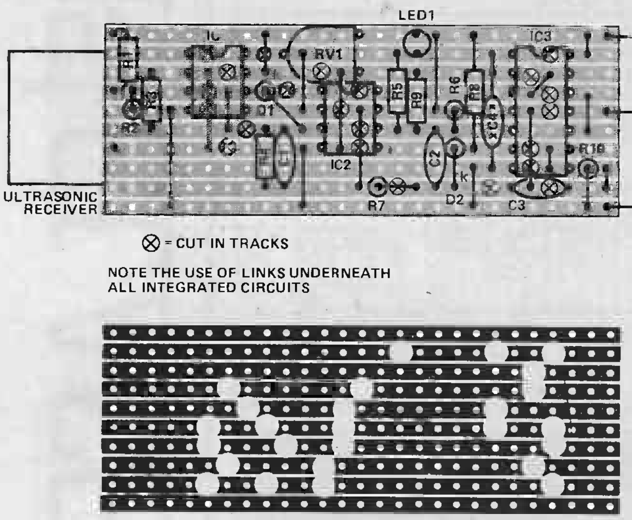
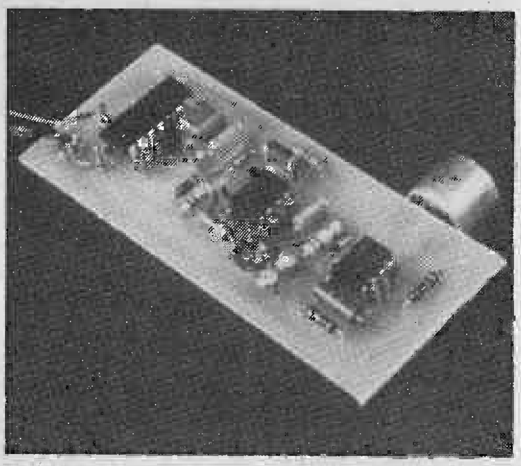


Fig. 6 The receiver stripboard track cuts and component overlay



preset RV1 of the receiver (not the transmitter, remember) slightly anti-clockwise — say a quarter of a turn. Connect a battery to the transmitter. Now, position the two parts of the project about six inches apart on a bench, with the two ultrasonic transducers facing each other. Set preset RV1 of the transmitter to mid-position. This is the basic test position.

The basic test is accomplished by connecting the two test points on the transmitter, using, say a paper clip. Two things may happen. First, the LED of the transmitter should light. Second, the receiver LED may light. If the second doesn't occur, adjust receiver preset RV1 slightly more clockwise until it does. Once both LEDs light, move the two parts further apart and try again, until the receiver LED does not light. Now adjust the transmitter preset one way or the other while doing the basic test.

You'll soon get the feel of the transmitter adjustment and see how the preset adjusts strength of transmission through a peak, according to preset position. As you do the test, keep moving the two project parts further and further apart, until you have the transmitter perfectly peaked.

Now, re-adjust the receiver for maximum sensitivity, as first explained. You should now find that the working distance between transmitter and receiver will increase to at least two or three metres. Further increases in working distance can, perhaps, be obtained by increasing the gain of the receiver amplifier stage (integrated circuit IC1 and associated components).

PARTS LIST — TRANSMITTER

RESISTORS (all ¼W 5%)	
R1,5	10k
R2	120k
R3	2M2
R4	3k9
RV1	10k miniature horizontal preset
CAPACITORS (all polyester layer)	
C1,2,4	10n
C3	470n
C5	1n0
SEMICONDUCTORS	
IC1,2	555
LED1	Red LED
MISCELLANEOUS	
B1	9V PP3 battery
SW2	push button switch
SW1	single-pole, single-throw
XTAL1	ultrasonic transmitter

Battery clip. Battery. PCB or stripboard. PCB pins.

RECEIVER

RESISTORS (all ¼W 5%)	
R1,2,9	10k
R3,10	2M2
R4	220k
R5	3k9
R6,7,8	100k
RV1	100k miniature horizontal preset
CAPACITORS (all polyeste layer)	
C1,4	100n
C2	10n
C3	470n
SEMICONDUCTORS	
IC1,2	741
IC3	4011
LED1	LED
D1,2	1N4148
MISCELLANEOUS	
XTAL1	Ultrasonic receiver

PCB or stripboard. PCB pins.

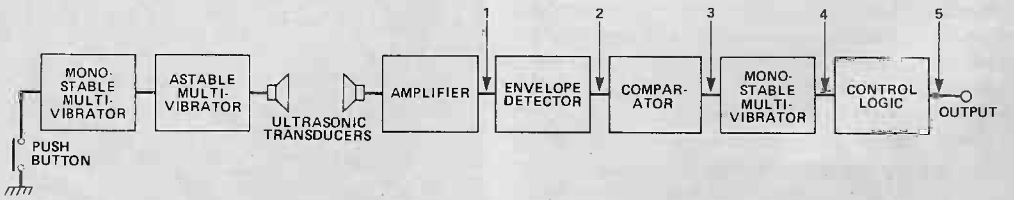


Fig. 7 Block diagram of transmitter/receiver system

1st CLASS

You can do this by increasing the value of the amplifier's feedback resistor R3, from its value of 2M2 up to, say 10M, in steps but you may find above a certain value that performance actually deteriorates rather than improving.

Once both parts are setup, you can disconnect the transmitter test points, reset the Camera Trigger, connect the whole shishkerboodle to your camera, and take your first remotely triggered piccy.

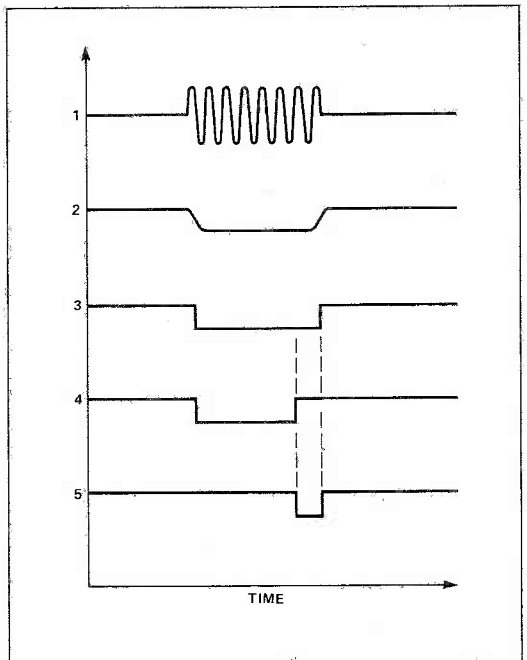


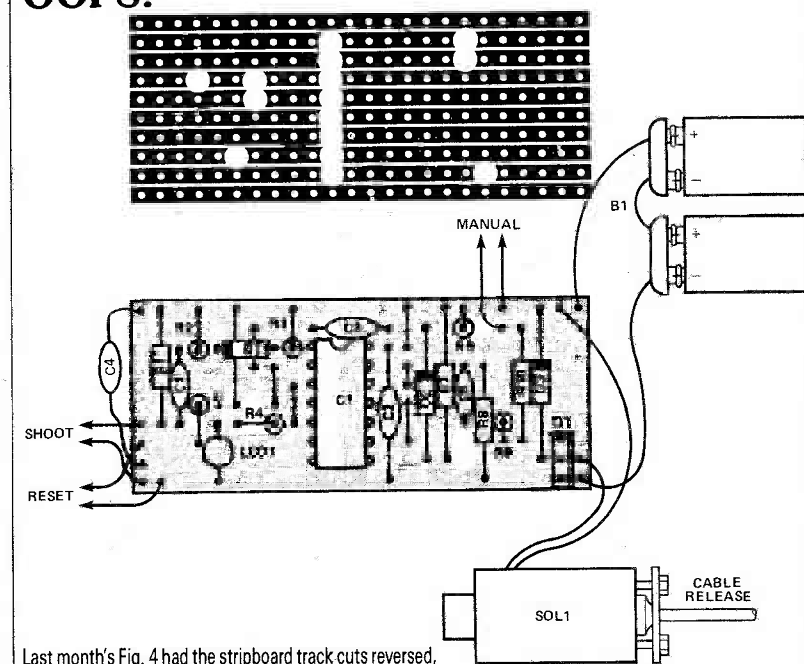
Fig. 8 Waveforms in the circuit

BUYLINES

All parts for both circuits should be easily obtained from most stockists. The ultrasonic transmitter and receiver are from Electromail. Stock numbers: 307-351 (transmitter) 307-367 (receiver).

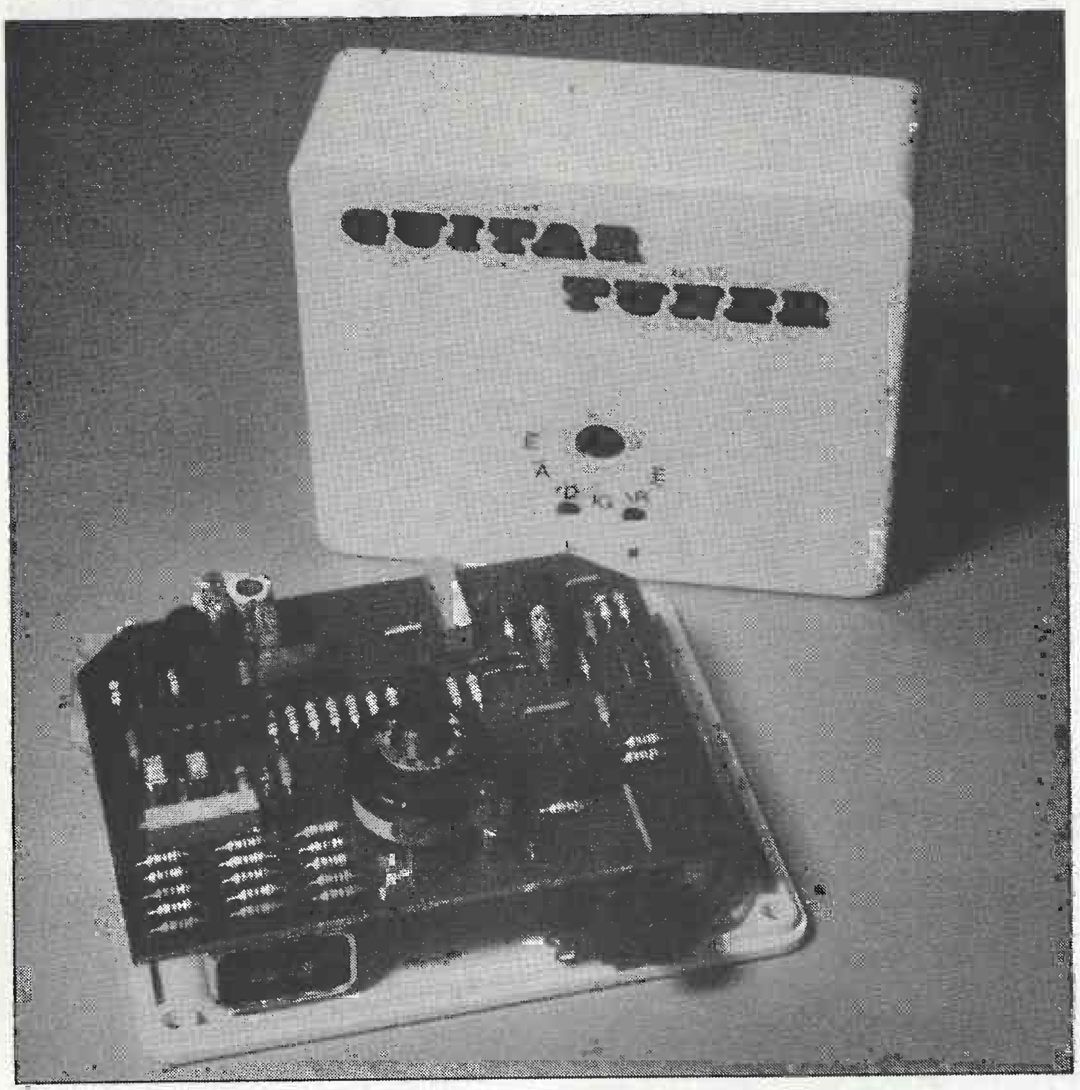
ETI

OOPS!



Last month's Fig. 4 had the stripboard track cuts reversed, upside down and generally wrong. The correct layout is shown here.

GUITAR TUNER



Laurie Barron keeps in tune with a guitar tuner that actually works with guitars

As a guitarist and bass player I have always considered that silent electronic guitar tuners, giving a visual indication when a string is in tune are an asset to any player.

Apart from poor performances, the best way to get your audience really agitated is to make them suffer fifteen minutes or so of random twangs as the band 'tunes up' prior to the performance. Silent tuners eliminate completely this most unprofessional and annoying prelude to a performance.

In 1981 I was therefore keen to build my own tuner when a project for an inexpensive silent tuner appeared in one of the electronic hobbyists magazines. On completion of this project I tested it using a signal generator and frequency meter. The unit worked perfectly and I was impressed with its performance . . . for about three minutes.

When I tried to tune my guitar with it, the indicator LEDs jumped around so much that I assumed I had read the project title incorrectly and it was in fact a random lighting display.

To date I have built about half a dozen tuners published in various electronics hobbyists magazines — all bar one with the same result — they work fine with the almost pure sinusoids or square waves of a signal generator but are completely useless for tuning guitar strings.

The only one that did operate correctly used an expensive 'top octave generator' IC, moving coil panel meter and two PP3 batteries. The cost of that project made a strong case for buying a commercially manufactured tuner.

My guess is that all of the designers of these projects suffered from the same handicap — they

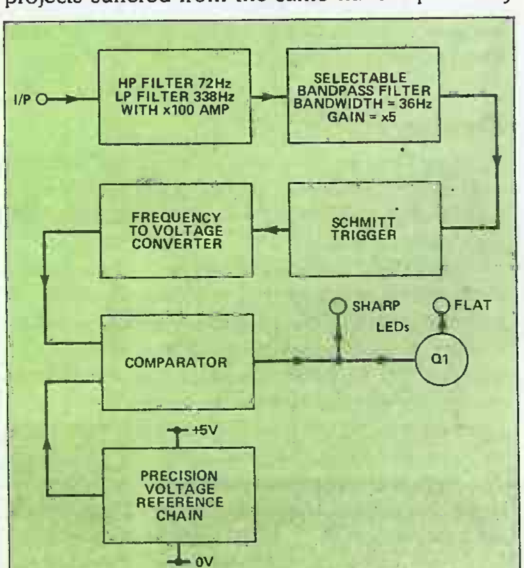


Fig. 1 Block diagram of the guitar tuner

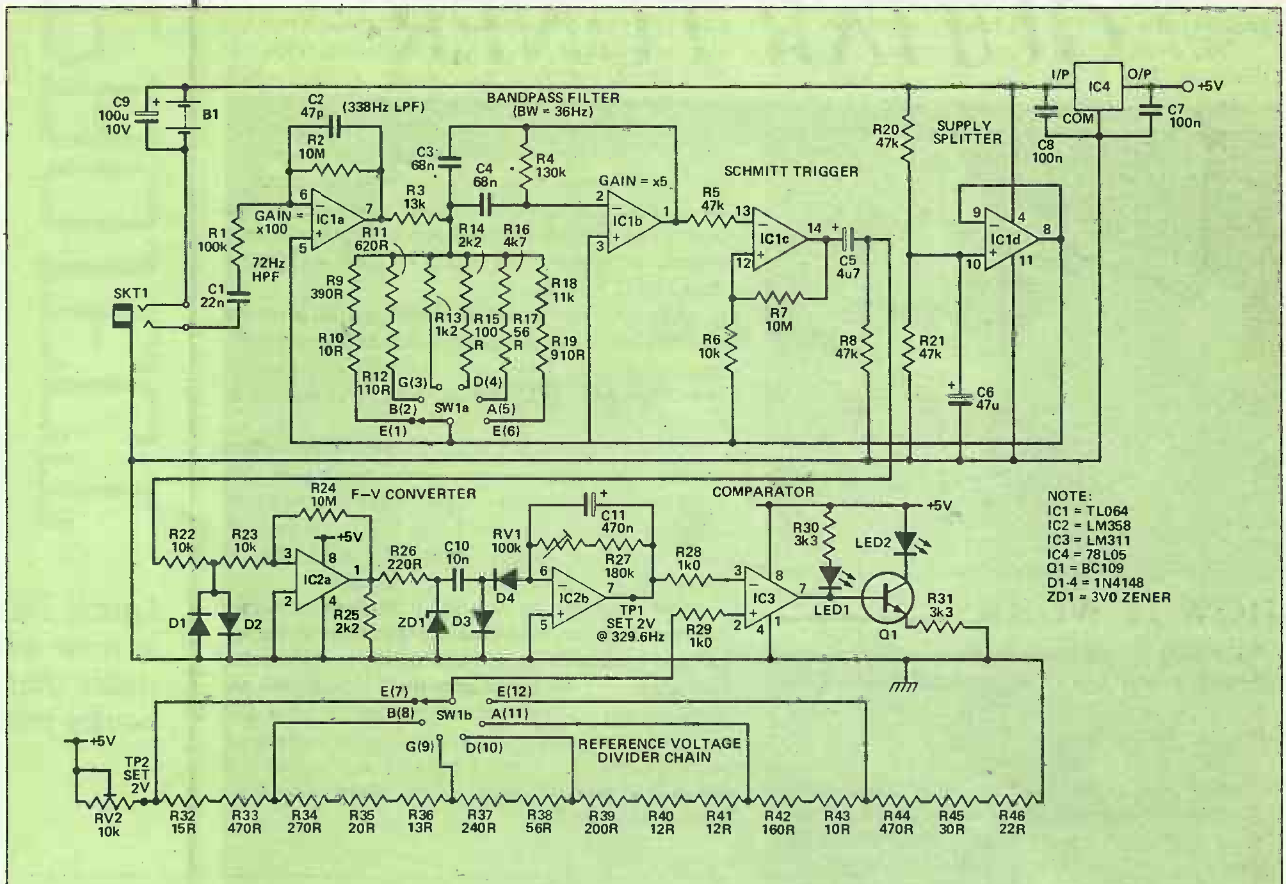


Fig. 2 The circuit diagram of the guitar tuner

were not guitarists and therefore did not possess guitars. In consequence of this, they all produced designs which responded correctly to waveforms that were almost pure but did not realise the output from a guitar is rich in harmonics and that these harmonics must be eliminated, leaving only the fundamental frequency before being compared with reference frequencies or voltages.

Guitar			Bass		
Tone	Frequency	Volts	Tone	Frequency	Volts
E	329.628	2.000	G	97.9989	2.000
B	246.942	1.515	D	73.4162	1.510
G	195.998	1.212	A	55.0000	1.137
D	146.832	0.916	E	41.2034	0.854
A	110.000	0.692			
E	82.4069	0.522			

Table 1 Tones, frequencies and outputs of F-V converter

Design Approach

The way I have approached this design is to look back over these failed designs, extracting the best ideas and adding efficient filtering to the input signal to effectively eliminate the unwanted harmonics.

The result is a tuner that uses a comparison of the output from a frequency to voltage converter with reference voltages derived from a precision voltage divider chain. The recent availability of cheap 1% resistors (3p each) from suppliers such as Maplin makes this an extremely economic approach which has produced a guitar tuner that costs less than £9,000 to build (excluding PCB and case).

Referring to the block diagram of Fig. 1, the guitar signal first passes through a high pass filter with a cut off frequency of 72.34Hz to remove mains hum.

Next follows a combined x100 amplifier and 338Hz low pass filter. From Table 1 it can be seen that the highest frequency required is about 330Hz so it makes sense to first remove all frequencies above that value. Because of the very high gain, the output from this stage is clipped, but this causes no problems in this circuit as the final waveform required is a square wave anyway.

The next stage is the switchable bandpass filter. This is probably the most important part of the tuner, (the one the others leave out!). It has a bandwidth of 36Hz and provides a signal gain of x5. The purpose of this stage is to effectively eliminate all frequencies not within 18Hz either side of the frequency of the note to be tuned. The output from this stage is a crude square wave of the fundamental frequency only.

The fundamental frequency now passes to a Schmitt Trigger stage. This gives a clean square wave at the fundamental frequency. The components selected for this stage ensure that its output amplitude and frequency will remain constant for several seconds, almost until the string ceases to vibrate, the amplitude of the input signal can decay to about 10μV before correct operation ceases and the string must be struck again.

The next stage is the heart of the unit. It is actually an adaption of Paul Chappell's *Frequency Meter Module* design, (ETI April 1986). This configuration provides the frequency to voltage converter block (F-V converter). Some component values are changed from the original design for use in this application but the principle remains the same.

The output does not exactly follow Mr Chappell's 'rule of thumb' formula, although if voltage/frequency is plotted from the values given in Fig. 2 it will be seen the relationship between voltage and frequency is still linear.

The purpose of this stage is to convert the filtered fundamental frequency of each string into a voltage level and then to pass this voltage level to one input of a standard LM311 comparator. The other comparator input is fed into a selected reference voltage, derived from a voltage divider chain, consisting of a series of 1% tolerance resistors.

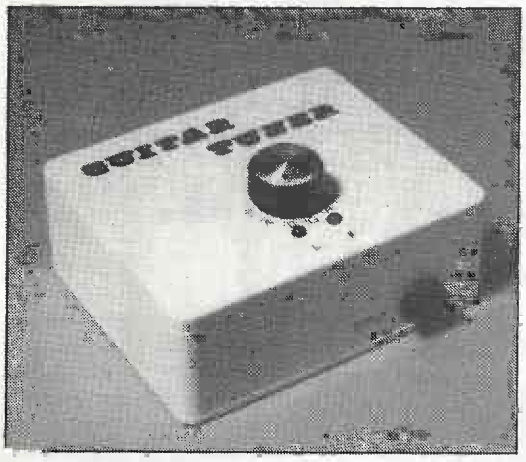
The divider chain is simply worked out using Ohm's law. The divider chain was calculated for a current of 1mA, this value helps to keep the power consumption of the unit low and also makes for extremely easy calculation of the divider chain as the value of resistance between each reference point and 0V is simply the F-V output voltage × 1000 which gives the required resistance in ohms.

The comparator stage simply compares the voltage level from the F-V converter stage with the selected reference voltage from the divider chain. If the F-V output is higher than the reference voltage (the note is 'sharp') then the comparator output will swing towards its negative supply rail (0V). This will light the 'sharp' LED indicator.

On the other hand if the voltage level from the F-V converter is lower than the reference voltage (the note is 'flat') then the comparator will swing towards its positive rail (5V). This supplies base current to transistor Q1, lighting the 'flat' LED.

When both the reference voltage and the output voltage from the F-V converter are equal, the comparator output will be at half of its high level, thus only allowing partial conduction of Q1 and hence both LEDs will now be equally illuminated, indicating that the string in 'in tune'.

For those of you who like to analyse each part of a circuit, so that individual blocks can be extracted for use in future designs, the diagrams and formulae for each part of the circuit up to the F-V converter are given in Fig. 3. Further information on the F-V converter part of the circuit can be found by reference to Paul Chappell's *Capacitance Meter Module* and *Frequency Meter Module*, in the March and April 1986 issues of ETI.



HOW IT WORKS

The low level guitar signal, which is rich in harmonics passes through the simple high pass filter of R1 and C1 with cut off frequency 72.4Hz and then the low pass active filter network of IC1a and associated components (cut off frequency 338.63Hz).

This combination from the tuner's input to the output of IC1a effectively gives us a simple bandpass filter of centre frequency 205.49Hz and a bandwidth of 266.3Hz. The low pass filter attenuates the unwanted frequencies above the top open string of the guitar and the high pass filter helps eliminate any mains hum pick up.

Frequencies within these passbands are amplified by a factor of ×100 which boosts the input signal to a usable value, which can be measured well into the decay time.

The amplified signal then passes through IC1b and associated components which constitute a selectable, narrow, bandpass filter of bandwidth 36Hz. This configuration effectively removes all of the unwanted harmonics, leaving only the fundamental frequency.

From the bandpass filter the signal passes through IC1c which with its associated componenets is configured as a Schmitt trigger. This serves the purpose of squaring up the signal fed to the frequency to voltage part of the circuit. The components for the Schmitt trigger are selected for very low upper and lower trigger points to activate the trigger almost until the string ceases to vibrate altogether.

IC1d and associated components act to split the single 9V supply into a dual 4.5V supply required for use by IC1.

From the Schmitt trigger the signal passes to IC2a,b and associated components, configured as a frequency to voltage converter circuit. This circuit is really an adaption of the 'Frequency Meter Module' published in ETI April 1986 and the reader is referred to this text for a detailed explanation of its operation.

At the bottom of the circuit diagram is the reference voltage divider chain of RV2 and R32-46. The value of each block of 1% resistors has been chosen to give a voltage division equal to the intervals between the notes of the open guitar strings after frequency to voltage conversion. TP1 is initially set up to 2.000V with RV2. This sets up the reference voltages which will remain accurate until the battery voltage falls to below 7V.

The outputs of the frequency to voltage converter circuit and the reference voltage divider chain are fed to the two inputs of comparator IC3 via resistors R28 and R29. This IC performs a comparison between the output of the V-F converter circuit and the selected output of the reference voltage divider chain.

If the note is flat, then the output of the comparator will be high, allowing Q1 to conduct, switching on LED2 fully and extinguishing LED1. If the note is sharp, the output of the comparator will be low and LED1 will be switched on and LED2 extinguished. When the note produces a voltage equal to the reference voltage divider chains selected voltage, the comparators output will be half of its high level, thus allowing only partial conduction of Q1 and hence LED1 and LED2 will be equally illuminated.

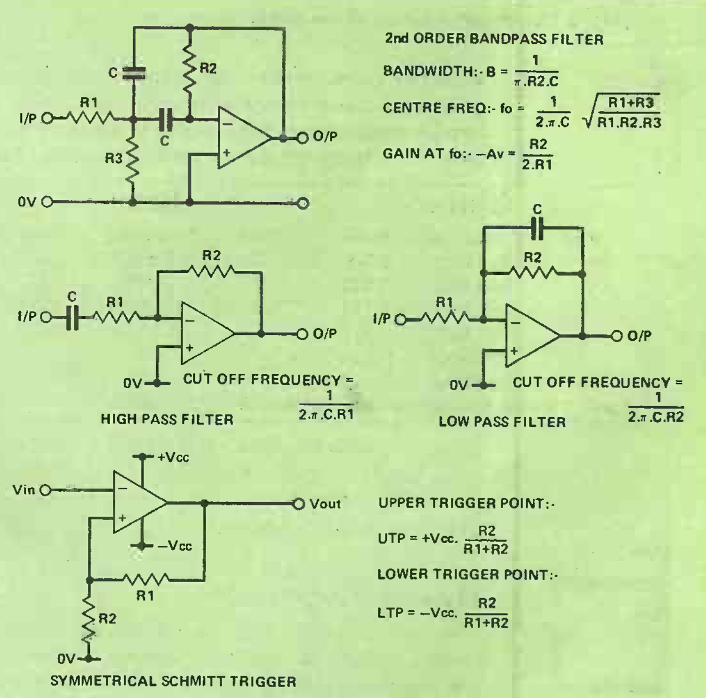


Fig. 3 Circuit diagrams and formulae for sections of the tuner

Construction

Although 1% resistors are used in the critical positions (and ideally for the entire assembly) even this degree of accuracy can cause problems with some of the larger resistors in the divider chain. In the worst case, resistors R33 and R44 (470R) could vary from their marked value by as much as 4R7 each. This variation would affect the accuracy of the tuner and I would recommend that all of the resistors of 200R or over in the divider chain (R33,34,37,39,44) are selected

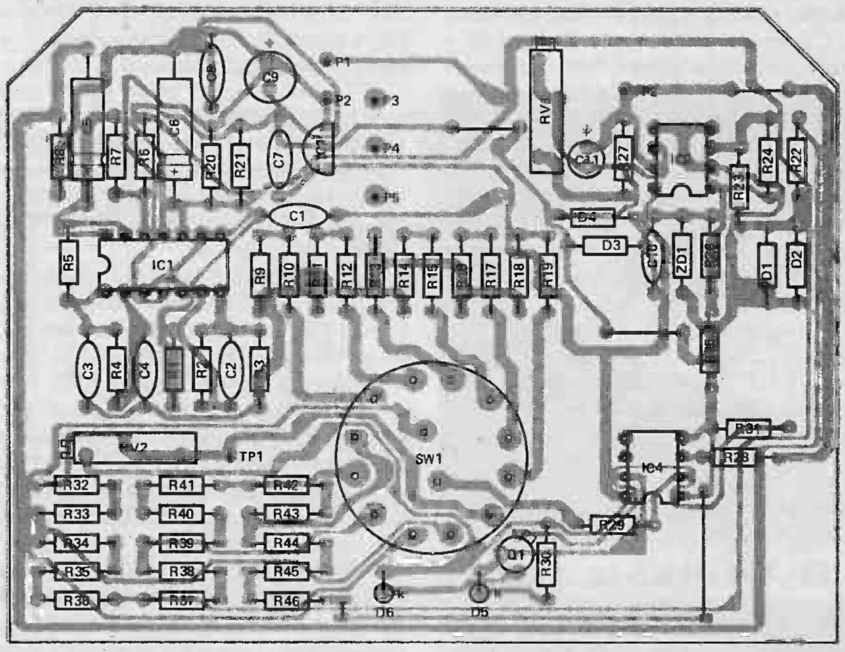


Fig. 4 The component overlay for the guitar tuner PCB

PARTS LIST

RESISTORS (¼W 5% except where specified)		R44	470R 1%
R1	100k	R45	30R 1%
R2,7,24	10M	R46	22R 1%
R3	13k 1%	RV1	100k 18-turn cermet preset
R4	130k 1%	RV2	10k 18-turn cermet preset
R9	390R 1%		
R10,43	10R 1%	**CAPACITORS**	
R11	620R 1%	C1	22n polyester
R12	110R 1%	C2	47p polystyrene
R13	1k2 1%	C3,4	68n 5% polycarbonate
R14,25	2k2 1%	C5	4µ7 10V axial electrolytic
R15	100R 1%	C6	47µ 16V axial electrolytic
R16	4k7 1%	C7,8	100n polyester
R17	56R 1%	C9	100µ 10V radial electrolytic
R18	11k 1%	C10	10n 5% polyester
R19	910R 1%	C11	470n tantalum
R23	10k		
R26	220R	**SEMICONDUCTORS**	
R27	180k	IC1	TL064
R28,29	1k0 1%	IC2	LM358
R30	3k3 1%	IC3	LM311
R31	3k3 1%	IC4	78L05
R32	15R 1%	Q1	BC109
R33	470R 1%	ZD1	3V 500mW zener
R34	270R 1%	D1-4	1N4148
R35	20R 1%	LED1,2	red LED
R36	13R 1%		
R37	240R 1%	**MISCELLANEOUS**	
R38	56R 1%	B1	9V PP3 battery
R39	200R 1%	SK1	stereo ¼in jack socket
R40,41	12R 1%	SW1	2 pole 6 way rotary switch
R42	160R 1%	PCB. MB3 case. Battery clip. Connecting wire.	

with an accurate digital multimeter or some other accurate device for measuring resistance, to select the values closest to those specified. The easiest way of achieving this is to order a pack of ten of each value from Maplins and select the best from each pack for each value.

The component overlay is shown in Fig. 4. Fit the wire links first, followed by the resistors, off-board connector pins, IC sockets, capacitors, presets, the rotary switch and last the semiconductors. Do not fit the LEDs at this stage.

The 14 PCB holes for the rotary switch must be drilled slightly larger (1.2mm) than those in the rest of the board. The pins of the rotary switch must have each eyelet cut off as close to the eyelet as possible, to allow the switch to be fitted to the board.

The next task is to drill the holes in the case for the rotary switch, LEDs and jack socket in accordance with the positions shown in Fig. 5. If you are not using the MB3 type box, pay special attention to the relative positions of the holes for the LEDs and the rotary switch.

Fit (but don't solder) the two LEDs to the PCB, ensuring that the anodes and cathodes are in the positions shown in Fig. 4. Remove the nut from the rotary switch and holding the PCB with the rotary switch uppermost, fit the rotary switch and PCB to the case. Fit the switch nut and tighten to finger tightness. Square the PCB to the case. Now push the LEDs into their respective holes in the case so that their entire dome areas are just proud of the case. Now solder the leads of the LEDs to the PCB, ensuring that their position does not move during this operation.

Fit the jack socket to the case and connect it. Screened cable is not necessary for this application. The battery connector wires should also be fitted to the PCB at this stage.

Calibration

This operation is carried out with the PCB assembly out of the case. To calibrate the tuner connect a 9V battery to the battery connector and insert a mono jack plug into the jack socket. Connect an accurate voltmeter between TP2 and 0V and adjust RV2 until a reading of exactly 2V is obtained.

Now connect a square or sine wave signal with a frequency of exactly 329.628Hz and an amplitude of between 20mV and 5V to the input of the unit. Turn the rotary switch fully anticlockwise. An accurate voltmeter is now connected between TP1 and 0V and RV1 is adjusted until a reading of exactly 2V is obtained. The tuner is now fully calibrated.

If you are not fortunate enough to possess a signal generator and frequency meter then simply connect an accurately tuned guitar or keyboard to the input of the tuner, strike the open top E string or play keyboard E of 329.628Hz, allow a half a second for the frequency of the string to stabilise and adjust RV1 until a reading of 2V is obtained with the voltmeter connected between TP1 and 0V.

The reading will remain constant for several seconds but the string may have to be struck several times with this method until the potentiometer adjustment reaches 2V.

The unit can now be replaced in its case and the respective switch positions of E, A, D, G, B, E, (eat all day great big eggs) in an clockwise direction marked around the switch.

Using The Tuner

Power is applied to tuner by simply inserting the guitar jackplug into the socket.

Select the required note on the switch and strike the appropriate string, after a short period the LEDs will stop jumping and an indication of whether the string is sharp or flat will be given by the LED that remains illuminated. It is always best to tune from flat upwards, so if the string is sharp, loosen it, strike the string again and turn the appropriate machine head of the guitar until both LEDs are equally illuminated. The string is now 'in tune'.

After very little experience with this unit you will find the tuning of each string can be achieved with only striking the string once and then adjusting the machine head.

The current consumption of the tuner is less than 12mA, and power is only applied to the unit when the guitar jack plug is actually inserted into the tuners socket. As the tuner is only used for the few minutes required to tune a guitar, a standard 9V PP3 type battery should last for many months. The tuner will remain accurate until the battery voltage falls below 7V.

Bass Players

If you're not a budding Eric Clapton but you are a potential Jack Bruce, don't despair, you haven't been forgotten. The same PCB can also be used to make a bass guitar tuner.

Simply substitute the component values and links as shown below for those in the main component list and omit components as indicated.

In addition, use a frequency of 97.9989Hz when adjusting RV1 or the top G string (or a G of 97.9989Hz on the keyboard).

The switch positions should be labelled E, A, D, G.

BASS PARTS

RESISTORS (all [illegible])	
R9	[illegible]
R10,36,41,44	[illegible]
R11	[illegible]
R12	[illegible]
R13	[illegible]
R14	[illegible]
R15	[illegible]
R16-19	[illegible]
R21	[illegible]
R32	20R
R34	330R
R35	[illegible]
R37	270R
R38	[illegible]
R39	820R
R40	[illegible]
R41	[illegible]
CAPACITORS	
C1	47n polyester
C2	150p polystyrene
C3,4	100n 1% polycarbonate

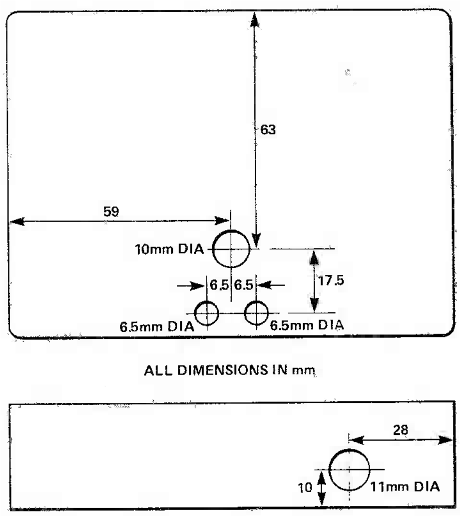


Fig. 5 Case drilling details

BUYLINES

All components can be obtained from Maplin or indeed many other suppliers. The PCB is available from the ETI PCB Service.

PROJECT

ETI

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BENCH POWER SUPPLY

Paul Chappell builds the essential item for any workbench

On any list of equipment needed to set up an electronics workshop, pretty close to the top will come an adjustable power supply. At a pinch you can struggle along by stringing batteries together or birdsnesting a few components onto a mains transformer but for sheer convenience there's nothing to beat a supply that gives just the voltage you need at the twist of a knob.

An important feature of any bench power supply is the current limiting. Most regulator ICs have on board short-circuit protection, which is fine for preventing the supply from going up in smoke but not always very useful for protecting the circuit under test. An adjustable current limiter which shuts down the supply if the project takes more current than you expect can save a lot of frustration and expense in replacing burnt components.

Current Limiter

The shutdown circuit of this supply goes a stage further than usual. Besides functioning as a normal supply current limiter, it can also monitor the current in any part of the circuit under test and will respond to excessive currents in either direction or to peak alternating currents at any point you choose.

The output of the limiter is not specific to the power supply in this project — it can be used to give almost complete shutdown of most variable regulators, to operate a crowbar circuit or simply to give a warning of over-current while leaving the action up to you.

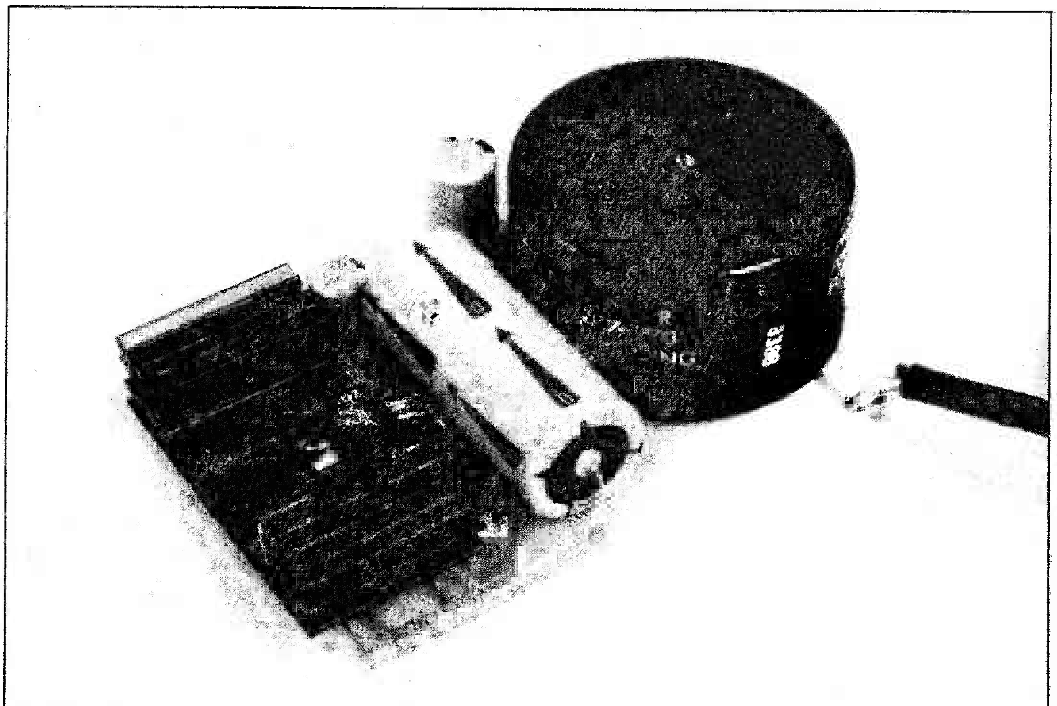
The circuit is shown in Fig.1. The front end might remind you of the first stage of a three amplifier instrumentation amp, which is not surprising since it's doing much the same job. The idea is to detect any difference in voltage between the two input terminals, at the same time allowing the common mode voltage to be anywhere within the test circuit's supply voltage range.

An NE5532 is specified as the IC for the job — it will track AC currents well and turns in a fairly respectable input offset voltage figure (in comparison with cheap and cheerful op-amps, anyway) and is easy to obtain and doesn't cost much. If you don't mind spending a pound or two extra, the PMI OP200 can be substituted, although you'll have to change one or two component values to take full advantage of its characteristics. I'll explain later.

After the difference amplifier comes a comparator, set to trigger when the outputs of IC1a and IC1b differ by more than 1.2V in either direction. Transistors Q1-4 form a pair of current sources to make the circuit's operation as independent as possible of supply voltage changes or ripple and of common mode voltage. It's a technique widely used in the internal circuits of op-amps and the like, adapted here to work with discrete components.

A factor to be considered when designing any kind of test equipment is how it will affect the circuit being tested. Whenever you connect up a meter to measure voltage, for instance, it will draw some current from the circuit and thereby alter the very voltage you're trying to measure. Testing for current always puts some resistance into the current path and so changes the current.

In test equipment there are two common approaches. The first is to standardise the effects in some way: voltage measurements, for example, are often specified as being measured with a standard 20k per volt test meter on a certain range, the idea being that if you set your own meter to the same range it should cause exactly the same amount of disturbance



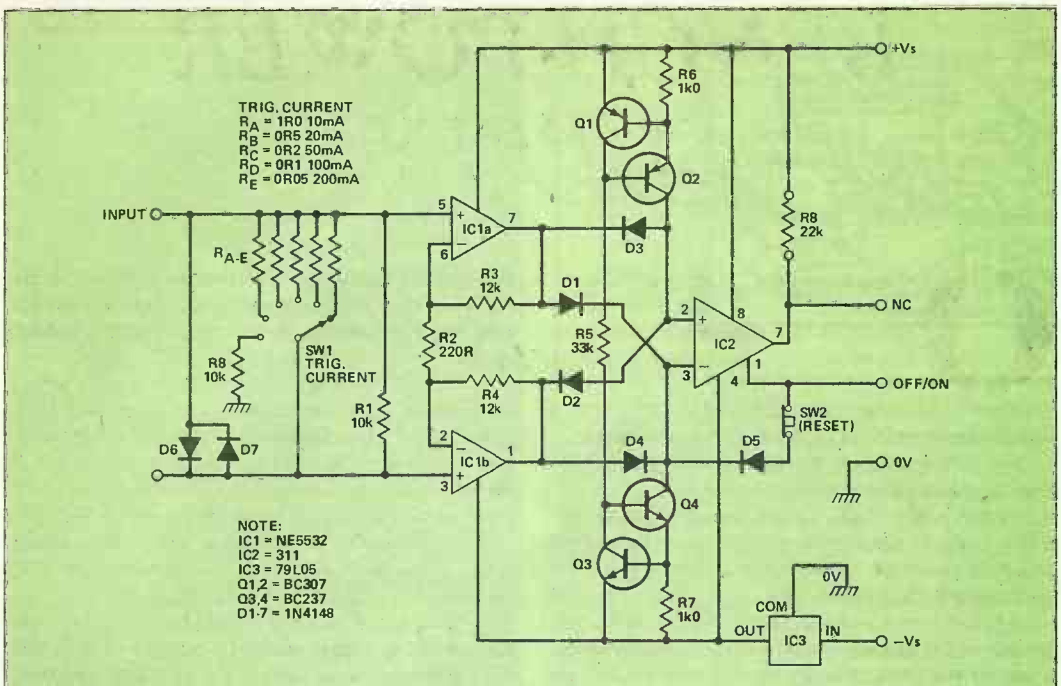


Fig.1 Circuit of the current trip

and so come up with the same readings. Oscilloscopes almost always impose a loading of 1M in parallel with 5p, so the trace seen on one band should look much the same as the trace on any other.

The other possibility is to aim for minimum disturbance: to give voltmeters the highest practical input resistance and ammeters the lowest practical resistance. The circuit of the current trip involves sensing the voltage developed across a resistor inserted in the current path — the lower the value of resistor, the less it will disturb the current.

The main factor determining how small the necessary voltage drop (and so how small the resistor can be made) is the input offset voltage of IC1. The offset voltages of the two halves of IC1 appear across R2, as does the differential voltage we want the circuit to respond to, so the basic rule is that the voltage developed across the input resistor must be large in comparison with twice the rated maximum offset voltage of the IC.

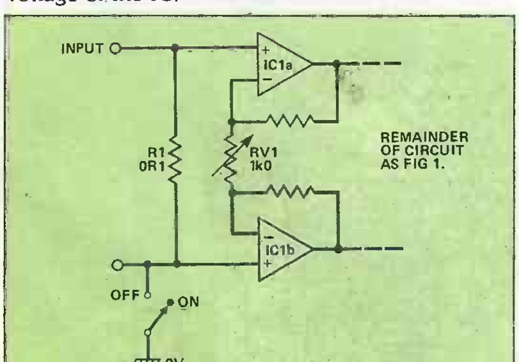


Fig.2 An alternative means of adjusting the sensitivity

For the NE5532, the input voltage required to trigger the circuit is set (with the component values in Fig.1) at 10mV, giving the input resistances shown. With the OP200, which is ten times better than the NE5532 in this respect, you can divide the value of R_A to R_E by ten, replace R2 with a 20R resistor, and you've got a circuit which presents a much lower resistance to the current. This is at the expense of high frequency gain, however, so if you intend to use the circuit to monitor rapidly varying currents, the NE5532 might be the better option after all. The choice is yours!

At the risk of losing all those who just want to be told how to build fings, there's another way to arrange the current setting of the circuit, shown in Fig.2. Here R2 is replaced by a 1k0 pot, RV1, which makes the trip current continuously variable from zero to about 500mA (for higher trip currents, increase the pot resistance: 2k0 for 1A, and so on).

Power Supply

The circuit of the power supply itself is shown in Fig.3. There's not a lot worth commenting on here: it's a transformer, rectifier, smoother and variable regulator, and that's that. The specified IC is one of the low dropout voltage variety — in this circuit it simply means that it will cope with a little more ripple on the smoothing cap than usual. It also has an on/off terminal which suits this project down to the ground.

If you just want a power supply without the trimmings, the circuit of Fig.3 will work perfectly well as it stands.

Construction

The construction shouldn't present any problems. For the supply I used a toroidal transformer which mounts directly onto the PCB (Fig.4) — it's neater than having a separate chassis mounting transformer with dangling

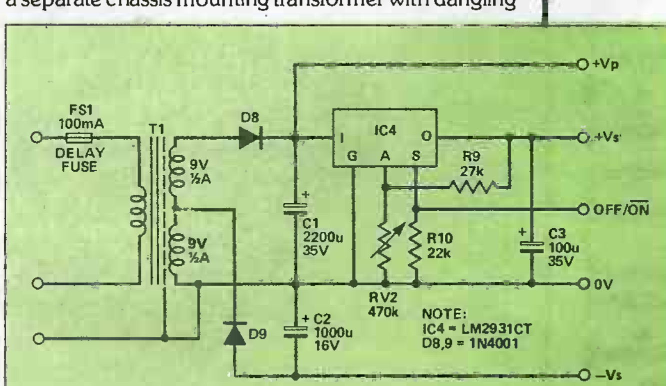


Fig.3 The main power supply and regulator

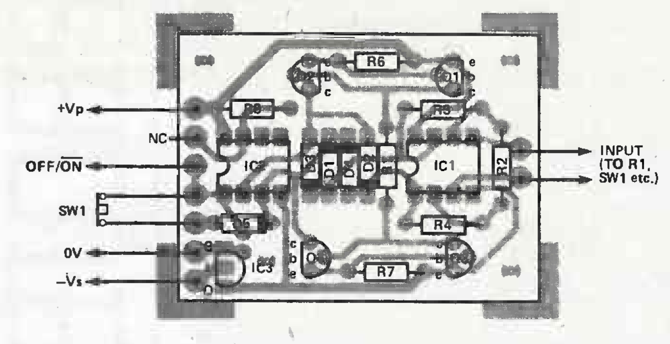


Fig.4a Component overlay for the current sense board

PARTS LIST

RESISTORS	
R1	10k
R2	200R
R3,4	12k
R5	33k
R6,7	1k0
R8,10	22k
R9	27k
R_{A-E}	See text
RV1	1k0 lin. (see text)
RV2	470k lin.
CAPACITORS	
C1	2200µV 35V
C2	1000µV 16V
C3	100µV 35V
SEMICONDUCTORS	
IC1	NE5532 (or OP200 – see text)
IC2	311
IC3	79L05
IC4	LM2931CT
Q1,2	BC307
Q3,4	BC307
D1-7	1N4148
D8,9	1N4001
MISCELLANEOUS	
FS1	100mA delay fuse
SW1	6-way rotary switch
SW2	push to break
T1	0-9 0-9 10VA mains transformer

PCBs. Fuseholder. 0-30V meter if required. Mains switch. Strain relief bush. Wire. Nuts and bolts.

wires and means the project will fit in a small case — no need for the supply to take up half the bench space! One thing I would recommend doing is to bolt the transformer to the PCB — it can be supported just by its pins but you soon discover the weakness of this method if you ever drop the supply or treat it with anything but the greatest care.

One thing I should point out is this: the transformer specified has an inter-winding screen, which means that one of the input-side pins is connected to mains earth. If you use another make of transformer, test it first to be certain that the connections run the same way. Bangs, flashes and fire can be great fun on November 5th but have no place in the lab.

The smoothing electrolytic C1 should be mounted last of all, since some of the other components stand in its shadow. Be sure that the metal sole of IC4 is flat against the heatsink — there's no need to insulate it but a little smear of heatsink compound to improve thermal contact will help it run cool. The best order of assembly is to bend the IC leads and post them through the holes, bolt the IC and heatsink to the PCB and then finally solder the IC leads.

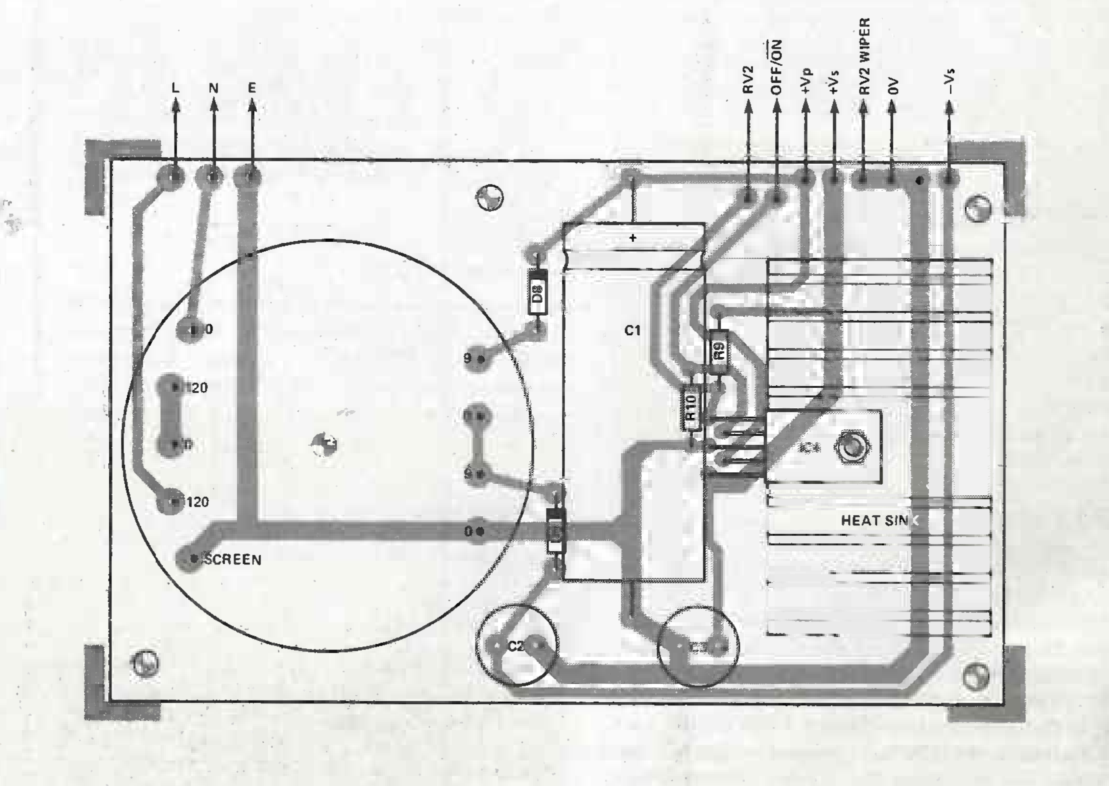


Fig.4b Component overlay for the power supply board

I haven't specified any particular case for the project — buy whichever one you like the look of. If you use a metal one, be sure to earth the case itself. Whatever the case material, make sure it's well ventilated. If there's no flow of cool air around the heatsink it will just get hotter and hotter until something melts — a consummation devoutly to be avoided if you want my opinion.

Figure 5 shows the interconnection between the boards and other off-board components but there's no need to follow the layout of switches and terminals — put them where they look best to you.

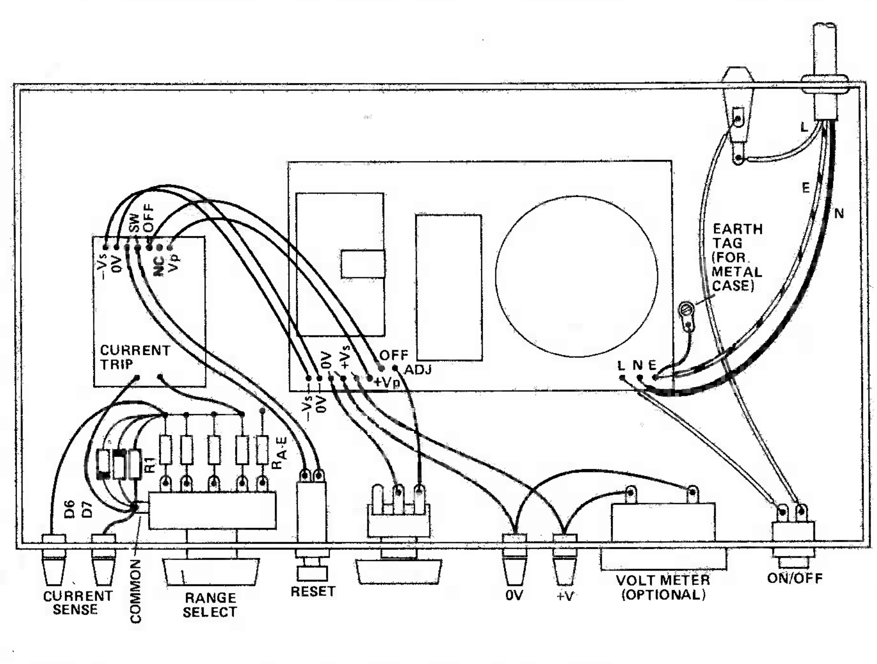
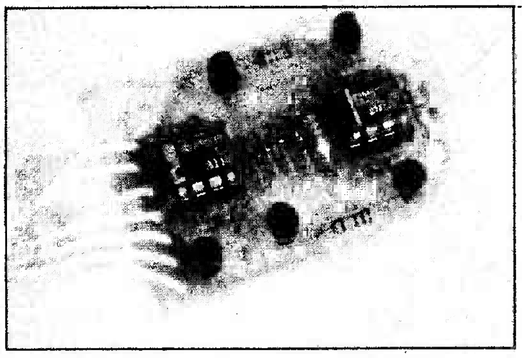


Fig.5 Interconnections between boards and layout of controls

Testing

If you turn the supply on, turn the adjustment pot and the voltage varies from about 2V up to 24V, there's a good chance that everything's OK. If it doesn't, you've made a boob. Now try the supply under load. Set the output to 3V, connect a 22R 1W resistor across the terminals, check that the output is still 3V, then let it run for a few minutes. Disconnect the mains supply and check that the regulator tab and heatsink are not getting too hot. If all is well so far, connect a 180R 5W resistor across the terminals and turn up the voltage to 24V. If you've got a scope, check that there's no 50Hz ripple on the supply. Now you can reasonably assume that all is well.



To check out the shutdown, use the circuit of Fig.6. Reducing the resistance of the pot should result in the circuit tripping at about 100mA. If too high, increase the value of R2. If it trips too early, reduce the value of R2. If everything is OK, leave R2 exactly as it is! If you increase the resistance of the test pot and press the reset button, the supply should be restored.

Tweaking

If you have problems with oscillation at the output of regulator IC3, a 4μ7 tantalum between output and 0V will settle it down. Try to keep the connections between the V_p terminals of the two boards fairly short. Oscillation at the output of the main regulator means you've used a dud cap for C3 — one from the spares box is a bit risky since it's got to be of fairly good quality and close to the value specified. You'll soon know about it if the main regulator does oscillate — the results will be picked up by every radio in the house!

You will probably find that the regulator misbehaves a little at both extremes of voltage setting. At the low end, the set voltage will reach a minimum and then rise again. If you find this annoying, a small resisitor can be wired in series with RV2 so that the voltage reaches a minimum when the pot is at the end of its travel. You can find the value by trial and error, or by connecting a preset (1k0) in series with RV2 and adjusting it for minimum voltage with RV2 hard against the end stop in the low voltage position. Strictly speaking, the IC is only supposed to regulate down to 3V — you can persuade it to give lower voltages with poorer regulation (it won't affect the regulation of higher voltages).

At the top end you may find the same situation in reverse (depending on the actual value of the full track resistance of RV2). The cure this time is to connect a large resistor (try 2M2 for a start) across RV2 so that maximum travel exactly hits maximum voltage.

To use the current trip with other regulators without a shutdown facility, you can reduce the output to a very low voltage by connecting pin 1 of IC2 to ground and pin 7 to the adjust pin on the regulator. Once again, a small resistor in series with pin 7 will often be needed to give the absolute minimum output voltage. R8 should be omitted, pin 1 of IC2 linked to ground using the link position provided on the PCB and pin 7 linked to the regulator via the PCB terminal marked NC in Fig.4a. This will work with any regulator adusted by a pot between the adjust pin and ground, which accounts for almost every common type. The latch will no longer function in this mode, by the way, so you can exercise your brain cells a little in thinking of another way to do it!

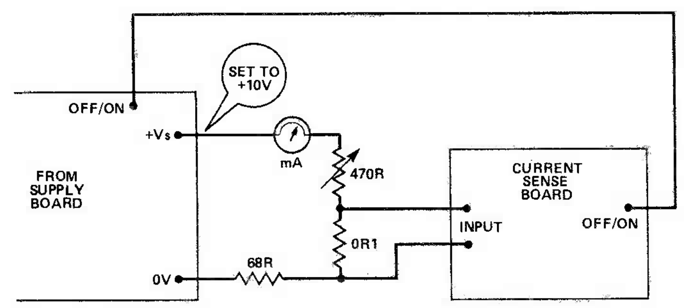


Fig.6 Current trip test circuit

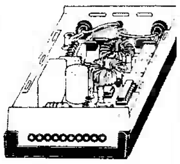
BUYLINES

[illegible] parts for this project are available from Electromail, except [illegible] PCBs which come from our PCB service. The transformer [illegible] 207-970, and costs around a tenner. If this is too exp[illegible] transformer can be substituted but be care[illegible]. Check that [illegible] voltage [illegible] goes not [illegible] and take [illegible] the text about the sc[illegible]

ETI

POWER CONDITIONER

FEATURED IN ETI
JANUARY 1988



The ultimate mains purifier intended mainly for lowering the noise floor and improving the analytical qualities of top-flight audio equipment.

The massive filter section contains thirteen capacitors and two current balanced inductors, together with a bank of six VDRs to remove every last trace of impulsive and RF interference. A ten LED logarithmic display gives a second by second indication of the amount of interference removed.

Our approved parts set consists of case, PCB, all components (including high permeability toroidal cores, ICs, transistors, class X and Y suppression capacitors, VDRs, etc.) and full instructions.

PARTS SET **£28.50** + VAT

A low cost (but high performance) mains conditioner is also available.
MAINS CONDITIONER PARTS SET £5.40 + VAT
RUGGED PLASTIC CASE £1.80 + VAT

KNIGHT RAIDER

FEATURED IN ETI JULY 1987

The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns. An LED display on the control box let's you see what the main lights are doing.

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The parts set consists of box, PCB and components for control, PCB and components for sequence board, and full instructions.
Lamps not included.

PARTS SET **£19.90** + VAT

RAINY DAY PROJECTS

All can be built in an afternoon!

JUMPIN' JACK FLASH (ETI March 1988)
Spectacular rock, stage and disco lighting effect! — £6.90 + VAT

CREDIT CARD CASINO (ETI March 1987)
The wicked pocket gambling machine — £5.90 + VAT

MAINS CONTROLLER (ETI January 1987)
Isolated logic to mains interface — £6.20 + VAT

MATCHBOX AMPLIFIERS (ETI April 1986)
Listen 50W of Hi-Fi power from an amp small enough to fit in a matchbox!

Matchbox Amplifier (20W)	£6.50 + VAT
Matchbox Bridge Amplifier (50w)	£8.90 + VAT
L165V Power Amplifier IC, with data and circuits	£3.90 + VAT

TACHO/DWELL METER (ETI January 1987)
Turn your Metro into a Porsche! — £16.40 + VAT

HI-FI POWER METER (ETI May 1987)
Measures Hi-Fi output power up to 100W – includes PCB, components, meters

Mono power meter	£3.90 + VAT
Stereo power meter	£7.20 + VAT

FEATURED IN ETI AUGUST 1988

There's nothing quite so encouraging as having a quantifiable result to show for your training efforts. If you are not particularly fit, your resting heart rate will be around 80 beats per minute. As your jogging, aerobics or sport strengthens your heart, the rate will drop dramatically – possibly to 60bpm or less. With the S101 you can watch your progress day by day.

Breathing is important too. How efficiently do you take up oxygen? How quickly do you recover from oxygen debt after strenuous activity? The S101 will let you know.

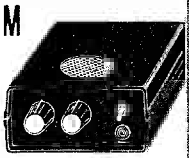
The approved parts set consists of case, 3 printed circuit boards, all components (including 17 ICs, quartz crystal, 75 transistors, resistors, diodes and capacitors), LCD, switches, plugs, sockets, electrodes and full instructions for construction and use.

PARTS SET **£33.80** + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £2 for lists, circuit, construction details and training info (free with parts set).

THE DREAM MACHINE

FEATURED IN ETI
DECEMBER 1987



Adjust the controls to suit your mood and let the gentle, relaxing sound drift over you. At first you might hear soft rain, sea surf, or the wind through distant trees. Almost hypnotic, the sound draws you irresistably into a peaceful, refreshing sleep.

For many, the thought of waking refreshed and alert from perhaps the first truly restful sleep in years is exciting enough in itself. For more adventurous souls there are strange and mysterious dream experiences waiting. Take lucid dreams, for instance. Imagine being in control of your dreams and able to change them at will to act out your wishes and fantasies. With the Dream Machine it's easy!

The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions.

PARTS SET **£16.50** + VAT

Ben Sweetland's best seller GROW RICH WHILE YOU SLEEP is now in stock. **£2.95** (NO VAT)

THE MISTRAL AIR IONISER

The best ioniser design yet - this one has variable ion drive, built-in ion counter and enough power to drive five multi-point emitters. For the technically minded, it has nine main drive stages, five secondary drives, and a four section booster to give an output capability of almost fifteen billion (1.47×10^{13}) ions every minute, or 2.45×10^{11} ions per second. With extra emitters this can be increased still further!

PARTS SET £24.80 + VAT

The parts set includes case, printed circuit boards, 126 top grade components, all controls, lamps, hardware, a multi-point phospher-bronze emitter and full instructions.

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit and construction details and further information (free with parts set).

READY-BUILT MISTRAL

The Mistral Ioniser (and most of our other projects) can now be supplied built, tested and ready to go. For details, please contact *Peter Leah at P.L. Electronics, 8 Woburn Road, Eastville, Bristol BS5 6TT. Tel: 0272 522703.* Evenings Only

INTERNAL EMITTER £2.69 + VAT

Can be used in place of the P-B external emitter, or both can be used together for the highest ion output. Parts set includes PCB, ion emitters, components and instructions.

IPA BOARD CLEANER £0.98 + VAT

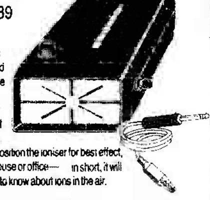
Essential for removing grease and flux residues from the Mistral PCB to achieve peak performance. Applicator brush supplied.

ION FAN £9.80 + VAT

An almost silent piezo-electric fan, mains operated, to pump ions away from the emitter and into the room. Increases the effectiveness of any ioniser by five times!

ION DISPERSION METER

FEATURED IN ETI
FEBRUARY 1989



The Q-ion is a hand-held meter which sniffs out ions in the air. It can tell the good ones from the duds if you're thinking of buying a commercial ioniser, check the efficiency and output of one you've made yourself, help you set up fans and position the ioniser for best effect, do an ion-survey of your house or office — in short, it will tell you anything you want to know about ions in the air.

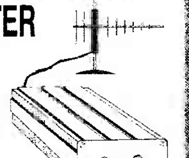
In direct mode the bar-graph readout will detect the presence of negative or positive ions and measure neg-ion strengths from 5×10^7 to 10^{10} ions per second, which covers the levels you can expect when an air ioniser is in use. For the smaller concentrations of natural air ions, integrate mode will increase the sensitivity as far as you like.

Our approved parts set comprises: case, ion collector, printed circuit board, all components (including six ICs, schottky diode, cermets, VDR, zener, 37 resistors and capacitors, LEDs, plug, socket, earth lead, etc.) and full instructions.

PARTS SET **£16.40** + VAT

Some parts are available separately — please send SAE for lists, or SAE + £1 for lists, circuit, construction details and further information (free with parts set).

TV BOOSTER



Good TV pictures from poor aerials is what this project is all about. Keith Brindley's Aerial Booster gives a **massive 23dB** gain to ensure good viewing for campers and caravanners, from indoor aerials, or wherever a properly positioned high-gain antenna is not practical.

Based on the OM335 hybrid amplifier, the booster has specifications to rival the best: wideband operation from 10MHz to 1.4 GHz, mid-band gain of up to 26dB and a wide supply range of 9V to 26V (it will run from car batteries for caravanners, dry batteries for campers, or a mains 'battery eliminator' in the home). No special UHF construction skills are needed — the project could be made by a careful beginner.

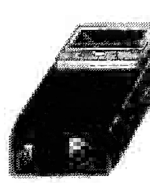
There are two parts sets for the project. AA1 contains the printed circuit board, OM335 hybrid amplifier, components and instructions. AA2 is the optional case set: rugged screened box, front and rear panels, waterproofing gaskets, feet, sockets and hardware.

AA1 PARTS SET **£12.80** + VAT

AA2 PARTS SET **£4.80** + VAT

BIO-FEEDBACK

FEATURED IN ETI
DECEMBER 1986



Bio-feedback comes of age with this highly responsive, self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

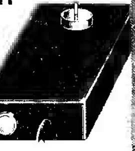
The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

PARTS SET **£15.80** + VAT
BIO-FEEDBACK BOOK **£4.50** (no VAT)

Please note, the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book, and will only be of interest to intelligent adults.

POWERFUL AIR IONISER

FEATURED IN ETI
JULY 1986



Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build . . . and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead, and even the parts for the tester. According to one customer, the set costs 'about a third of the price of the individual components'. What more can we say?

Instructions are included

PARTS SET WITH BLACK CASE **£11.50** + VAT
PARTS SET WITH WHITE CASE **£11.80** + VAT

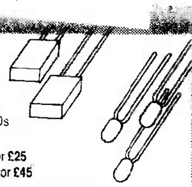
BURGLAR BUSTER

Be safe from intruders with our Burglar Buster alarm system! It has all the features you'd expect from a high-tech alarm: entry and exit delay, anti-tamper loop, delay warning and control-box protection.

The parts set includes *all four* PCBs and all components to go on them. Other parts (case, switches, etc.) are available separately, if you haven't got anything suitable in your spares box. Set contains 4 PCBs, ICs, transistors, relays, capacitors, resistors, diodes, regulator, piezo sounder and full instructions.

BB1 PARTS SET **£12.80** + VAT

LEDs

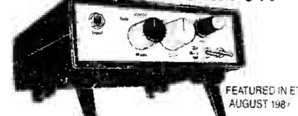


Green rectangular LEDs for bar-graph displays.

50 for £3.50	500 for £25
100 for £6	1000 for £45

DIGITAL AND AUDIO EQUIPMENT LEDs
Assorted 3mm LEDs: red, green, yellow and orange.
25 of each (100 LEDs) for **£6.80**

BRAINWAVE MONITOR



FEATURED IN ETI AUGUST 1987

The most antonishing project ever to have appeared in an electronics magazine. Similar in principle to a medical EEG machine, this project allows you to hear the characteristic rhythms of your own mind! The alpha, beta and theta forms can be selected for study and the three articles give masses of information on their interpretation and powers.

In conjunction with Dr. Lewis's Alpha Plan, the monitor can be used to overcome shyness, to help you feel confident in stressful situations, and to train yourself to excel at things you're 'no good at'.

Our approved parts set contains case, two PCBs, screening can for bio-amplifier, all components (including three PMI precision amplifiers), leads, brass electrodes and full instructions.

PARTS SET **£36.90** + VAT ALPHA PLAN BOOK **£2.50**
SILVER SOLUTION (for plating electrodes) **£3.60** + VAT

Parts set available separately. We also have a range of accessories: professional electrodes, books, etc. Please send SAE for lists, or SAE + £2 for lists, construction details and further information (free with parts set).

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EASi

Pat Alley baffles the burglars with modules and podules to add to the EASi loop

EASi by name, easy by nature. The Event Alarm System installation uses a single wire around your home (and beyond!) and yet offers a positive plethora of possible protection devices to guard against fire, theft or your prawns defrosting.

The central control box was described last month, as was the protection of outbuildings and a simple test probe in case of a ravenous rodent ruining your continuity.

This month and next, we examine the various sensors and additions that have been made to the EASi circuit.

The main requirements when these were designed were that the circuits had to work under low voltage conditions so as to conserve the loop voltage, that they were cheap, and that if the sensor itself does not have a fast switching action then the circuit must generate the 1V voltage pulse sufficient to trigger the alarm.

The units described here need no batteries or additional wiring as they take their power from the EASi loop (with the exception of the gas sensor which is mains powered).

To test these units without plugging them into the EASi loop, you can breadboard the constant current generator shown in Fig. 1. This is almost identical to the loading in the control box so that the circuit should behave identically when inserted into the loop.

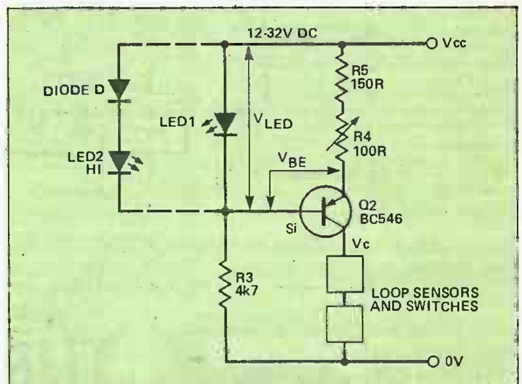


Fig. 1 Constant current supply circuit to test modules

A point that will bring peace of mind to hamfisted constructors is that there is no mistake you can make in a sensor circuit that can result in any blown components when it is inserted into the loop. The EASi loop current is only 5mA even if the loop is completely shorted out and 5mA rarely destroys anything.

Pressure Mats

The diagram shown in Fig. 2a illustrates the simple method of using normally open switches such as a pressure mats with the EASi loop.

Conventional systems usually have a completely separate loop with pressure mats in parallel or else connect each mat across a normally closed loop and its tamper loop. This complicates wiring and makes troubleshooting a dreadful task.

Using a transistor as an inverting switch does however have the problem of having its collector-emitter voltage (about 0.8V for silicon transistors) lost from the loop voltage. This obviously limits the number of pressure mats that are possible without using up too much of the loop voltage — using germanium transistors (Fig. 2b) helps since this cuts the c-e voltage to about 0.4V.

When the mat switch closes, the base-emitter junction is shorted and the transistor stops conducting. The collector-emitter voltage rises until caught by the diode and LED at about 2.3V — a rise large enough to trigger the alarm.

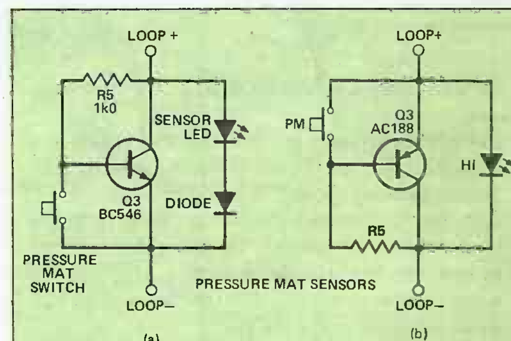


Fig. 2 Triggering from a pressure mat using (a) silicon (b) germanium transistor

Note that with a germanium transistor the diode and LED can be replaced with a high intensity LED but bear in mind that if a burglar sees a glowing light on the floor he is likely to tread elsewhere. Place the LED inconspicuously.

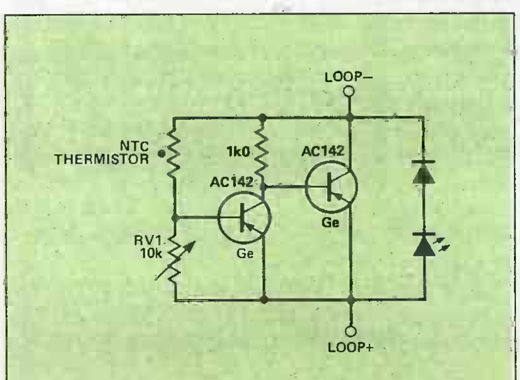


Fig. 3 Circuit diagram for the fire detector

Fire Detector

A simple fire detector can be made on stripboard from the circuit in Fig. 3.

The thermistor has a negative temperature coefficient — use any cheap bead type with resistance exceeding 2k2 at 25°C (such as Mullard's VA1106 or STC's KR222CW). Adjust RV1 for the trigger temperature — 135°F (57°C) is the most common. The detector removes about 0.4V from the loop voltage. There might be some triggering troubles since if temperature rise is slow the 'snap' action of the circuit is affected — using higher voltage diodes should cure this.

Bi-metal mechanical fire switches are more expensive but have the advantage of not consuming any loop voltage as well as guaranteeing a snap action.

Delayed Entry And Exit Module

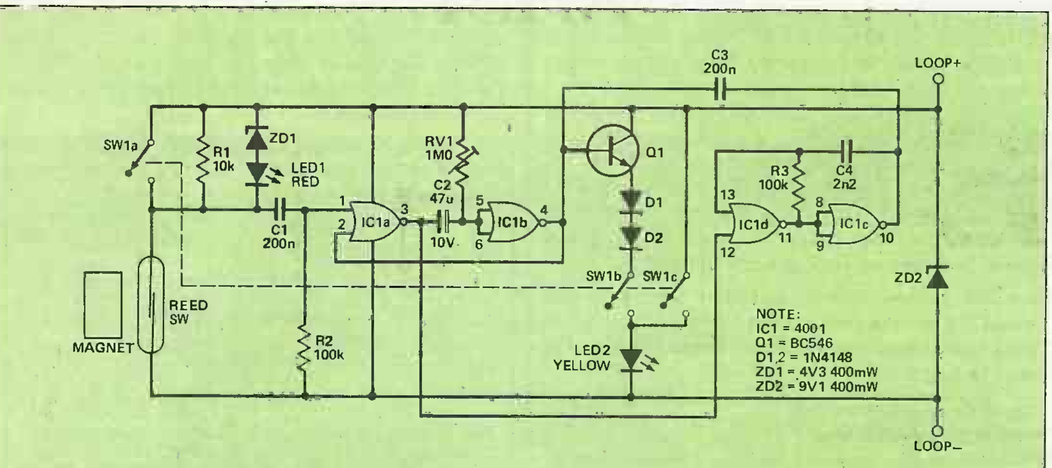


Fig. 4 Circuit diagram for the delayed entry/exit module

The system described so far includes an external keyswitch paralleled across the main front door so that you can enter and leave the house without setting off the alarm.

You may prefer to construct the more sophisticated circuit of Fig. 4 which gives a timed delay for you to get in or out of the house before the alarm sounds. It takes advantage of the fact that EASi will not sound for a negative loop voltage pulse.

The component overlay is shown in Fig. 5. If your door jam is not wide enough to accommodate the whole sensor the reed switch can be mounted off the PCB. The original 3-pole 6-way switch used for SW1 is no longer manufactured and is difficult to obtain. However, a 3-pole 3-way can be modified as follows:

- using pliers squeeze the two end stop lugs in line with the top plate. Lever down the spindle projection allowing about 270° rotation (eight clicks).
- Remove the nuts from the underside of the switch. Under the cover remove the two slider contacts in-line with the spindle projection. Replace the switch contact plate and bend the three short lugs to be soldered to the PCB.
- Solder in the three lugs and the long lugs using short lengths of wire.

The normal position is one click from anticlockwise or clockwise, verified by normal illumination of LED1 when the door opens. The delay position is three clicks further — with the control box on test the yellow LED2 should light with the door closed.

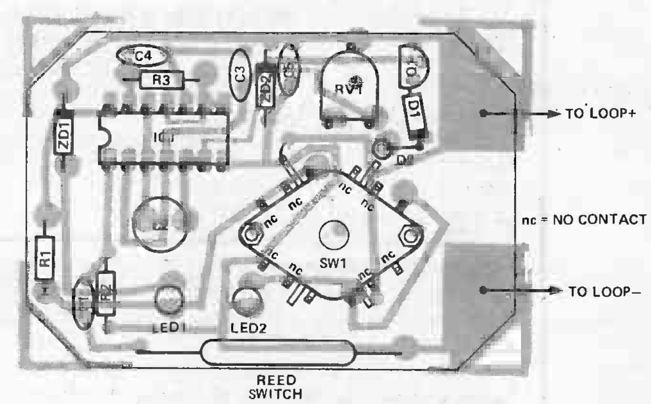
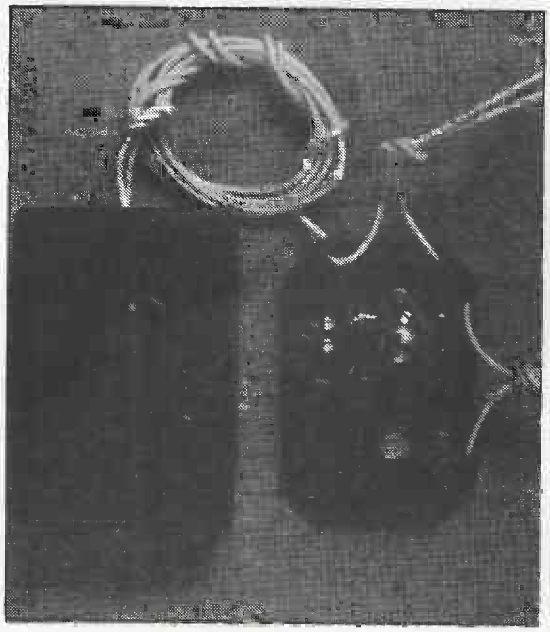


Fig. 5(a) Component overlay for the delayed entry/exit module

PARTS LIST

RESISTORS (all ¼W 5%)	
R1	10k
R2,3	100k
CAPACITORS	
C1,3	200n 12V
C2	47µ 10V electrolytic
C4	2n2
SEMICONDUCTORS	
IC1	4001
Q1	BC546
ZD1	4V3 400mW
ZD2	9V1 400mW
LED1	red LED
LED2	yellow LED
D1,2	1N4148
MISCELLANEOUS	
SW1	3-pole 6-way
Reed switch. Magnet. Wire.	



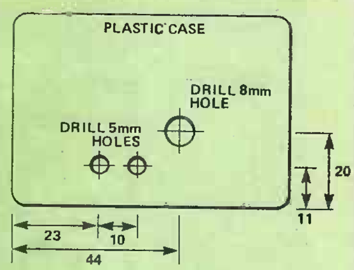


Fig. 5(b) Case drilling for entry/exit module

Panic Switch

It is a very simple matter to add push-to-break switches anywhere in the loop to act as instant alarms in the case of personal attack of injury. Simply fit the switch across the loop as shown in Fig. 6.

Positioning of these switches should obviously be made with some thought — if you have children or pets that could regularly find and press them, you will soon short them out in annoyance.

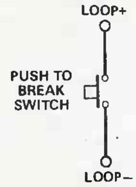


Fig. 6 Connecting a panic switch to the EASi loop

Freezer Sensor

Freezers often have neon warning lights to alert you of power failure but the rarity of failure makes it unlikely that you'll notice it or realise its significance if you do. Yet the price of failure when it does occur can be enormous.

Worry no more because with EASi you can arrange for an event alarm to sound if the freezer temperature rises above $-5°C$.

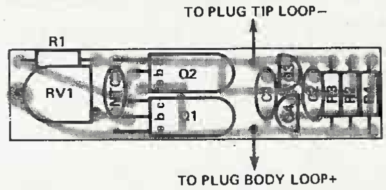


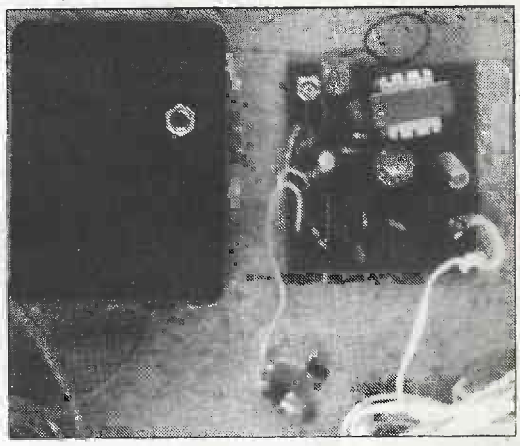
Fig. 7 Component overlay for the freezer sensor

Combined Gas And Smoke Detector

The detector circuit is shown in Fig. 9. It uses the Figaro TGS813 gas sensor which requires some 160mA at 5V AC. Obviously this can not be obtained from the loop voltage and this sensor does require separate mains power. This means that in the case of mains failure, protection is lost.

The sensor often goes into the alarm state for a few seconds on power up. To avoid this false alarm the input to IC1 is inhibited until C1 is charged by R3.

In normal operation the output of IC1b is high, illuminating the LED and inhibiting the astable. Q2 is biased on with its collector-emitter voltage taking about 0.1V from the loop.



PARTS LIST

RESISTORS (all ¼W 5%)	
R1	8k2
R2	22k
R3	5M6
R4,5	100k
R6	10k
RV1	22R 1W
RV2	1k0
CAPACITORS	
C1	10µ 25V
C2	1000µ 25V
C3	1n5

SEMICONDUCTORS	
IC1	4001
Q1	BC546
Q2	BC556
LED1	high intensity red LED
MISCELLANEOUS	
FS1	1A fuse
PL1	2.5mm jack plug
SENS1	TGS813 gas sensor
SW1	push-to-make
T1	6-0-6 mains isolating transformer 1.5VA

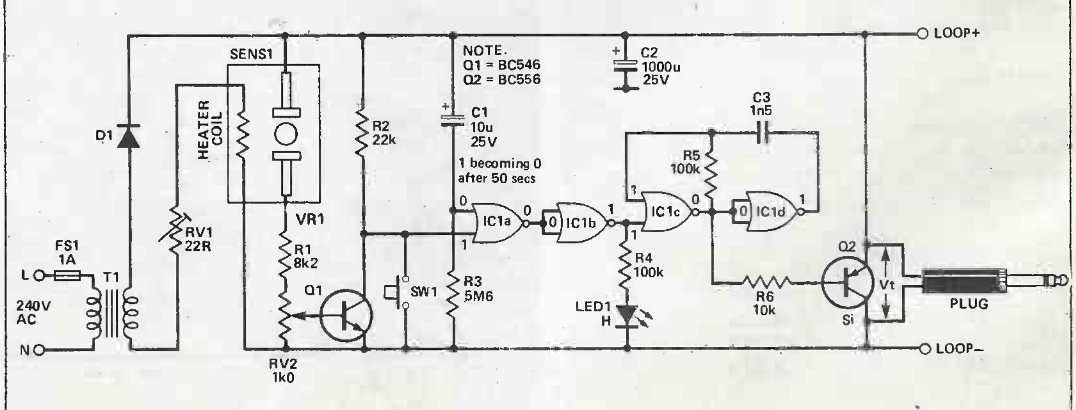


Fig. 9 Circuit diagram for the gas and smoke detector

PROJECT

The circuit is shown in Fig. 8 and the component overlay in Fig. 7.

Transistor Q2 dictates the quiescent voltage consumption at about 0.35V and when there are no problems Q3 and Q4 are in 'hibernation' — they might as well not be there. However as the thermistor warms up, voltage V_t will rise and the tone oscillator of Q3 and Q4 will leap into song, sending its tones along the loop resulting in an event alarm.

Although the Schmitt trigger action of Q1, Q2 is not very pronounced, we have high repeatability since the whole circuit is inside the freezer, with absolutely controlled temperature conditions.

Calibrate the circuit to −5V using RV1 then seal the box in a dry and preferably cold atmosphere. Put a few pellets of silica gel inside if you have any, then seal it well. The sensor can be hardwired into the loop or plugged in using a loop socket.

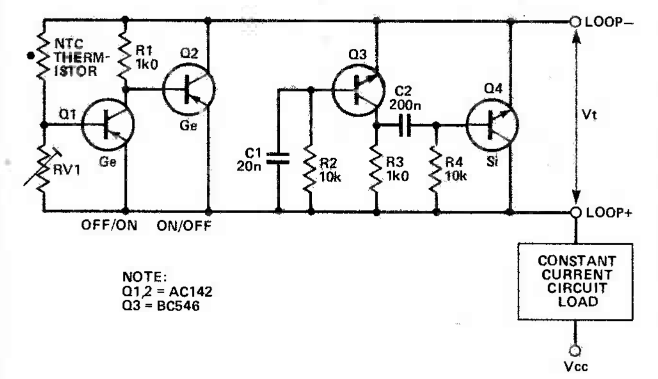


Fig. 8 Circuit diagram for the freezer sensor

When gas or smoke is detected the sensor's resistance falls and the voltage at the base of Q1 rises until it conducts, gating the astable and modulating Q2 to cause an event alarm.

SW1 tests the alarm logic so that you can tell if it is the detector or the circuit that is faulty in case of failure. The detector can be plugged into the loop using a loop socket as described above.

Calibration

Calibration of the sensor can be performed as follows: Power the circuit from the mains but do not connect to the EASi loop. Adjust RV1 to give 5V AC across the sensor heating coil, let the circuit settle for 15mins and adjust RV1 again as necessary. Again wait 15mins then measure voltage V_{R1} (see Fig. 9) and adjust RV2 to set the voltage at the base of Q1 given from Table 1.

This calibrates the detector to trigger at between 2000 and 5000ppm, while the minimum concentration of methane in air to cause an explosion (the Lower Explosion Level or LEL) is 50000ppm.

The sensor will also detect smoke so don't place the unit above a cooker. Methane rises so the sensor should be high up, near or on the ceiling close to the most likely source of gas leaks. (Note the sensor can also detect butane and propane but for this purpose should be about 20cm from the floor.

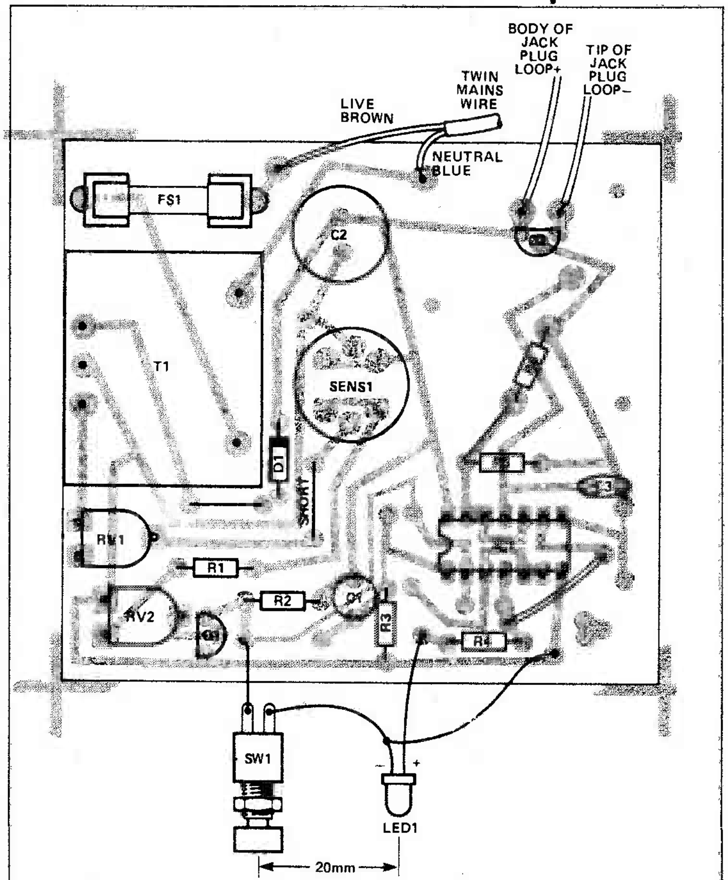


Fig. 10 Component overlay for the gas and smoke detector

Construction

The component overlay is shown in Fig. 10. The unused copper tracks and pads are present since the design can incorporate an internal sounder.

Construction is straightforward. Care must be taken since in use there are live mains tracks on the board — make sure that if you drill a mounting hole on the rear of the case you avoid this area of the board.

Drilling

The box diagram in Fig. 11 shows the necessary holes for cooling, sensing and so on. In addition drill a 3mm hole between the case and lid to take the wires to the loop socket of EASi.

V_{R1}	set the base voltage of Q2
1V	0.18V
2V	0.22V
3V	0.26V
4V	0.31V
5V	0.35V
6V	0.39V

Table 1 Calibrating the gas sensor

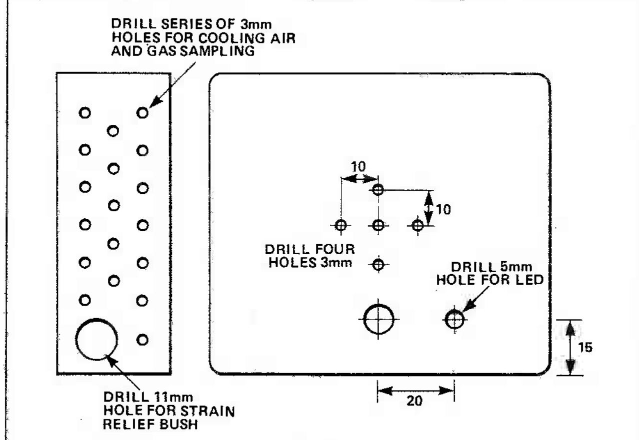


Fig. 11 Drilling instruction for the gas sensor box

Companies interested in marketing the patented EASi system should contact Mulberry at the address below.

Light Sensor

The circuit of Fig. 13 will catch out any intruder who turns on a light when the owners are absent. Place the light dependent resistor inside a black box to avoid reflections and align with a hole drilled in the front of the box.

Build the circuit on stripboard. Solder in the LED and poke it through another hole in the box where it can be seen.

To calibrate connect to EASi or the constant supply of Fig. 1, rotate RV1 towards the minimum, close the lid but don't screw it up. Pointing the unit at a light source should illuminate the LED, putting your thumb over the hole should extinguish it. Sensitivity is not vital but adjust RV1 to get the best results. Expect a maximum range of about 20ft using a 60W bulb.

For reversing the role and detecting an intruder 'breaking a beam of light' the three transistor circuit of Fig. 14 can be used. A suitable PCB design is shown in Fig. 15. Since Q3 is silicon there is a higher quiescent voltage drop. The alarm voltage excursion is guaranteed by the high intensity LED plus V_{be} of Q2 (this transistor replaces the usual shunted components). The LED is in this position to momentarily latch the circuit since your average burglar's profile may not break the beam long enough to sound the alarm. It might spot Dolly Parton, but Raffles would get through undetected!

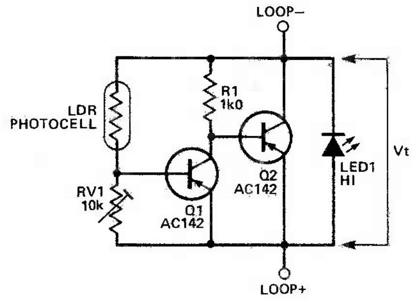


Fig. 13 Circuit diagram of the light sensor

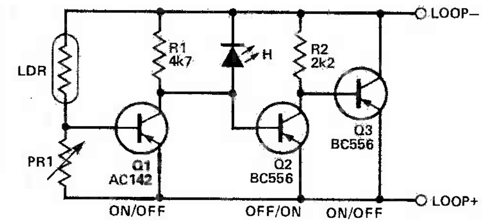


Fig. 14 Circuit diagram of the 'broken beam' light sensor

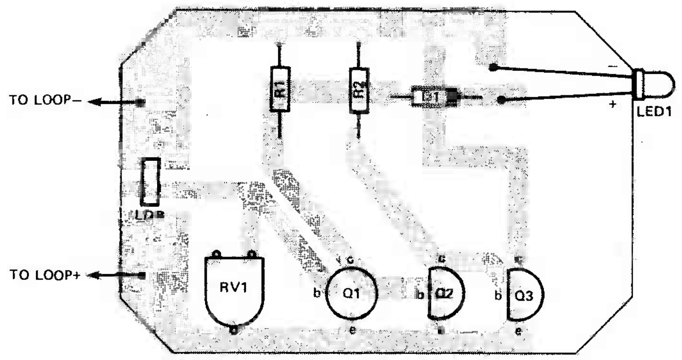


Fig. 15 Component overlay for the 'broken beam' light sensor

The problem with this circuit is that a mains failure would cause a false alarm, something that we must not allow. Happily the control box has a safeguard against this (see last month) but this doesn't remove the possibility of an alarm due to a bulb blowing. The easiest solution to this is a twin bulb source for your light beam. A second possible solution is to use a 2-transistor light sensor positioned at 90° so that bulb or mains failure results in one sensor switching off as the other switches on, cancelling out their respective pulses. This will however take about 1.2V in loop voltage so the twin bulbs are a better solution.

Loop Sockets

The loop socket is the simplest way of extending the loop if you find you've laid it too short. It is also a handy way of attaching sensors into circuit since you can remove them later without needing to short the loop.

It could hardly be more simple — just a standard mono 2.5mm audio jack socket. The contacts are closed (loop complete) unless a jack plug is inserted in which case the loop is extended down the wires on the plug. Be careful of polarity — to avoid confusion standardise connections as shown in Fig. 15.

The shunted LED is there merely to prevent an accidental open circuit in case of a defective socket — you would never expect it to light (if it did it would show up on the control box).

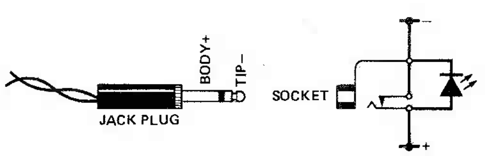


Fig. 15 Connection of a loop socket to the EASi loop

Although a false alarm while connecting or disconnecting the jack plug has never occurred in my experience, it is recommended that you do this with the loop set to *test* or *part*.

BUYLINES

Mulberry Electronics can provide materials and components for the EASi alarm system at the following prices.

Control Box: metal container (predrilled and artwork) £14. Main PCB £12.00, PSU PCB £1.70. Internal siren £6.50. Transformer £1.60. Relay £1. Battery (2.6AH) £16. All other components £22.50.

Kits: door/window sensor £1.10, magnet £0.85, house [illegible] £0.85, panic switch £0.60, fault probe £0.80, fire sensor £3.[illegible], loop socket £0.60 (without LED £0.48, plug £0.18), pressure [illegible] sensor £1 (pressure mat £4, stair mat £2), freezer sensor £4.55 (PCB only £1.50), gas sensor £16.10 (PCB only £4.00 [illegible] sensor only £6.95), delay entry/exit £7.50 (PCB only £4).

Bell 12V 6in £18. Red bell cover £9. 100m reel of [illegible] white wire £2.40. LDRs for light detectors £0.60.

Prices include VAT but please add £1.50 p[illegible].

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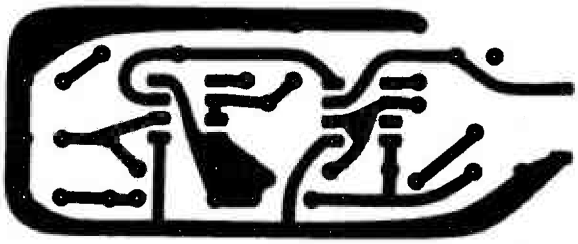
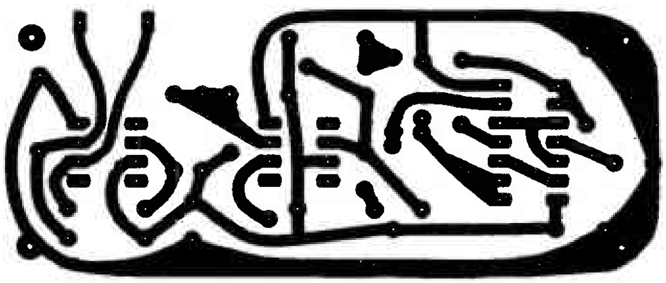
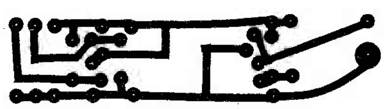


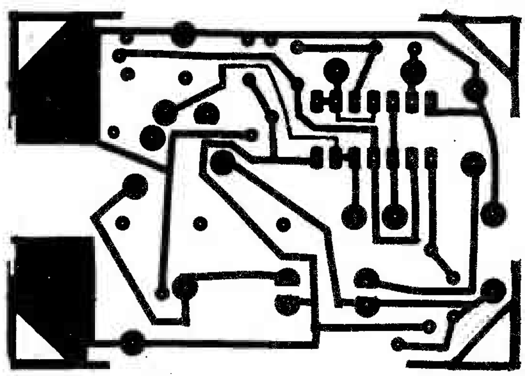
The ultrasonic camera trigger receiver foil



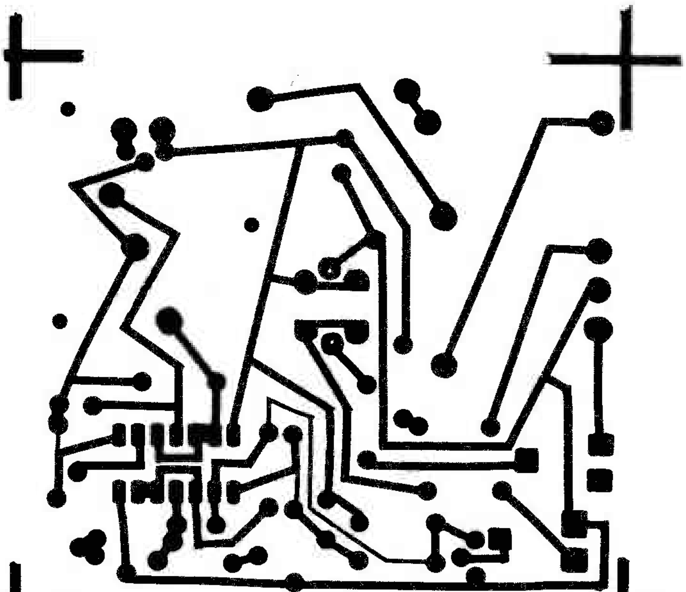
The ultrasonic camera trigger transmitter foil



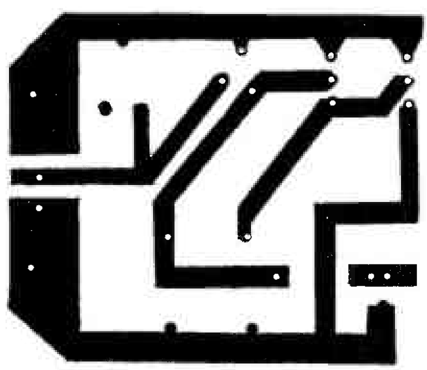
The EASi freezer sensor foil



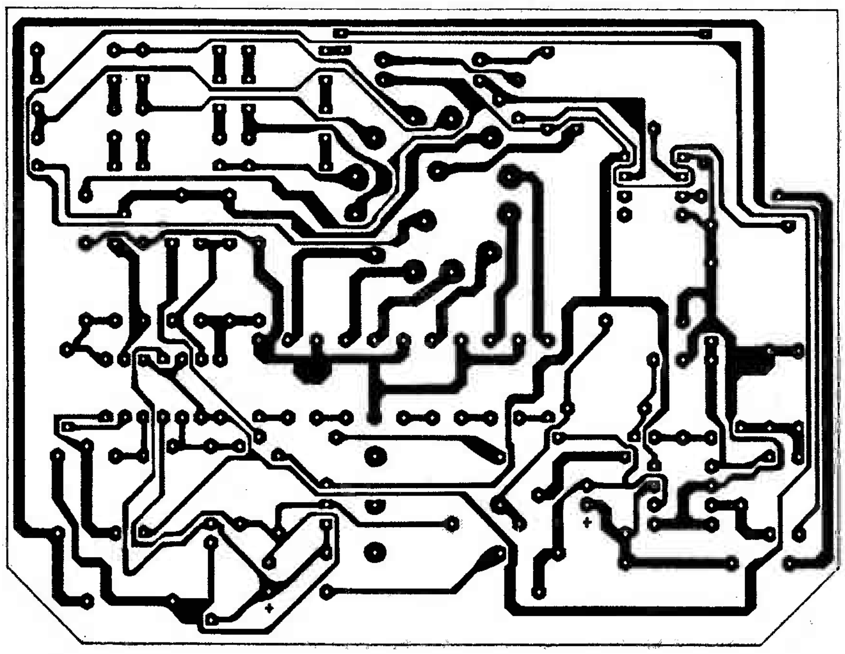
The EASi delayed entry/exit module foil



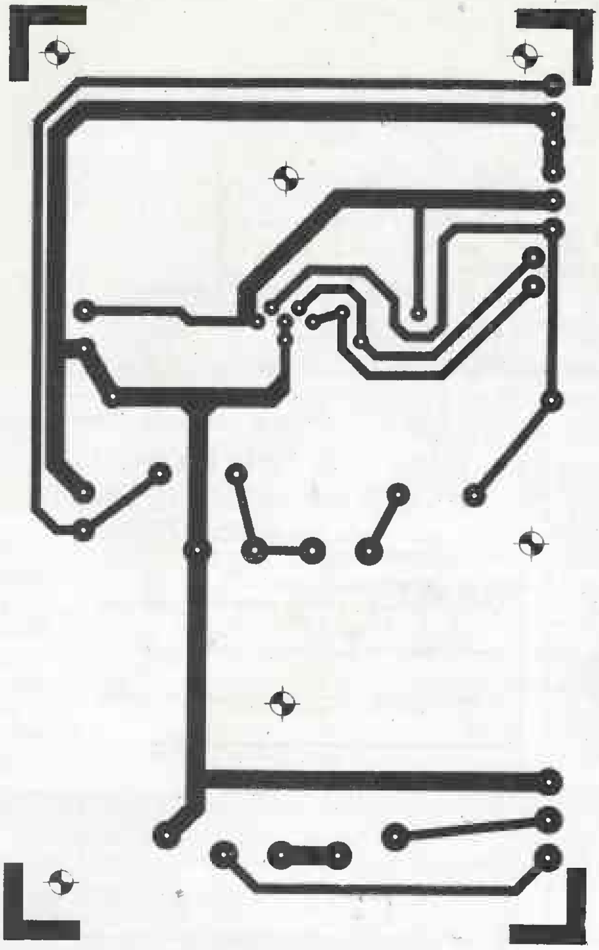
The EASi gas and smoke detector foil



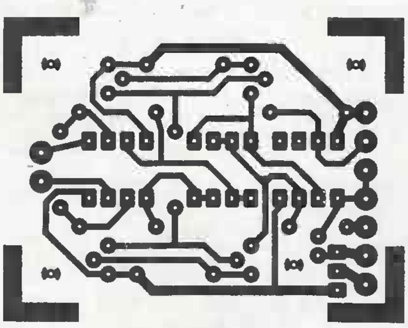
The EASi 'broken beam' light sensor foil



The guitar tuner foil



The bench power supply PSU board



The bench power supply current sense board

EEG Monitor (September 1987)
The wiring for the switch SW1 in Fig. 5 shows all the wires for selecting Alpha and Beta waves swapped. A_1 should read B_1. A_2 should read B_2 and so on. The easiest remedy is to swap the front panel labelling shown in Fig. 6 so that the switch labelling reads Theta, Beta, Alpha.

Combo Lock (April 1988)
The transistors in the Parts List are muddled. The correct components should be Q1,3,5=ZTX300, Q2,4,6,7,8=ZTX500.

Chronoscope (November 1988)
In the overlay diagram for the counter PCB (Fig. 3) the polarity of C12 is shown the wrong way around. SW1a-d is shown as SW1-4. In Fig. 4 the cathodes of LED 8 and 9 are the righthand and lefthand pads respectively. The cathodes for LED 6,7 are marked as the wrong pin. In the text section on Battery Operation, Q1 should read T1. In Fig. 5 SW2 is incorrectly labelled SW5.

Doppler Speed Gun (December 1988)
In Fig. 2 the labelling of pins 7 and 4 of IC2 are transposed. IC10a Pin 1 and IC9c Pin 10 should connect together and not to the 5V rail. The positive terminal of C3 should connect to the junction of R2/R3. Pin 7 of IC2 should connect to the 12V rail and not to Pin 6/R1. So the pin labelling of CONN1 runs left-right on the overlay diagram, the corresponding labelling in Fig. 2 should be 3-1-2, reading downwards. Fig. 4 is correct in all respects except for the orientation of Q2 for which the c and e labels should be transposed. In addition the extra switch to be seen in the photograph of the prototype is a hangover from a previous incarnation. Just ignore it!

Burglar Buster (December 1988)
The foil part of the component overlay for the basic alarm (Fig. 1) was printed the wrong way around. It should be rotated through 180° as in Fig. 5.
In Fig. 4a the connections around Q4 are somewhat confused. The base of Q4 should have a connection drawn to the collector of Q3. The emitter of Q4 should only be connected to +12V, not to the collector of Q3. The component overlay in Fig. 5 is correct.

Christmas Present For Granny (January 1989)
In Fig. 3 capacitor C7 is shown with the wrong polarity. This is correct in Fig. 5, however there should be an additional connection between the collectors of Q3,4 and the base of Q8.

Rev-Rider (January 1989)
In the parts list RV2 is incorrectly given at 33k. It should be 22k as in the circuit diagram. A 'blob' went missing from the circuit diagram. RV2, R7, R4, C1 and D3 should all be connected.

Tech Tips (March 1989)
In the Car Courtesy Delay circuit C1 should be 15uF not 15pF and the switch in the existing light should select from the bulb to the lower three points.
In the Opto Counter there should be an earth connection between the start and stop sensor LDRs.

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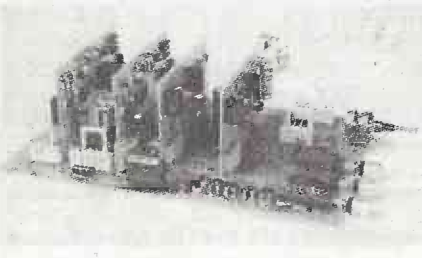

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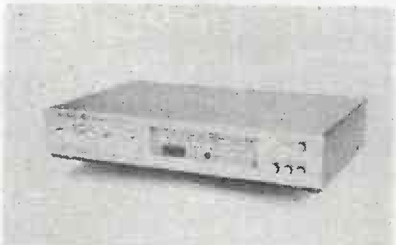

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Between popping our corks over John Linsley Hood's amplifier and fitting the entire ETI workshop and studio into crates for the move to Hemel Hempstead, we've still found time to put together a powerful package of perspicacious projects and fascinating features to fill the pages of the June issue of ETI.

*

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Plus all the regular columns, comment and communiques to keep you in touch with whatever happens in the wide world of electronics over the next month.

The above articles are in preparation but circumstances could prevent publication.

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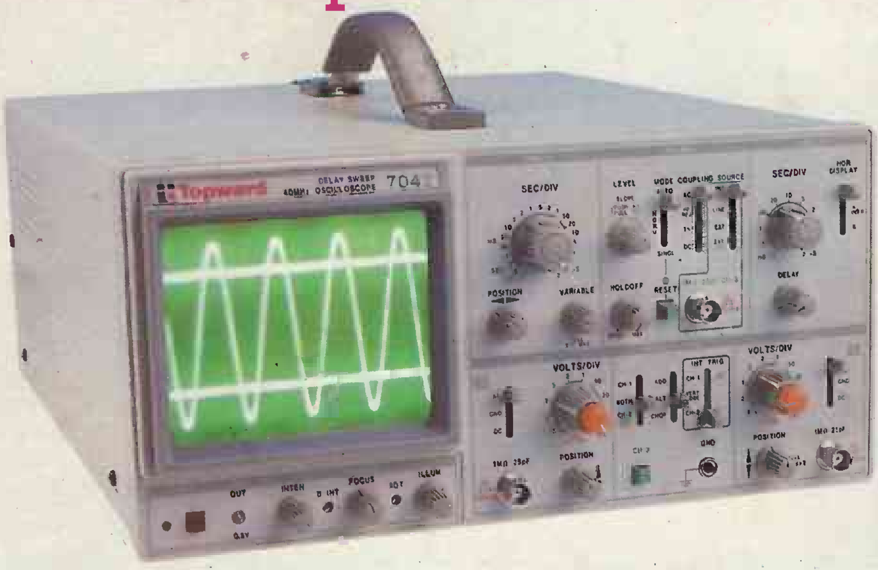

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