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MINI FM STATIONS – The future for radio?

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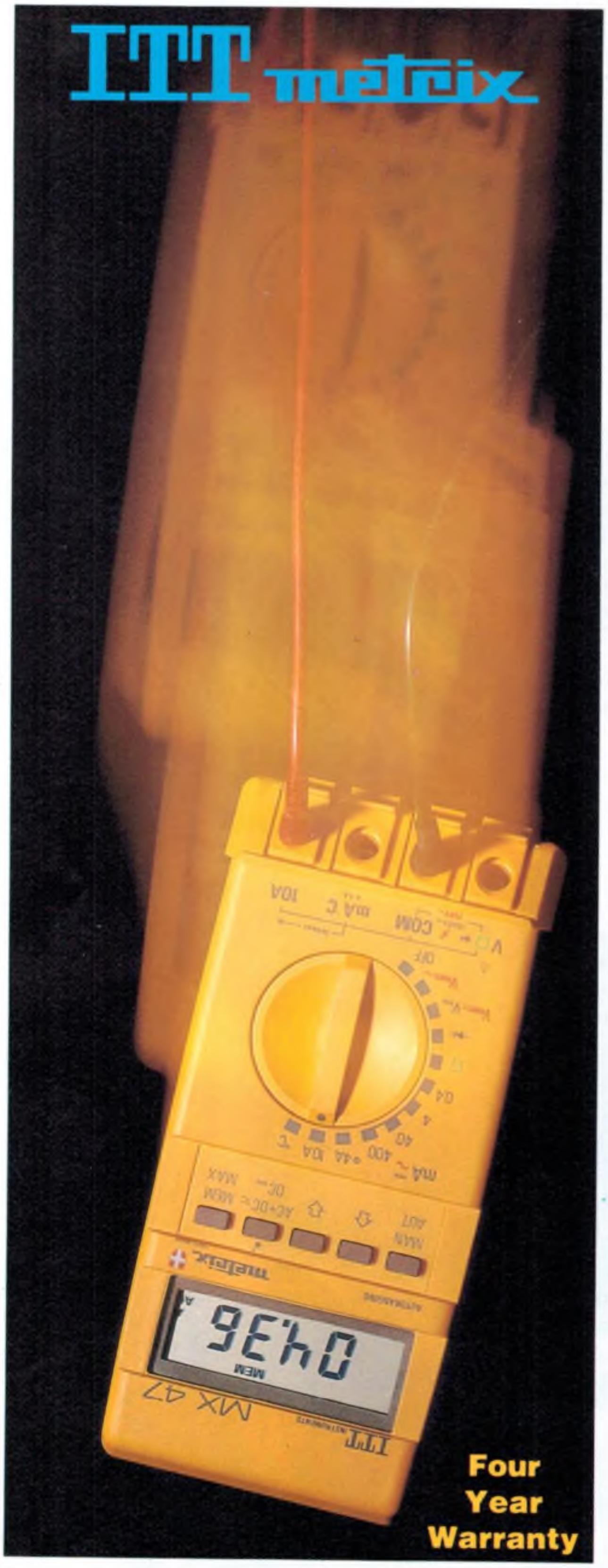
- **LOW COST SUB-WOOFER ADAPTOR UNIT FOR YOUR HIFI**
- **AN EASY TO BUILD PASSIVE IR MOVEMENT DETECTOR**
- **PCB FEATURE: HOW TO CHOOSE THE RIGHT LAMINATE**



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Electronics Australia

May 1989

AUSTRALIA'S LARGEST SELLING ELECTRONICS MAGAZINE – ESTABLISHED IN 1922

Subwoofer adaptor

Adding a subwoofer to your existing hifi system is easy with this low cost adaptor. It has adjustable crossover frequency, plus biphase outputs – so you can use a spare stereo amp in bridge mode for higher power! See page 62

Passive IR detector

Need an infra-red movement detector for your burglar alarm system? Here's a very compact and economical design that's also easy to build and get going. Low in cost too, so you can afford one for each room. See page 68.

PCB feature

Which PCB laminate is best for your job? Our article starting on page 100 explains the characteristics of each main type. Other stories describe PCB manufacture in Australia, the latest PCB products – and how to build a vertical etching tank for prototype PCB's.

On the cover

Volunteer announcer Ruth Jordea at the mike of Tasmanian community FM radio broadcaster 7RGY, in Geeveston. See our feature story starting on page 14, for more details. (Photo by Tom Moffat)

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Entertainment Electronics

Projects and Technical

News and Comment

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Letters to the editor

Component supplies

Boy – you sure know how to get me upset!

As you know, I enjoy reading *EA* from cover to cover every month, but in March I nearly siezed up when I read your Forum article. I could not believe your assertion that component supplies were better in the 1960's than they are now.

You gave some examples to 'prove' your point. I would like to take you up on these examples:

NPO ceramic capacitors: We (Jaycar) only specify the NPO type when we source our ceramic caps. Most of the time we find that 'NPO' is no longer branded on the NPO type, but other coefficients like 'N750' usually are. Marking is a problem, but not availability. Incidentally Jaycar carries ceramic capacitors from 1pF to 0.47uF in the E12 range of values, as well as a small range of high voltage ceramics – 54 discrete values. We also carry a mixed ceramic pack, and special packs of ceramics in bulk, by value. Not to mention monolithic ceramic capacitors for bypass applications!

10 watt wire-wound resistors: These very slow moving items are still stocked by Jaycar, but we are reducing the range. We carry from 1.0 ohm to 1k, but some E12 values will be dropped.

Air dielectric tuning capacitors: We stock these in both tuning and trimmer types. We no longer carry the 'ROBLAN' type 415pF tuning gang (common for old crystal set designs) because it would have to sell for about $30 – which we think is too dear. This information is on page 72 of the 1989 Jaycar catalogue, which was inserted in the same edition of your magazine as your 'Forum' article.

'Sturdy' metal cases: Jim, you look back through rose-coloured glasses – the best way to get a sturdy metal case in the 1960's was to make it yourself!

Your very magazine went to great pains to give detail drawings of metalwork, so it could be constructed by the dedicated (you can say that again!) enthusiast. I can remember 'Horwood' cases being around, and vaguely remember a few others, but valve designs virtually necessitated custom chassis.

Not only does Jaycar *still* carry a wide range of Horwood cabinets, we carry 23 other 'sturdy' metal cabinets. I agree that many metal cabinets are on the lightweight side (I didn't include these in the above) – we stock them because of their low cost, or the fact that many people actually find them OK! Over a dozen of these are carried as well.

We also carry a huge range of metal/-plastic and plastic/plastic instrument cases and parts storage cases as well. I know of no company in the 60's or early 70's – except perhaps Radio Parts in Melbourne – which carried a comparable range.

Reduction Drives, 3-pole 8-way switches: Jaycar purchased the remaining stock from the two remaining suppliers of these products, some time ago. Both companies discontinued the lines because the demand was virtually non-existent. The stock purchased was put into Jaycar 'Bargain Bags'. I agree that you would now have a great deal of trouble sourcing such products. These products were, however, much more likely to be used in projects of 20 years ago than today.

In conclusion, I think that you may have a point regarding the flimsiness of some products. Many metal cabinets are flimsy, and certainly many electromechanical components such as switches, pots, jacks, plugs etc., are also. Many of our competitors are tempted to buy the cheapest parts they can get. Never mind the quality! You don't need to pay much more to get a part that is OK, though.

Some people argue that if the part does the job, then the quality is good enough. This pragmatic approach has probably made for the success of thousands of cost-effective projects, that would never have got off the ground if they were too expensive in the first place – because industrial grade parts were specified for a consumer product.

I don't know whether you classify Jaycar as a supermarket chain, or not. We operate 8 stores in three states, plus mail order. It is certainly not hard to buy from us!

At present we carry about 5000 separate product lines – lines that an electronics enthusiast in the 60's and early 70's could only dream about. I think that it is grossly unfair to draw conclusions like you have in the March 'Forum', based on the flimsy evidence of a search for a few components that were commonly used in the 60's but hardly touched today. You didn't complain that valves were now difficult to obtain!

I'm sure that I can speak for our many competitors as well, when I say that I am proud of the range of products available to the enthusiast in this country.

Gary Johnston, Managing Director
Jaycar Electronics

Comment: Thanks for your comments, Gary. I agree that in many areas, enthusiasts do have an excellent choice of components nowadays; much better than in the 1960s. But my main point was that in other areas, such as electromechanical components and metal cases, the situation doesn't compare nearly as well – and frankly your comments seem to support much of what I said, including the suggestion that supply availability must ultimately reflect demand. By the way, you're not suggesting that all of the hard-to-get bits are for building ancient crystal sets and valve projects, surely?

Circuit symbols

I have been following the circuit symbols argument with interest. I agree with you and most of your correspondents that the old, tried and true symbols are the ones that we should stay with.

Some of us were born and bred with zig-zags and curlicues, while others learned them later in life. The basic symbols pre-date electronics, so who are we to argue that they are wrong, inappropriate or confusing. I would hazard a guess that even those who use and promote the rectangles are still able to read old circuit diagrams without confusion.

All of which makes me wonder about your plea for conformity, when you are desperately trying to introduce the nanofarad and (God forbid!) millifarads.

There was a time when we used mmf for 'Micromicrofarads', a clumsy if reasonably accurate term for a million-millionth of a farad. This was later changed to picofarads, or pF pronounced 'puff'. The change was adopted very quickly because only the name changed – not the values. What's more, it was easier to say and write.

There was a time, too, when microfa-

Continued on page 127

Editorial Viewpoint

Pay TV – inevitable, but later or sooner?

Having recently read the report by the Department of Transport and Communications on 'Future Directions for Pay Television in Australia', itself rather equivocal and unenthusiastic, I was interested to see a recent story in the *Sydney Morning Herald* reporting that the existing commercial TV networks are concerned about the likely adverse effects of pay TV on their revenue. Apparently one network has already decided to argue against its introduction, on this basis, while the others – and FACTS as a whole – look like conceding its inevitability, but pushing for both a delay on its introduction and a prohibition on it carrying any advertising.

I can understand that the existing commercial stations and networks would be worried. Any addition to the current modest range of available viewing choices must inevitably reduce their viewer base and hence revenue-earning potential, regardless of whether the additional viewing channels are able to carry advertising or not. And I guess that the presence of additional 'media' may also provide further competition for programme material, adding to production costs.

But the fact remains that Australian viewers now have a considerably smaller range of viewing choices than is available in a number of other countries (now including those in Europe), where viewers have effectively 'voted with their wallets' in favour of those greater choices. Whatever one may think of some of the programme material presented via the additional choices, it's probably inevitable that we will get them too, sooner or later.

Why should it be sooner? Because if we delay yet again, this will be one more area in which Australia will be a technology *follower* rather than a *leader*. And as a very perceptive Telecom executive recently pointed out to me at a press function, it's the technology leaders who end up as *exporters*, and the followers as *importers*. Small wonder that we've been nett importers in some many areas, and ended up with such chronic balance of payments problems.

We probably still have the opportunity to become a leader in the pay TV area, by pioneering the use of optical fibre cable for the reticulation of pay TV, music, news and data as an integrated part of the next revamp of the telephone/fax network. But we'll have to get cracking, if we're not to miss this boat as well.

Jim Rowe

What's New In

Entertainment Electronics

New Akai AM/FM stereo tuner

Akai's new 'flagship' AT-93 AM/FM stereo tuners offers automatic operating modes for those who simply want to sit back and listen to optimum FM reception.

The unit's automatic features include two antenna inputs for deciding which of the two antenna inputs provide the best signal; selectable wide or narrow IF modes for improved channel selectivity; stereo blend facility to reduce noise from a weak stereo signal; and a high-cut filter to further reduce noise and interference. These automatic facilities can simply be overridden by a manual operation. All these features are controlled by the AT-93's internal microprocessor.

Additionally a unique sequential station-call function allows for automatic selection of up to three different stations. This allows desired stations to be memorised and then recalled when the tuner is turned on via a timer.

The AT-93 uses dual-gate MOSFETS in the RF stage for greater sensitivity and a phase-locked-loop, quartz synthesised tuning system. All modes of operation are clearly indicated on an easy to read fluorescent display.

The AT-93 has RRP of $1,099.00 and is available only at selected Akai dealers and stores.

'Audiophile' CD player from Marantz

A new compact disc player from Marantz is claimed to set new standards in construction and features in its price class.

The CD85 inherits many of the design concepts pioneered in Marantz's widely hailed $5,999.00 three-piece CD12 and its $1,699.00 CD94 flagship models.

The CD85 will sell in Australia for a recommended $1,299.00. It features twin 16-bit digital-to-analog converters, with four-times oversampling.

Other features designed to give the CD85 ultimate sonic purity include:

- An ultra-compact single-beam pivoted laser which ensures accurate tracking and eliminates acoustic feedback problems.
- Marantz's High Resolution circuit philosophy, which involves refinements like double-thickness copper tracks on circuit boards, and the use of expensive, custom-designed capacitors and other components for superior low-noise performance.
- Four independent power supplies to keep digital and analog sections totally isolated, preventing digital noise from reaching the analog stages.
- A diecast chassis and copper-plated rear panel to eliminate vibration problems due to electro-magnetic coupling.
- Gold-plated output sockets for optimum signal transfer to the amplifier and long-term protection against signal deterioration. For the ultimate in sonic purity, an optical digital output is also provided, allowing amplifiers with this provision to be linked via optical fibre cable.

A full-function remote control allows armchair programming with direct access to 99 tracks and a 20-step memory which can program by track, index point or time. The remote can also be used to control volume.

Compact ceiling speaker & grille

Over the last ten years there has been a dramatic increase in audio sound systems in public and commercial buildings. The 'Industry Standard' loudspeaker used in these systems has traditionally been the 200mm (8″) type with plastic louvred ceiling grille. But there has been a recent trend away from the 200mm type to smaller, hence less conspicuous, 100mm (4″) models.

It is therefore timely that Altronics has released its new wide range 4″ driver, together with an attractive matching ceiling grille. The new driver, designated CO626, is rated at 15W RMS. It has excellent mid range 'presence' and is very efficient with a sensitivity of 96dB/1 watt/1 metre.

A pair of these drivers mounted in your gamesroom or den ceiling will also make a low cost set of extension speakers for the hi-fi system.

A version fitted with a 100V line transformer is also available for Commerical PA and background Music Systems. This is designated C2006, the transformer being tapped to allow speaker load of 0.5, 1, 2 and 4 watts RMS.

The injection moulded ceiling grille has push-in flush caps to hide the fixing screws.

Further information is available from Altronic Distributors, 174 Roe Street, Perth 6000 or phone (09) 328 2199.

Hybrid ribbon/dynamic speaker from Dali

The new 'DaCapo' loudspeaker system from respected Danish firm Dali is apparently the first of a series of 'panel' systems, which Dali calls its Dipole Dispersion Series.

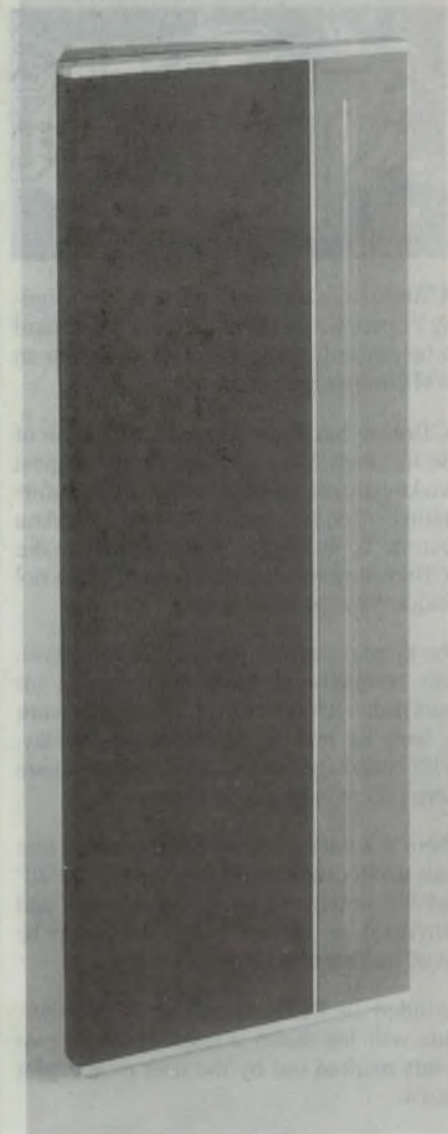
The DaCapo is a hybrid design, incorporating a 200mm (8″) electrodynamic bass driver and an ultra-thin ribbon midrange/tweeter element 1016mm (40″) long by 19mm (3/4″) wide. Dali claims that this represents the first successful integration of the two divergent driver principles into a single, musically coherent system, and has applied for patents covering various novel aspects of the design.

System crossover frequency is 450Hz, and the woofer 'drives' a large membrane (area 3 square feet) via a small captive column of air to give bass dispersion characteristics similar to the 'dipole' pattern of the ribbon element at higher frequencies. System resonance of the sealed bass enclosure is 50Hz, with a Q of 0.8.

The polyester foil ribbon in the midrange/tweeter has three current paths, giving an impedance of 4 ohms. Only 36 microns thick and weighing 0.7 grams, it is rigidly supported in a 16kg yoke frame. A linear phase third-order crossover network is used, together with linear-crystal oxygen-free copper internal wiring.

Power rating of each DaCapo speaker is 80W, with a rated frequency response of 50-20,000Hz +/-3dB and a sensitivity of 87dB/1m/1W (2.83V). External dimensions are 1200 x 500 x 150mm.

Recommended retail price is $3990 per pair, and further information is available from Dali distributors Scan Audio, of 52 Crown Street, Richmond 3121 or phone (03) 429 2199.



Audio/video receiver from Vector Research

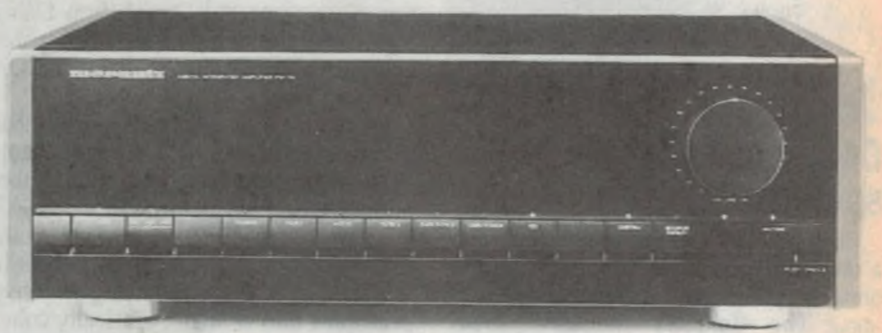
Vector Research's AM/FM Audio/Video receiver, the VRX-5200R, has the convenience of infrared remote control, plus a well-thought out design that gives more features at a very competitive price.

The VRX-5200R features 20 radio presets accessible via remote, programmed to either FM or AM as one wishes. In FM tuning, one can switch independently to mono reception and interstation muting.

Unlike other audio/video receivers which automatically default to the last-used mode, the VRX-5200R defaults to manual tuning. Other features of the unit are a 3-LED signal-strength 'meter' to help orientate an antenna, a discrete output stage (with separate transistors to give distortion free music peaks and plenty of dynamic headroom), and a heavy duty power transformer for stable performance and extended reliability.

Tone controls feature approximate adjustment range of ±10dB at 10kHz for the treble, ±9dB at 1kHz for the midrange, and ±15dB at 20kHz for the bass.

For further information contact NZ Marketing, 8 Tengah Crescent, Mona Vale 2103 or phone (02) 997 4666.



'Digital' amp sells for under $1500.00

Very few true 'digital' amplifiers have been released in Australia. One of the few is the Marantz $5,999.00 PM95, which created enormous interest among reviewers and audiophiles when it was demonstrated by Marantz design chief Ken Ishiwata in Sydney last November.

Now it has been joined by the 110 watts-per-channel (DIN) PM75, sporting many of the same innovative features – but selling for a recommended $1,499.00.

Like the PM95, the PM75 has inbuilt D-to-A circuits built to the same exacting standards as Marantz's state-of-the-art compact disc players. Novel jitter elimination circuits, also featured in Marantz's $5,999.00 three-piece Reference CD12 compact disc player, are claimed to banish distortion across the entire bandwidth.

The PM75 can be connected to a compact disc player or other digital source either by electronic digital cables or by optical fibre cables.

The amp has one optical and three electronic digital inputs, and one electronic digital output. Analog LP record lovers aren't forgotten, however. The amplifier features a phono input with moving coil option. Tone controls are provided, but they can be bypassed to ensure the best possible reproduction.

Linear Drive power supply and High Resolution circuits – features of all Marantz amplifiers – ensure constant high current supply, even when driving difficult speaker loads, and boost the stereo image to very high levels.

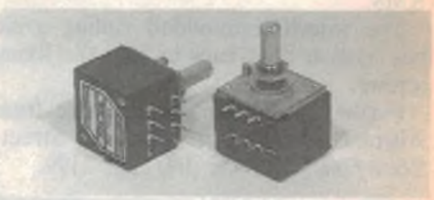
The PM75 also comes with remote control for armchair listening.

Precision matched dual pots for audio

Local amplifier designer and manufacturer Peter Stein, of ME Sound has found it necessary to source specially-made ganged pots for the controls in his firm's range of high-quality stereo amps, because those available had poorly matched elements – which introduced unacceptable changes in balance, etc. Having had to commit his firm to fairly large orders from the manufacturer, to get suitable precision matched parts, Peter is now in a position to make them available to both other manufacturers and discerning home constructors.

The pots are made by Alps Electric in Japan, and are produced by automatic laser trimming of the rearmost resistance element over its full length, to match closely the value of the front element for each angle of rotation.

Two models are available. The VR-50KB stereo volume control has two



50k log taper elements, matched within 1.5dB from 0 to – 60dB. It has a 315° rotation angle, no detents, a 15mm bushing with 10mm long 6mm diameter shaft and PCB terminals. The VR-100KD stereo balance control has two 100k complementary M- and N-tapered elements (full R for 50% of rotation), with a single detent at the centre of its 300° rotation. Tracking error is less than 2dB from 0 to –70dB, with mechanical specs the same as for the VR-50KB.

Both parts are available for $29.00 each, plus 20% sales tax in single quantities, with discounts for quantity purchases. Further information is available from Speaker Technologies, PO Box 50, Dyers Crossing 2429. Phone (065) 50 2254, or fax (065) 50 2341.

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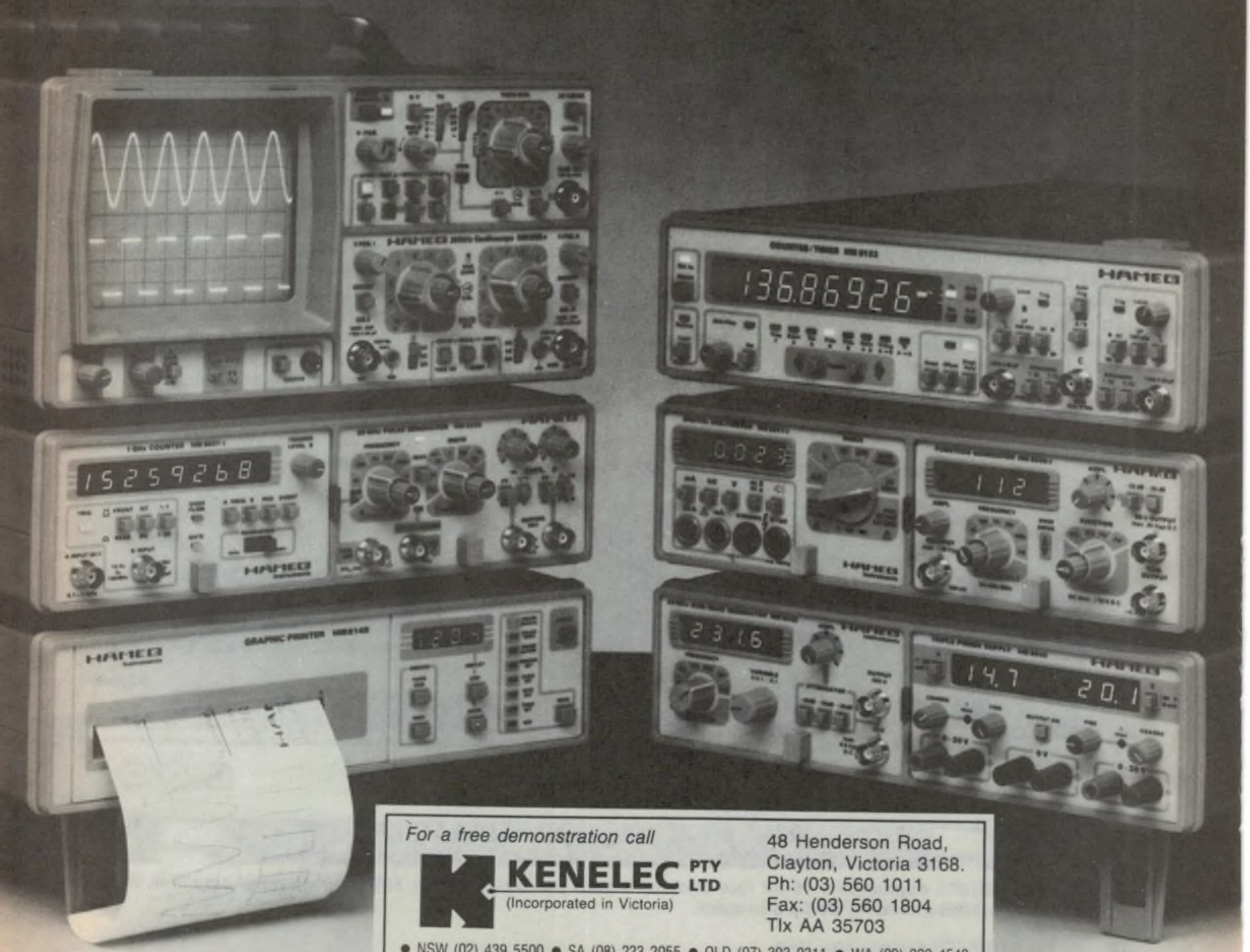

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'Surround Sound' processors:

Cinema sound – in your home

Audio processors that make your home living room sound like a big downtown cinema – will these be responsible for the next consumer market boom?

by IAN GRAHAM

When you watch a movie in a large city cinema, the soundtrack assails you from all directions. The dialogue comes mainly from the front of the theatre, while the music and sound effects blast from a battery of speakers alongside and behind the audience. A shout from the left, an explosion to the right, an aircraft screaming overhead towards the rear left emergency exit – it all helps to place the audience in the middle of the action.

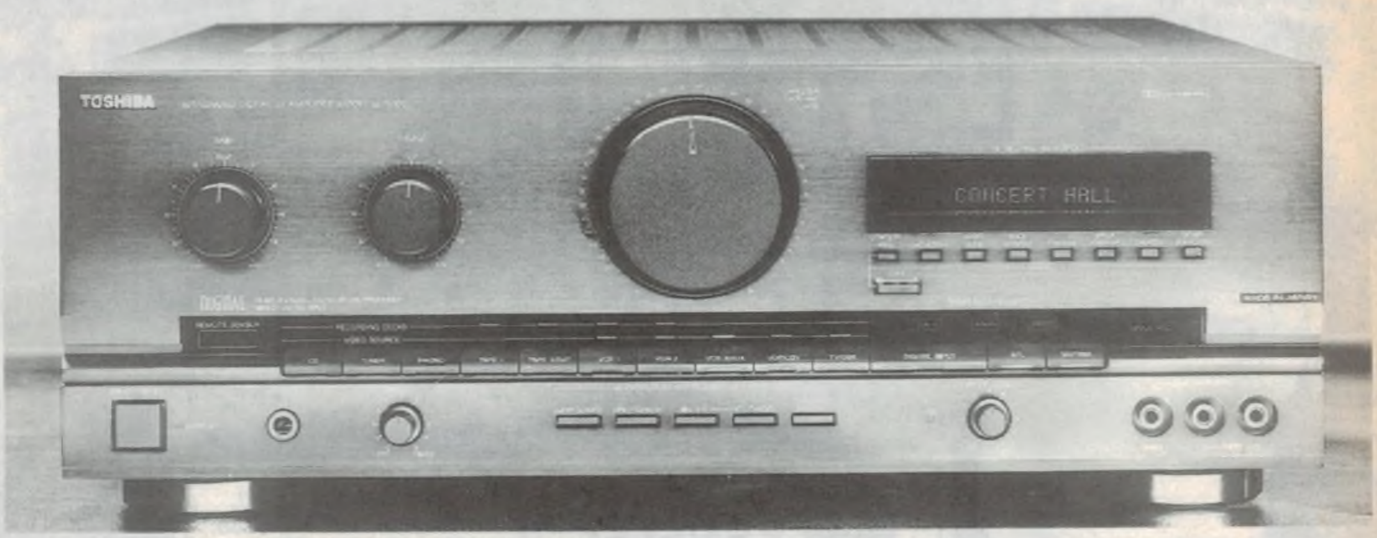
But when a video tape of the same film is played at home, the three-dimensional sound experience is lost. Even a stereo video recorder and television set can't do it justice. That being so, it might surprise you to learn that when a movie is released on video, the information used by the cinema sound system to separate out the various audio channels and feed them to the cinema's impressive array of loudspeakers is transferred onto the humble video tape along with the film.

Although the home video recorder and television cannot decode the audio channel information on the tape, a surround sound processor can. Sound processors capable of recreating cinema-quality sound in the home from ordinary pre-recorded video tapes of movies are now beginning to come onto the market. Prices are still relatively high for the best processors, but hi-fi amplifiers and even video recorders with built-in surround sound decoders are already becoming readily available.

Two into four

Most movie sound is recorded in Dolby Stereo. Although it's called Dolby Stereo, the tape's two audio tracks contain enough information to decode four audio channels. The simplest processing system, called Dolby Surround, creates four channels from the two on the tape by a rather rudimentary technique. The left and right channels are fed to the left and right speakers. The two input channels are added together and fed to the centre front speaker. Signals that are in phase, such as dialogue, are reinforced by this, while out of phase signals are attenuated. The out-of-phase signals largely lost from the front channel are fed to the rear (surround) channel.

This rather crude signal processing means that any sound is heard from at least three speakers, and is therefore less precisely directed than in the cinema. In fact, some Dolby Surround processors do away with the centre front speaker altogether and reduce the system to three channels – left, right and surround. For convenience, so that the system can be set up with two stereo



The Toshiba XB1000 combines a 16-bit four channel sound processor with a 50W four channel amplifier. It has eight preset sound modes including Dolby Surround.

The Lexicon CP-1 from the United States features four sound modes each with three options. In addition to these 12 preset modes, which include Dolby Pro-Logic, the CP-1's memory can store up to a dozen settings keyed in by the user.

amplifiers, this version of the system uses one stereo amplifier for the left and right channels and a second stereo amplifier for two identical surround channels. A 20 millisecond time delay is also inserted between the main left/right and surround channels. Separation between right and left channels or front and surround channels is quite good, but separation between either side and centre or either side and surround is poor.

Fig.1: The original movie soundtrack has four channels – one for dialogue and three for music and sound effects. These are combined into two tracks when the movie is transferred onto domestic video tape.

AV amplifiers

Some Dolby Surround decoders are available as separate add-on units, but most are built into audio amplifiers or 'AV amplifiers' (amplifiers capable of switching both audio and video signals). Amplifiers with built-in surround sound decoders normally also have two extra channels of 30W output rating, or thereabouts, to drive the surround speakers. And the companies that market surround amplifiers normally offer small surround speakers as optional extras.

Fig.2: The most basic surround sound processors cannot separate the four channels sufficiently to recreate the cinema soundtrack accurately. Any sound comes from at least three speakers.

Although Dolby Surround does offer a significant improvement in video sound quality, it clearly doesn't recreate the sound field generated in the cinema. A more sophisticated processing standard called Dolby Pro-Logic comes closer to the professional cinema system. Pro-Logic boosts the dialogue sent to the front speaker and removes it from left to right. If a sound is intended to be heard on one channel only, Pro-Logic removes it from the other channels by superimposing a cancelling signal on those channels. The cancelling signal is merely an inverted copy of the original signal. When the two are combined, the result is destructive interference – i.e., silence.

Similarly, if a sound is intended to be heard somewhere between the speakers, Pro-Logic balances the signal strengths of the various channels to make the sound appear to come from thin air at the intended position. This ability to steer sounds around a room is Pro-logic's great strength.

Delaying tactics

The system's electronics must react to incoming information from the tape in real time, sensing phase and loudness relationships and adjusting signal output levels before the sound has to be passed to the speakers to keep pace with the

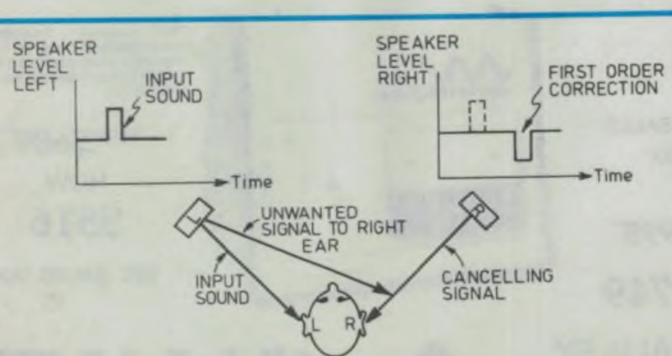


Fig.3: A sound intended to be heard by the left ear only is also heard by the right ear, a fraction of a second later. It can be removed from the right ear by sending a cancelling signal. This is called first order correction. However, the correction signal itself may be heard in the left ear, so a further correction signal may be necessary – second order correction. Higher orders of correction produce more accurate sound steering.

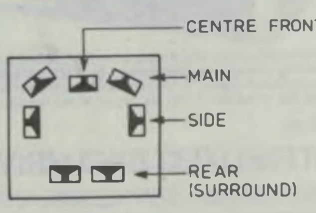


Fig.4: The best speaker arrangement for both music and cinema soundtracks. A sub-woofer can be added, beside or underneath the centre-front speaker.

Cinema sound

picture. If the processing should take longer than this, the sound would be heard before the on-board logic began to steer it, presumably producing some very odd and nightmare-ish effects. This places very demanding limitations on the time available for signal processing.

Some decoders buy extra time for signal processing by deliberately delaying the whole signal by up to 20 milliseconds. It seems a lot, but it's about the same delay as one would experience in the front row of a cinema – so the lag between picture and sound is quite acceptable.

Badly recorded source material can cause problems. Any misalignment of the playback heads or the film when the movie is transferred from film to video tape can produce small time differences between the two audio tracks. Errors of up to 50 microseconds are common, and the time difference between the tracks may vary as the tape plays.

Fifty millionths of a second doesn't sound much, but especially at high audio frequencies even this tiny error can produce significant differences in phase between channels. As the decoder uses these phase relationships to determine where sounds should be steered to, errors in phase will produce incorrect steering.

There are three ways of overcoming this. Cutting the treble in the surround channel, where steering errors are likely to be the worst, masks any differences between them and the other channels. Alternatively, deliberately narrowing the separation between left and right channels subjectively reduces any treble differences between them.

The best Pro-Logic decoders can detect and correct these input errors, so that even defective software can give satisfactory results without the need to cut or attenuate any part of the input signal. They do this by continually checking that the dialogue is centred accurately, and automatically correcting any errors that tend to shift it to either side. If it is done efficiently, there is no need for a balance control on the front panel – the processor does all the necessary balancing automatically.

Pro-Logic decoders are currently very expensive, and they normally require between four and eight channels of amplification to be added together with the appropriate number of loudspeakers. The total outlay to get one of these systems up and running is thus considerable. The best of them produces astoundingly realistic effects from Dolby Stereo encoded material.

Even the cheapest of the Dolby Surround decoders improves video sound quality significantly. In addition to Dolby Surround or Pro-Logic modes, most decoders also offer processing modes to deal with mono and stereo material that is not encoded in Dolby Stereo.

Whilst basic Dolby Surround processors are falling in price to the point where they will undoubtedly enter the mainstream hi-fi market, Pro-logic processors are still something of a toy for the wealthy. Judging by the activity in the whole surround sound area, the manufacturers believe that there is a demand for it, or perhaps that they can stimulate a demand for it.

Most of us have bought our video recorders and compact disc players and so the industry must look for growth elsewhere. Surround sound could be a lucrative area for the industry, because sales of processors not only creates a new market in itself, but it also boosts sales of amplifiers and loudspeakers to deal with the extra audio channels involved.

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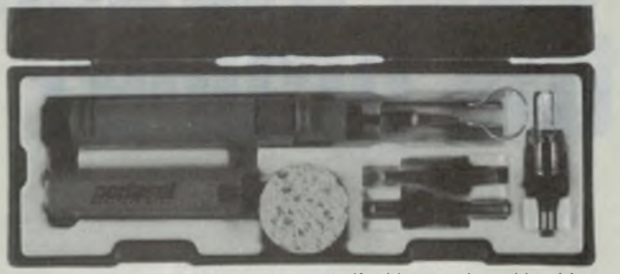

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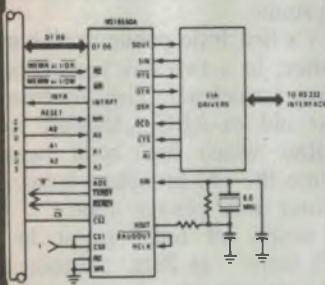

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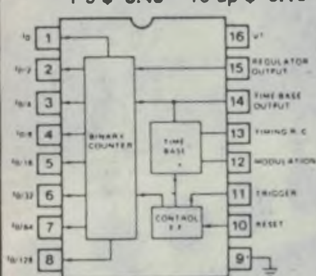

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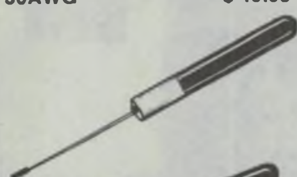

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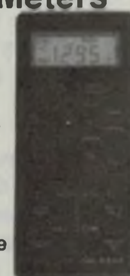

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'Mini' radio stations: key to the future?

Currently half the commercial radio stations in Australia are said to be losing money. After visiting a small Tasmanian FM community broadcaster, the author believes that its 'appropriate technology' approach may be the way to ensure not only that commercial radio broadcasting has a future, but also that it provides the kind of service our communities need.

by TOM MOFFAT

I've just been reading a story in a Melbourne weekend paper about a well-known provincial radio station. A take-over by 'out-of-town yuppies', 25 of the 40 staff members lose their jobs. Another 'local institution' bites the dust, to be replaced by a 'soul-less juke box'. Is this the future of local radio in Australia, particularly in country areas? Perhaps not, if a ground-swell of new broadcasting ideas gains enough strength.

Pressure is mounting in rural areas of Australia for the government to look again at its broadcasting policies with a view to allowing the establishment of simple, cheap, and locally programmed commercial FM outlets to serve small communities. This is in direct contrast to the current trend of setting up big-smoke based networks which relay one program to many rural centres. Country people, it seems, want their own programs, not ones pre-packaged for them in Melbourne or Sydney.

Common wisdom places big price tags on FM broadcast stations – $3 million here, $5 million there. But with a bit of scrimping and the application of what has become known as 'appropriate technology', there's no reason why a small local-coverage FM station can't be put on air for less than the cost of a good used car. 7RGY, at Geeveston in Tasmania, is a case in point.

Geeveston is about 60km southwest of Hobart, in the Huon Valley, which must be one of the most beautiful parts of Tasmania. Although the area is now considered within commuting range of Hobart, it has a long rural tradition and an intense community spirit. Geeveston has a high school that is central to the district, and within it a teacher named Peter Johnson who has always had a keen interest in radio.

Although the area is supposed to be within the primary service area of Hobart's commercial AM stations, Peter Johnson says the reception is virtually unlistenable during the day, and swamped by mainland stations at night. In other words, a perfect candidate for a local radio station.

Back in 1978 Geeveston High School had started a closed circuit broadcasting station within the school, using studio equipment funded by the Schools Commission. Two years later the federal government began offering experimental 'on-air' licences to potential community broadcasters, and a group of people in the Huon Valley decided the time for their very own radio station had come. But they couldn't drum up enough interest or finance to do it on their own, so it was decided to join forces with the school, where there was already an operating studio.

7RGY's first little public squeak came soon after, in a two day test transmission over a weekend. They borrowed a 20 year old ex-ABC television sound transmitter which had been tweaked down into the FM broadcast band. The transmitter was placed upon "a four year's supply of toilet paper in the school's store", as Peter Johnson puts it. The antenna was a simple ground plane, attached to the school's roof.

With a power output of ten watts, the

The main on-air studio at station 7RGY, at Geeveston in Tasmania's Huon Valley. It became operational in November 1983.

7RGY volunteer announcer Ruth Jordea at work. Ruth lives on the other side of the Huon river, and travels 45km each way to the station.

broadcasts were clearly heard by Huon Valley people up to 12km away. Used to the scratchy signals from Hobart, the listeners all had a common reaction to the new signal: "But it's so LOUD!". 7RGY was on the air, briefly.

Full time operation would require a proper licence, and here's where the trouble started. The station's backers had to provide a 'draft planning proposal', which was then to be commented on by other media organizations. Once the government thought a community radio station for the Huon would be a good idea, it called for formal applications.

Although there was only one applicant, the Australian Broadcasting Tribunal still had to hold a full hearing. So the entire Tribunal, complete with entourage, travelled to Geeveston. Even though there were no other broadcasters within VHF range of Geeveston, few other VHF radio services, and the intended power output was only ten watts, it was still necessary to do a full city-style interference survey calculation. According to Peter Johnson, the cost of all this activity, both to the government and the applicants for the licence, was enormous.

As this is being written the hearing procedure is underway yet again, with the A.B.T. visiting Hobart to consider applications for a commercial FM licence for the city. Three newcomers, and the two existing commercial AM broadcasters, are all vying for the service. The newcomers estimate that each of them has so far spent $200,000 to $300,000 to prepare their proposals. If any of the new companies gets the nod it will be up for anything up to $1,600,000 to establish a station.

Of course the two existing commercial broadcasters are resisting the newcomers for all they're worth. They say Hobart is a two station market, and there's no room for a third station. That is, unless they're allowed to run it themselves. Under 'free enterprise' principles, an extra station would be allowed, and if there were only room for two in the market, then the two best performers would survive. It will be interesting to see what the government decides.

But back to 7RGY. After three years of wallowing about in red tape, the station became operational in November 1983. Now they've installed a commercially made FM exciter, still running ten watts, in a fire tower on Doody's Hill near Geeveston.

The studio has been further upgraded, with a larger mixer panel that was retired from Hobart station 7HO when they went stereo. There are new tape recorders, cartridge machines, and monitor speakers, all ex-ABC, bought at auction for rock-bottom prices. And there's a bank of volunteers, both students and adults, who keep the 7RGY's programs going out several hours each day.

7RGY has developed a fine record collection and a great sound, and if you didn't know any better you'd swear it was a fully professional, commercial radio station. Except, of course, there aren't any commercials. If, somehow, 7RGY could suddenly sell commercial 'spots' to businesses in the Huon Valley, and if the volunteers could then be paid, it might be a hint of things to come in rural broadcasting in Australia.

An alternative?

7RGY got its licence, but what a slog! There must be an easier way. Peter Johnson, and many of his colleagues, feel that in rural areas at least, the issue of broadcasting licences for low power stations could be almost 'open slather'. Commercial licences should be available, as well as public licenses.

There should of course be minimum technical standards to ensure clean signals. But once the standards are met, "if someone wants to put up their money and open a station, it should be a simple matter to do it". After all, if you want to start a newspaper in the country, you start a newspaper. If you go broke, that's too bad.

One thing that seems to stand in the way of easy country licences is the attitude of existing broadcasters to new competition. Peter feels that "they are supposed to be the bastions of free enterprise, but they are only interested in protecting their patch". Even, it appears, if the proposed competition is on the very fringe of their patch, where they can barely be heard at the best of times.

Curly question time: What if, somewhere down the track, licensing laws

About the author

Tom Moffat is a journalist, writer, and electronic designer who has had many years experience in commercial broadcasting, both in Australia and in the USA. In the 1970's he says he foolishly believed expert advice that "FM broadcasting would never work in Australia". Nowadays, FM licences are now among the most sought-after commodities in commercial broadcasting. In this article Tom discusses some directions Australian radio broadcasting could take in the next 20 years or so, and relates a visit to a small Tasmanian broadcaster which could be an example of things to come.

were loosened up, and some manufacturer found it profitable to produce a low-end, ten watt, type-approved FM transmitter which could sell for a couple of thousand dollars or so?

This isn't as silly as it sounds; after all you can buy a 25 watt VHF transmitter/receiver for your car for much less than that. So the technology is there, only the market is needed.

Once you've got your transmitter, what else is required? A mixing console, a couple of turntables, a microphone, a tape recorder – that would do, for starters.

In the USA, where licensing laws are not so restrictive, many country radio stations are operating with little else. They might not look too flash, but the listeners need never know. The listeners hear the music they want, and they hear an announcer who is part of their community talking about things that affect them directly.

How much would all this cost? A small 'recording' mixer with good specifications and lots of frills like graphic equalizers can be had for around $500. There's a nice one in the Altronics ad in the December *Electronics Australia*. In the same ad is a smaller four-channel mixer that even has proper record cueing facilities, for $199. I've worked in stations using mixers like this, and they work just fine.

The broadcasting experts out there will say "But those mixers aren't professional! You can't use them!" And I'll say "Why not?"

Our 'appropriate technology' broadcast studio will also need a couple of low-end belt drive turntables, say $150 each. A reasonable microphone, $50. A reel-to-reel tape recorder, used, say $300. A monitor speaker and amplifier, $15 ex-ABC auction. We'll of course need our $2000 transmitter, and for an antenna, a simple ground plane will do for starters. That's what 7RGY is using. Any radio ham could build one.

Add in a few other bits and pieces and we're probably looking at around $5000 to get on the air with a 'minimum' FM station. The cost of a good used car.

Purists who think in millions will say this is a silly idea, but consider for a moment the first FM station I worked in, in the USA. The building housing it was a Nissan hut, bought for a song through Army disposals. The transmitter was third or fourth hand; big, bulky, inefficient – but cheap. The mixer had been retired from the sound system of a roller skating rink.

The single turntable was home-made by an audio enthusiast who believed the only way to achieve ultimate quality was to belt-drive the thing with a big rubber band. Consequently when you turned it on the motor would start spinning, eventually followed by the heavy turntable platter which would slowly accelerate. It would soon reach a point where the stored energy in the rubber band would sling it past the correct speed. So it would cycle up and down in speed, fighting with the motor, until everything stabilized about two minutes after switch-on.

This rather unique turntable was turned on in the morning and left running all day, as deft fingers put records on and off it while it was still spinning. To play the record you just dropped the needle on it and hoped. This wasn't as bad as it sounds since the station played mostly classical music, an entire record side at a time. Most of the announcers had good, cultured radio voices, and the sound the station produced was not unlike that from ABC-FM today. The listeners never knew that the station was built from junk.

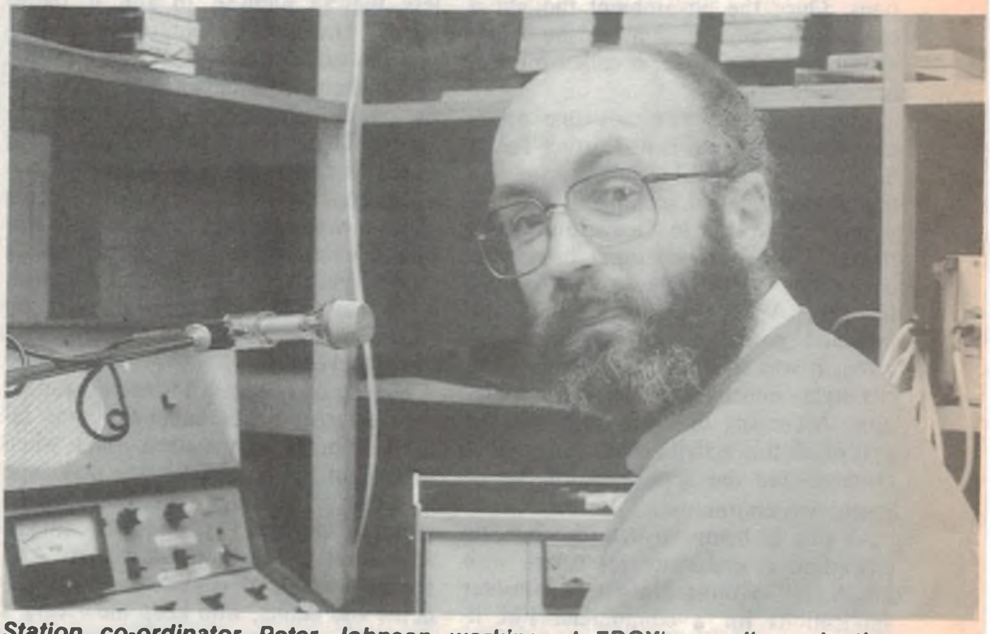
You may also notice that there's no mention of cartridge machines in our hypothetical 'minimum' station. Experience has shown that it's quite easy to get along without them in a small station, at least in the early stages. Later you might get lucky. I once saw a brand new, unused 'Cuemaster' machine go off for $10 at a government auction here in Hobart.

Cartridge machines are usually used for playing pre-recorded commercials, although some stations like to put their most-played records on 'cart' for convenience. At another AM station where I once worked, cartridge machines were seen as an unnecessary luxury. So were copywriters. So most times we ad-libbed commercials direct to air, usually off a newspaper advert.

You opened the mic, kept one eye on the clock, the other eye on the newspaper, and then raved on for thirty seconds about the great specials to be had at Joe's Shoe Store. When Joe's next booking came up, you did much the same thing again, but scrambled up the order of the items. So no two commercials ever sounded the same. It wasn't slick or sophisticated, but the sponsors loved it. So did the listeners; 'live' radio wins every time.

7RGY's Peter Johnson raises an interesting question: Will a little radio station in a small country town raise enough revenue to pay the employees needed to keep it going? After all, an announcer with just about zero experience will still get at least $20,000 a year. And to cover say 15 hours of broadcast time throughout every day...

The above-mentioned tin-pot AM station was a traditional family-owned small business, and it managed to support eight employees and their families.

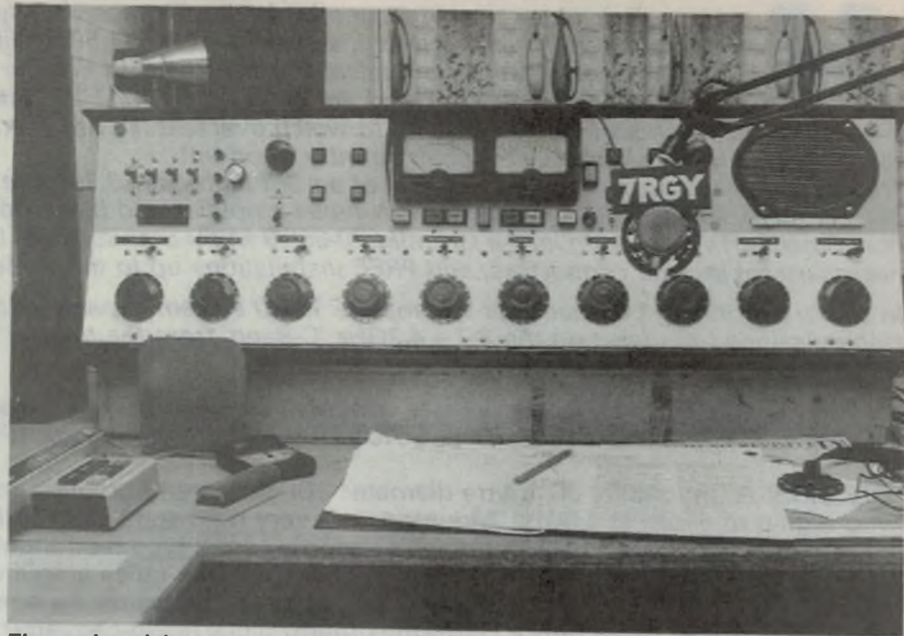


Station co-ordinator Peter Johnson working at 7RGY's small production studio console.

This was possible because everyone who worked there, no matter what their official job, did an on-air shift. These included the secretary, the accountant, the sales manager, and the station's owner. My proper job was Chief Engineer, but as well I produced a half-hour news service every evening followed by a four-hour music program.

A lot of work, all this doubling up? Perhaps, but we all loved it. The station's advertising rates were such that we were never short of sponsors, and the business gave good, secure incomes to the employees and a tidy profit to the owner.

Twenty years on, with costs skyrocketing daily, would it still work? Well, that station is still on the air and something must be paying for it. So would 'mini' FM stations have a future in rural Australia, providing live, local entertainment and selling advertising spots for Fred's Used Cars in beautiful downtown Geeveston?



The main mixing panel at 7RGY is elderly, scrounged from Hobart commercial AM station 7HO after it modernised its studios.

No way, under the present licensing system. But what's to stop the government introducing a 'Class Z' commercial FM licence – with the idea that the holder must use a type-approved 10 watt transmitter, and sink or swim fiancially.

There have been suggestions of a 'hybrid' licence; public radio part of the day, and commercial radio for the other part. Already public stations are taking limited commercial sponsorship, but it's very restricted. Still, it's a start.

This whole matter raises some deep philosophical questions that have affected business efforts in Australia for a long time. Is it the role of government to prevent the establishment of a business, simply because it might not succeed? If a business becomes shaky, should government move in to prevent its demise (as in the case of Rothwells in WA)? Is it the government's role to ensure the prosperity of existing business interests, by preventing the establishment of new ones that might openly compete with them (as in airlines).

The ABC's *7.30 Report* recently did a story on commercial broadcasting. They said that half the commercial radio stations in Australia are losing money. And of those that are profitable, most are only keeping up with inflation. Could this be because they're trying to service multi-million dollar investments? Would multi-*thousand* dollar rural operations, scattered all around Australia, be more viable? The only way we'll even know is if the Federal Government gets brave, bites the bullet, and says to would-be small commercial operators, "Go for it!"

Already, with Aussat up and running, so much of what we see and hear nowadays is networked out of one central studio in Melbourne or Sydney. The trend is for more of the same. There's even a suggestion of a big central satellite station in the sky, broadcasting direct to car radios so travellers always have a 100% clear signal and never have to retune. Personally when I drive into a town I don't know, the first thing I do is listen to its local radio station to get a feel of the place. So which way is radio going to go? It's getting close to decision time.

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5. Description of the competition and instructions on how to enter form part of the competition conditions.
6. The competition commences on 28th February, 1989 and closes with last mail on Jun 30, 1989. The draw will take place in Sydney on July 3, 1989, and the winner will be notified by telephone and letter. The winner will also be announced in The Australian on July 7, 1989 and a later issue of this magazine.
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TV RECEIVING SYSTEM

How to prevent, or at least detect

Electrical Fires

The mention of the word fire is often enough to invoke mild paranoia. Having recently suffered the consequences of a fire caused by an electrical fault, we decided it was time to look at the causes of electrical fires – and what to do to prevent them.

by PETER PHILLIPS

The cause of a fire is often open to interpretation. Was the cause the result of an electrical fault, or did electrical energy cause the fire, through no fault of the appliance? The fire fighting authorities view an electrical fire as one in which the electrical energy was at fault. This implies that a fire started by an overturned electric radiator is not an electrical fire, rather it is the result of an overturned electric radiator.

Given this interpretation, in which an electrical fire is one caused by an actual fault, it is heartening to know that electrical fires are not all that common. The statistics for 1987, supplied by the research division of the NSW Board of Fire Commissioners, shows that of the 23,872 fires reported in NSW, only 2023 were the result of heating from electrical equipment, arcing or overload.

This gives a figure of less than 10%, which itself is seen as being unrealistically high by experienced researchers in the field. It seems that a figure of around 2% is more likely, according to Mr John Boath, Inspector-in-charge of the NSW Fire Brigades Fire Investigation Unit. He, like other experienced fire officers believes that many fires are attributed to an electrical fault in the absence of the true, but hard to find reason. The news media, often renowned for its rapid assessments, will usually state the cause as being electrical just to conclude the story. The Police have even been known to report the cause of a fire as being electrical, even though power to the premises had been cut off some four years previously.

However, while fires caused by an electrical fault may not be as common as popular opinion may hold, fires resulting from electrical energy as such still represent a sufficiently high proportion of the total to be a worry. This article therefore looks at the types of faults that cause fires, and describes what measures should be taken to minimise the risks.

After all, readers of an electronics magazine such as *EA* are likely to be more involved in electricity than most people. It is possible that some readers are not sure what the risks are, or would like reminding anyway. We also look briefly at fire alarm systems, in case this article creates a feeling of insecurity. Hopefully, as a result of this article, you will not form part of the 1989 electrical fire statistics.

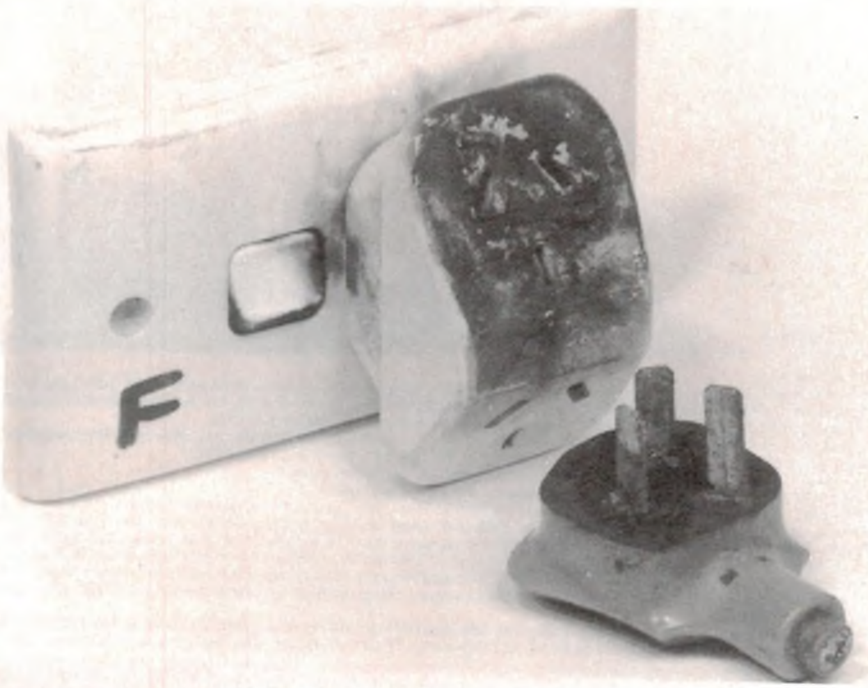
Some causes

The three causes of fire, according to the experts are men, women and children. This is probably simplifying the issue, but it makes sense to some extent. In most cases, an electrical fire could have been prevented, if only...

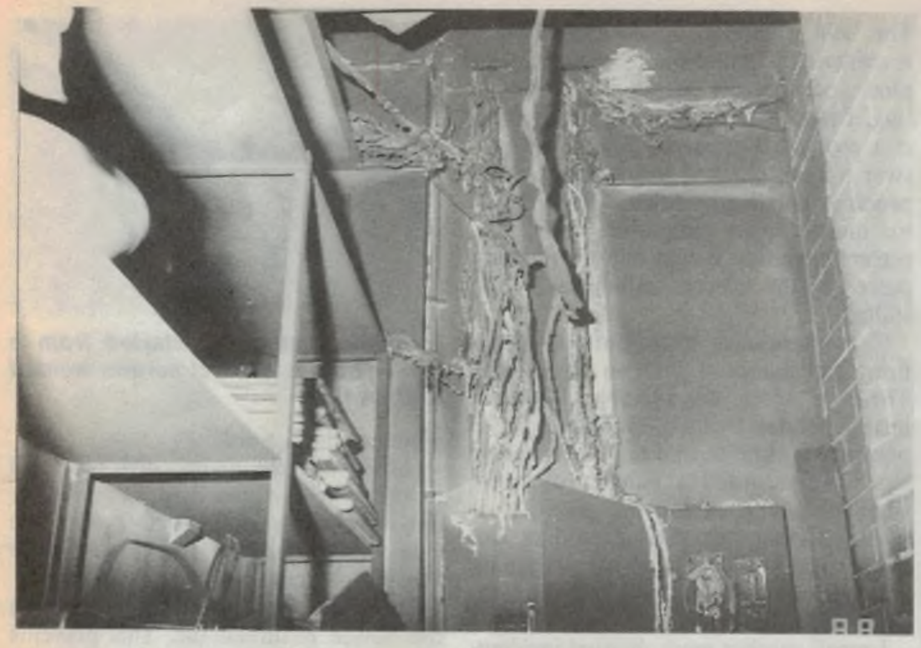
Here are a few examples of fires caused by electricity – whether the fault lay with the equipment or the user. They are all actual situations, some related to me by the NSW Fire Brigade, others from my experience.

Fault 1: This event occurred during my days as a boarder with a little old lady. She was such a dear, that when her TV set broke down I decided to surprise her by fixing it while she was at church. Unknown to me, she had stored her electric radiator under a couch in her bedroom, leaving it plugged in to a double power point shared by the TV set.

I duly repaired the set, restored it to her living room, completing the job by reconnecting it to the power point. However, I unknowingly turned on the power to the radiator, rather than the TV set, then left to prepare some dinner. Several hours later I was disturbed by violent knocking on the front door,



This double adapter and plug combination caught fire, as a result of heavy current passing through loose and dirty contacts.



The results from even a small fire can be quite disastrous – and extremely expensive to rebuild.

the purpose of which became very apparent when I went to answer the door. The whole bedroom was ablaze, and the 60 year old house about to burn down. Fortunately, the fire brigade had been alerted, and the house was saved.

The moral here is obvious: never store a radiator that is still connected to a power point.

Fault 2: A 150W flood lamp in a shop window blew, causing the globe to disintegrate. The white hot embers from the filament set alight to the combustible materials on the floor, destroying the shop. Moral: caution with unattended flood lamps.

Fault 3: A fault in the thermostat of an old fridge caused local heating that eventually became so intense it burnt through the case of the fridge and set alight to surrounding combustibles. The investigating team found that the power fuses had been fitted with 60A fuse wire, instead of the usual 15A wire.

The owner of the gutted building had only recently bought the place, and had never checked the fuses or the electrics. It seems that some people solve their electrical overload problems by replacing the fuses with nails. Have you checked your fuses lately?

Fault 4: The owner of a 1930's radio left it plugged in to the power point, and turned it on or off with the switch on the radio. However, the single pole switch operated on the neutral, and on an occasion the owner was absent, the active and earth potentials existing between the primary and the core of the old transformer proved to be too much. The resulting heat eventually ignited the radio and blew the fuse in the switch board. Too late – his house burnt to the ground.

This happened to a friend of mine, and I am now most distrustful of any old equipment. The moral is – always switch the active wire.

There are many such examples of how an electrical fire can be caused, either through a fault or misuse. The Fire Investigations unit cited extension leads under carpets as the most common cause. The insulation around each conductor is eventually worn away by the stresses created by people walking on the lead, leading to shorting and possible ignition.

Another common cause is a coiled extension lead. The use of retractable spools tends to leave most of the lead wound around the spool. If a heavy load is attached to the lead, the heat generated in the coil can be sufficient to melt the insulation and set fire to the lead.

Fluorescent lighting has long been known as a cause of fires. The ballast or the power factor capacitor can catch fire, and set alight to the ceiling. The ballast in a fluorescent light usually runs at a fairly high temperature, and there are many recorded cases of them catching fire. The fuse is unlikely to blow until it is too late, and the older the fitting the more likely the chance of it becoming faulty.

Ceiling fans occasionally seize up, and eventually get so hot that a roof fire starts, fanned by the upward draft through the fan opening. Kitchen fans, where grease and other combustibles are likely to have accumulated are renowned for starting fires, and some states have made it illegal to fit such a fan unless it exhausts to the open air, often via a ducting.

And so the list goes on. Any electrical appliance is a potential fire risk, although some are worse than others. Maintenance, or at least checking appliances is one way to reduce the likelihood of them catching fire. But appliances are not the only culprits that cause fire - the mains wiring is as much a source of ignition as the devices it powers.

Bad connections

Bad electrical connections are a very common cause of fire. Wherever there is current and resistance there is heat generated. If the heat is sufficient, it can make the resistance of a connection higher – giving more heat, and so on.

Obviously, the higher the current, the greater the likelihood of heating, and the 240V mains has sufficient energy to create lots of heat. Most roof fires are caused by bad connections in junction boxes, particularly if the installation is an old one. Current advice from the experts is – solder the connections. Even the best of screwed terminators will eventually loosen after time, particularly if the house is subject to vibration. The statistics show that 50% of roof fires are the result of an electrical fault, so it pays to spend the time and solder each connection, in conjunction with the usual screwed connector.

The power point is another connection point. Loose connections of the power wiring to the outlet will generate considerable heat, particularly under heavy load conditions. The use of double adaptors of the 'stacks on the mill' variety is asking for trouble. Each adaptor adds its own resistance, and the total effect can create sufficient heating to cause combustion, even under relatively light loads.

These days, the multi-outlet power board has become popular. However, according to the Fire Brigade, these are another fire hazard, as they are often overloaded through misuse. Their advice is simple – use only those boards that have overload protection. They also suggest that if someone is using lots of these boards, they should consider rewiring the house.

The connections of the appliance lead at both the appliance and the 3-pin plug are another source of the resistive joint. Because it may receive more stress and

Electrical Fires

movement, the connections within the plug are most likely to deteriorate over time. It pays to check all appliances such as heaters or dishwashers regularly. Of course, you can solder the connections to reduce the incidence of the problem.

Leaving a 3-pin plug permanently in the outlet is likely to cause a resistive connection, especially if you live in a humid environment. The verdigris build up will soon cause problems, made worse if the wiping effect of continual removal/replacement of the plug is not occurring.

In summary, solder all connections, and don't overload.

Dust

The build up of dust in an appliance can go undetected for years. In fact, the idea for this article came as I gave the family fan heater its annual cleanup. The dust build up in fan heaters, clothes dryers and air conditioners can be quite rapid, causing instantaneous ignition when you least expect it.

The Fire Brigade recommend that the vacuum cleaner be applied to these devices every time a cleaning session is underway. Everything helps, but my experience is that it is necessary to give these appliances a thorough cleaning regularly.

Dust behind fridges and freezers is likely to be left for years, and can be a cause of fire if the buildup is too great. The recommendation is to fit wheels to these appliances, so that cleaning can be undertaken regularly.

The TV set is the greatest dust attractor of all. The high tension around the picture tube will attract dust with a vengeance, giving a potentially hazardous condition. Leaving the set on unattended is when the troubles can arise, as the tell-tale preliminary smells will go undetected. Some people will leave a TV on when they go out for the evening, to suggest occupancy to a would-be thief. Not a recommended practice!

Equipment faults

So far, the faults causing fires have been those primarily associated with the mains. Statistics point to mains faults as being the most common, but this doesn't rule out fire resulting from faulty equipment. For example, there is evidence to suggest that a particular brand of emergency lighting currently being imported is causing fires.

The charging circuit contains a capacitor mounted close to the transformer. The heat generated by the transformer is sufficient to cause the capacitor to explode, occasionally setting fire to the fitting. Brand new equipment causing fires is a problem – it seems there is no answer if both old and new equipment is prone to bursting into flames! The lights in question are imported, and the recommendation is that only equipment passed by the relevant authorities be installed.

Computers have been know to catch fire, particularly if left on overnight. There is often considerable localised heat generated by the power supply of a personal computer, and the fire authorities have recorded a number of cases where the cause of fire was traced to a personal computer. The exploding capacitor is a fairly common occurrence in computer power supplies, particularly in the cheaper 'clones'.

I recall another more unusual incident where a soldering iron was close to a rag left on the work bench. The rag actually caught fire, although the user was present and able to prevent things getting any worse. A soldering iron burning through its mains cord is not uncommon, and the risk of fire through the combined heating effects of the short circuit and the hot iron is high.

Any of these events are more likely to end in disaster if a flammable liquid is nearby, such as methylated spirits or the like. In a workshop situation, fire hazards are more common, and many fires have been recorded as having started in the garage or workshop. Hobbyists beware!

Preventative measures

Minimising the possibility of a fire destroying everything you own involves two things – preventing the fire starting in the first place, or being alerted as soon as a fire starts. A combination of both is probably the best way, as no amount of care can completely eliminate the possibility of a fire starting.

The foregoing has possibly caused you to recognise a few potential risks present in your own environment. Obviously, the age of the equipment you use, or the manner in which you use it will relate to that equipment's safety. Here's a check list that you might like to apply.

Age of equipment: Old electrically powered devices, such as test equipment, radios, heaters, motors and so on are more likely to catch fire than new appliances. The usual cause is a breakdown of the insulation surrounding the wires or windings that operate at mains potential, although dust and grease build-up is also a significant factor. To

Evidence that a fire started from a power outlet: contact screws welded to the wires.

minimise the fire risk:

(1) Replace the mains cord, plug and on-off switch. If you wish to retain the old wiring for authenticity, then be aware of its fragility, and never leave the unit plugged in to a power point.

(2) Ensure the active is switched when the device is turned off. This prevents the mains potential existing between the frame (earth) and the electrics when the unit is (supposedly) switched off. Old motors and transformers are particularly susceptible to breakdown through the insulation surrounding the windings.

(3) Clean the appliance, particularly around those sections where mains (or higher) potentials exist.

(4) Replace any capacitors used as mains suppressors. Make sure the replacement is a good quality, 250V AC rated equivalent. Preferably, also install an internal fuse, between the active and the on-off switch.

Lights: (1) Incandescent lights can ignite wood, paper, chemicals and so on if close enough. The use of a naked globe should be avoided, for this and other safety reasons. Also, don't use high wattage globes in fittings not designed for them.

(2) Fluorescent light fittings represent a higher risk than incandescent globes, suggesting they should not be left on unattended. If this is necessary, for security reasons or whatever, ensure the lighting circuit is protected properly, either with an earth leakage detector, or at least with the correct gauge of fuse wire.

Mains wiring: Herein lies the real problem. Often potential trouble spots are hidden in walls, ceilings or under the house. Old installations are a much higher fire risk than new installations, although bad connections are a possibility in both. If you notice that the lights go dim when the stove is turned on or when the fridge starts up, start looking for bad connections.

(1) Old wiring (50 years or more) can cause fire through faulty insulation and

bad connections. Ideally, have the wiring replaced by a licensed electrician. If this is not possible, check the fuse box and all power outlets for signs of heat, and fit plug-in circuit breakers to the fuse box. These units are designed to plug into the original fuse holder, are inexpensive and available from most hardware stores. They offer a higher degree of protection than a fuse, as they detect overloads that the same rated fuse may not.

It would also pay to check as many connections as possible, although disturbing old wiring can often create more problems than it solves.

(2) New wiring should not be dismissed as being trouble free, as a loose connection or overload is still possible. If you find that a power circuit continually blows fuses or trips the breaker, you need another power circuit.

(3) In the workshop it is likely there will be many appliances connected to the mains. To ensure everything is turned off, consider fitting a main isolating switch that interrupts both the active and the neutral. I even have an indicator light fitted remotely to the workshop, to remind me if the power is on.

(4) Bodgy mains wiring is common in workshops. Always follow the rule that you will eventually forget whatever limitations apply to your wiring. In other words, run any exposed wiring in conduit, use the correct gauge (2.5mm for mains power) and cover any exposed connections.

I had an occasion recently when a monstrous storm caused water to leak into the garage and behind an old fashioned power outlet supplying a grinder. As I watched, the power point began to smoke. Fortunately I had fitted a main isolating switch, but this turned off the lights as well – leaving me in darkness. Needless to say I replaced that power point and its positioning as soon as I could. I was glad I happened to be there at the time.

Capacitors Over the years, I have formed the opinion that capacitors are the greatest fire hazard of all, in particular, those used as mains suppressors. These are usually fitted to amplifiers, computers, some fridges – in fact to a lot of appliances. The aim is to reduce transient noise at switch off.

(1) Only a few months ago I was using a tape head demagnetiser, which hadn't been used for some time. The unit was around 15 years old, and simply comprised a coil, a press-button and a suppressor capacitor. My use was sufficient to warm the coil somewhat, and when the job was over, I left it lying on the carpet and attended to other things. Soon the house was filled with smoke, and I was galvanised into action.

I traced the cause to the suppressor capacitor, which had broken down, helped on its way by the internal heating of the coil. No house fuses blew, and I'm sure it would have eventually started a fire.

The remedy is to either replace or remove the suppressor capacitor in equipment that is more than 10 years old. Always use the correct replacement type, that is one specified for 250V AC. Most mains suppressor capacitors have a 'self healing' dielectric, unlike other capacitors. In other words, don't assume a 600V or even a 1kV working voltage for a capacitor makes it suitable as a mains suppressor. Alternatively, add an internal fuse to the appliance, between the incoming active and *any* device it is connected to - including a suppressor capacitor.

(2) Beware of electrolytic capacitors. Tantalum capacitors get incredibly hot if connected with the wrong polarity, and can set fire to a combustible material quite easily.

Conventional electrolytics used in power supplies can undergo considerable stress, due to the internal heating caused by the charge/discharge currents. Sometimes the manufacturer will fit capacitors that incorporate a pressure release system, which prevents them actually exploding. Any replacement should have a similar type of protection.

There are probably countless other fire hazards that I haven't covered. I'm sure readers could recite many examples, both typical and bizarre where electricity has caused a fire. There is no simple answer of course. Therefore the other thing that you might like to consider is fitting some sort of alarm system.

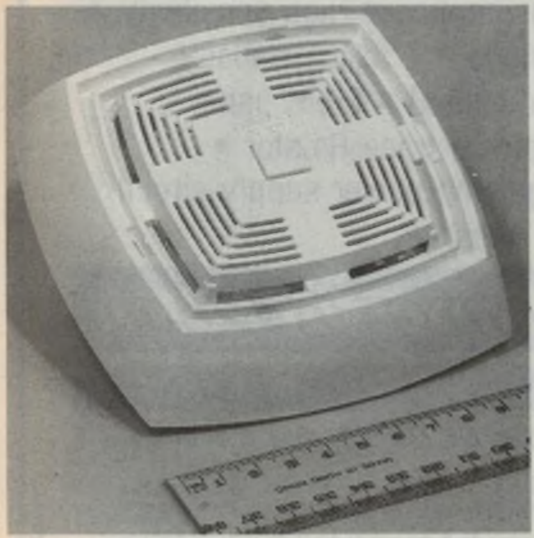
Fire alarms

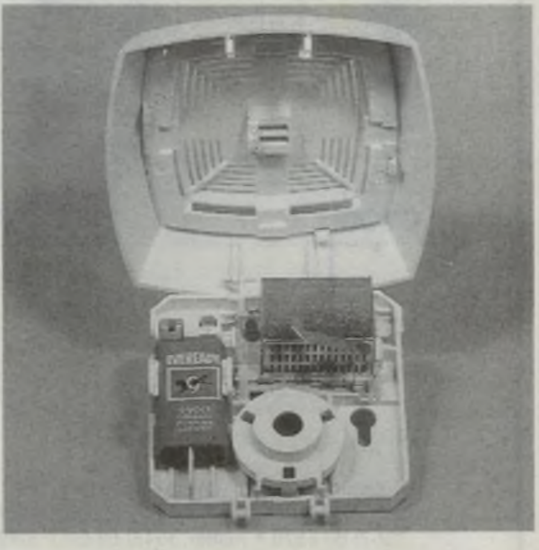
Fire alarms can range from a complex sprinkler system, such as those fitted in industry and public places, to single point heat or smoke detectors. According to Superintendent Ross Freeman from the NSW Fire Brigade fire prevention unit, there have been no recorded cases of a loss of life in a building fitted with a sprinkler system.

Similarly, statistics show that smoke detectors reduce the possibility of a fatality, and the recommendation from various officers from the Fire Brigade is to fit at least one single point smoke detector in the home.

Thermal detectors are sometimes used in alarm systems, but these have a delay of up to 15 minutes, and are not generally recommended in a domestic situation.

There are two types of smoke detectors commonly used – one works on





Outside and inside views of the Ten-Tek/Dicon SA-4 smoke detector, discussed in the text. It offers reliable protection at low cost.

ionisation, the other uses an infrared beam and is known as the photoelectric type. In this type of detector, a pulsed beam of infrared light is beamed across a darkened chamber. When smoke enters the chamber, the light will be scattered, and picked up by a photoelectric device within the chamber, setting off the alarm. The photoelectric type is less prone to false alarms, but is more expensive.

The ionisation type is the most common, and works by ionising the air in a chamber to create a small electrical current between two charged plates. When the tiny particles created by a fire reach a preset density in the chamber, the current will fall, activating the alarm.

In Toronto (Canada), every house is required to have at least one smoke detector/alarm that can be heard in all bedrooms with the doors closed, and no doubt similar laws apply in other parts of the world. A typical detector is an integral unit, containing the detector and the alarm. They can be battery or mains powered, and usually have some sort of test function and low battery indicator.

The question of which type of detector and how it (or they) should be powered is a matter for the individual. Battery operation is more convenient from the installation point of view, and also provides protection in the event of the mains failing. However, the batteries need to be replaced annually, and the possibility of a flat battery is always present.

We are aware of at least two brands of smoke detectors being available in Australia, one costing around $40, the other $70.

The $40 unit is the Ten-Tek/Dicon SA-4, imported from Canada by Smoke Detectors Australia. It is battery powered and has an 85dB piezo alarm. It also has an operating LED that flashes every 60 seconds to indicate that the unit is powered, and will beep every 60 seconds (for up to 30 days) to indicate when the battery needs replacing. Installation is simply a matter of attaching it to the ceiling (or wall) with two screws.

No information was forthcoming on the other locally available detector, from Wormalds, but presumably it has similar operating characteristics. The point is, smoke detectors are available, and they are not expensive.

Summarising

Articles like this often make uncomfortable reading (and writing) – almost like a list of all the things that are bad for you.

We started by saying that electrical fires, where the electrical energy is at fault are not as common as popular belief holds. Then comes a dissertation on the likely causes of these types of fires – enough to make you want to change to an alternative energy source.

But if we have made you think, and perhaps act to remedy a few potential fire hazards, then this article will have been useful. The two most important things to check are your fuses and if the garden hose is attached to the tap.

Finally, for further information on smoke detectors, contact (a) Smoke Detectors Australia, at PO Box 587, Neutral Bay 2089, or phone (02) 969 5816; or (b) local branches of Wormalds.

Our thanks to the NSW Fire Brigade for their help in the preparation of this article. Particular thanks to Messrs John Boath, Bruce Johnson and Ross Freeman. Thanks also to Ron Richards, of Smoke Detectors Australia.

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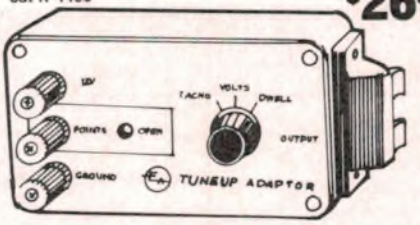

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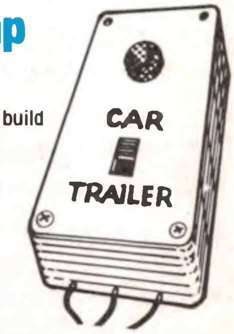

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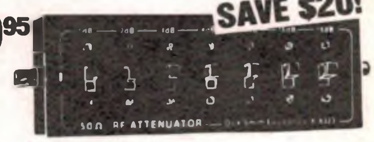

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Robotics: the slow motion revolution

Despite the fact that industrial robots were originally developed in the USA, the vast majority of American manufacturers are still not using them. As in most of Australian industry, the robotics revolution is really still only getting started – as this report explains.

by STEVE KAUFMAN

As a half-dozen robots simultaneously swing their arms at lightning speed inside the 90,000-square-foot facility at Adept Technology in San Jose, California, Brian Carlisle can't help but feel optimistic.

"There's enormous potential in the robotics industry" boasts Carlisle, the lanky, 37-year-old co-founder and chief executive of one of the nation's few profitable robot manufacturers.

Ostensibly, he's right: Among the 70,000 durable goods manufacturing plants in the United States, only about 400 use robots. Altogether, they contain nearly 30,000 robots – about five times the number in use in 1982.

Nonetheless, most observers say that the robot – once touted as the best hope to revive the country's ailing manufacturing sector – may still be decades away from widespread acceptance.

Carlisle's company is one exception, but the heady days of growth in the robotics industry have been short-circuited. Despite a boom in the manufacturing sector, sales among US robotics makers fell 32% in 1987 to US$299 million, the third consecutive annual decline, and sales were depressed again in the first quarter of 1988.

GM slashes budget

Perhaps the most obvious symbol of the industry's problems is General Motors, which fueled the nation's interest in robots by ordering thousands of the machines as part of a massive plant modernization program in the early 1980s.

But GM has been plagued by slipping market share and problems in meshing its robots with the rest of its manufacturing operations. As a result, the giant automaker canceled nearly US$100 million in robot orders in 1985 alone, and since has curbed orders substantially.

Not surprisingly, few observers are optimistic about the robot industry's short-term prospects. Robots tend to be one of the last pieces of equipment purchased, and one of the first to be cut when budgets are squeezed.

"Robots are still considered a luxury, not a necessity," says Melinda Pyle, a robotic industry analyst at Dataquest in San Jose. Pyle and others add that horror stories about the implementation of robots have given many prospective buyers cold feet. Generally, the process has consumed many more months than expected. Companies have found that exacting robots don't tolerate slight variances in parts, further slowing the manufacturing process. Factories also must continue to ship products while complex robotics systems are installed, and the juggling act is never simple.

Too good?

And robots may be too flexible for their own good. "We know what a machine tool does: It cuts. But what exactly does a robot do?" says Laura Conigliaro, a computer-aided design and computer-aided manufacturing industry analyst at Prudential Bache Securities Inc. in New York. "It's tougher to sell something that can do so many different things. Most companies don't know exactly what they would do with one."

Longer term, though, many US companies may have little choice but to embrace robotics as a matter of survival.

Even the industry's most pessimistic observers concede that robots usually improve quality. Their flexibility also enables factories to keep pace better with rapidly changing products, experts say. This is especially true in high-tech industries, where many products have shrinking shelf lives of two years or less.

Yet another compelling reason for robotics in the United States is that the Japanese – the world's acknowledged leader in manufacturing excellence – use about four times as many robots as US manufacturers do, observers say. California's Silicon Valley could have the most to fear on this front: Japanese manufacturers are increasing the use of robots in electronics assembly at a faster clip than in any other industry.

Frederik Schodt, the author of a new book about robotics in Japan, says robots there have helped make the Japanese fierce competitors. As one example, he cites the extensive use of robotics at a Casio calculator plant south of Tokyo, which can make changes on assembly lines in a matter of minutes to accommodate the production of 16 kinds of calculators.

"Nothing in US manufacturing approaches this level of flexibility," Schodt says.

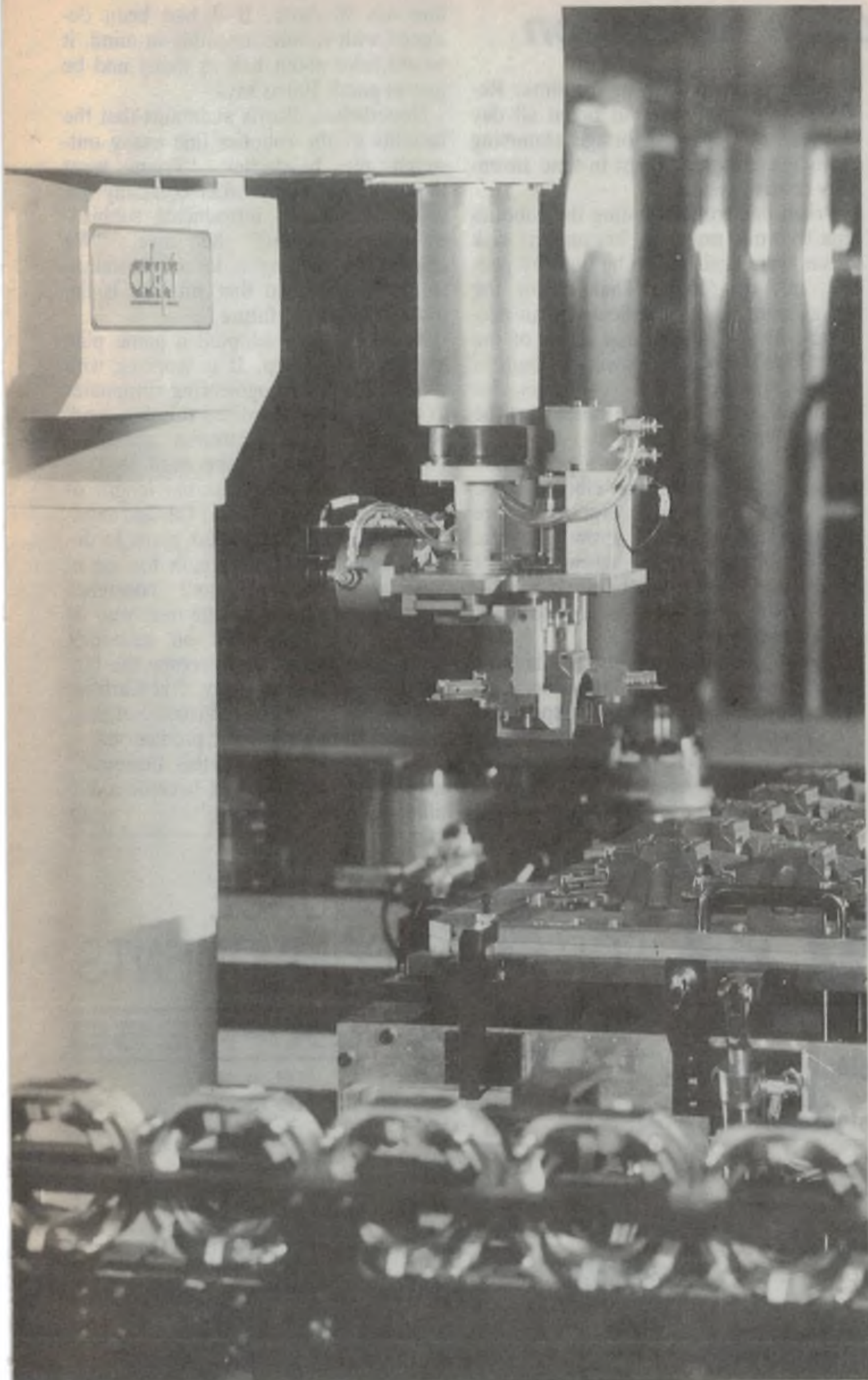
More significantly, robots improve quality by virtue of their ability to endlessly perform the same task precisely the same way, Schodt and others say.

"The most critical thing in manufacturing assembly is stabilising the level of quality", Schodt says. "Once you achieve that, it's much easier to improve quality. It's very hard to make progress if things are done differently every day at various steps throughout the manufacturing process."

More time needed

In the short term, robotics may find the most promise in the electronics industry. Some Silicon Valley companies, such as Komag of Milpitas, a maker of high-capacity memory disks for small computers, say they wouldn't be able to run their businesses without robots.

When Komag started shipping its products in October 1984, it used four light-assembly robots on one production line. Today, it has 42 robots in three buildings encompassing 200,000 square feet, and the company plans to order at least a dozen more in the next year. "Our ultimate goal is complete automa-



An AdeptOne robot picks up an upper bracket for assembly into a Discovery II vacuum cleaner motor, at the Electrolux plant in Piney Flats, Tennessee.

tion," says Ron Allen, Komag's automation group manager.

The potential in such markets isn't lost on the nation's largest robot maker, GMF Fanuc Robotics of Auburn Hills, Michigan – a joint venture of General Motors and Fanuc of Japan.

GMF felt the sting of GM's cutbacks on robots. Sales fell 45% last year to US$102 million, and the company lost money. Now it's trying to diversify into the electronics, construction equipment and aerospace industries. The company says 45% of its revenues will have come from non-automative industries in 1988, up from only about 15% in 1986.

"The challenge is getting across the message that robotics makes sense in thousands of different kinds of companies, both large and small," says Eric Mittelstadt, GMF's chief executive and president.

Adept Technology obviously wants to make the same point – and it should find it easier to do so. It is the US leader in small-parts robotic handling and assembly, with 34% of the US market. Adept has an installed base of 1,400 robots, and they're commonly found in the electronics, household appliance, automotive, aerospace, pharmaceutical, food processing and consumer goods industries.

Adept also sells vision systems separately, for manufacturing inspection and quality control. The privately owned company, which was founded in June 1983, has fared well by the standards of the robotics industry. It posted sales of US$31 million in its fiscal year ended in June 1988, up from $18.6 million in fiscal 1986, and it projects sales of nearly $40 million in fiscal 1989. The company says it has been profitable since December 1985.

Adept has been able to achieve such results partly because it avoided the mistakes of its bigger competitors. Unlike GMF, it has never relied heavily on the cyclical automobile industry.

It also has specialized in making light-assembly robots, the industry's fastest-growing segment. Moreover, Adept's approach to installing complex robotics systems that work in sync with other factory equipment seems to shine, in an industry with a notoriously bad reputation when it comes to making robots work correctly inside a factory.

"Adept Technology is miles ahead of other companies in the robotics industry," says Conigliaro of Prudential Bache.

Dataquest's Pyle says, "Adept is a very savvy marketer, in an industry in which most companies just try to get an order any way they can."

Still, growth would be more impressive if it weren't hampered by the unusually long selling cycle in the robotics business, co-founder Carlisle says.

Because the average robotics work station costs nearly $200,000 and repre-

Robotics: slow motion revolution

sents unfamiliar technology, companies may take up to two years before they decide to buy one, he says. Once the sale is made, a systems engineering company may take a year or more to design a work cell around the system. Installing the system in a factory and working out the bugs can take up to six more months.

Start-up problems

Disk-drive maker Priam spent US$5 million to install 22 Adept robots in one of its two San Jose manufacturing plants in 1987. Ron Barris, the company's vice president of operations, figures the system has paid for itself in less than two years.

And the next time Priam develops a new drive, the robots will enable the company to put it into commercial production in half the time it otherwise would take, Barris says. "We have one of the most sophisticated robotics systems in the world", the 45-year-old manager says.

But getting the robotic line to the point where it could produce disk drives in commercially acceptable yields wasn't easy. It took 14 months. Even today, the line is down 15% of the time. Recently, the line was shut down all day because of a parts shortage stemming from the company's just-in-time inventory control system.

Priam had trouble getting the robotics line to work properly, because its disk drives were designed to be built by people, not by robots. That meant the drives were more complicated than necessary. It also meant that many of the disk drive's components weren't built to precise specification. Screw holes, for example, often weren't bored to the proper depths.

That's not a big deal to a production worker, who can apply elbow grease and make the screw fit. But robots are programmed to turn a screw a precise number of turns. If the screw still isn't secure, the robot ships the drive to a repair station, where it is disassembled and painstakingly fixed.

These problems spotlight the lack of communication between engineers who design products and those responsible for designing the systems to manufacture them, Barris says. "There's still a big cultural gap there."

The disk drive made on the robotics line has 90 parts. If it had been designed with robotic assembly in mind, it would have about half as many and be just as good, Barris says.

Nonetheless, Barris maintains that the benefits of the robotics line easily outweigh the headaches. "Priam went through what every other company has to go through in introducing sophisticated automation," he says. "We learned by making a lot of mistakes. But I'm convinced that robotics is the foundation of the future."

Adept recently adopted a game plan to speed things up. It is working with six of its systems engineering companies to develop a standardised robotics work cell for use in electronics assembly. That would eliminate the need for custom engineering and cut the length of the sales cycle up to 70%, Carlisle says.

The company has similar plans to develop standardised work cells for use in mechanical assembly and consumer goods packaging within the next year or two. If things proceed on schedule, Adept eventually could become the biggest US robotics company. But Carlisle, a 13-year robotics industry veteran, hesitates to make specific predictions.

"Things take time in this business", he says. "Robotics won't become a $10 billion industry overnight."

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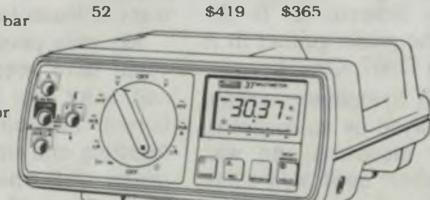

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- Touch Hold™ function

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- Safety Yellow case
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- Two year warranty

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DM6235	$99.60	$83
DM6335	$118.80	$99

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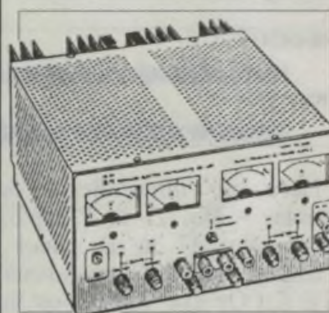

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Compact Disc Reviews

by RON COOPER

BEETHOVEN

Beethoven Piano Sonatas
Volume II
John O'Conor
Telarc CD-80160 DDD
Playing Time: 64 min 10 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

Here are three Beethoven Piano Sonatas – No. 21 in C Op.53 'Waldstein', No. 17 in D minor Op.31/2 'Tempest' and the 'Les Adieux' No. 26 in E flat Op.81a. These most impressive piano works were written at various intervals between 1802 and 1809, when Beethoven's deafness was encroaching.

As such, it is also the sonata from Op.31 which is best able to give some hint of the inner turmoil affecting its creator at the time, for these sonatas are contemporareous with the famous 'Heiligenstadt Testament', the anguished letter – part will and part howl of desperation that Beethoven penned in 1802.

"Ah, how could I admit an infirmity," he lamented, "in the one sense that ought to be more perfect in me than in others."

Pianist John O'Conor was introduced to American audiences with the best references from Europe. This Irish pianist and his performances are marked by critical acclaim everywhere and on serious listening to this disc it is not surprising. Any words I might add would be superfluous as this disc is simply superb in all respects.

I think it fortunate that John O'Conor is on Telarc as I feel this organisation produces such consistent top quality recordings to put them right up with the best, if not ' the best', in the world.

This disc is even better as my previous 'mild' criticism of Telarc was playing time. Now at 64 minutes and 10 seconds, and with excellently detailed cover notes, this disc is a bargain at whatever price.

normal. However, the piano solo tracks do lack some depth in the balance and appear to be recorded at a lower level than usual.

Although this disc is a late recording and the sound quality quite well balanced, it lacks acoustic coherence and is a little edgy. Perhaps on lesser playback equipment this may be less noticeable and in any case it is certainly worth the low $9.90 price tag.

SCHUBERT

Franz Schubert
London Festival Orchestra
David Blackside
VMK Globe 100.41802 DDD
Playing time: 62 min

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

This disc contains 62 minutes of very popular Schubert works, including the delightful Symphony No. 5 in B flat major. The other works are: Impromptu Op.142 No.2 in A flat major (1821), 'Moment Muscial', Op.94 No.3 in F minor (1828), the Scherze in B flat major (1817) and the piano quintet in A major, (The Trout) D667, Op114.

Curiously the 5th Symphony, written in 1816 was only played by an orchestra of mainly amateur musicians and was not formally published until well after Schubert's death. The first performance was in 1873. The piano works above have become part of the concert repertoire and will be familiar to most listeners.

The musicians here are first class with sensitive playing and the tempos are

DAVIS

Carl Davis
London Philharmonic
Strauss, Brahms, Delius, Copland, Davis
Virgin Classics VC 7 90716-2 DDD
Playing time: 67 min 2 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

The title of this disc should really be 'Well played semi-popular pieces'. Carl Davis, while an excellent conductor, is not known by most people and this is a very good recording of music to play when you don't know quite what you want to listen to.

My only personal regret is that there could have been a little more Copland and a lot less Delius – but yes, I am biased. The selections are otherwise interesting and introduce some very good pieces with which most people will not be familiar. The selections have excellent cover notes and are Carl Davis – Philharmonic Fanfare; Johann Strauss (son) – Suite 'Die Fledermaus' (arr. Carl Davis): Overture, Fledermaus Polka, Tik-Tak Polka, Czardas, Du und Du Waltz; Johannes Brahms – Andante from String Sextet No. 1 in B flat major, Op.18; Frederick Delius – Orchestral Suite from 'A Village Romeo and Juliet'; Aaron Copland – Fanfare for the Common Man.

Davis's own Philharmonic Fanfare is a great piece and was written as a greeting to the audience at some of his concerts. It introduces each section of the orchestra in turn, starting with the brass.

The music from 'Die Fledermaus' is a well known favourite with wide appeal, and the very pleasant nineteen minute selection presented here was arranged by Carl Rains.

Braham's Sextet for Strings was used in the French film 'Les Amants'. Impressed by this Carl Davis's suggestion to David Mathews culminated in this excellent arrangement presented here which exploits the rich harmonies of this great composer.

The Delius work has a fine opening. I don't find this composer's musicci terribly inspiring, but no doubt it has a 'certain appeal'.

The Copland is a bright and delightful contrast, to end this most interesting disc which is well recorded, with very good overall balance and acoustics.

SMETANA DVORAK

The Bartered Bride
Slavonic Dance No.2
Symphony No.9 'From the New World'
London Symphony Orchestra
Alfred Scholz
ZYX Classic CLS 4015 DDD
Playing time: 64 min 4 sec

PERFORMANCE
1 2 3 4 5 6 7 8 9 10

SOUND QUALITY
1 2 3 4 5 6 7 8 9 10

This is a budget ($9.90) disc offering very appealing music performed brilliantly by mainly, little known artists.

Smetana's comic opera 'The Bartered Bride; was first performed in 1866. Its naive story and humour is reflected in the character of the music, with typically Czech folk dances and melodies. It is a national opera in its homeland and the music can be described as light, colourful and foot-tapping. The performance of these dances here is quite stunning, with its brilliant pace and string virtuosity.

The Salvonic Dance No. 2 is a quieter melancholic piece, giving a short contrast to the previous selection.

The New World Symphony of Dvorak is a real evergreen, and is very well played with a slightly slower opening adagio than usual. The following Allegro is quite brisk, with the rest of the tempos 'quite normal'.

The sound is somewhat over-reverberrant with a tendency to sound slightly hollow at times, but this was less evident in the 'Bartered Bride' which seems to have a better acoustic environment.

The greatest appeal of this disc is the performance of the 'Bartered Bride; and the price – considering the amount of playing time.

When I Think Back...

by Neville Williams

On organs – electronic and otherwise

The now ubiquitous electronic organ has been conceived and developed within the 55-odd years that I have been associated with the electronics industry. I've always been fascinated by them, not just in isolation but against a background of much older acoustic instruments – ranging from the humble harmonium to giant pipe organs like the one in the Sydney Town Hall.

At a personal level, I was encouraged to 'learn' the piano as a lad. But tiring of scales and exercises without sufficient other motivation, I invented so many excuses for not practising that my teacher finally gave up.

I emerged from the experience with the rudiments rather than the fundamentals of the art, at best able to stumble through the 'Chariot Race March' in a most un-Ben Hur-like fashion!

But left to my own devices, I later discovered that I could cope reasonably well with the chord music that generations of hymn writers had written for generations of adherents in small churches. In fact, there came the day when, in the absence of my mother, I was asked to play for a Sunday afternoon service in a typical country community hall.

It involved playing not the beer-stained Beale piano, but a portable Estey reed 'organ', of the kind beloved by one-time street evangelists: an abbreviated keyboard, no stops and a drop-down stand, fitted with two pedals connected by canvas webbing straps to the somewhat leaky bellows.

Playing it was a breeze, in more ways than one. As with other organs, notes sounded while ever the relevant keys were pressed, effectively concealing my limited digital dexterity. Given the humble nature of the music and the limited resources of the instrument, it was perhaps not all that surprising that several people assured me that I had "managed very well".

In fact, I was sufficiently encouraged by the experience to take up my grandmother's offer to play her beloved 12-stop Estey any time I liked – a traditional Victorian reed instrument if ever there was one, surmounted by a mirrored superstructure, with shelves for hymn books and family whatnots. So began an interest that turned out to be a useful complement to a career in electronics.

As it happened, my younger brother followed much the same path to familiarity with reed-based instruments – variously described in their day as reed organs, 'American' organs or harmoniums.

A few years on, we were able to pick up unwanted reed organs for a proverbial song. They were often battered and unserviceable, but worth inspecting as a possible candidate for restoration to the melodic kind of instrument we both hoped one day to find.

Pipe organs

Brought up in the country, neither of us had been exposed much to pipe organs of any kind. They belonged to a world far removed from the small country – later suburban – churches which our family attended and in which we sometimes took a turn at playing.

In 1930, while I was still a student at Parramatta high school, Western Suburbs Cinemas had opened their 'Spanish' Roxy theatre in that suburb (now city) – complete with an 1850-pipe Christie organ and a much publicised resident American organist, Eddie Horton.

A class-mate Wilbur Kentwell, himself a young church organist of more than usual ability, struck up an acquaintance with Eddie Horton and was occasionally allowed to play the big

A church organist at age 11, Knight Barnett was an original member of the staff of Sydney's pioneer radio station 2BL. He later became a featured organist on the Sydney theatre circuit and on Sydney radio, playing at eleven theatres including the Capitol and Prince Edward. He is pictured here in 1938.

Christie – usually on Wednesday afternoons, when he should have been at sport! Wilbur later earned quite a reputation as a theatre, radio and recording artist but, at the time, his exploits were simply a topic for classroom – and staffroom – chatter.

However, I shall never forget the night, shortly after starting work at Reliance Radio in Sydney, that I went along to the Burwood Palatial theatre, to hear Knight Barnett at the organ. I was astounded by the virtuosity of the player, the resources of the instrument, and its massive, clean sound – in true stereo – from the pipes and effects ranged on either side of the proscenium.

At that point, I became an instant enthusiast of the theatre organ and an eager listener to on-air recitals by contemporary organists like Knight Barnett, Jim Williams, Paul Cullen and Norman Robins. I still have a Regal-Zonophone 78rpm record that I bought to check radiograms at Reliance Radio – Reginald Dixon's 'Blaze Away' and his memorable 'Parade of the Tin Soldiers'.

Even now, I have no difficulty in recapturing that early reaction, when I hear their modern-day counterparts like George Wright, Lyn Larsen and Melbourne's Tony Fenelon.

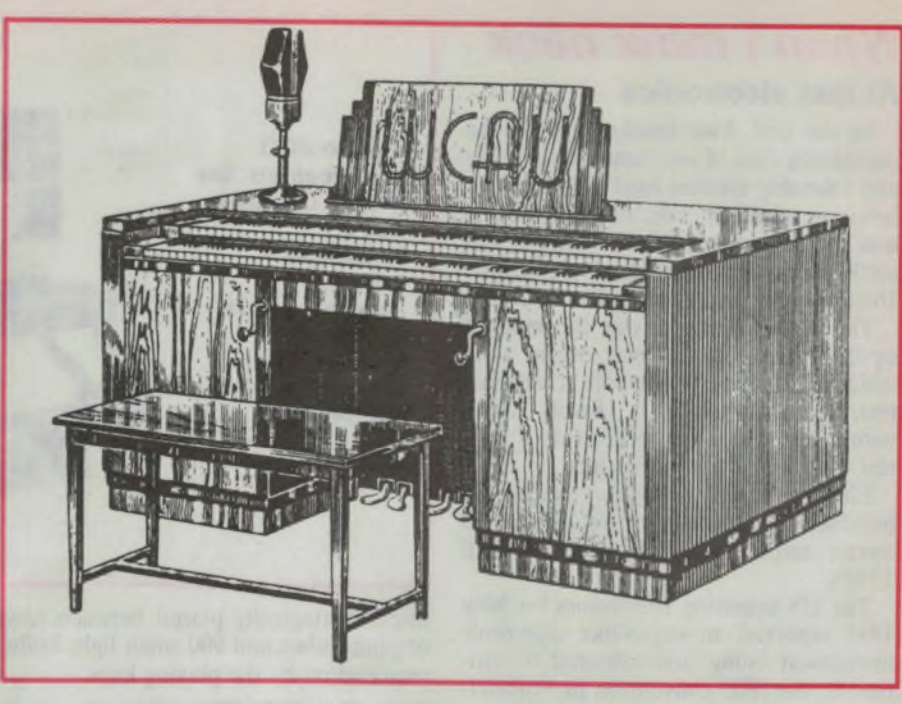
I was later to develop a different kind of regard for the huge 5-manual 9,000-odd-pipe classical organ in the Sydney Town Hall. Indeed, the most massive organ sound that I recall ever hearing was won from that same instrument by Marcel Dupre playing the Marseilleise! Yet, in the same recital, he coaxed from the organ the most delicate, lingering harmony that one could imagine in such an environment.

A vain quest

But back home, like many of our humble counterparts in local church groups, my brother and I were for ever on the look-out for the unlikely, if not the impossible: a more pipe-like, less reedy reed organ that we could afford.

Somebody mentioned one in the headquarters of a fringe religious group, that was supposed to be available for little more than the cost of removal. It turned out to be a very bulky instrument with two manuals and pedalboard, and a separate electrically powered blower.

It was a traditional French instrument, we were told, that had been played by many well known organists and highly praised for its pipe-like qualities. Unfortunately, we had no way of verifying this, because the blower wasn't working.



Developed in the early 1930s at American radio station WCAU, this organ-like instrument derived its tones from patterns on a moving film. A later, more versatile model relied on holes in spinning discs placed between small lamps and phototubes.

No less to the point, the building had been added to since the organ had been installed and there was no way of getting it out, except in pieces smaller than the manufacturer had originally envisaged. Enough said!

Another find

We did, however, manage to get hold of a two manual reed organ shortly afterwards. Branded Aeolian, as I remember, it comprised, in effect, two fairly normal reed chambers, one mounted upside-down above the other. They were pumped by a common set of bellows and foot pedals, the manuals being pneumatically coupled by a forest of 1/4" (6.5mm) O/D rubber tubes. The existing tubes had long since perished, but we reckoned that it would be easy enough to fit new ones.

As we took delivery of the organ, my brother was already working out how he could replace the bellows with an electric blower and add a pedal clavier coupled through to the 16ft reeds. In fact, in an earlier burst of enthusiasm, he had already cut out and sanded a set of pedals, which were stowed under the bench in the garage.

But first, with the internal works of the Aeolian checked and repaired and the reed banks de-bugged, we faced up to the job of re-coupling the manuals, armed with a large spool of black rubber tubing.

We set about the task late one afternoon, but decided to work on through the winter evening – in an unlined galvanised iron garage, with the help of a couple of lights and a single 1000W radiator. Pushing the tube-ends over rows of brass nipples was rough on the fingers but we got the job done, switched off the power and went our separate ways.

Next morning, I got a call from my brother, sounding utterly devastated. He'd just been down to look again at our handiwork: Alas, in the frosty, wee small hours, a lot of the rubber tubing had hardened, split and fallen off the brass nipples.

Fortunately, we were able to do it all over again with the then relatively new PVC tubing, which proved rather more durable. But the pneumatics could never be entirely trusted and we finished up leaving the back off the organ so that, if a tube fell off, one of us could reach around and replace it, surreptitiously or otherwise!

The novelty soon wore off, however, and the enthusiasm for adding a blower and pedal clavier cooled – the latter of necessity: a senior member of the family, fossicking around the garage for garden stakes, found a dozen or more bits of wood under the bench that were about the right length!

When I think back

At last electronics

In the end, I/we finally came to the conclusion that, if one wanted a reliable and tolerably musical reed organ for the home or small church, the best course was to forget all the fancy notions and settle for a conventional, single-manual 16-stop Estey or a close equivalent.

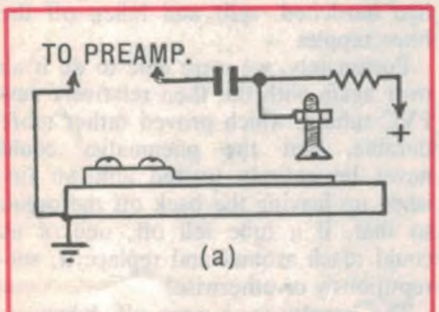
This we did, and it was the kind of small-church or cottage organ with which I tended to compare electronic instruments when they finally came within our grasp. It was scarcely a contest – but more about that later.

Electronic instruments, commonly heralded as 'pipeless organs', began to attract attention in the early to mid 1930's.

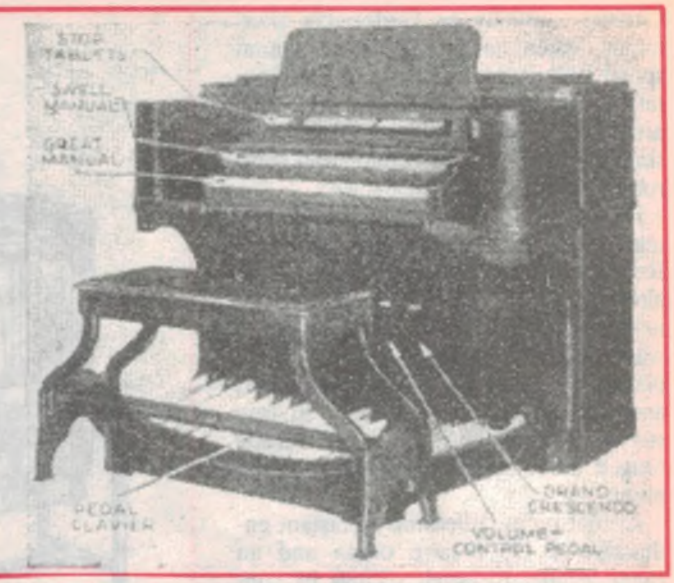
The US magazine *Electronics* for May 1934 reported an organ-like electronic instrument being demonstrated to visitors at the IRE convention in Philadelphia. Developed in the studio/laboratory complex of radio station WCAU in that city, it produced tones derived from photographic patterns recorded on continuously moving film loops.

In July 1934, the same magazine carried an article on a piano-like 'clavier' developed in a factory at Kalamazoo, Michigan. It used steel reeds which, when plucked, set up signal currents in adjacent magnetic pickup-up coils. Amplified and subjected to attack and tone control, frequency doubling and optional vibrato, a wide variation in sound timbre was said to be possible.

The WCAU enterprise was mentioned again in the July '35 issue of the American *Radio News*, with the development of a more practical organ, having two manuals and a row of stop tabs. The source signals for this model were produced by patterns of holes in spinning discs, strategically placed between rows of phototubes and 900 small light bulbs, switched on by the playing keys.



Illustrating the principle of electrostatic signal pickup from a reed. The principle was used in the Everett Orgatron in the 1930s but was seldom successful when added, handyman fashion, to existing reed organs.



Built to AGO specifications, the Everett Orgatron was an impressive looking instrument. But its interim reed/amplifier technology was short-lived.

The Everett 'Orgatron'

Coming nearer to home, and reality, the Baptist church in Auburn (Sydney) circa 1936, replaced their traditional two-manual reed Estey with an Everett Orgatron. This was after a recital in competition with the most obvious alternative at the time, the newly released Hammond.

Conforming to AGO (American Guild of Organists) specifications, the Orgatron was essentially a two-manual and pedal reed-based instrument, fitted with tiny brass screws which picked up electrical signals from the vibrating reeds by capacitive coupling. (See diagram). According to Everett, their design philosophy was to use air-driven brass vibrators (reeds) rather than oscillating valves to generate the basic tones, the vibrators being selected, tuned and voiced by time-proven methods.

The reed chambers were muffled, to minimise the direct sound output, while the screws were critically positioned relative to the vibrational mode of each reed to optimise the harmonic content for the desired voice. The signals were merged, selected and processed electrically, under the control of conventional stop tabs, expression pedal etc., and reproduced by amplifiers and loudspeakers.

I heard the instrument only once, in routine use but, while it seemed to be quite good, I did wonder whether it was chosen by the church as much as anything for its traditional styling and non-radical technology.

I gather that Estey and Wurlitzer also showed short-term interest in reed generators but, to the best of my knowledge, the approach won only interim acceptance and was soon overtaken by Hammond – and by a variety of other organs which relied on valve oscillators for tone generation.

But electrostatic pickup certainly caught the imagination of frustrated reed organ owners, and articles appeared in various magazines suggesting how the idea might be applied in existing – and usually ageing – instruments. In practice, most individual attempts along these lines proved abortive.

Apart from anything else, in a home or small church, the direct sound from the reeds would still be prominent, largely defeating efforts to superimpose a better sound electrically.

Again, the scope for inserting pick-up screws in an existing reed chamber was usually limited and the harmonic structure of the derived signal largely a matter of chance. Add to this problems of mal-tuning and intermodulation, and the end result was more likely to resemble the sound of an indifferent accordian than a pipe organ!

Hammond's approach

But to get back to Hammond: An American company founded by Laurens Hammond, it was known early-on for its electric clocks. However, Hammond had been fascinated from boyhood by church pipe organs and, as a graduate engineer, saw the need for an instrument that would be more affordable and easier to instal and maintain.

His well-proven synchronous clock became the starting point for his own answer to the problem – an electronic organ built around a set of electromechanical tone generators. The system, as illustrated, was the subject of patents applied for in January 1935 and granted in January 1936 – the same year in which the instrument was released to major markets, including Australia.

It involved the provision of eighty or more cam-shaped or toothed tone wheels, spun in groups at constant speed by a mains powered synchronous motor. A magnetised polepiece carrying a pick-up coil was positioned close to each tone wheel, such that a continuous waveform was generated across the coil as the teeth passed the pole-tip.

A separate tone wheel was provided for each frequency component required by the organ, the rotational speed and the number of 'teeth' being selected to bring its output frequency as close as mechanically possible to the required musical pitch. As well, the geometry of the teeth and pole tips was so arranged as to generate a predominantly sinusoidal waveform.

Drawbar attenuators, calibrated 32ft, 16ft, 8ft, 5-1/3ft, 4ft, etc., made available various harmonic pitches, allowing the synthesis of many different 'tone colours' – so that pressing any key would produce a composite or 'sum' signal, as determined by the drawbars. This was fed to an amplifier system controlled by an expression pedal, and optionally embellished by chorus, tremolo, attack, decay, reverberation and so on – effects which tended to multiply with each successive model.

While the use of harmonic drawbars seemed totally logical to Hammond engineers and technically-minded musicians, it tended to confuse and alienate others accustomed to thinking in terms of traditional drawknobs or stopkeys, voiced and preset by the organ builders.

The early Hammonds

The first Hammond which I heard to advantage was an early model installed in the then-new studios of Sydney radio station 2CH, and frequently played by Des Tanner. Yes, it sounded somewhat 'electronic', but by no means unpleasantly so. And if it lacked the harmonic complexity of a pipe organ, it was far more pipe-like and listenable than any reed instrument I had ever encountered.

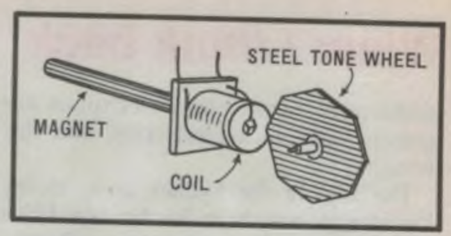
Being much less expensive and far easier to install than a pipe organ, later and more highly specified models found their way progressively into concert halls, large churches, theatres, resorts and radio/recording studios around the world.

An odd copy of the *Hammond Times*, which ended up in my files, features a Hammond organ with orchestra at the Hamburg Opera House (Germany), at radio studios in Warsaw and Poznan (Poland), at the Sacred Heart Cathedral in Broken Hill (NSW) and the Savoy theatre in New Lambton (Newcastle, NSW) – played at the time by Wilbur Kentwell. These, plus hotels and entertainment centres in various countries, and accomplished organists touring with a Hammond.

According to the Theatre Organ Society, other resident organists featuring on theatre Hammonds in the Sydney/-Newcastle area in the 1930s and '40s included Jim Williams, Les Waldron, Ron Boyce, Iris Mason, Peter Rowe, Geoff Robertson, Stanfield Holliday and Des Tanner.

For smaller churches and private homes, the spinet models also proved popular, being notable for their reliability, freedom from tuning worries and the 'roundness' of their sound.

Some of those early Hammonds are still soldiering on, tonally bland by comparison with modern solid-state instruments but distinguished by the fact that, with their sinusoidal tone structure, mistakes by inexperienced players are never quite as noticeable as on an instrument with a more prominent harmonic structure.



The Hammond principle involving a magnetic pick-up coil adjacent to a spinning tone wheel. The serrations could be cam-like flats for very low frequencies, and actual teeth for high frequencies.

But all that is now history. The tone wheels have given way to crystal locked solid-state signal sources, and even the Hammond name has changed hands. Sad, even if sentimentally so!

Building one's own

Such was the appeal of the early Hammonds that the idea of building one's own grabbed quite a few organ

The Stromberg-Playmaster kit organ, described in this magazine during 1961-2. Small electronic organs like this took over from reed instruments, showing the way for bigger and better spinet models which are now routine in homes and small churches.

When I think back

enthusiasts – particularly electronics engineers with mechanical skills, and vice versa.

The first in the Sydney area, to my knowledge, was built in the late 1930s by Neville Oates, an engineer at Stromberg-Carlson, who was subsequently involved in that Company's belated and abortive venture into electronic organs.

Encouraged by his success, a group of engineers and enthusiasts addressed themselves to the same task, pooling their resources to organise the necessary bits and pieces in job lots. One member of the group was a friend from the old Reliance Radio days, Ray Tonks; another was Ernest Benson (now Dr Benson, retired), a senior AWA engineer.

Back in 1942, I remember visiting Ern Benson's home to look at his finished organ, in the company of *R&H* science writer Calvin Walters – an amateur pianist with a ready repertoire of popular tunes. Ern had the console and loudspeakers set up in the lounge room and the tone generator mechanism in the basement, with signal cables coming up through the floor. As I write this, it is still working, 47 years on!

Not surprisingly, my brother and I decided that this is what we'd really been looking for. I supplied the good intentions; he set to work to stamp out a couple of hundred mild steel discs for the tone wheels – but that's about as far as we got.

Talking with him during the preparation of this article, he remembered where the pile of steel discs had finally ended up: as counterweights for the home-made tilting door on his garage!

The Stromberg/Playmaster

My ultimate venture into organ building was much less adventurous. Faced with a downturn in the production of TV receivers, Stromberg/Carlson A'asia had reached agreement with Thomas organs in the USA to build and market their basic single-manual model in Australia.

The organ which convinced the writer of the futility of building one's own: the GEM C-150. With an excellent array of preset voices on both manuals, accessed by tabs, it even included a set of Hammond-like drawbars for the upper manual.

Production had barely got under way when the Company was faced with closure and, as Editor of *Radio, Television and Hobbies*, I was asked whether we would like to present the organ as a home construction project – to absorb the inventory of components which Stromberg-Carlson had purchased.

We took up the offer and the project was covered in a series of articles in the magazine beginning in December 1961. In fact, I/we went one better, by adding extra facilities and voices not provided in the original instrument.

With a price tag well below market prices at the time, quite a few of the organs were built by readers for private use or for installation in small churches. Simple though they were, they were invariably preferred to the existing reed organ.

Electronic organs have since become routine in small churches and the homes of amateur organists; a reed organ, still in place, is a now real curio. Why else would I spend an hour in a relative's home in the Shetland Islands, re-activating enough reeds in their long-silent organ to play a few tunes from the kirk hymnbook? Or talk my way into playing few chords on an organ similar to my late grandmother's Estey, in the Wingham (NSW) Town Museum?

But home construction of electronic organs of any description is now a rare exercise – despite the efforts of Jim Rowe, a few years back, to re-kindle interest. The simple fact is that the economics of developing and presenting a design and marketing the necessary components is totally against it.

At a stage when I might well have proceeded, personally, to build something more pretentious than the Stromberg/Playmaster, Grace Bros came up with an Italian-made solid-state GEM (Generale Ellettromusica) organ. Apparently based on build-it-yourself circuitry devised by Philips, in Eindhoven, it was attractively priced and very well voiced for church and home use. What's more, I could have one immediately. So I said "yes", took out my wallet and put my soldering iron away!

The GEM has since given place to a more modern Technics, with electronic rather than mechanical keying, electronic chorus and tremolo, and various other refinements. But that, in turn, is 'old hat' to what small churches and amateur organists can acquire nowadays, if they are prepared to loosen their purse strings a bit.

Incidentally, one of the reasons Jim Rowe was looking into electronic organ design in the 1970s was because he'd

From my files, this 1983 model Allen digital computer organ ADC 8000 employs an AGO standard drawknob console and provides the equivalent of 78 stops or 94 ranks, with 'no unification or duplexing'. Without being alerted, few would be aware of the difference in sound between it and a large pipe instrument.

come to realise that he'd never get around to using the pipe ranks that he'd once bought and stacked in the loft! If, as Editor, I couldn't find time to build a more pretentious electronic instrument, I can't imagine how one would ever get around to tackling a pipe organ!

Cinema organs again

When large luxury theatres were overtaken by the television era, the old Wurlitzers and Christies were unceremoniously ripped out, to clear the way for wide-screen multi-theatre complexes. The organs would have become so much junk, had it not been for the intervention of enthusiasts who bought them for a fraction of their original cost and somehow managed to store them against the day when they could be rebuilt.

Without being able to quote actual figures, a lot of them certainly have been rebuilt, and are variously available again for regular use or special occasions.

In my own area, the big Christie that was once the pride of the Parramatta Roxy is currently being refurbished and re-installed in the new Hills Centre at Castle Hill, Sydney. Donated to the Centre by its rescuers, they claim that, when complete, it will be the largest surviving Christie in the world.

No less interesting is another old Christie currently installed in the Epping (Sydney) Baptist Church. Obtained originally from the nearby Eastwood theatre, the church re-installed at the time as much of it as seemed appropriate to their requirements.

Recently, faced with the need to refurbish the instrument, they decided to return it as near as possible to original specifications and to take advantage of extra ranks which had become available.

Built, in the first instance, by a manufacturer of classical organs, Christies have considerable potential in that role. In the hands of an organist like Cliff Bingham, the refurbished Epping instrument performs as a Christie always did. But equally, in periodic recitals by well known concert organist David Rumsey, it assumes a totally different personality.

But this has not come cheaply, and it never does. It takes a lot of money – $200,000 in the case of the Roxy Christie – to 'adopt', refurbish and re-install a big pipe organ. This is just for essential materials and professional services. Even then, it would be impractical in most cases but for a huge number of 'person-hours' donated by supporters and enthusiasts.

Meanwhile, the most pretentious electronic organs, like the big computer-based Allens, have overtaken small pipe instruments and are getting ever closer to the sound of their large acoustic counterparts. Somewhere down the track, pipe organs too may become a rarity, if not a curio.

But it will take a bit of getting used to. Listening to a well-played pipe organ, large or small, the organist is seen intuitively as an accomplished 'musician'. Playing a traditionally styled electronic, the point can still be conceded. But standing alongside someone playing a big Yamaha, with its row upon row of computer-like buttons and lights, the lingering mental image is of a musically gifted technician.

I have a sneaking suspicion that it's the extension of an image that dogged Des Tanner and Wilbur Kentwell, in the tone wheel Hammond era! An image that was encapsulated in a remark made by our former Editor John Moyle: "It's like playing your own amplifier!"

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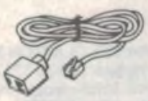

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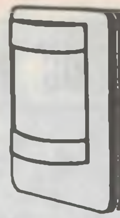

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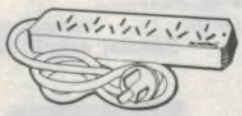

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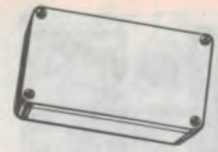

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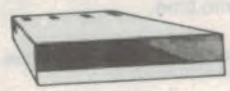

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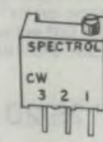

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R14800	20K	R14810	50K
R14820	100K	R14830	200K
R14840	500K	R14850	1M

Quantity

1-9	10+
$3.50ea	$3.20

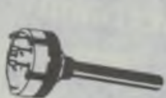
MAIL ORDER HOTLINE 008 335755

SINGLE ROTARY POTS

6.35mm (1/4) PLAIN SHAFTS

LINEAR			LOG
Value	Cat.No.	Value	Cat.No.
0.5	R12001	1K	R12023
1K	R12003	5K	R12025
5K	R12005	10K	R12027
10K	R12007	25K	R12030
25K	R12010	50K	R12032
50K	R12012	100K	R12033
100K	R12013	250K	R12034
250K	R12014	500K	R12035
500K	R12015	1M	R12036
1M	R12016	2M	R12038
2M	R12018		

1-9	10+	100+
$1.75	$1.65	$1.30



DUAL ROTARY POTS

6.35mm (1/4") PLAIN SHAFTS

LINEAR			LOG
Value	Cat.No.	Value	Cat.No.
10K	R12100	10K	R12120
25K	R12102	25K	R12122
50K	R12104	50K	R12124
100K	R12106	100K	R12126
250K	R12107	250K	R12127
500K	R12108	500K	R12128
1M	R12110	1M	R12130

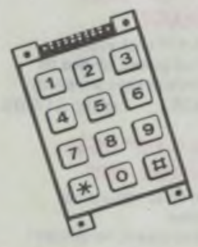
1-9	10+	100+
$3.50	$3.25	$3.15

RECHARGEABLE 12V 1.2AH GEL BATTERY

Leakproof, long service life batteries ideal for security systems, emergency lighting or as a computer backup power supply, etc.

Cat. S15029 Normally $19.95

1-9	10+
$13.95	$12.95



NUMERIC KEYPAD

Unencoded keypad, 10 digit keys plus two utility keys. Light grey in colour.

OUTPUT ARRANGEMENT

Output Pin No.	Symbol
1	N.A.
2	Shield plate
3	Column 2
4	Row 4
5	Column 3
6	Row 1
7	Column 1
8	Row 2
9	Row 3
10	N.A.

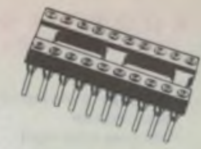
Catalogue No. C19030

1-9	10+	100+
$2.95	$2.50	$1.95

LOW PROFILE IC SOCKETS

Save a small fortune on these "Direct Import" low profile Ic sockets! PCB mounting solder tail. All tin plated phosphor bronze or berryllium and dual wipe for reliability.

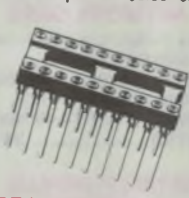
Cat. No.	Description	1-9	10+
P10550	8 pin	$0.20	$0.15
P10560	14 pin	$0.25	$0.20
P10565	16 pin	$0.35	$0.20
P10567	18 pin	$0.40	$0.30
P10568	20 pin	$0.40	$0.30
P10569	22 pin	$0.40	$0.30
P10570	24 pin	$0.40	$0.30
P10572	28 pin	$0.50	$0.40
P10575	40 pin	$0.50	$0.40



GOLD INSERT LOW PROFILE IC SOCKETS

- Gold machined pins
- Extremely high quality
- Anti-wicking
- Ideal for professional use or where field service components is required.

Cat.no.	Description	1-9	10+
P10620	8 pin	$1.20	$1.10
P10624	14 pin	$1.60	$1.50
P10626	16 pin	$1.90	$1.80
P10628	18 pin	$2.00	$1.80
P10630	20 pin	$2.20	$2.00
P10632	22 pin	$2.40	$2.20
P10634	24 pin	$2.60	$2.40
P10640	28 pin	$2.90	$2.60
P10644	40 pin	$3.00	$2.70



WIRE WRAP IC SOCKETS

These quality 3 level wire wrap sockets are tin-plated phosphor bronze

Cat.no.	Description	1-9	10+
P10579	8 pin	$1.50	$1.40
P10580	14 pin	$1.85	$1.70
P10585	16 pin	$1.95	$1.80
P10587	18 pin	$1.95	$1.80
P10590	20 pin	$2.95	$2.70
P10592	22 pin	$2.95	$2.70
P10594	24 pin	$3.95	$3.50
P10596	28 pin	$3.95	$3.50
P10598	40 pin	$4.95	$4.50

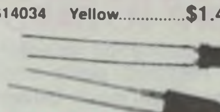
TEXTOOL SOCKETS

P17016 16 pin............ $14.95
P17024 24 pin............ $18.95
P17028 28 pin............ $24.95
P17040 40 pin............ $29.50

CHROME LED BEZELS

- 9mm hole, available 3 colours

Cat. no.	Description	Price
S14030	Red	$1.20
S14032	Green	$1.45
S14034	Yellow	$1.45



QUALITY LEDS

Cat. no.	Description	Price
Z10140	3mm Red	$0.15
Z10141	3mm Green	$0.20
Z10143	3mm Yellow	$0.20
Z10145	3mm Orange	$0.20
Z10150	5mm Red	$0.10
Z10151	5mm Green	$0.15
Z10152	5mm Orange	$0.15

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Socket (P10150)............... $2.25

RCA GOLD PLATED CHASSIS SOCKET

For the ultimate connection!
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1-9	10+	100+
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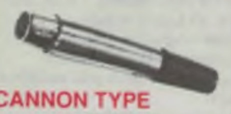

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Cat. no.	Description	Price
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- Velcro at mount for easy removal

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386 MAIN BOARD

- Intel 80386 CPU (16 MHz)
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- Keyboard controller and attachment
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X18101 (without RAM) $2,390

X18105 (2 M/Byte RAM) $3,500

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Increase the performance of you sluggish XT* approximately four times with this super fast motherboard

- 8088-2 running at 10 MHz, no wait state
- Turbo/ Normal selectable
- 640K fitted
- 8 Expansion slots
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- Keyboard port

Excluding RAM.......$199

Including RAM.........$624

BABY AT* MOTHERBOARD

(WITHOUT MEMORY)

- 6/10 MHz system clock with zero wait state. 12 MHz, 1 wait state
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X18201 (incl. 2 MB RAM) $1,649

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- Built-in 15 pin D type connector
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- Meets the IEEE 802.3 standard

X18160.....................$489

R-NET/S INTERFACE NETWORK CARD

- Fully compatible with SMC, Novell Arenet card
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X18162...................$312

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- Processor 80386-25
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- Memory: 32KB Cache memory (35ns)
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X18105.................$4,395

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An intelligent front end communication adaptor featuring 6 asynchronous RS232C ports and communication co-processor. With many driver routines supported for various operating systems, this card lets your AT* (and compatibles) be connected with ASCII terminals, modems or other serial devices operating UNIX-V like systems (eg: M/S XENIX, SCO XENIX, Microport Unix) or DOS environment. With either Xenix/ Unix or DOS configurations, your AT* can be turned into a full scale super microcomputers that rivals or exceeds the performance of systems costing much more.

X18152..$995

XT* TURBO MOTHERBOARD

- 8 MHz
- 8088 Processor
- Expandable to 640K on board
- Keyboard connector
- 8 Expansion slots

X18030 (excl. RAM)......$135

X18031 (incl. 640K RAM) $560

5 1/4" DISK STORAGE

- 100 x 5 1/4" disk capacity
- Smoked plastic hinged lid
- Lockable (2 keys supplied)

C16020.........only $15.95

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- 50 x 5 1/4" Disk capacity
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- Holds up to 40 x 3 1/2" diskettes
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(DOUBLE SIDED)

10+ DISKS	100+ DISKS	1,000+ DISKS
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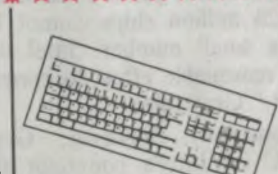

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These new keyboards are both XT* and AT* compatible!
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- Enlarged "Return" and "Shift" key
- Positive feel keys
- Low Profile Design, DIN standard
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- Additional Functions: Key-in-Lock, Previous Word, Next Word, Fast Repeat, Line Feed, Pause, Reset, Clear Screen

X12022.............only $109

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Check these features and our prices. We're sure you'll agree they're exceptional value for money!
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- 12 months warranty!
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256K RAM, Single Drive, Graphics and Disk Controller Card.......................................$995

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& dual 360K Disk Drives...$1,695

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& dual 360K V.C. H.D.........$2,295

BABY AT* COMPATIBLE COMPUTER!
2M/B RAM $2,695

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- 80286 CPU
- Colour Graphics Display Card
- 8 Slots
- Floppy & Hard Disk Controller
- Printer Card and RS232
- Keyboard
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- Size: 360(W) x 175(H) x 405(D)mm

With 20 M/Byte Hard Disk.$2,695
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- Option for 80287 & 80387 co-processor socket
- Operates in page mode with interleave memory subsystem
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- Seven direct memory access (DMA) channels
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- AMI 386 BIOS/ Phoenix 386 BIOS/ AWARD 386 BIOS (AMI fitted)
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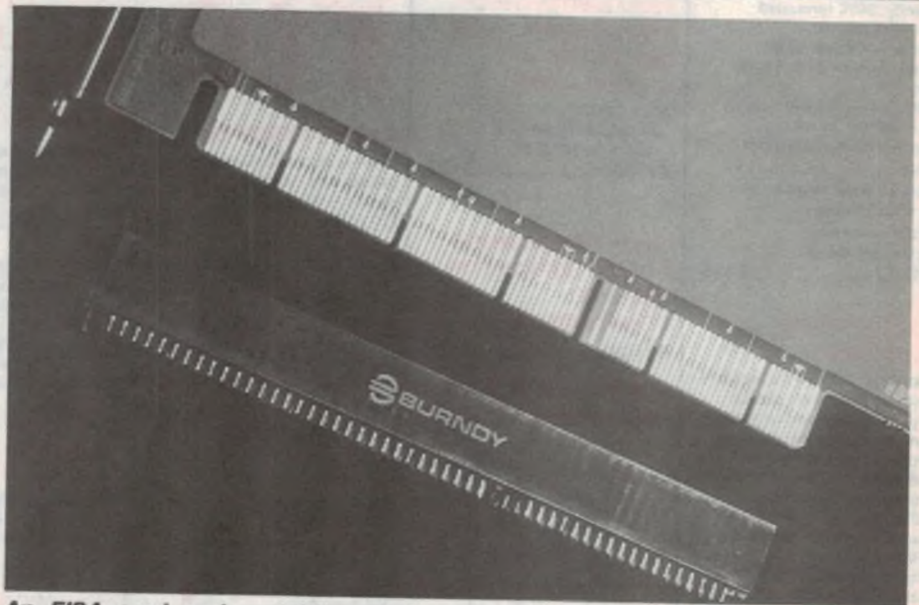
Silicon Valley NEWSLETTER . . .

Computer bus wars

To date, some 100 computer manufacturers and developers have announced their support for the new EISA (extended industry standard architecture) PC system bus, which they hope will compete with the 'MicroChannel' bus launched by IBM with its PS/2 series of machines. Among the protagonists of the EISA standard are Compaq, Hewlett-Packard, Tandy and many other MS-DOS PC makers.

The first EISA chip sets are expected to be available in sample quantities from Intel, this month. The first systems using the EISA bus are likely to appear around December.

In contrast with the IBM MicroChannel bus, which was designed to compete with and replace the existing PC/AT bus with proprietary IBM technology, the EISA standard is a natural extension of the existing bus and designed to allow all participating vendors to provide compatible higher performance machines. EISA's backers believe that many PC buyers will shy away from a standard that locks them into a single vendor and removes the benefits of market competition.



An EISA card and matching motherboard connector socket, as displayed recently by Compaq Computer Corporation.

NEC wins microcode copyright case

After nearly a year of deliberation in the landmark Intel-NEC microcode lawsuit, Federal District Court Judge William Gray ruled that microcodes are protected by US Copyright laws. But the big winner in the case was NEC, which was cleared of charges that it illegally copied Intel's 8086 and 8088 microcodes in its V20 and V30 microprocessors.

The decision was hailed as a victory for the overall US semiconductor industry, as its will protect the huge investments companies make in the design of advanced microprocessors against pirates. In addition to using US Customs authorities to prevent illegal copies of microprocessors to be imported into the United States, chip makers will also be able to use the ruling to put pressure on the government to take retaliatory measures against countries that allow illegal copies of their products to be manufactured and sold in markets outside the US.

Not benefiting from the decision, however, will be Intel, despite the millions of dollars the company spent in legal fees. Judge Gray ruled that Intel had forfeited its copyright claims, by allowing three of its 12 licensed manufacturers of 8086 and 8088 processors to market their versions of the chips without a proper copyright notice identifying Intel as the originator of the processor's microcode design. NEC was one of those licensees. In all, some 2.8 million processors were sold by various manufacturers without bearing the proper Intel copyright marks printed on them. "10.6% of 28 million chips cannot be considered a small number. Intel did not make a reasonable effort to correct the oversight," Gray ruled.

Most importantly, however, Gray cleared NEC of Intel's copyright infringement charge. "It is my conclusion that the NEC microcode, when considered as a whole, is not substantially similar to the Intel microcode within the meaning of the copyright law," Gray wrote.As a result, NEC will not have to pay any damages to Intel. Worse, Gray's ruling could mean that the other 11 licensees may not have to pay Intel any additonal royalties on the sale of their versions of the Intel processors.

Murdoch buys car navigation company

Etak, the Silicon Valley company which developed a revolutionary navigation system for automobiles, has been acquired by Australian publishing mogul Rupert Murdoch.

According to Etak president Charles Hart, his company, which had 1988 sales of US$10 million, has agreed to a merger with Murdoch Electronic Publishing for an undisclosed amount of cash.

Etak was started in 1983 by Atari-founder Nolan Bushnell. In 1985, the company introduced its 'Navigator' system which shows drivers their exact position on the street maps of major metropolitan areas in the United States. In operation, the car's position remains fixed in the centre of a 4" display mounted in the dashboard, while the map moves in accordance to the speed and direction the car is driving.

The relatively high price of the system, about US$1,500, has limited sales to the public, as only about 3,000 of the units have been sold to individual drivers. The bulk of the company's sales have been to ambulance services, police and fire departments, express mail, courier and other transportation-orientated services.

According to Hart, Murdoch's interest in the company and its technolgy is in combining Etak's huge street map data base with Murdoch's database of hotel, restaurant, and other entertainment information. When combined with Etak's mapping technology, the Murdoch data could be marketed effectively to travel agents and corporate travel planners. It would enable plotting on computerised maps the hotels with the best rates that are closest to a traveller or executive's key destinations in a particular city.

Zilog now profitable

Which major Silicon Valley chip maker has been profitable for the past 36 consecutive months? Would you believe Zilog?

Yes indeed. The company which had mastered the art of losing money, to the point where it was about the only firm in the red during the biggest boom in chip industry history (Spring 1984), is making money. Lots of money in fact.

After 10 long years of milking the petty-cash register of oil giant Exxon, Zilog is returning money to its parent in chunks of several million dollars a quarter. This in itself would seem enough to put Zilog on the list of Eight Wonders of the World, and should earn company president Ed Sack a Nobel Prize.

The new-and-improved Zilog is markedly different from the old Zilog in its product strategy as well. No longer is the firm clamoring for the covers of Home Computing, Hobby PC, and Do-It-Yourself Computing with ever faster versions of its Z80 processor. Instead, the firm is zeroing in on markets for which there are no specific trade publications, such as advanced embedded controls for industrial equipment, computer communications, television sets and other consumer electronics equipment.

In particular the latter market represents a bold move, as most other major US chip firms won't touch the consumer electronics area with a ten-foot pole, and are subsequently locking themselves out of a multi-billion market.

IBM sells Rolm to Siemens

After four years of frustration, IBM has decided to sell its Rolm subsidiary to Siemens of West Germany, but under the terms of the agreement, IBM will co-market Rolm products.

IBM bought Rolm in 1984 for a whopping $US1.26 billion, making it the largest takeover in Silicon Valley history. At the time, IBM said it would allow Rolm to operate as an independent subsidiary, and would not change anything in Rolm's unique and highly valued corporate culture – which includes extensive on-site sports facilities.

Although neither IBM or Siemens would disclose the sale price, sources inside the company and Wall Street analysts put the purchase price at about $US300 million.

To be sure, hopes were high for a successful relationship between Rolm and IBM when the giant computer firm took a 20% equity position in Rolm in 1983. IBM hoped a close relationship with Rolm would enable the company to more easily integrate Rolm's telecommunications products into IBM computers.

When IBM found that it could not steer Rolm in the precise direction it wanted, both Rolm and IBM decided it would be better if IBM bought the whole operation.

But four years and hundreds of millions of dollars in annual losses later, the worst fears of industry analysts and Rolm workers have come true. Rolm, just as analysts had predicted, quickly lost the competitive edge it had over the competition when it operated in a free-spirited independent environment.

And the company has been all but completely absorbed into IBM's overall corporate structure, as many Rolm employees had feared. Today, the Rolm group employs only 2,200 at the Santa Clara campus, down from a peak of more than 6,000 at the time of the acquisition.

Wall Street analysts believe Rolm has been losing around $100 million a year during most of the past four years.

AMD pioneers total smoking ban in Texas wafer fabs

If working for AMD and other US semiconductor companies isn't nerve-wrecking enough these days, with the continuous threat of lay-offs hanging above people's heads, AMD has made the experience even more difficult to bear for those who tend to calm themselves down by smoking.

AMD has put into effect a total smoking ban at its facilities in Texas, where it employs more than 3,000 people at plants in Austin and San Antonio.

It is supposed to be a pilot program, but analysts said they expect smoking bans to sweep the industry in the coming year as companies try to eliminate this potential source of contamination in the chip-making process.

Already smoking is banned in cleanrooms in the industry. But when workers smoke in the cafeteria or outdoors during their breaks, they are likely to return to the cleanrooms with smoke and cigarette particles stuck to their clothing and hair. These particles, however small, often become air-borne inside the cleanroom and end up contaminating delicate circuits of the surface of wafers when they are exposed to the air during various stages of the manufacturing process.

As part of the program, AMD is removing all ash trays and cigarette machines from the facilities and is encouraging workers to join smoking-cessation classes designed by the Amercian Cancer Society.

Hewlett recovering from second heart attack

Less than a week into the 50-year anniversary of his company, Hewlett-Packard co-founder William Hewlett suffered his second heart attack while on vacation in Idaho.

Hewlett was listed in a stable condition in a Boise hospital, where he was rushed. He last suffered a heart attack some 10 years ago. Ironically, that attack also occurred while visiting his winter vacation home near Boise. Five years ago, Hewlett also underwent heart bypass surgery.

Vitelic raises $US39 million for Taiwan DRAM plant

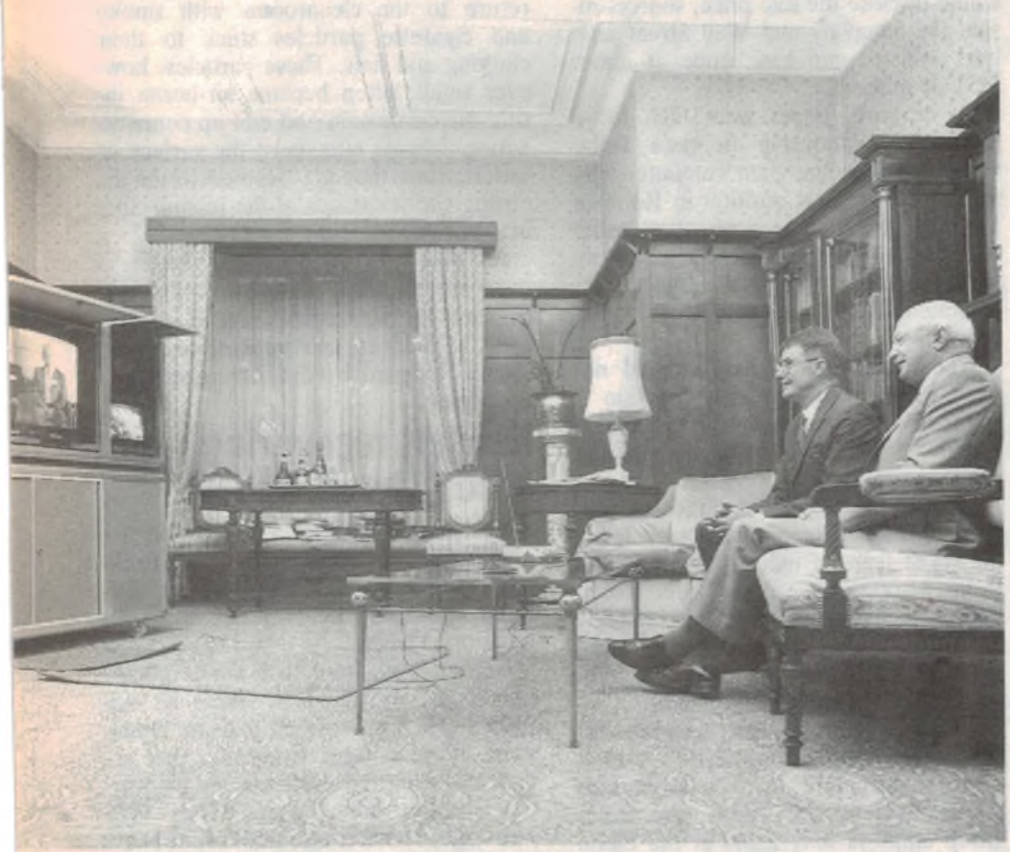
DRAM maker Vitelic in Santa Clara announced it has raised $US39 million from computer manufacturers and venture capitalists, as part of the funds necessary to build an $80 million DRAM production facility in Taiwan.

With the planned facility, Vitelic will join Texas Insutruments, Motorola, and Micron Technology as the only US chip makers with a DRAM manufacturing capability. To date, Vitelic has relied on the foundry operations of Japanese, Korean and Taiwanese DRAM makers to produce its high-speed DRAMs. The Taiwan plant is scheduled to be completed some time in 1990, and will produce Vitelic's 1-megabit high-speed DRAMs.

Among the companies contributing to the $US39 million venture pot are Western Digital, Sigma Designs, and Genoa Systems.

News Highlights

Telecom trials video distribution via fibre optics



Telecom Australia has begun the second phase of its residential fibre optics trials in Sydney's Centennial Park area, with the supply of multi-channel television programmes to some 10% of the 80 households participating in the trials. The programmes include ABC and SBS transmissions, plus educational/demonstration video material produced by Telecom. Provision has also been made for a fourth split-screen channel, to give viewers a 'run down' on all programmes available.

The signals are being transmitted from the respective TV stations to the Television Operating Centre in Telecom's City South Exchange, where signal quality is closely monitored. From there they pass to the East Exchange, and on to the customer premises all via 10um/125um single-mode glass fibre.

At the official opening of Phase II of the trials, a high-quality digital two-way TV link was set up between Telecom's city headquarters and the home of Professor Neil Runcie, one of the enthusiastic Centennial Park residents participating in the trials. The picture shows Professor Runcie and Telecom's General Manager of Network and Consumer Services (South), John Davies, sitting in Professor Runcie's lounge room and chatting with executives at the Telecom end via the mobile 'conferencing unit'.

Phase I of the trials ended in December 1988, with the successful connection of basic telephony services to the 80 participating homes via optical fibre cables. The current phase, delivering video services to 10% of these homes is scheduled to run for two years. It is expected to give much valuable experience in the planning, installation and management of optical fibre services.

The success of the trials should bring Australia one step closer to the 'intelligent home', with interactive information videos, home video conferencing, electronic mail and the ability to transfer funds electronically. By 1995, Telecom predicts that optical fibre could bring as many as 40 TV channels, 20 hi-fi stereo audio channels and many other data/information services.

Practel Incentive Award

A major broadcasting industry award introduced last year to recognise the efforts of young technicans has been renamed and expanded.

The Titan Electronics Award, previously restricted to technicians under 30, is now called the Practel Encouragement Award and is open to anyone working in the television broadcast industry or production houses. It carries a prize of a return trip to the NAB Conference in Atlanta, Georgia next year plus $500 spending money.

The Managing Director of Practel Sales International, Mr Neville Woodcock, said the award aimed at encouraging technicians working within the industry in Australia to stay in Australia and help develop the general electronics industry.

"The Practel Encouragement Award is our way of trying to discover the talents we have in Australia – often quietly working alongside us – and promoting them."

Entry forms are available from Neville Woodcock on (08) 266 3433.

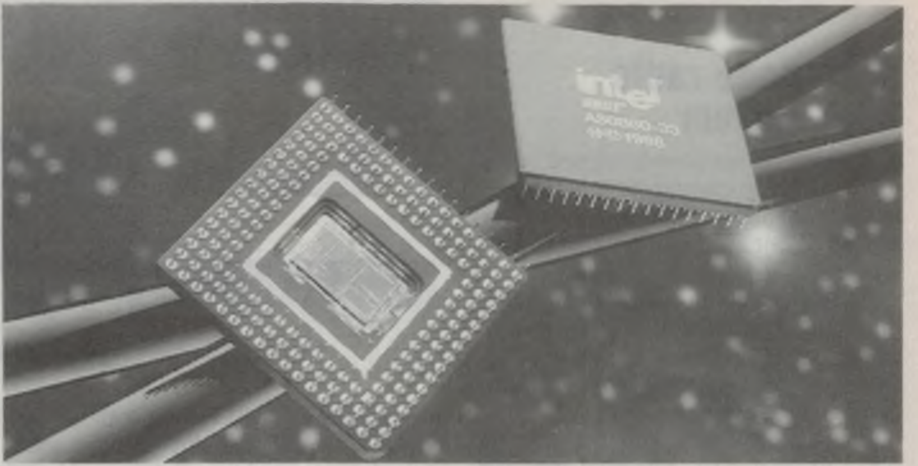
WIN-4, ABWN-5A ending VHF transmissions in June

As part of the Federal Government's Television Equalisation Program, viewers in Southern NSW are now able to receive commercial channel WIN and ABC channel ABWN on UHF channels 59 and 35 respectively. The existing VHF transmissions from these stations, on channels 4 & 5A, will cease on June 30. By that time, it is planned that all necessary UHF translators should be in place to provide either the same number of channels in each area, or in many cases more.

Viewers in both Canberra and Wollongong will before long be able to view all three commercial networks, in addition to ABC-TV and SBS-TV. In Wollongong a new service from CBN/CWN (Orange/Dubbo) is now available on channel 65, while SBS-TV is available on channel 53. Similarly in Canberra, WIN is now available on channel 31 and CBN/CWN on channel 34, in addition to SBS-TV on channel 28.

The equalisation program will also provide new services for the Central Tablelands (Orange), Central Western Slopes (Dubbo) and South Western Slopes (Wagga Wagga) regions. These services are due to begin in December 1989.

Intel announces 'supercomputer on a chip'



Intel Corporation has announced a new 64-bit microprocessor chip that integrates on a single chip the computing capabilities previously associated only with supercomputing systems.

The new i860 microprocessor contains more than one million transistors, and makes use of RISC (reduced instruction set computing) design techniques to achieve a performance rate of 90,000 Dhrystones per second. It contains separate and independant integer and floating-point arithmetic/logic units on chip, along with a memory management unit, instruction and data cache memory and a graphics processor. The chip has a 64-bit data bus and a 32-bit address bus, and includes 32 x 32-bit registers and 16 x 64-bit registers.

Within the floating point unit, pipelining and parallelism allow the processor to deliver two results per clock cycle, resulting in a peak performance rate of 80 megaflops (millions of floating-point operations per second). Specialised graphics hardware supports rendering of three-dimensional objects. The data bandwidth for the processor is 1 gigabyte per second, eliminating any throughput bottleneck.

The i860 is manufactured using Intel's CHMOS IV 1-micron process. Samples which operate at 33MHz and 40MHz are already available, with production quantities scheduled for later in the year. Actual size of the chip itself is 10mm x 15mm, and in operation it dissipates around 3 watts.

Intel is reputed to have invested some US$250 million into developing the 1-micron CHMOS technology used in the chip, plus another US$250 million in the company's new 'Class 1' fabrication facility being used to make it and other new products.

US pricing of the i860 in 1000-piece quantities will be $750.

Computer retailer burning-in PC clones from Singapore

Sydney personal computer retailer Compuhelp Australia doesn't sell machines or systems over the counter. Instead, they are delivered a week or so later – but Compuhelp MD Graeme Neuhaus says this is a step forward, not back.

Orders placed for the firm's range of IPC computers are fully assembled and configured in IPC's factory in Singapore, and even put through a 48-hour burn-in to ensure that any problems are found before the systems are delivered to the customer. Neuhaus says this procedure has solved the reliability problems which have often dogged Asian machines in the past.

According to Neuhaus, his firm selected IPC Computer machines because of both their exceptional quality and the full factory configuration and burn-in service which IPC provides. "Unlike many Asian manufacturers, IPC does everything from research and development through to burn-in. And when you look inside one of their machines you see quality!"

The IPC machines are also covered by Honeywell Bull's 'TotalCare' warranty service. Compuhelp can supply a full range of models, from basic XT compatibles through to 'tower' models with either 286 or 386 processors. Almost every possible combination of disk drives, memory and display is available, and all machines include fully licensed BIOS, MS-DOS and GW BASIC together with full documentation. Compuhelp also offers a 100% money-back guarantee if the customer is not fully satisfied.

The Compuhelp demonstration centre is at 35-37 Higginbotham Road, Gladesville, or phone (02) 809 6966.

Epson announces 48-pin dot matrix printer

Epson has released a new high speed, high definition dot matrix printer, tailored for executive offices of large to medium size businesses and law offices. The printer employs 48-pin print head technology to produce documents of crystal sharp clarity, with the resolution of 360 x 360 dpi.

Called the TLQ-4800, the new 136 column printer offers over 100 different print styles, including some that cannot usually be printed by dot matix printers. Printing speed is 300 characters per second in draft mode and 100 characters per second in True Letter Quality mode.

Radio Amateurs losing 576-585MHz

During the WIA/DOTC Joint Meeting in Canberra on November 22nd and 23rd, 1988, the WIA representatives were advised that, as a result of the Federal Government's television equalisation scheme which has placed considerable pressure on the limited amount of UHF spectrum available for broadcasting purposes, the 576-585MHz band was to be resumed in the near future.

Negotiations were entered into, exploring a number of options, including the possibility of using an 'adjacent' channel to the 576MHz band. (DOTC have subsequently advised that there is no such spectrum space available on an Australia wide basis.)

In a letter dated 24th December 1988, DOTC officially notified the WIA that they would withdraw the use of the band by the amateur service as from 1st March 1989. However, DOTC have agreed to one of the WIA proposals that exising amateur television repeater stations allocated in the affected band will be permitted to continue to operate until the frequency band is required for the respective area. However, no applications for new Amateur Television repeaters will be acepted for the band 576-585MHz.

Aust-made radio telex system

A new Australian-developed radio telex system is creating considerable interest among radiotelephone users around Australia, say the manufacturers.

The system is the ARQ Radio Telex, made and distributed by the Perth company Barrett Communications – the only Australian manufacturer of automatic request systems.

The company says you can use the ARQ to send error corrected messages over high frequency radio circuits up to half way around the world. You can create computer files using a word processor and transmit them direct from disc to air using an ARQ terminal modem.

You can also use the system where no telephone lines are available, to enter Telecom's telex network via the Overseas Telecommunications Commission and transmit messages direct to any telex machine in the world.

The system includes a complete selective calling (selcall) system with 456,976 codes. International ship number codes are also accessible to the user. Mining companies, exploration companies, government agencies, ships and Interpol are among those using the system.

Kambrook to manufacture computers

The Australian electrical manufacturer Kambrook Industries has confirmed its intention to enter the local manufacture of computers and other high technology electronic products.

The company has installed production lines in its Huntingdale plant and is presently producing a limited amount of PC/AT style computer systems to meet a number of bulk orders.

"Unfortunately the company will not be in a position to produce products for general release until later in 1989," said the company's national manager, Office Automation Division, Mr John Reardon. Since May last year the company has been testing the market through its subsidiary Goldstar Distributing with a range of XT and AT style systems sourced from Korea.

In-flight satellite phones

British Airways has introduced a novel service for its passengers – the world's first international passenger in-flight satellite telephone service. The airline will be offering this service on two of its Boeing 747 aircraft.

A telephone service from the air has only been available up to now in the USA, on domestic flights using air to ground communications.

"The British Airways service is a unique telecommunications link which opens up the skies on intercontinental flights using spare satellite capacity provided by INMARSAT, the International Maritime and Aeronuatical Satellite organisation," said Ms Belinda Howell, Public Affairs Manager for Australia and New Zealand.

Four telephone handsets have been fitted to the bulkheads of the aircraft – two in First Class and two in the Club World cabin, for a six month trial period. The telephones are operated by inserting a credit card, which releases the handset and enables the passenger to return to his seat to make the call.

Initially, customers will only be able to make outgoing calls at a cost of $US9.50 a minute.

Cray buys GaAs chips worth US$29 million

GigaBit Logic of California has been awarded a US$29 million order for custom gallium arsenide logic and memory integrated circuits, for use in the Cray-3 supercomputer. The 1989 order is more than triple the unit volume of the company's program for Cray in 1988.

"We're pleased the Cray-3 program has set new milestones for the utilization of digital GaAs IC's," stressed Jim Brye, GigaBit Logic vice president of sales. "With Cray Research and many others of our customers entering production and pre-production phases of their programs in the last year, we have established a new benchmark for the utilisation of digital GaAs ICs."

GigaBit Logic believes this order is at least three times larger than any previously reported merchant market GaAs IC order for shipment in a single year.

Optical Fibre Technology Centre established

The University of Sydney has established a centre for the development of optical fibre technology, intended to keep Australia in the forefront of this new field.

The leaders of the interdisciplinary group who will manage the centre are Dr Ian Bassett in Theoretical Physics, Dr Mark Sceats, in Physical Chemistry, Associate Professor Tony Stokes in Electrical Engineering, and Dr Simon Poole, who recently joined the group from the University of Southampton.

The original members of the group were drawn to the need to make the fibres to their own specifications to solve a problem in the measurement of high-voltage currents. Similar conclusions were drawn by the Transmission R&D Group at OTC, working in advanced telecommunications technology. The potential of special purpose fibres in sensor telecommunications technology is now widely known, with some of the outstanding ideas conceived in Australia at the Australian National University.

The heart of the centre will be its ability to make these special purpose fibres and this will now allow the full potential of the optical fibre technology to be exploited in Australia.

The interest generated by the venture has already been significant, with OTC providing the stimulus for work in optical amplifiers which can replace electronic devices in long-distance fibre optic telecommunications. BHP is interested in mining and process control applications and has been holding discussions with the Centre's management group.

Dr Simon Poole, an internationally renowned expert in the field, is Technical Director of the Centre. He will establish the production facilities and collaborate with research groups in Chemistry, Electrical Engineering and Physics which are involved in both fundamental and applications research. The first fibres are expected to be drawn in October.

News Briefs

- Victorian electronics engineering firms ***Associated Calibration Laboratories (ACL)*** and ***LMG Communications*** have been merged, to provide an integrated supplier of specialised audio-metric and RF digital/analog services and equipment. The companies will operate under the Lampglass Holdings parent, with John Day (FIEEE USA) and Philip Fitzherbert (AFMA, MBA) as co-directors.
- Electronics retailer ***Dick Smith Electronics*** has re-opened its store in Logan Road, Buranda (Brisbane), next door to the store which was destroyed by fire last December. The company has also opened a new store in Hurstville, in Sydney's South, at 124 Forest Road. This effectively replaces the former Blakehurst store, which closed last year.
- Components manufacturer/importer ***Rifa*** has changed its name to ***Ericsson Components***. MD Neil McCormick says that the move is in line with rationalisation and growth programs begun 12 months ago.
- Phil Micklesson has been appointed NSW sales manager for component supplier ***Augat***. Phil's previous experience came from Anitech and Royston Electronics.
- Relay, components and industrial electronics supplier ***Email Electronics*** has appointed Klaus Bachmaier, formerly of Siemens, as Quality Manager. Greg Norton-Smith has also been appointed Marketing Services Manager.
- Sydney-based communications specialist ***Captain Communications*** has expanded its centre in Parramatta, with the addition of the adjacent premises at 26 Parkes Street. This gives over 20,000 square feet of display space – probably the largest of its type in Australia.
- The Communications Product Group of ***Sony Australia*** has undergone changes, with Graham Bennett having been promoted to the position of Brisbane Regional Sales Manager. Richard Everitt has been promoted to the corresponding position in Sydney, while Martin Richmond has been similarly promoted in Melbourne.
- ***GEC Plessey Telecommunications (GPT)*** has become the first telecommunications company to join the Federal Government's 'Partnership for Development Program'. Under the terms of the agreement, GPT will progressively increase its R&D expenditure in telecomm products to at least 5% of its Australian turnover, by 1995-96.
- ***Plessey Australia*** has acquired a majority shareholding in Australian space systems design house AUSPACE, by taking over the 65% holding formerly held by French company Matra. AUSPACE is accredited with the Australian Space Board, ESA and NASA, and acted as prime contractor on the Endeavour UV telescope for the US space shuttle.

FORUM

Conducted by Jim Rowe

What's better than a long – or even giant – crystal OFC speaker cable?

Remember my somewhat skeptical pieces in the September and December issues on the use of 'oxygen free' copper for speaker cables, hifi amplifier wiring and other electronic gear? I've had a very thought-provoking response to them, from an experienced radio engineer in Melbourne, and I'm sure you'll find it as interesting as I have.

I know some of you are probably a bit sick of the topic of OFC (oxygen-free copper) by now, having perhaps made up your mind either that it's either a wonderful development in the quest for higher fidelity, or a load of old cobblers being foisted on gullible hifi addicts by unscrupulous marketers. But it *is* an intriguing subject; I for one would like to get to the bottom of things and find out if OFC really does have any objective, measureable benefits – as opposed to vague claims about things like 'greater transparency' and 'sharper attack'. Wouldn't you?

Anyway, if we look at it again this month, it will give you all time to write in those blistering letters, taking me to task for last month's piece about the death of experimental amateur radio. (What – not started yet? You'd better get cracking, because if there aren't any responses I'll have to assume that it isn't just amateur radio that died...)

Right then – who's in favour of talking about OFC this month? And against? I think the ayes have it, folks.

Well then, the most thought-provoking response on this subject came in the form of two letters, both from the same writer and arriving within a couple of weeks of each other. The writer is Alan Fowler, a very experienced Chartered radio engineer from Melbourne, who has worked in both broadcasting and research and written many professional papers as well as articles for *EA* in the past.

Mr Fowler's letters were quite long – particularly the first – but because he takes such an objective line, I'll try to quote as much as I can. Here's a fairly complete sampling from his first letter:

Like most engineers, I have previously felt that I won't believe that a cable can cause distortion until I see the distortion actually being measured. However, your 'Forum' in the December 1988 issue started me thinking again, and I have looked at some earlier scientific papers more carefully.

In particular, I have re-read several papers where the authors use the non-linear voltage/current characteristic of metallic conduction (Refs. 2, 3, 4) to measure the performance of relay contacts. Whitley (Ref. 2) explains that metals are inherently non-linear electrical conductors, since higher current causes more heating and the resultant temperature rise increases the resistivity.

A 100-watt electric light globe is a good example of the effect. Its resistance varies from 43 ohms cold to 576 ohms hot, an increase of some thirteen times. When they were students, Bill Hewlett and Dave Packard used the non-linear characteristics of a globe as a control element, to stabilise the output level of an audio oscillator. That oscillator was the foundation of the Hewlett-Packard empire.

The heat generated and the change in resistance depends on the current density. Relay contacts do not touch over a large area. Because of microscopic irregularities in their surfaces, they only touch at a small number of what are quite literally points, and which are called 'asperities' (Ref. 2). The current flowing between the contacts is constricted to flow through these asperities, which have a very small cross-section and mass, and consequently show very marked and rapid changes in resistance with changing current. Kaczmarek and Kosmowski (Ref. 4) used the distortion to an audio frequency signal, caused by this rapid change in resistance, to measure the performance of contacts.

Is it possible that there is a similar effect at the junctions between adjacent grains in a copper wire? Consider the actual structure of a copper conductor at the microscopic level, and how a current flows along it.

The following points summarising current flow at the atomic level are not intended to be precise, but to give a general understanding of what is happening. A full explanation would involve a much more detailed understanding of solid-state physics than I have:

1. *The atoms in a crystal are arranged in a very precise three dimensional array. This is usually referred to as a lattice.*
2. *The current is carried by the conduction electrons from the outer shell of each atom. Because of the way the atoms are arranged in the lattice, the outer shell of one atom overlaps the outer shells of those next to it. The conduction electrons are then free to move throughout the metal.*
3. *If the lattice contains imperfections, or is disrupted anywhere, the conduction electrons will not be able to move so freely. They will be deflected or 'scattered' from their normal path. The conduction electrons will be further scattered if the conductor is heated. These two effects are the cause of the resistance of a conductor.*
4. *The electrons carrying the current do not move through the metal at high speed. If it is assumed that one electron of every atom takes part in the current, then, for a current density of 6A/mm², the average velocity at which the electrons drift along the conductor is only 0.5mm/s (Ref. 5).*
5. *High conductivity electrical grade wire is drawn from an ingot which is formed by melting copper under*

carefully controlled conditions, and pouring the liquid copper into a mould. As the molten metal cools, a very great number of individual crystals form and grow throughout the liquid. The orientation of the lattice of each crystal is purely random.

6. *The individual crystals can be seen clearly under a microscope, and each appears to be separated from the next by a distinct boundary. This boundary is generally not a physical gap between the crystals. Samples are prepared for examination under a microscope by polishing, then etching. The rate of etching may vary with the orientation of the crystal lattice, so there may be a step between adjacent crystals after etching. The etching may produce grooves of various depths at the boundaries, or both steps and grooves may be produced (Ref. 6).*

7. *Copper oxide and other impurities may be swept ahead of the crystal face as it grows, until it meets another crystal growing towards it. In this case the copper oxide and other impurities will be trapped between the two crystals.*

8. *In non-electrical grade copper products, the oxygen present may be locked up by adding a material such as phosphorus to the molten metal. This combines to form an oxide of phosphorus, which tends to collect at the grain boundaries. The addition of 0.1% of phosphorus will HALVE the conductivity of copper (Ref. 7).*

9. *In Oxygen Free High Conductivity (OFHC) copper, any oxygen present is probably in the form of copper oxide and oxides of the other impurities.*

10. *The individual grains (or crystals) in a copper wire are not completely surrounded by an oxide film as has been suggested. With only about 3 to 5 parts per million of oxygen present (Refs. 1, 8), the oxide is unlikely to cover the whole surface of any crystal.*

11. *Where an oxide film is present at a grain boundary, it may be thin enough to allow electrons to move from one grain to the next by tunnelling.*

12. *There are only a few orientations of adjacent crystals which will give a good match along the boundary between the two lattices. At other orientations there will be a mismatch, and a large degree of atomic disorder near the boundary. This mismatch will certainly effect the freedom of conduction electrons to move across the boundary.*

13. *In a pure metal, there will be no physical gap at the grain boundaries, just the effects of the poor alignment of the lattices of adjacent grains.*

14. *If the wire were made from a single crystal, then the current density would be the same anywhere through a cross-section of the wire, for a direct current.*

15. *The current density at the boundary between two crystals will be highest at the places where the lattice has a 'best fit' with its neighbour. For a direct current, the average current density will be uniform across the diameter, but there will be local areas of high or low current density at the boundary between the two crystals. Cornelius (Ref. 8) likens the electron flow through a wire to that of water through a tube packed with sand.*

Forum

I would like to suggest an alternative source for the distortion, to that put forward by Mr Kamada. It appears from the above that, at a microscopic level, the disruption to the lattice structure at the grain boundaries is analogous to the asperites in a relay contact. If this is the case, the electron flow will tend to concentrate at the places of best fit of adjacent lattices. It is also likely that there will be lower thermal conductivity around the disruptions to the lattice, so that there may be increased local heating.

The question now is 'Does the current density at these preferred spots on the boundaries ever become high enough to cause local heating at a microscopic level?' If it does, the wire will be a non-linear resistor – i.e., the V/I curve will not be a straight line.

The signal will be distorted if the heating and cooling caused by the high current densities follow the electrical waveform, i.e., if the thermal time constant is short enough. The peaks of the signal will be compressed, causing odd-order distortion.

The effect will depend on whether the areas of best fit between the lattices of adjacent grains are small enough and few enough. Kaczmarek and Kosmowski (Ref.4) have shown that the areas carrying the current on a pair of relay contacts are small enough for the resistance changes due to heating to follow a 10kHz signal. They have measured the distortion products produced, and used this as a measure of the quality of the contacts.

If this is the cause, the wire in the speaker voice coil may be a major source of the distortion. It may be desirable to use 'single crystal' high conductivity wire for the speaker voice coil, as well as for the leads.

Distortion is usually measured on the voltage waveform present across the load. The typical hi-fi amplifier has a very low output impedance, and may be considered to be a voltage source. In this case it may be easier to measure the distortion to the current wave flowing in the load.

Table 1. Properties of cast copper rods

Properties	OCC*	OFC**	ETP***
Density (g/cm^3)	>8.939	>8.917	>8.810
O_2 content (ppm)	<5	<10	<500
H_2 content (ppm)	<0.4	0.5~3	0.5~3
Purity (%)	>99.997	>99.99	>99.95
Residual resistivity ratio (ρ273K/ρ4.2K)	<10000	<700	<700
Tensile strength (kg/mm^2)	12	18	—
0.2% proof stress (kg/mm^2)	2	10	—
Elongation (%)	70	50	—
Surface roughness (μm)	<0.1	<0.5	<15

*OCC ... 1.5mmØ **OFC ... 14mmØ **ETP ... 55 x 115 mm

I suggest that the above ideas could be tested by making up a number of 4 ohm non-inductive resistors, from various gauges of copper wire. These could be driven in turn from a high quality, low distortion, amplifier. In this case, the current waveform may be distorted, and it should be possible to measure the degree of distortion, either with a distortion meter as shown in Fig.1, or by using one of the techniques in references 2, 3, 4, and 9. Skov and Pearlstein (Ref. 9) use a technique which they claim is able to measure distortion of 0.000001%.

Provided that all the resistors are made from the same grade of material, I would expect the thinner wires to show the greatest distortion.

I would like to offer the following further points to ponder:

A. *Could a single crystal of copper be produced, either by repeated zone refining, or by the crystal pulling technique used to make silicon crystals?*

B. *Would this be an ideal starting material for drawing into wire for audio use? Or would the stresses caused by drawing to a smaller size cause dislocations to the crystal lattice?*

C. *Would the relative conductivity of the single crystal copper be much different to OHFC copper?*

D. *The connections between the speaker cable, the amplifier and the speaker may also introduce distortion, unless they make very good contact to the terminals.*

E. *Will relay contacts used in any speaker protection circuitry or equipment add to the distortion?*

F. *From Bock and Whitley's work (Ref. 2), it appears that conduction by electron tunnelling through thin films along the grain boundaries will DECREASE the distortion.*

G. *When copper is annealed by heating to a high temperature, then cooling, the grain structure changes (Ref.7). Many of the grains grow larger at the expense of their neighbors, leading to fewer grains.*

H. *Annealed copper has a higher conductivity than hard drawn copper (Ref. 5).*

I. *A temperature rise of 2.5°C will increase the resistance of a copper wire by 1%.*

The above notes have been put together after discussions with several metallurgists and physicists. I trust that they will cause a lot more thinking, and perhaps even move a few people to carry out the calculations and make the suggested measurements – to prove the ideas one way or the other.

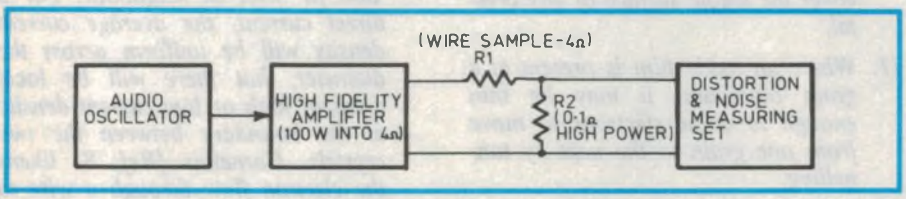


Fig.1: Alan Fowler's suggested method for measuring the distortion which may be introduced by a speaker cable.

So that's Mr Fowler's first letter, and I think you'll agree that it raises quite a lot of interesting points. By the way, before we go any further here are the references he referred to – in case you may want to follow them up yourself:

1. Rowe, J. 'Forum', *Electronics Australia*, Vol.50, No.12, December 1988, pp40-44.
2. Whitley, J.H., 'A Measurement of Constriction Resistance Based on its Non-linearity', *Proceedings of the Third International Symposium on Electrical Contact Phenomena*, Orona, Maine USA, June 1966, pp 65-69.
3. Block, E.M. & Whitley, J.H., 'Tun-

nel Film Resistance Utilizing Nonlinear Constriction Resistance Measurements', *Proceedings of the 16th Annual Holm Seminar on Electrical Contact Phenomena*, Chicago, Illinois USA 1970, pp 45-49.

4. Kaszmarek, J. & Kosmowski, B.B., 'Constriction Resistance Measurements Based on the Method of Third Harmonic', *Proceedings of the 19th Annual Holm Seminar on Electric Contact Phenomena*, Chicago, Illinois USA October 1973, pp 155-158.
5. Cornelius, P., *Electrical Theory on the Giorgi System*, Cleaver-Hume Press Ltd, London 1961, pp 8-9.
6. Leech, P.W. & Gifkins, R.C., 'The Character of Grain Boundaries Revealed by Etching and Slip-Line Continuity', *Metals Forum*, Vol.1, No.2, June 1978, pp.102-109.
7. Fowler, A.M., 'Radio Frequency Performance of Electroplated Finishes', *Proceedings of the Institution of Radio and Electronics Engineers Australia*, Vol.31 No.5, May 1970, pp148-164 (Fig.8).
8. AS 1574-1984, *Copper and Copper Alloys – Wire for Electrical Purposes*, Standards Association of Australia.
9. Skov, C.E. & Pearlstein, E., 'Sensitive Method for the Measurement of Nonlinearity of Electrical Conduction', *Review of Scientific Instruments*, Vol.35, No.8, August 1964, pp962-964.

Whew! I thought Mr Fowler's point 10 was a particularly interesting one, because it suggests that I was wrong in my own suggestion that if Mr Kamada's theory of semiconducting/capacitive layers around the grains were true, then a copper wire shouldn't conduct DC. Obviously if these barriers to conduction only extend over small fraction of the boundary of each grain, this wouldn't be so.

In confess that I still have lingering doubts, though. If the oxide barriers do exist on only a small fraction of the surface of the metal grains, this must mean that (a) they would have an extremely low capacitance; and (b) they are effectively 'short-circuited' by the much larger and relatively good conduction paths existing over the rest of the surface area. So wouldn't this mean that they are likely to have negligible effect?

I guess this would be true more with OFC than with standard ETP copper, of course, so perhaps I'm still supporting Mr Kamada's theory – or Mr Fowler's own. And Mr Fowler's point about localised heating does make you think, doesn't it? If the size of the oxide 'patches' on the grain boundaries is significant, as they may be with ETP copper, the areas of good 'contact' between the crystal lattices may well be quite small. This would not only cause high localised current densities and heating, but because of the tiny dimensions involved there may also be short thermal time constants – allowing things to follow audio waveforms, and introduce audible, and perhaps measureable distortion.

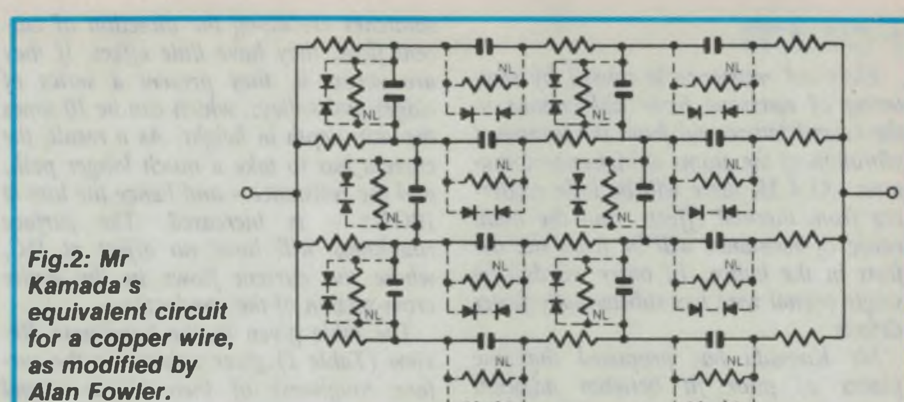


Fig.2: Mr Kamada's equivalent circuit for a copper wire, as modified by Alan Fowler.

It sounds like someone with the right resources and time will really have to try carrying out the measurements that Mr Fowler suggests, using either a standard THD measurement set or the super-accurate system he refers to in his reference No.9.

It's still rather confusing, though, particularly when you try to consider all of the points raised by Mr Fowler. And even if it does turn out that the floggers of super speaker cables are essentially right, and OFC/LC-OFC/GC-OFC is the only way to go, there may not be too much cheering from the golden-eared brigade.

For example, my impression is that the many fine conductors in most OFC cable are made by hard drawing – and this may well introduce more dislocations into the crystal lattices. Moreover as Alan Fowler himself points out, there may be just as much – and possibly even more – distortion introduced by things like the contacts of speaker protection relays, than by non-linear effects within the cables or the speaker voice-coil itself.

It seems to me quite possible that when we do finally get to the bottom of the OFC debate, the results may not turn out to be of much comfort to anyone. The quest for high fidelity may in fact get very much more complicated and expensive than anyone anticipated.

But I'm forgetting Alan Fowler's second letter, which is in many ways a post-script to the first – and just as interesting. Here it is:

Since my first letter, I have been given two extracts from the Sumitomo Electric Technical Review, No.27, dated January 1988. These describe how Sumitomo Electric Industries Ltd of Tokyo and Osaka, are producing single crystal copper wire for audio and video applications – using a crystal pulling technique developed by Professor Atsumi Ohno of the Chiba Institute of Technology. It seems I'm just too late with my ideas. Oh well, I didn't really want to be rich!

A table given on page 141 of the Review compares the Residual Resistance Ratio of the single crystal copper with that of oxygen free and electrolytic tough pitch grades. The values are obtained by dividing the resistance at 273K (Kelvins) by that at 4.2K. The single crystal copper has a ratio of 10,000, compared to 700 for the other two – i.e., at low temperatures the single crystal is a much better conductor than the others.

Forum

Electrical resistance is caused by scattering of electrons from dislocations in the crystal lattice and from the increased vibration of the atoms at higher temperatures. At 4.2K there will be little scattering from thermal effects, and the main cause of resistance will be from the defects in the lattice. In other words, the single crystal wire has substantially fewer defects.

Mr Kamada has proposed that the places of poor fit between adjacent grains may act as capacitors. If it can be assumed that the standard formula for a parallel-plate capacitor holds, at the small distances involved, a quick calculation gives a capacitance of about 10nF per square millimetre for a spacing of one nanometre between the faces of adjacent grains – i.e., a spacing just a few atoms thick.

At 1kHz, a 10nF capacitor has a reactance of approximately 16,000 ohms. I suggest that such a capacitor will be shunted by the very small constriction resistance, where the atomic lattices of the adjacent grains do line up, and that the equivalent series resistance will be almost vanishingly small.

I suggest that Mr Kamada's equivalent circuit for a metallic conductor should have a small value non-linear resistor placed in parallel with each of the capacitor and diode pairs, as shown in Fig.2. This would take into account the 'constriction resistance' at the grain boundaries, and would also provide a path for direct current.

At 10GHz, the reactance of a 10nF capacitor will be 1.6 milliohms, and it could effect the Q of the resonators as described in your December 'Forum'. However there are other possible causes for the variations in Q of the three samples, and I would like to be sure that these have been taken into account in preparing the resonators.

At these frequencies, surface roughness can have a major effect on the Q of a cavity or other resonator. The skin depth in copper at 10GHz is 660 nanometres. If I remember rightly, that's about the wavelength of red light.

I think it was J. Allison and F.A. Benson in the mid 1940's who published several papers in the Proceedings of the IEE on the effect of surface roughness on attenuation in waveguides. They showed that the surface finish on the inside of the waveguide changed the attenuation – the smoother the finish, the lower the attenuation.

The abrasives used in metal polishing leave a series of fine scratches. If the scratches are along the direction of current flow, they have little effect. If they are across it, they present a series of ridges and valleys, which can be 10 times the skin depth in height. As a result, the current has to take a much longer path, and the resistance – and hence the loss at 10GHz – is increased. The surface roughness will have no effect at DC, where the current flows in the entire cross-section of the conductor.

The table given in the Sumitomo Review (Table 1) gives values for the surface roughness of their single crystal wire, oxygen-free copper and electrolytic tough pitch copper. You can see that there are substantial differences, and it is possible that the variations in Q measured by Mr Kamada are due to the surface finish of each resonator.

Please don't think I'm knocking Mr Kamada's work. At this stage I'm trying to keep an open mind, and make sure that all the possible explanations are being considered.

Well, as you can see, this letter certainly raises some further interesting points. It's surprising to learn not only that true single-crystal copper wire *can* be produced, but that Sumitomo has in fact been making it – and speaker cables from it – for well over 12 months. And they're not just single-crystal copper, but oxygen-free as well!

I'm even more surprised that none of the hifi marketing people has announced its availability in Australia. After all, there's surely only one thing better than OFC, LC-OFC or GC-OFC, and that's 'SC-OFC': *single crystal oxygen-free copper*, with only one crystal making up the whole cable conductor.

All the same, I'm still a bit unsure of the exact significance (or relevance) of that much higher figure for 'Residual Resistivity Ratio'. It does show that the single-crystal copper has a much lower resistance than either normal OFC or ETP copper, down at 4.2K (-268°C). And I guess this does suggest that lattice defects do play a significant part in conductivity at these temperatures, as Alan Fowler suggests. But let's face it: we normally operate our speaker cables at about 25°C or 298K, along with the rest of our hifi gear. Or at least I do!

As far as I can see, at these temperatures the electrical resistance of the SC-OFC – as measured by normal means – seems to be much the same as regular OFC, or even ETP copper. Presumably this is because at these temperatures, it's thermal energy which is the main determinant of resistivity, rather than lattice defects. And if that's the case, we seem to have come full circle: I'm left wondering just what is the *measurable* advantage of the single-crystal copper, at normal temperatures and for signals at audio frequencies!

Incidentally, it's a pity that the Sumitomo people didn't give figures for the actual conductivity of their single-crystal copper at say 273K, and compare this with normal OFC and ETP. Instead they gave us just those esoteric 'Residual Resistivity Ratio' figures. Could this be because there are almost no measureable differences in conductivity at normal temperatures – or do I just have a suspicious mind?

As before, we seem to be left with microscopic considerations, and subtle distortion effects – yet to be quantified – caused presumably by localised heating at the grain boundaries in multi-grain types of copper. Or have I missed something?

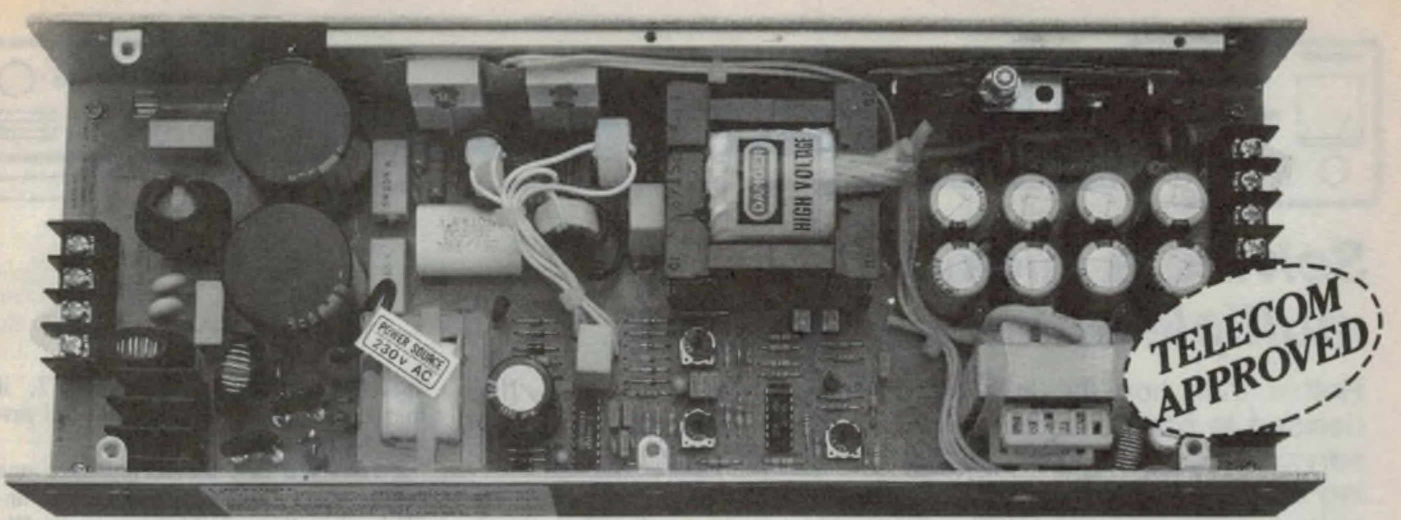
I notice that in his second letter, Alan Fowler's calculations of the reactance of Mr Kamada's inter-grain capacitance at 1kHz seem to support my own earlier comments, that these capacitors would surely be 'shorted out' by the good conduction paths between the grains. So I can hardly disagree with Mr Fowler's suggested modification to the equivalent circuit, as shown in Fig.2.

Alan Fowler's comments about the relevance of Mr Kamada's measurements at 10GHz are also very interesting. It does seem as if there are many pitfalls in drawing conclusions from the earlier results, particularly in terms of implications for audio signal frequencies. If Mr Kamada *didn't* make due allowance for surface finish, this looks as if it would have a dramatic impact on the significance of his results – and the validity of his theory.

Ah well, we don't seem to be all that much closer to resolving the original question, do we – even though Alan Fowler's letters have thrown a lot of interesting light on the subject. Thanks for that, Alan, although in some ways we now seem to have even more unanswered questions than before.

I don't know about you, but the more I learn about the subject of oxygen-free copper, the more confused I'm getting. One thing's certain, though – at present, I still see no sound reason for throwing away my low-cost speaker leads (using figure-8 power cable), and investing hundreds of hard-earned dollars in fancy OFC and/or single-crystal super cables.

But stay tuned, because you never know. Miracles might happen, and I may yet be convinced!



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The Serviceman

Solving a sticky multiple-antenna problem

Rather than hog the limelight myself again this month, I've decided to hand over to my old mate J.L., who runs his own servicing business in Hobart. In this story he tells about solving a problem that had tricked others in the past, yet only required commonsense to give the customer just what he wanted.

There are some people who are lucky enough to live in an area where all the local TV channels can be received on an indoor antenna, without any sign of ghosting. But most of us are not so lucky, and there are a sorry few who have to put up with miserable pictures because they live in a hollow, or on the wrong side of a hill.

The Hobart suburb of Taroona is one such location. Tucked in under the shadow of Mt Nelson, it's a picturesque suburb and most residents would never leave their leafy surroundings – even if they do envy the TV service available in less salubrious areas.

Soon after television began in southern Tasmania, the local commercial channel built a translator to serve the Taroona area. The translator was located across the river, at a point known as White Rock.

Unfortunately, White Rock is in almost the opposite direction to the main transmitters on Mt Wellington. So, to get good reception of the commercial station and to make use of any ABC signal that found its way over the hill, owners had to install two antennas – one facing each way.

In many cases, the ABC signals were so poor that viewers just didn't bother with a low-band antenna. They watched commercial TV only, until video-recorders gave them some respite from the interminable ads.

Wherever both services were available, signals were brought into the lounge room on separate cables. Changing channels meant changing antennas as well, but this was considered a small price to pay for having the choice.

Combining the signals onto a single cable had been tried, but was never really satisfactory. The spurious reception of high channel signals on the low channel antenna, and vice versa, caused unacceptable ghosting on both channels. It was easier to run two cables and swap them over when changing channels.

Until recently, I had never been called on to install a two-antenna system. When I looked at the difficulties involved in running two cables, I decided to investigate the chances of combining the signals, while evading the problems that had led other installers to adopt the two cable system.

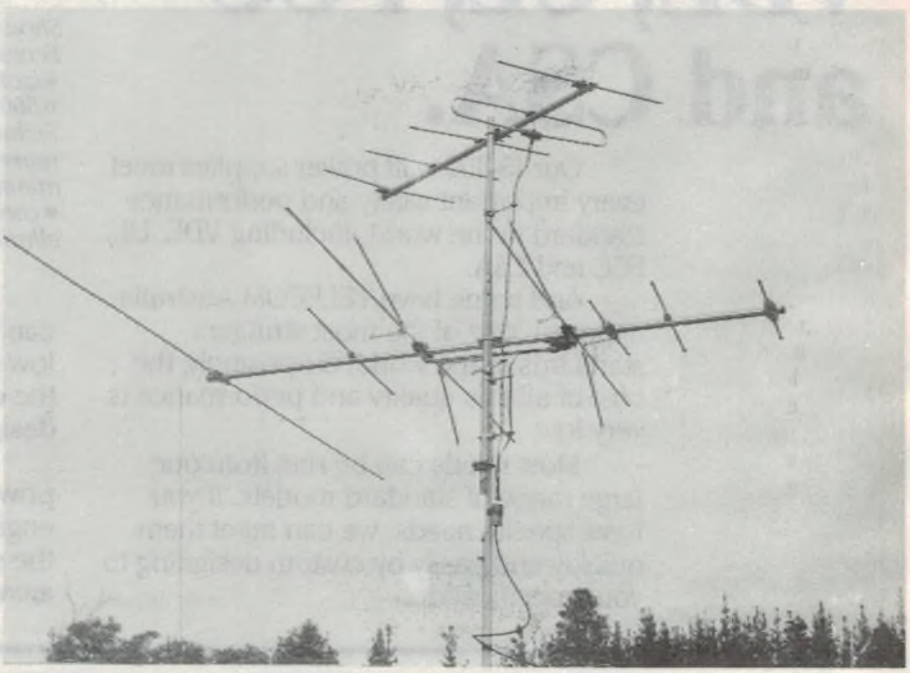
Previous residents at this location had erected a Channel Master 3112 antenna with a 300 ohm ribbon lead-in, directed on the commercial translator at White Rock. The new owners wanted (1) the ribbon replaced with coax and (2) the antenna redirected to Channel 2, if there was sufficient signal while still getting the commercial channel.

I explained that they could have one or the other, but that it was most unlikely that they could have both. We had reason to believe that the ABC signal would be quite usable, but their request would demand reception of the high channel off the back of the antenna.

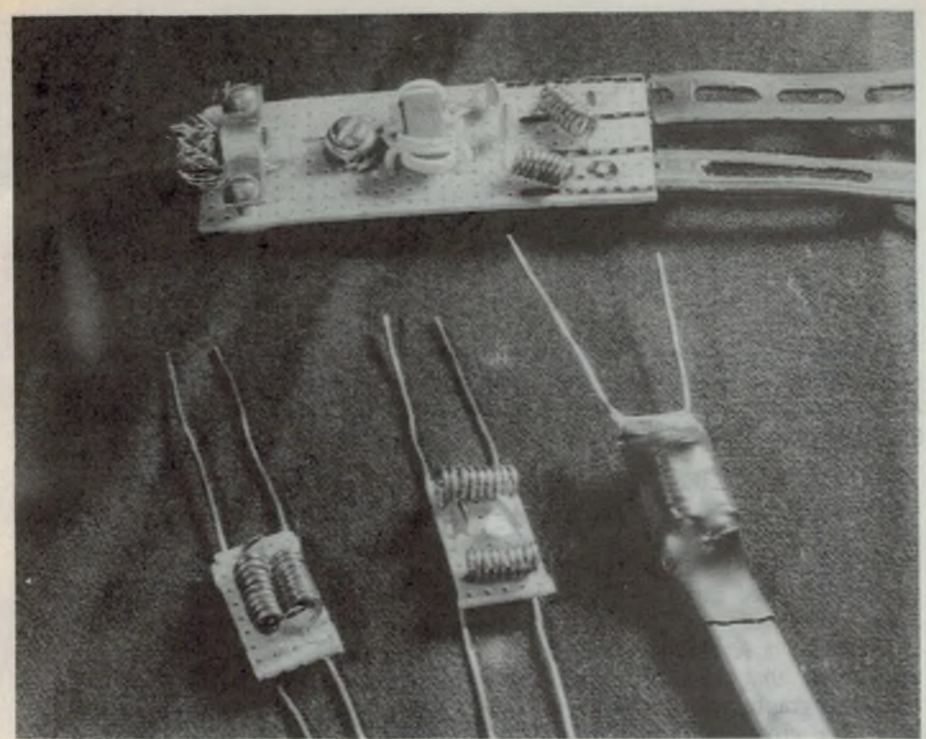
From past experience, I knew that the 3112 doesn't have a startling front to back ratio, so there was just a chance that the one antenna could do the two jobs. Unfortunately, there was no way to predict what would happen. One could only put it up and try.

The new cable went up fairly quickly and was soon connected to the antenna. The first test showed a perfect picture of the commercial station off the translator and a most disappointing one from the ABC.

With the antenna rotated to the other direction, the results were just the op-



The finished antenna assembly. The high band yagi is at the top of the mast, then the 3112. The combiner in its pill-box enclosure is strapped to the mast, just below the 3112.



Homemade antenna filters. Unit at top of picture is the combiner/balun, while the bottom row shows left, the low pass filter, centre the high pass filter, and right, the low pass filter sealed in its heat-shrink plastic and plugged with silastic.

posite. Perfect ABC and useless channel 8. So, there was no alternative to a two-antenna system. The remaining question was – could I devise a way to use only one lead-in cable?

It so happened that I had an old channel 9 Yagi that I had salvaged from an earlier job. It needed a bit of repair work, but was soon fit to be used, at least for tests at the Taroona site. With a short extension mast and a couple of U-bolts, I was ready to begin my experiments.

First, I carefully adjusted the 3112 antenna for the best possible results on channel 2. Then I mounted the Yagi on the extension mast and bolted it in place about four feet above the other antenna.

I connected this one to the lead in and adjusted it for the best view of the commercial channel. Then, I joined both antennas together with firstly, a common combiner (actually a splitter used back to front) then with a VHF-UHF diplexer.

The diplexer was a write-off, because the UHF branch would pass no channel 8 at all, even though 8 and the lowest UHF channels are not all that far apart. I had hoped that it would pass some signal, but it was quite unusable.

The combiner was also unusable, but for a different reason. In this case the spurious pickup on each antenna was such that the resulting picture was too smeary and ghosty to be of any use. Despite the perfect picture from each antenna separately, together they could deliver only rubbish.

The answer seemed to be to find some way to keep down this spurious pickup. Keep channel 2 out of the high band Yagi and channel 8 out of the 3112. But short of screening the whole of each antenna, there seemed little hope of making this scheme work.

Then I had an idea. It may not be possible to keep the offending signals out of the antennas, but it may well be possible to keep them out of the cables, before they are combined on the common lead-in.

What I needed was a low pass filter on the channel 2 antenna and a high pass filter on the other one. Mounted right at the antenna terminals, these filters should minimise the interference. Or at least they might – I hoped!

Some time ago I had devised what I then called a Wave Trap, to reduce channel 2 in a receiver that was suffering from insufficient AGC control. That had worked quite well, reducing the channel 2 signal by about 12dB, enough to solve that problem. But would it be enough to solve this problem? I set about finding out.

I made up two little filter sets, consisting of two 10pF disc ceramic caps and 2 small inductors wound from 1mm enamelled copper wire. The values were selected entirely by guesswork, using a little theory and absolutely no mathematics.

The components were mounted on small pieces of Veroboard, about 10 x 15mm. They were arranged in a square format, as shown in the diagram. The filter could be used for either high pass or low pass, simply by selecting the side of the square to be attached to the antenna.

The theory works like this: An inductor has an impedance directly proportional to frequency. So considering the channel 2 antenna, if the low band signals were fed in series with the inductor they should pass with almost no attenuation. At the same time, the inductance should restrict the high band signal passing on to the cable.

On the other hand, a capacitor offers little impedance to high frequency currents, so the filter capacitor which sits virtually across the antenna terminals acts as a short circuit to any high band signal which appears on the antenna. Another similar capacitor at the input to the feed line also tends to short out any high frequencies which may reach the line.

For the high band antenna, the filter is effectively 'rotated by 90º' and it can be seen that the inductors will now form a short circuit to low frequency signals across the antenna terminals and the input to the feedline. Conversely, the capacitors offer a low impedance to high band signals passing on to the feedline.

I fitted each filter to its appropriate antenna and took some signal strength measurements before I combined the two cables. I had been prepared to find several dB's of insertion loss after fitting the filters, but as far as I could measure, the loss was less than 1dB for

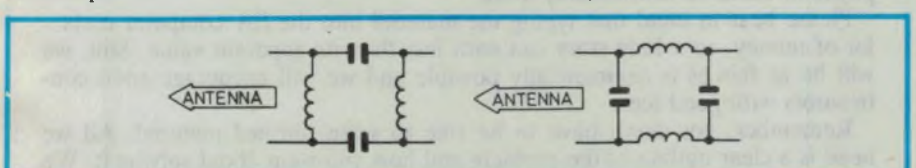


Fig.1: Schematic diagrams for the antenna filter units. The high-pass filter is on the left, the low-pass on the right.

Serviceman

the wanted signal in either case.

For the unwanted signal though, the story was very different. The high band signal on the channel 2 line was down by 12dB, and that of channel 2 on the channel 8 line was fully 15dB less than before the filter was fitted.

The output from each of the two antennas was on 300-ohm ribbon, and I didn't have a suitable combiner of this type. There are commercially made diplexers that might have served in this position, but they have to be specially ordered. In any case, they are all 75-ohm equipment and at this point I was working in 300-ohms.

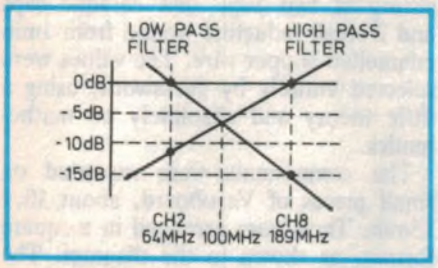


Fig.2: Graphic representation of combined filter action. Filters are most effective on widely separated channels. With this arrangement channels 4 and 5 would be seriously attenuated.

In fact, I had very little 300-ohm gear at all. The only thing I could find was an old Hills outlet socket adapting 75-ohm coax to a 300-ohm socket. It consisted of a balun and a coax saddle clamp fitting on a small square of circuit board.

I considered adapting the board to make it into a combiner and balun, but then decided that I could do the same job, only better, by reassembling all the parts onto a strip of Veroboard.

I also wondered about the effect on the impedance of the coaxial cable by paralleling two 300-ohm inputs. But at this stage I was just experimenting and any mismatch could be corrected later, if it was seen to be necessary.

Then I had another idea. Why not incorporate more filter elements in the combiner? Inductors in the low band lead and capacitors in the high band lead. Theory suggested that these should do no harm and it cost me almost nothing to pop them in.

With everything wired up and connected to the television set, we got absolutely perfect pictures on both channels, without any sign of ghosting or interference.

I must admit, I was surprised with the result. Knowing the difficulty that others have had with the one-cable system, and from the early tests on the combined signals without the filters, I would never had expected such a good result.

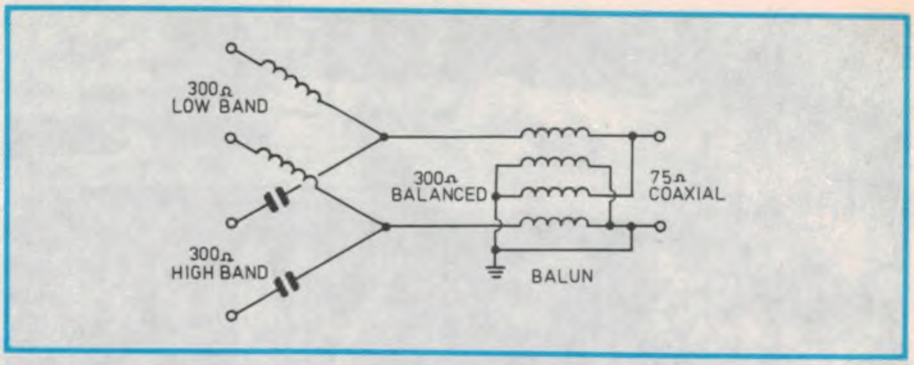


Fig.3: Schematic diagram of combiner and balun. The extra filter components in the combiner result in steeper attenuation slopes than those shown by the graphs in Fig.2, which were calculated for the antenna filters alone.

There was a secondary effect on this installation that was not appreciated until the graphs (Fig 2.) were plotted later. The crossover point is some 7dB down from the two television channels. This crossover just happened to be in the middle of the FM band, so the system has the added advantage of reducing the possibility of FM interference.

I have made up another set of filters and a combiner, for use on an up-coming job where I may be able to surprise the customer by eliminating his antenna switch.

Ever thought of contributing to 'Serviceman'?

Our regular 'Serviceman' is getting on toward retiring age, and does not wish to continue 'slaving away' full time in his own workshop. This means that there will be fewer stories of his own to relate in these pages.

But while he might be getting a little beyond hoisting heavy TV's onto the bench, he can still drive his word processor – and is still capable of writing up the stories, provided the 'raw material' is available. And of course we're still very keen to keep the 'Serviceman' column bubbling along, because it's extremely popular.

This is where you come in. If you are an active 'electronics technician' fixing electronic gear (not just TV sets), and you have the ability to describe an interesting problem and the way you went about solving it, then you can be a contributor to these columns. And you don't even need to be writer to do it – although we're quite happy to accept stories that are already written, if you're able to do this.

But if writing isn't your bag, here's all you need to do: simply get a cassette recorder and a copy of the relevant circuit diagram. Record your description of the symptoms, your investigation, and the final solution. Send us the cassette and a copy of the circuit diagram, and leave the rest to us.

If your story is used, this will of course earn you a publication fee. It's not possible to say what the payment for any particular contribution might be, because it all depends on the time needed to turn your notes into a story. But anything that is usable must be worth at least $50. If the contribution is in good shape and needs little work to get it to publication standard, then the payment could be considerably more.

Please bear in mind that typing the material into the *EA* computer costs lot of money, so a long story can earn less than its apparent value. Still, we will be as fair as is commercially possible and we will encourage good contributors with good fees.

Remember, you don't have to be able to write finished material. All we need is a clear outline of the problem and how you went about solving it. We use 18 to 24 different stories each year so there is plenty of room for your contribution. Why not give it a go?

The parts can be built up on any scrap of Veroboard or similar PCB material. The capacitors are common disc ceramic or tubular ceramic items. I used 10pF units, but any low value caps would do. The lower the value, the greater the rejection figures would be although only a mathematician (which I am not) could tell you by how much.

The inductors were wound from 1mm enamelled copper wire, salvaged from the heater winding of an old valve TV set power transformer. I wound eight turns around the 2.7mm diameter shaft of the largest tool in a set of Jeweller's screwdrivers. The inductance could be anywhere from a little to a lot, but whatever it was, it worked well in this application.

The values selected for these filters just happened to suit the channel 2 – channel 8 separation required for this installation. They would also suit most other situations, with 1-2-3 low band channels and 7-9-10 high band.

If required to separate channels 3 and 6 (or similar closely spaced channels), then much steeper slopes are needed and this can be achieved by using larger inductors and/or smaller capacitors. Again, a mathematician could calculate the requirements, but the filters are so easy to make that it's quicker to try it and see.

The filters were attached to a short length of 300-ohm ribbon then covered with heat-shrink plastic and the open end filled with silastic. I imagine that this will make a totally weather-proof fitting.

The combiner was enclosed in a plastic pill box, about 3cm in diameter and 8cm long. I drilled a hole for the coax in the bottom and cut two slots for the ribbon in the lid. After assembly and testing, I closed the box and sealed the top slots with silastic. It was then firmly taped to the mast and should stay up there for years.

As I said earlier. It was all done with a little bit of theory and no maths at all.

As a footnote to this story, I should tell you about the customer's reactions when I told him I would replace the old channel 9 antenna with a proper channel 8 unit, as soon as I could get one.

He would have none of it and insisted that the old one was working perfectly and he wanted it left where it was.

I didn't argue but simply told him that I wouldn't charge him for the old wreck, only for the time I had spent repairing it for the tests. I warned him that rough weather might knock the old antenna about, but he was quite unconcerned.

When his cheque arrived, it was made out for $20 more than my bill, and there was a note saying 'Thanks for your efforts; the extra covers the antenna which wasn't charged on your bill.'

Why can't all customers be like that?

Fault of the Month

Sony KV-1612AS

SYMPTOM: Won't start up. Remote control can turn on the stand-by light, but there are no other functions accessible either from the handset or front panel controls.

CURE: R603 (47k ohms, 1 watt non flammable) open circuit. This resistor supplies Vcc to the pulse-width modulator and error amplifier in the power supply. Without it, the chopper could never get started.

This information is supplied by courtesy of the Tasmanian branch of The Electronic Technicians' Institute of Australia. Contributions should be sent to J.Lawler, 16 Adina Street, Geilston Bay, Tasmania 7015.

Construction project:

Versatile Sub-woofer adaptor

Upgrade your hi-fi system with this inexpensive box of tricks. It incorporates an active low-pass filter with a variable cut-off frequency, and dual-phase outputs for running a stereo amp in bridge configuration.

by ROB EVANS

It's a familiar story. Your faithful old speakers with the 12 inch (sorry, 300mm) bass drivers have been given the flick, in favour of a pair of those clean sounding bookshelf units. It may have been a space crisis, spouse pressure, or simply sonic considerations that forced the retirement.

But while the immediate problem is solved, a niggling feeling still remains. The old monoliths may have sounded pretty ragged in the mid-range area, but you do miss the extended bass response they offered. Well, here we have a low-cost solution – the *EA* Sub-woofer adaptor.

This design is really a combination of two ideas. Firstly, it attenuates, adds and filters the output signals from the existing system, producing a suitable drive signal for an additional amplifier and sub-woofer combination. Secondly, it inverts this signal to generate an extra output which, in combination with the first, will drive a stereo amplifier in bridge mode for (theoretically) four times its normal output power.

For those not familiar with the concept of running an amplifier in a bridged configuration, this was discussed in some detail in an article entitled 'Bridge adaptor for stereo amplifiers' in the June '85 edition of *EA*. But for those without the patience or back issues, a brief explanation may be in order.

A bridged stereo amplifier effectively runs in 'push-pull' mode, with both channels of the amp driving only one loudspeaker. One channel is supplied with a signal that is 180° degrees out of phase with the other, by use of the inverter mentioned above. For the sake of explanation, consider the input signal at a single point in time, say the positive peak of a sine-wave.

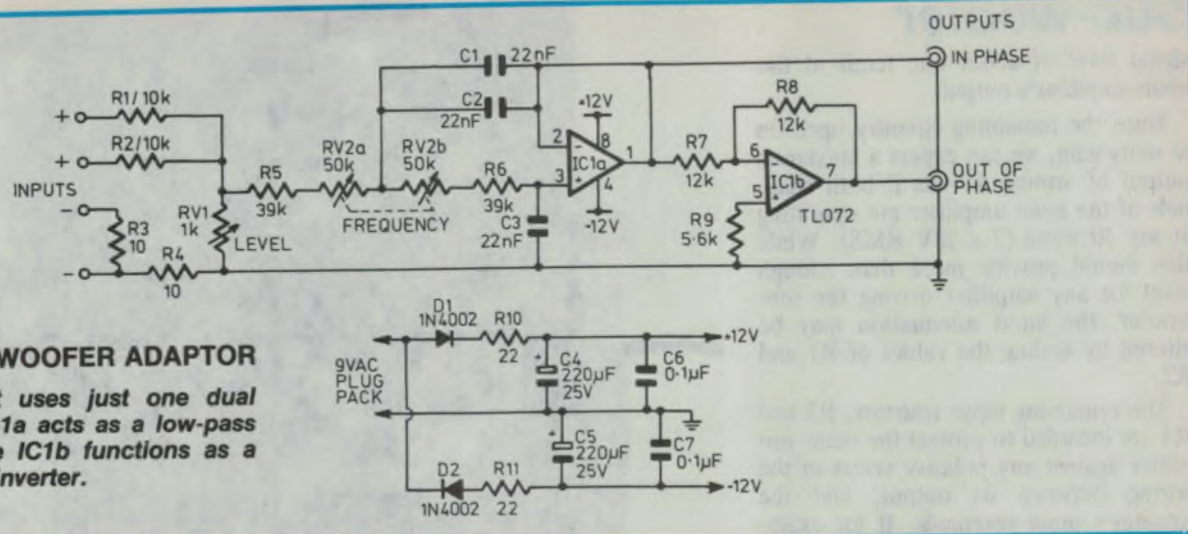
In this case, an amplifier capable of 50W (into 8 ohms) will produce a maximum of about +28 volts at its active output terminal. If one of the channels has an inverted input (now a negative peak), its active output will be –28 volts. So, if a loudspeaker is connected between these two points, the total voltage appearing across its terminals is 56 volts. Presto! 56 volts (peak) into 8 ohms represents 196W RMS.

However, in reality not many amps make it quite this far. This is because in effect, each channel is running into 4 ohms, where due to losses, few amplifiers deliver double their 8 ohm power figure. Nevertheless, a figure of 80W into 4 ohms is quite common, and will produce a very respectable 160W in bridge mode.

So there we have bridge amps; but what benefits can we expect of a sub-woofer system itself? Apart from the obvious extension in the overall low frequency response, there are a few hidden advantages.

In fact *hidden* is just what a sub-woofer system may be, at least in physical terms. The actual sub-woofer enclosure can be installed well out of sight without affecting its performance, since the low frequency energy from such a system is largely non-directional. It is this directional freedom that allows us to sum the low frequency information from the two primary stereo channels, and use only a single sub-woofer ampli-

The completed prototype of the adaptor. Independently powered by a low-cost plug-pack, it can easily be connected to almost any hi-fi system.



SUBWOOFER ADAPTOR

The circuit uses just one dual op-amp. IC1a acts as a low-pass filter, while IC1b functions as a unity gain inverter.

fier and speaker combination. The final result has the response and power of a much larger system, but to the casual observer it appears as just the two main satellite speakers.

Of further advantage is the ease in which a sub-woofer may be added to an existing system. No modifications are necessary, since the Sub-woofer Adaptor simply samples the signal at the main amp's speaker terminals. Because the basic system does not have to be changed (or upgraded) in any way, a sub-woofer must be the easiest and cheapest way to improve your current setup.

However the cost may be reduced even further if a retired stereo amp and speakers are pressed into service. The spare amp may be run in bridge mode for a dramatic increase in power, and for example, the extended bass response of your old monoliths utilised. While the speakers may not have the power overhead you really need, the narrow bandwidth involved (say 30Hz to 80Hz) reduces the continuous dissipation to some degree. In practice, this setup works surprisingly well.

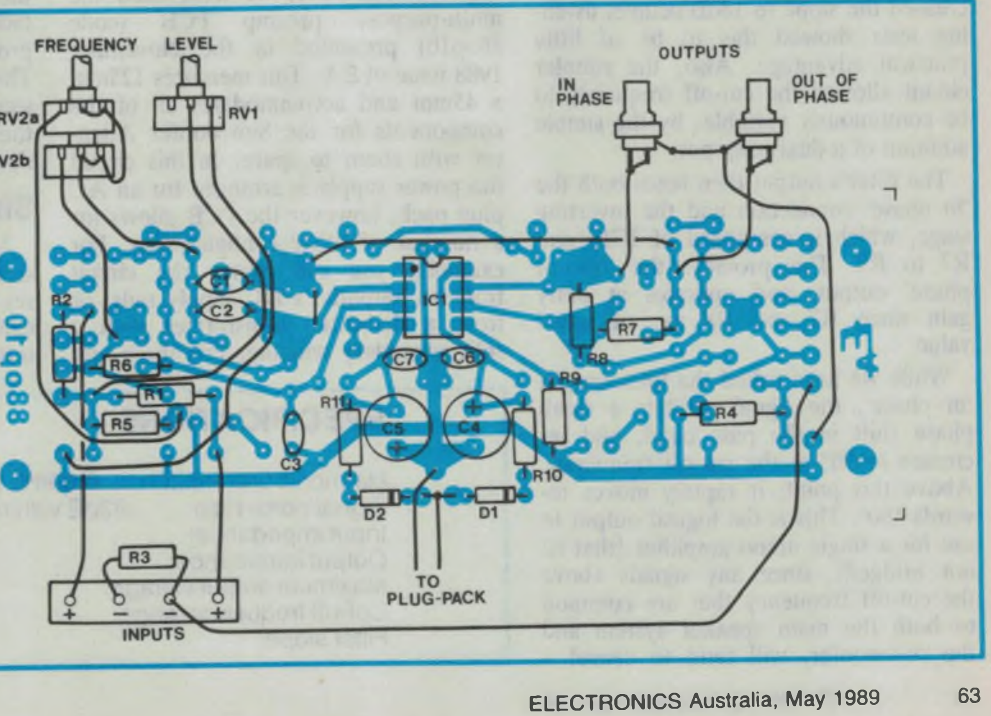
Nevertheless, for the best possible results we would recommend constructing the '100W sub-woofer speaker enclosure' (or similar), as described in the August '82 issue of *EA*. This delivers a flat response down to about 30Hz, and uses a rugged 250mm speaker that is readily available.

So if the concept of a sub-woofer is appealing, read on – we'll show you how our new circuit works, how to build it, and how to loosen your lounge room floorboards!

The circuit

As you can see from the circuit diagram, there's really not much to the Sub-woofer Adaptor. The low-pass filter stage is formed around IC1a and produces the 'in phase' signal, while the remaining op-amp (IC1b) is arranged as an inverting buffer to generate the 'out of phase' signal. A TL072 FET-input dual op-amp was chosen for IC1 due to its favourable noise and distortion performance, and of course its low cost and general availability.

In order to process the output signal from the main amplifier, the left and right channels are summed and attenuated in the circuit by R1, R2 and RV1 (the 'level' pot). This provides an appropriate low impedance source (less than 1k) for the filter circuitry, and a



Use this component overlay as a construction guide. The PCB is our multipurpose pre-amp board as published in November '88.

signal level of about one tenth of the main amplifier's output.

Since the remaining circuitry operates at unity gain, we can expect a maximum output of around 4 volts if both channels of the main amplifier are operating at say 50 watts (2 x 20V RMS). While this should provide more than enough level for any amplifier driving the sub-woofer, the input attenuation may be altered by scaling the values of R1 and R2.

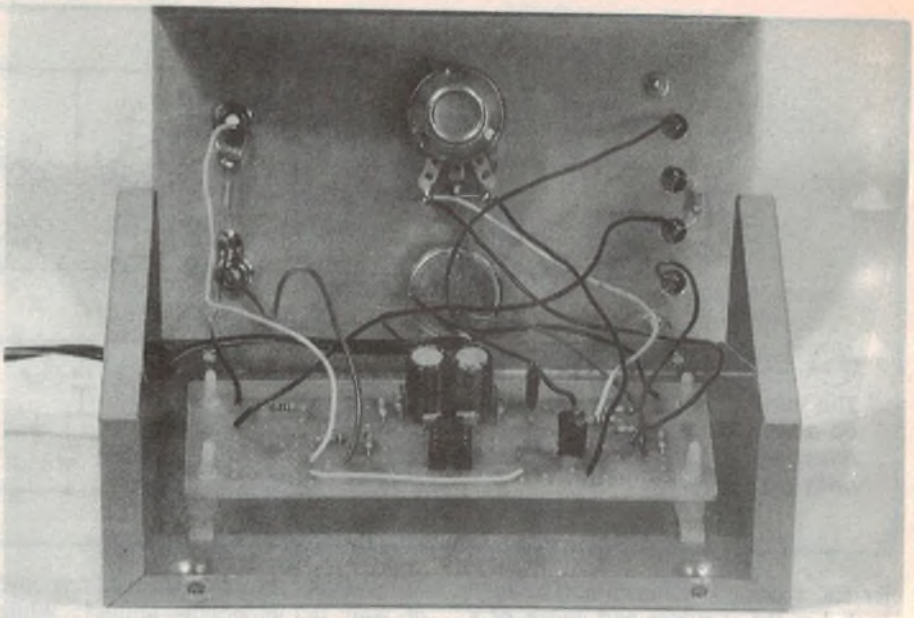
The remaining input resistors, R3 and R4 are included to protect the main amplifier against any polarity errors in the wiring between its output, and the adaptor's input terminals. If for example, the positive and negative from one channel were transposed, the positive would be connected to ground via one or both of the 10 ohm resistors. In this case the resistor(s) will take the full speaker signal, and quickly burn out.

While this may seem a little destructive, if the negative inputs were wired directly to ground, a polarity error would short circuit the main amp's output (since the negative output is generally at ground potential) causing a severe overload – this would be rather more destructive and expensive.

After the input attenuator network, the signal passes to a low-pass filter comprised of IC1a, R5, R6, RV2 and C1 to C3. This is a 2nd order design, and results in an attenuation rate of 12dB per octave above the cut-off frequency. While a more complex 3rd order configuration would have increased the slope to 18dB/octave, listening tests showed this to be of little practical advantage. Also, the simpler circuit allowed the cut-off frequency to be continuously variable, by the simple addition of a dual gang pot.

The filter's output then feeds both the 'in phase' connection and the inverting stage, which is composed of IC1b and R7 to R9. This provides the 'out of phase' output, and operates at unity gain since R7 and R8 are of equal value.

While we have called the filter output 'in phase', the signal exhibits a small phase shift in the pass band, and increases to 90° at the cut-off frequency. Above this point, it rapidly moves towards 180°. This is the logical output to use for a single mono amplifier (that is, not bridged), since any signals above the cut-off frequency that are common to both the main speaker system and the sub-woofer, will tend to cancel – this results in quite a smooth low-end response.



Inside the unit. Note that the case is connected to the signal common via the RCA output sockets.

The remaining circuitry involves the power supply, which rectifies and filters the output of an AC plugpack. Diodes D1 and D2 rectify the positive and negative half cycles respectively, while R10 and R11 limit the charging current to the smoothing capacitors C4 and C5. The resulting positive and negative rails are applied directly to IC1, while C6 and C7 bypass the supply at high frequencies.

Construction

For convenience, we have used the multi-purpose preamp PCB (code 88op10) presented in the November 1988 issue of *EA*. This measures 125mm x 45mm and accommodates all of the components for the Sub-woofer Adaptor with room to spare. In this circuit the power supply is arranged for an AC plug pack, however the PCB allows for a number of other configurations. For example, you can power the circuit from an amplifier's DC supply rails, or from a dedicated transformer with a split secondary winding. For these and other alternatives, see the November '88 issue.

Begin the construction by mounting the lower profile components, including the three wire links. The long link across the top of the PCB should be run in insulated wire, so as to avoid any electrical contact with other components. Work through to the larger components, taking particular care with the polarity of IC1, D1, D2, C4 and C5.

Next, fix the pots and input/output sockets to the front panel of the case, and mount R3 between the negative terminals of the output connector. Using the component overlay as a guide, wire the plug pack lead to the PCB, and attach lengths of hookup wire to the appropriate pads for the pots and sockets. Then the PCB may be mounted on standoffs to the base of the case, and the hookup trimmed to length and soldered to the front panel parts.

Shaking the floor

Using the Sub-woofer adaptor is quite straightforward. First, connect another set of speaker leads in parallel with the existing system (at the main amplifier terminals is easiest), and wire these to

SPECIFICATIONS

Harmonic Distortion:	0.006% THD (ref: 300mV output)
Signal/noise ratio:	–83dB with respect to 300mV output
Input impedance:	10k ohms
Output impedance:	less than 1k ohms
Maximum output voltage:	approx 6V RMS
Cut-off frequency range:	60Hz to 130Hz
Filter slope:	–12dB per octave

PARTS LIST

1 PCB 125 x 45mm, code 88op10
1 aluminium box 150 x 95 x 55mm
1 plug-pack, 6-12V AC
1 spring loaded speaker connector, 4-way
2 chassis mount RCA sockets
2 knobs
4 PCB standoffs

Resistors

All 1/4W, 5%: 2 x 10 ohm, 2 x 22 ohm, 1 x 5.6k, 2 x 10k, 2 x 12k, 2 x 39k
1 1k log single gang pot
1 50k linear dual gang pot

Capacitors

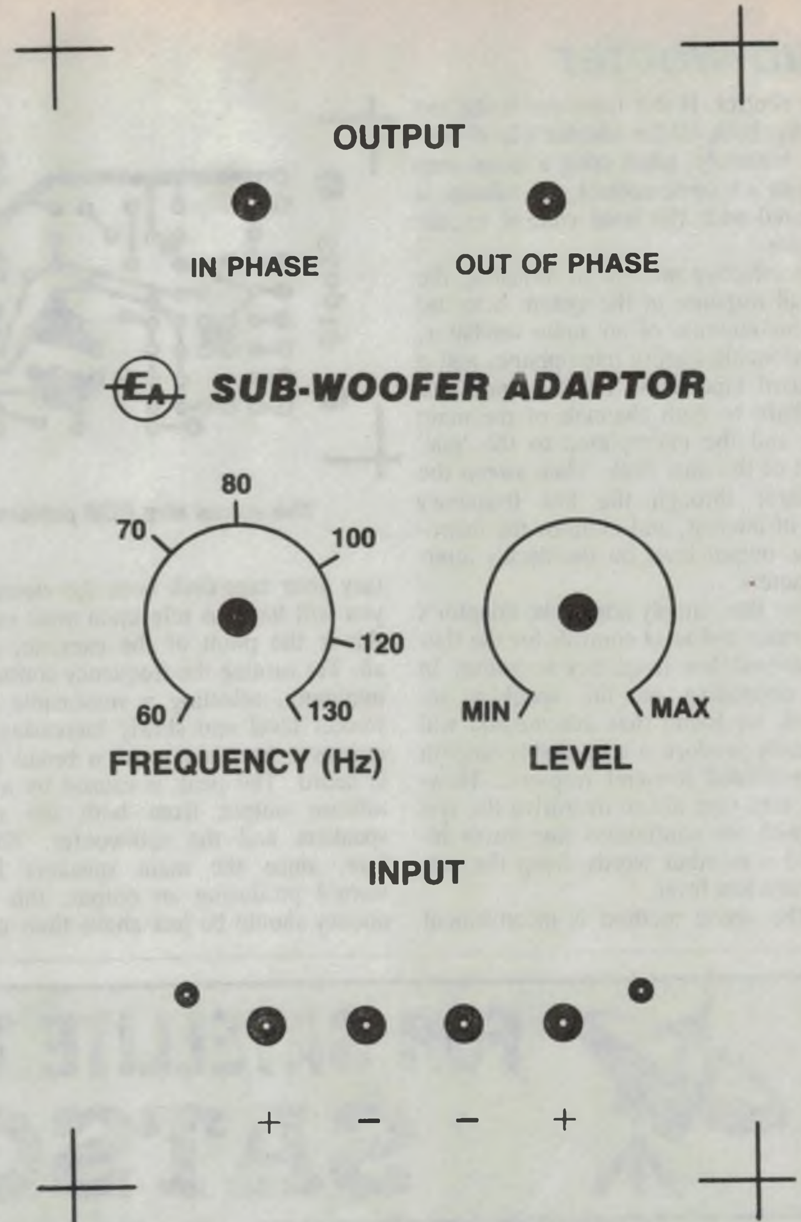
2 0.1uF monolithic ceramic
3 22nF metallised polyester
2 220uF 25V PCB mount electrolytic

Semiconductors

1 TL072 (or similar) dual op-amp
2 1N4002 diodes

Miscellaneous

Nuts and bolts, hookup wire, rubber grommet or cable clamp.

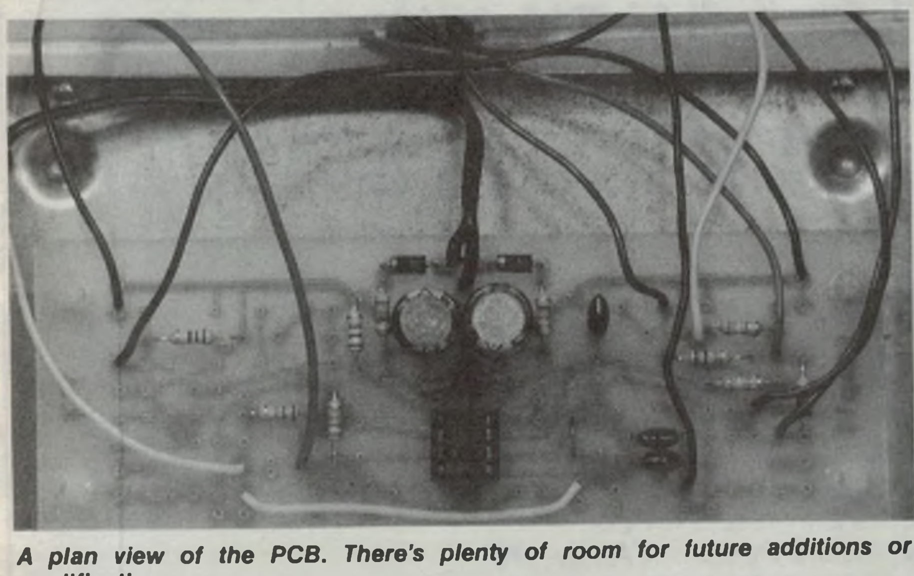


A full size reproduction of the front panel artwork.

the input of the adaptor. They may be light duty wire, due to the high input impedance of the adaptor. Also, only one negative wire is really necessary since the negative terminals are internally connected.

Then connect the adaptor's output to the amplifier chosen to drive the sub-woofer. If the amplifier is a mono unit, simply use the 'in phase' output. However, to connect a stereo unit in bridged mode, the 'in phase' output should be sent to one channel (say the left auxiliary input), while the 'out of phase' signal should go to the other ('aux' right). To preserve the phase sense, the positive connection of the sub-woofer speaker should be wired to the positive (red) terminal of the amp's left channel output. Conversely, the speaker's negative wire goes to the positive terminal of the amplifier's right output. Note that the amp's negative terminals are left unconnected.

Next, select a signal source, wind up the wick of the main amplifier and see what happens. When driving the sub-woofer with a bridged stereo amp, try leaving the adaptor's level control at maximum, and adjust the volume balance between the main speakers and the sub-woofer with the sub-amplifier's vol-



A plan view of the PCB. There's plenty of room for future additions or modifications.

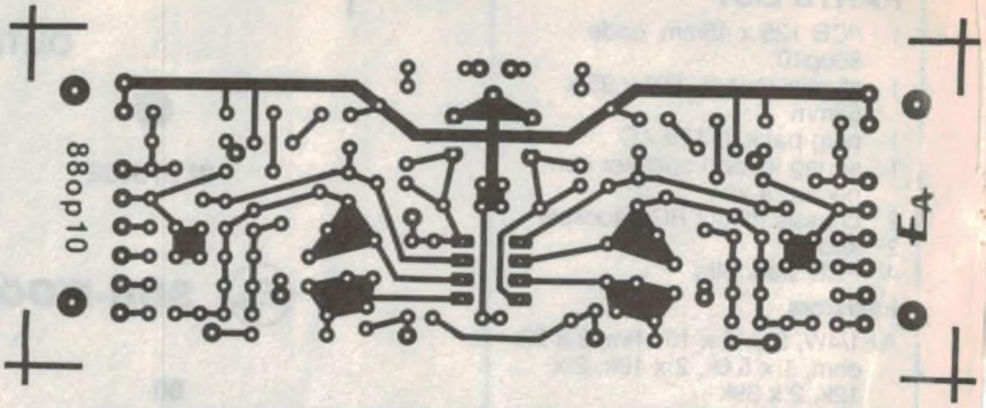
ume control. If this turns out to be too touchy, back off the adaptor's level control. Naturally, when using a mono amp without a volume control, the balance is adjusted with the level control on the adaptor.

An effective method of adjusting the overall response of the system is to use the combination of an audio oscillator, a reasonable quality microphone, and a standard tape deck. First, connect the oscillator to both channels of the main amp and the microphone to the 'mic' input of the tape deck. Then sweep the oscillator through the low frequency area of interest, and monitor the microphone output level on the deck's internal meters.

After that, simply adjust the adaptor's frequency and level controls for the flattest overall low frequency response. In fact depending on the speakers involved, we found that this method will generally produce a remarkably smooth and extended low-end response. However, take care not to overdrive the system with the continuous sine-waves involved – in other words, keep the volume to a low level.

If the above method is inconvenient (say your tape-deck is at the cleaners), you will have to rely upon your ears – this *is* the point of the exercise, after all. Try turning the frequency control to minimum, selecting a reasonable subwoofer level and slowly increasing the crossover frequency until a broad peak is heard. The peak is caused by a significant output from both the main speakers and the sub-woofer. Therefore, since the main speakers have started producing an output, this frequency should be just above their natural low-frequency cut-off point. So, back off the frequency control a little, and you are in the ball-park area – after that, it's purely subjective tuning.

In fact, subjective tuning is the bottom line, regardless of the initial balancing technique. For example, you may enjoy the system with extra energy in the 40 to 60Hz region, which can provide spectacular results on some program material. What's important above all else, is how *you* like to listen to your music.



The actual size PCB pattern for those who wish to make their own.

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Construction project:

Low cost IR movement sensor

Protect your home with this compact, inexpensive passive infrared movement detector. It costs under $40, and is smaller than many commercial units.

by JEFF MONEGAL and PETER PHILLIPS

Home burglar alarms are now almost a necessity – a sign of the times, it seems. Having an alarm system is fine, providing all it does is warn the owner of intruders. The phenomenon of the false alarm is now almost as common as the alarms themselves, and usually results in the owner switching the thing off altogether, or the rest of the public ignoring it when it does go off.

The passive infrared detector (PIR) is now the preferred device as the sensor in most current model alarms, as it is a more reliable way of detecting an intruder without detecting everything else.

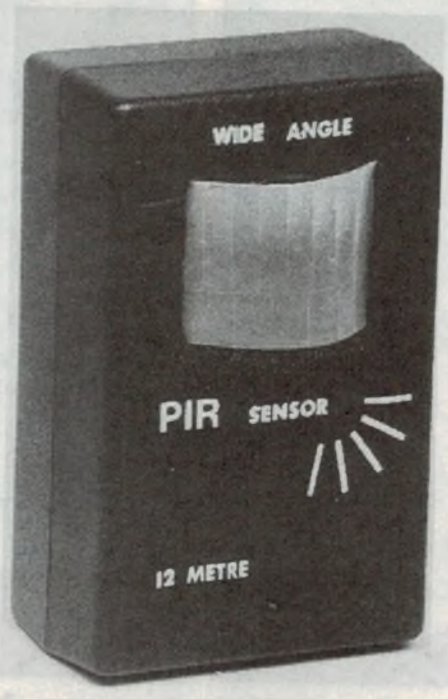
Previously, sensors such as ultrasonic devices or Doppler type microwave units used movement as the means of detecting an intruder, and on many a windy night alarms could be heard going off with monotonous regularity. One also wonders how many cats and dogs were relegated to the great outdoors when the alarm was set for the night. And who can forget the Bogon moth plague – sirens were sounding for a week!

The infrared detector to be described in this article could very likely be interfaced into an existing alarm system, so you could update rather than replace your entire alarm. Or you can make your own alarm system, as this project includes an interface PCB, which can accept up to four PIR detectors. The interface has a relay stage and an integrator to 'count' pulses, minimising false alarms. It also has a voltage regulator, and can power all four modules.

The project is therefore more versatile than commercial units, but at a fraction of the cost. The complete kit (detector plus interface) is available for only $47.90 from Oatley Electronics. The complete PIR module is even less at $39.95. The PIR device is also available from Philips.

The unit has a range in excess of 10 metres and uses a dual element sensor. Also, with the addition of a white filter (supplied) it can be used in daylight conditions (direct sunlight excluded) and could even be used inside your car. The kit even includes two lenses – with a choice of narrow or wide angles of acceptance.

By adding a light dependent resistor (LDR), it could be used to switch on a light at night as you approach, but be disabled during the day. Very handy at the front entrance. Such a device might also deter an intruder, or you could switch the sensor over to the alarm circuit when this type of protection is wanted.



The completed passive IR sensor unit itself, only slightly smaller than actual size. The circuit involves only three op-amp ICs.

For those with an upmarket sense of automation, the sensor could even be used to detect someone's presence and activate an automatic door opener. It's really a case of letting your imagination decide what you want it to do.

The heart of the project is the passive infrared sensor (PIR) device. This works by sensing a change in radiated heat, caused by movement of a human body and is one of the most reliable means of people detection around today. Once the heat change has been detected a pulse is generated, which is passed on to the interface PCB.

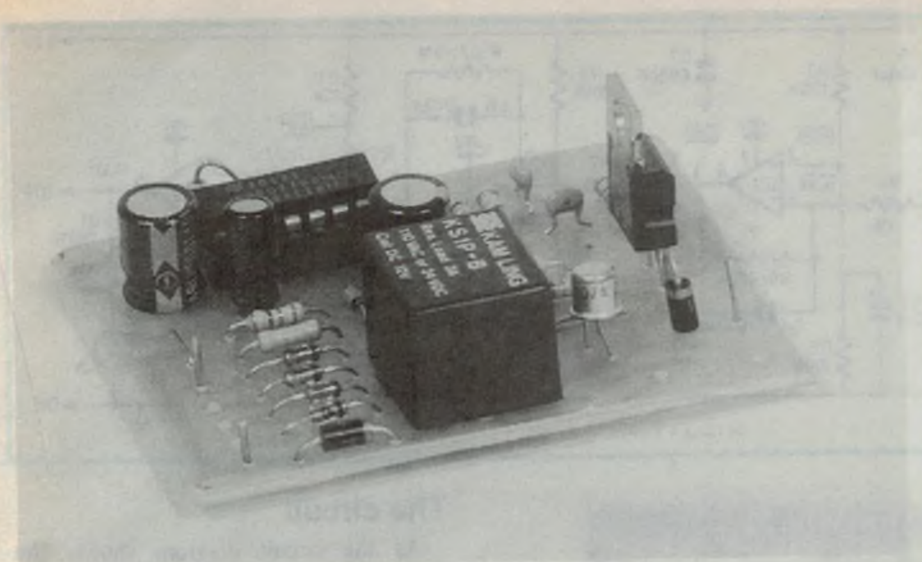
If there are sufficient closely spaced pulses, the integrator section within the interface PCB will cause a relay to operate, which can then be used to drive various other devices, for example, a larger 240V AC relay, allowing mains powered appliances to be operated.

The time that the device remains turned on is adjustable by selecting different timing resistor values during construction. But before we deal with such details, let's first take a look at the PIR sensor.

The PIR sensor

The sensor relies on the fact that the human body emits infrared radiation – assuming it is alive, of course! This radiation is in the 8 to 10 micrometre wavelength region of the spectrum, and the sensor used in this project is sensitive to radiation in this band. The emission of infrared radiation by the human body is present under all conditions, regardless of clothing or the surrounding temperature.

Fig.1 shows the internal circuit dia-



The interface section, shown here on a separate PC board. It can be used with up to four of the sensor units, and includes an integrator.

gram of the PIR sensor used in this project. Two heat sensitive *lithium titanate* elements are used to detect the infrared radiation, and because of the two elements, the sensor is known as a dual element type. Single element types are available, but are not as sensitive as the dual type.

When heat energy from a person falls on these elements, a small voltage is produced. In the dual element type the voltages produced by the two elements will cancel each other if the energy is common to both elements. This feature ensures rejection of *common mode heat*, such as changes in the ambient temperature.

However, if heat is focused onto one element at a time, a differential output voltage will result. This way, energy that enters the sensor from all directions, making it common to both elements, will produce no output voltage; but energy that is directed onto a single element will produce a voltage. A voltage that is twice that from a single element device, according to the manufacturer.

The problem is how to focus the heat from a distance of up to 10 metres onto the device – as without focusing, the sensor will only produce a useable output voltage for a range of around 1 metre.

During the early 1800's, Augustin Jean Fresnel, a French physicist experimented with lens systems and light and defined the principles of bending light using a lens. He knew nothing of the PIR of course, that was many years away, but it was his work that eventually led to the development of the *Fresnel lens*.

The Fresnel lens used with a PIR detector is made of *polyethylene* and has a special pattern of grooves and ridges moulded into one side. These are then divided into sections, with each one forming a separate lens as shown in Fig.4. It is this pattern that gives the PIR sensor its greater range. The lens used with the prototype actually achieved ranges up to about 12 metres with a field of view of nearly 70°.

The lens is mounted so that it curves around the sensor. The distance the lens is placed away from the sensor should equal the focal length and in this project the distance is 15 to 20mm, as shown in Fig.3. The sections of the lens divide the field of view into fields or *beams*, as illustrated in Fig.4.

When a heat source, such as that from a human body moves across these beams, energy is focused onto the sensor elements, one at a time. This causes that element to produce an additional voltage, overcoming that produced by the other element due to the ambient radiation level.

The end result is that an AC voltage is produced when someone moves across the field of view. The frequency of this voltage is directly related to the speed of movement, and at normal walking speed this frequency is about 6Hz. The output voltage developed by the elements is buffered by the FET mounted inside the sensor case.

The PIR sensor is a very sophisticated device, and our description is merely a basic coverage. There have been several books published about these devices, if you want to know more about the subject.

Having explained the sensor, now to the circuit of the complete project.

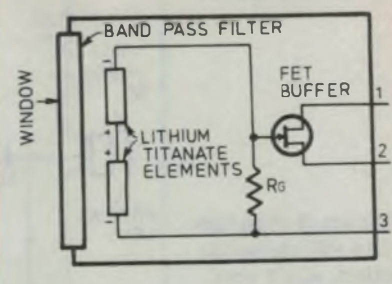


***Fig.1:** Showing the internal circuit of the PIR detector.*

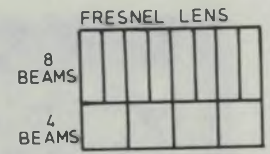


***Fig.2:** The Fresnel lens for the detector is divided into a number of sections.*

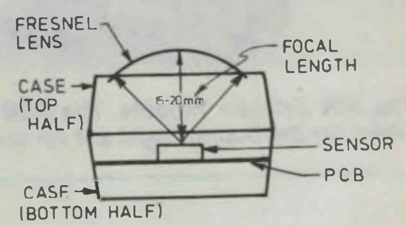


***Fig.3:** The focal length of the lens used in this project is around 15 to 20mm.*

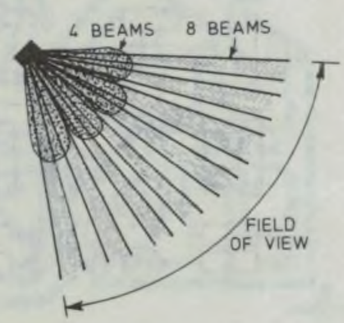
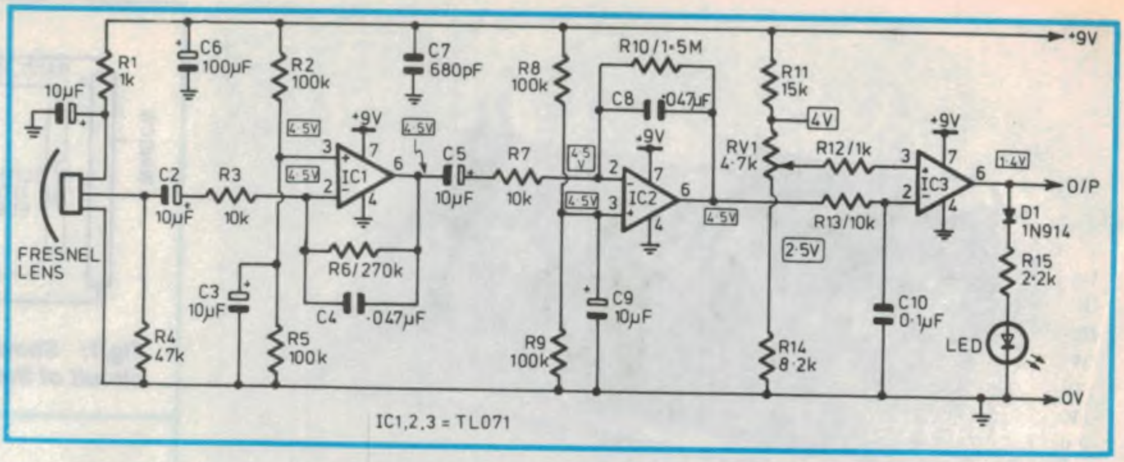
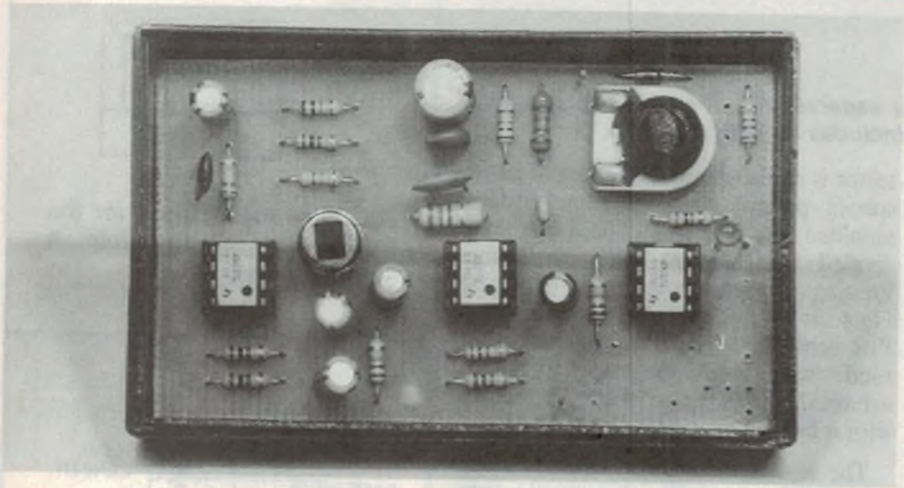


***Fig.4:** The Fresnel lens divides the field of view into a number of beams spanning almost 70 degrees.*

IR sensor



The circuit diagram of the PIR detector section. ICs 1 and 2 amplify the output of the detector, and IC3 is a comparator.



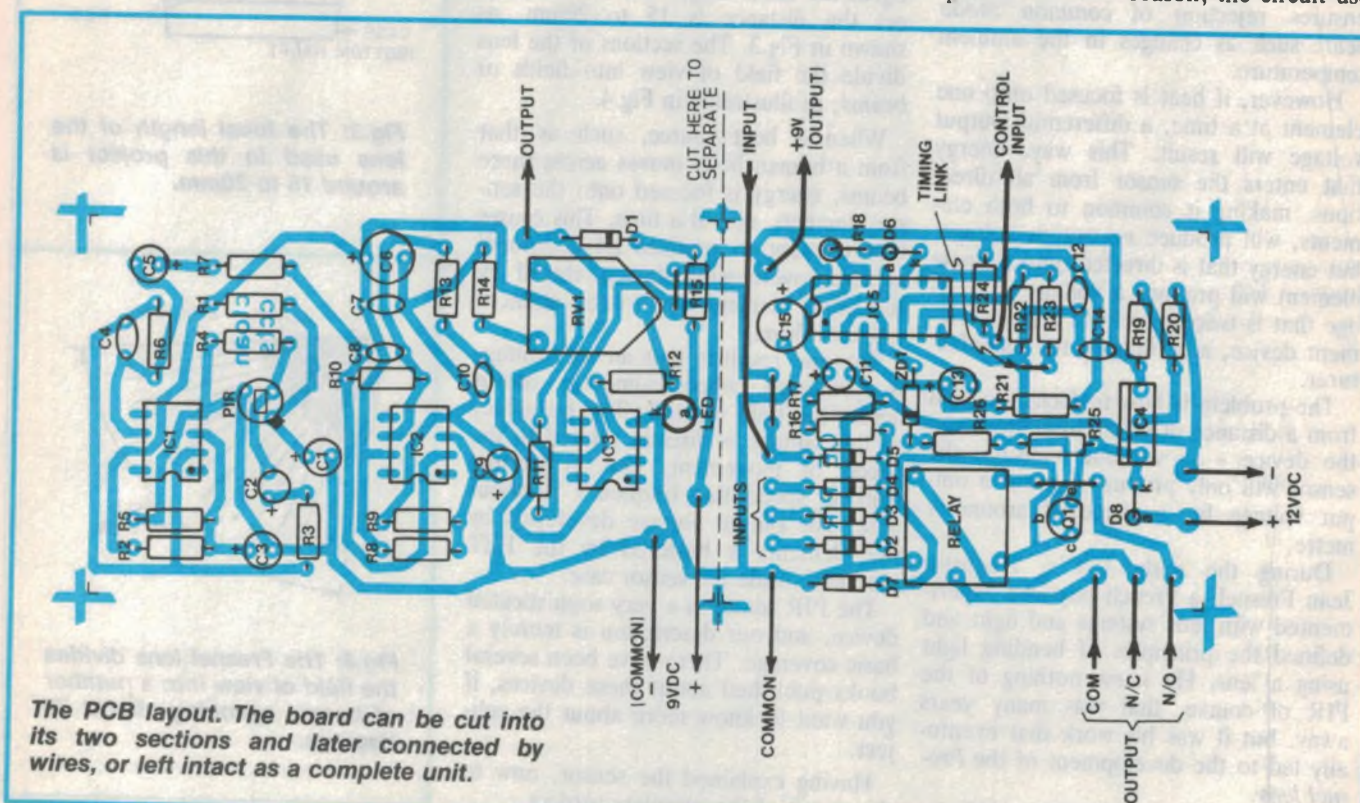
The PIR detector module. The PCB has since been changed slightly and the holes on the bottom right are for components now on the interface PCB

The circuit

As the circuit diagram shows, the whole thing is quite simple. However, despite its apparent simplicity, this circuit was the result of considerable research.

We started with a circuit based on the PIR manufacturer's suggested circuit, using an LM324 quad op-amp. This was finally rejected as being unreliable, in that some LM324 ICs worked and others gave false alarms. We could find no explanation, as the circuit was otherwise performing correctly.

We finally decided that quad devices have different characteristics to four *single* op-amp ICs; perhaps there is some interaction between the individual amplifiers. For this reason, the circuit uses

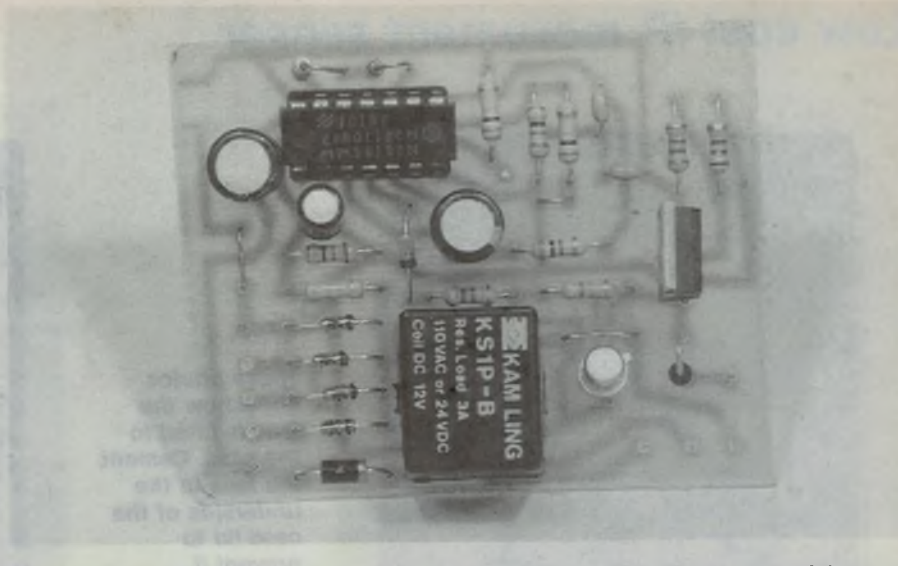


The PCB layout. The board can be cut into its two sections and later connected by wires, or left intact as a complete unit.

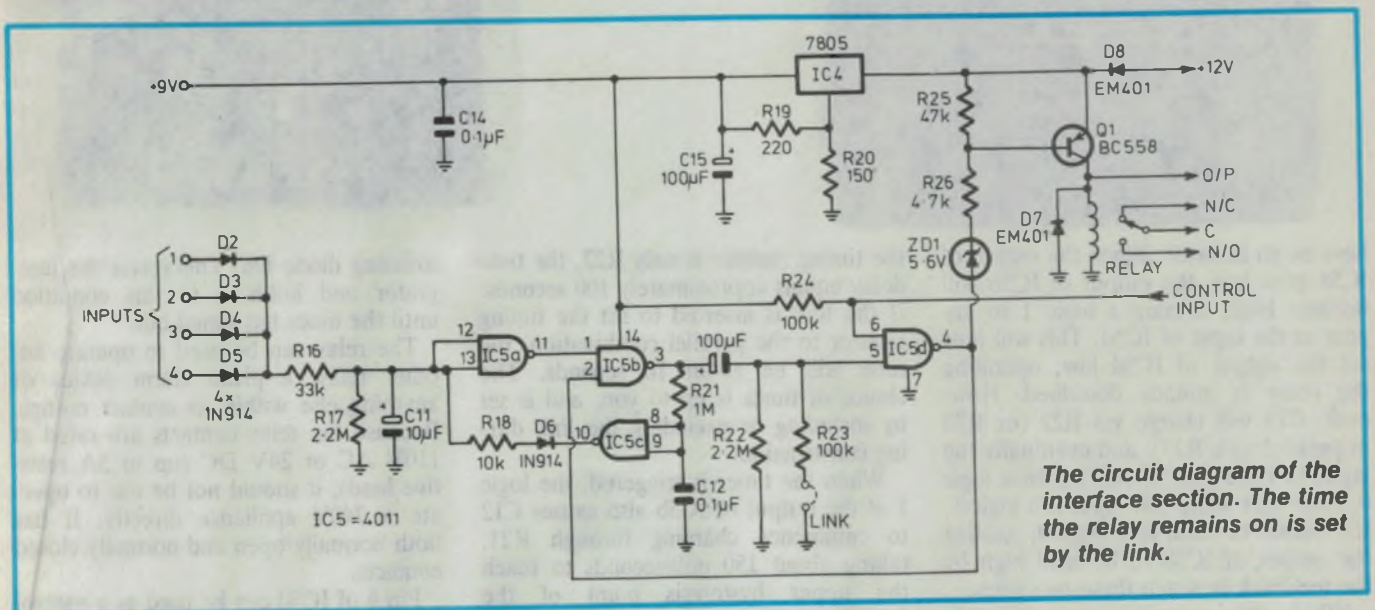
individual ICs for each amplifier, although the final circuit is totally different to the manufacturer's suggested one.

Starting with the PIR device, R1 and C1 decouple it from the supply line and R4 is the load for the sensor. The signal from the sensor is coupled to the input of the first amplifier (IC1) by C2. Resistors R2 and R5 (decoupled by C3) bias the amplifier so that its output is at half rail voltage, allowing the AC signal to swing around this quiescent value. The gain of IC1 is set to 27 by R5 and R6, and this stage acts as a buffer (with gain) to the sensor.

The amplified signal is applied to the input of the second amplifier IC2, via C5. This stage has a gain of 150, determined by R7 and R10. Capacitor C8 sets the frequency response of the amplifier to a suitably low value, to minimise transients and amplification of high frequency noise. The total gain of the two stages is therefore approximately 4050. IC2 also has its output biased at half rail and under no-signal conditions its output will be around 4.5V DC.



The interface PCB. Up to four detector modules can be connected to, and powered by the interface.



The circuit diagram of the interface section. The time the relay remains on is set by the link.

IC3 is a voltage comparator and compares the output of IC2 to the voltage at its non-inverting terminal. This voltage is adjustable via RV1, with its upper limit set to 4V by R11 and its lower limit set to 2.5V by R14. These two voltage limits were determined by experiment, and give the highest sensitivity without false triggering for one setting, or a range of only a few metres for the other.

When infrared energy falls onto the sensor, a signal is produced as already described. This voltage is amplified and applied to the comparator. If the signal voltage causes the inverting terminal of the comparator to become negative with respect to the non-inverting terminal, its output will swing positive. This will light the LED and produce a pulse that can now be used by the interface circuit.

The interface

The interface section can have up to four detector modules connected to it. In fact you can have even more if you want to add extra isolating diodes.

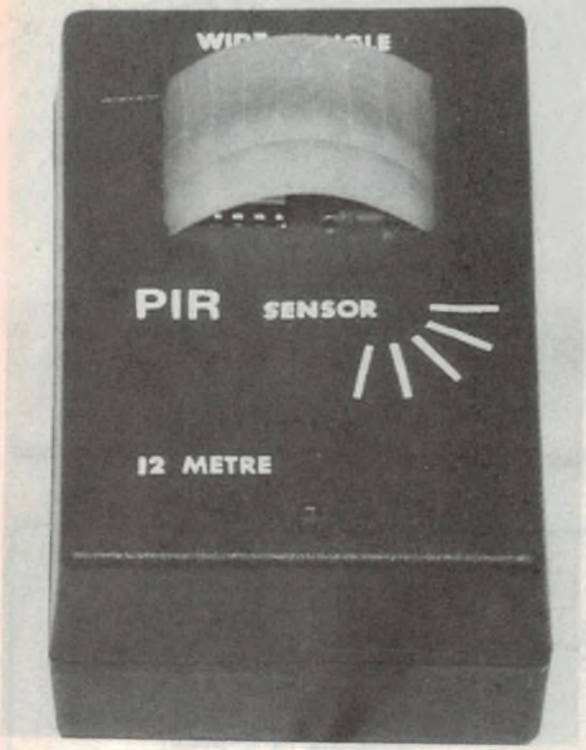
The positive-going signal from a detector module will be passed to R16 by the diode which that module is connected to. The diodes effectively act as an OR gate, while also isolating each module from the others.

When a pulse is received, it will charge C11 by a small amount. If no more pulses occur C11 will be discharged by R17. However if someone (welcome or otherwise) is moving to intersect the beams, a series of pulses will be generated as each intersection occurs. Each pulse will further charge C11, until after 2 or 3 closely spaced pulses the voltage across C11 will reach the upper hysteresis point of the Schmitt input NAND gate IC5a, causing its output to switch to 0V.

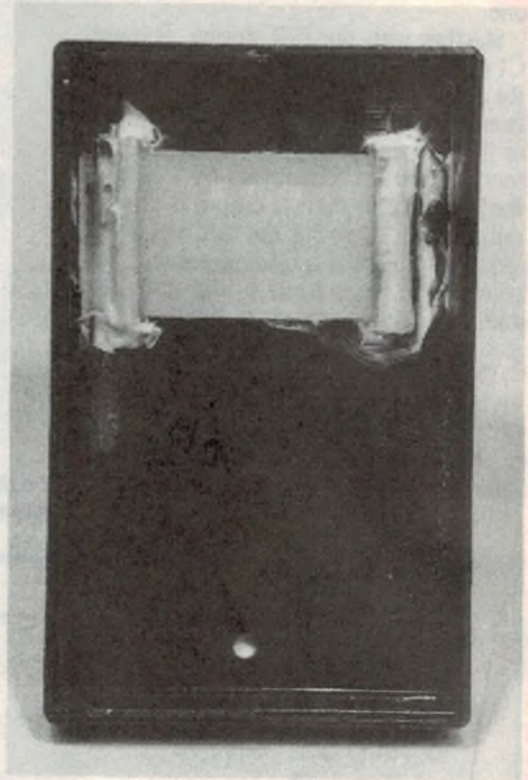
NAND gates IC5b and IC5d act as a timer, and the output of the timer (pin 4 of IC5d) is used to drive Q1, via ZD1 and R26. Transistor Q1 is turned on when the output of IC5d goes low, in turn operating the relay. The time that the relay stays on is determined by C13, charging through either R22 or the parallel combination of R22 and R23.

Normally the output of IC5d is high, causing the NAND gate of IC5b to be-

Low cost IR movement sensor



These photos show how the lens is fitted to the case. Cement the lens to the underside of the case lid to prevent it moving.



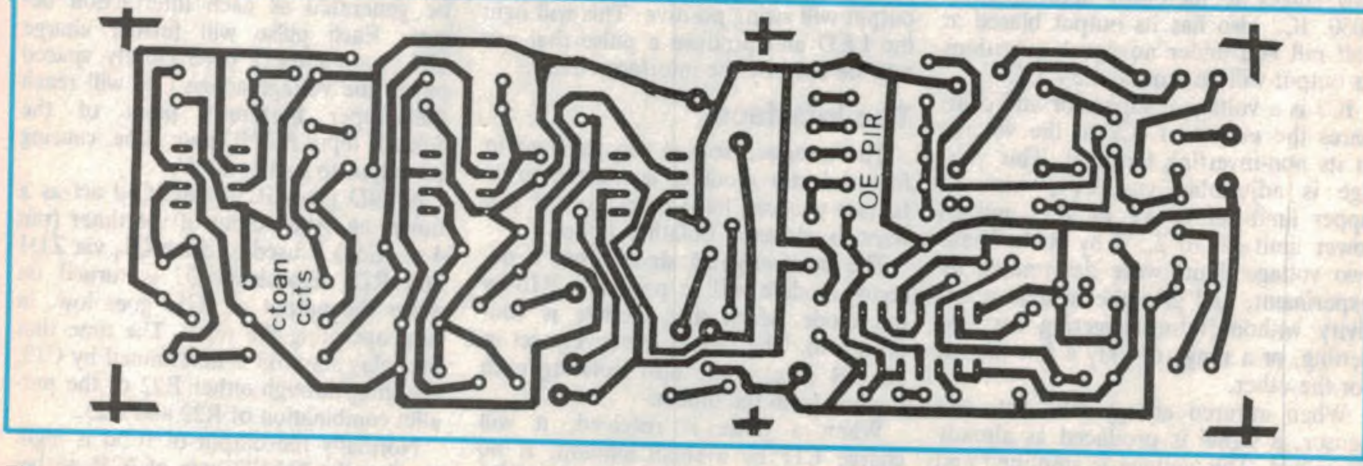
have as an inverter. When the output of IC5a goes low, the output of IC5b will become high, causing a logic 1 to appear at the input of IC5d. This will now set the output of IC5d low, operating the relay as already described. However, C13 will charge via R22 (or R22 in parallel with R23), and eventually the input to IC5d (pin 5) will fall to a logic 0. Note that while this input is a logic 1, the output of IC5d is a logic 0, causing the output of IC5b to be held high by the feedback between these two gates.

When the capacitor is sufficiently charged, the input to IC5d falls to a logic 0, resetting the whole circuit. If the timing resistor is only R22, the time delay equals approximately 100 seconds. If the link is inserted to set the timing resistor to the parallel combination, the time will be about 10 seconds. The choice of times is up to you, and is set by including or excluding the link during construction.

When the timer is triggered, the logic 1 at the output of IC5b also causes C12 to commence charging through R21, taking about 150 milliseconds to reach the upper hysteresis point of the Schmitt trigger input of IC5c. When this point is reached, the output of IC5c goes low, discharging C11 via R18 and isolating diode D6. This resets the integrator and holds it in this condition until the timer has timed out.

The relay can be used to operate another relay, a piezo alarm device or anything else within its contact ratings. Because the relay contacts are rated at 110V AC or 24V DC (up to 3A resistive load), it should not be use to operate a 240V appliance directly. It has both normally open and normally closed contacts.

Pin 6 of IC5d can be used as a control input. By taking this input low the timer will be reset and any remaining time cancelled. The control input must be



The PCB artwork, reproduced actual size.

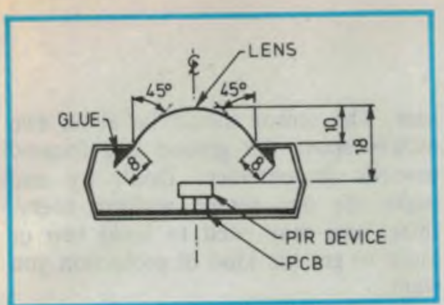


Fig.5(b): The lens will protrude into the underside of the case, and can be cemented to the case. Mount the PIR to give a focal length around 18mm as shown

taken high or allowed to float before the timer can be retriggered. If this input is taken to ground via an LDR (light dependent resistor) then the unit can function as an automatic light switch that only operates during the night hours.

IC4 is a 5V three-terminal regulator with its reference pin held about 4 volts above ground by the voltage divider action of R19 and R20. This gives a supply rail of about 9V DC. The input voltage is 12V DC, via protection diode D8. The interface PCB can be used to power the modules.

Construction

Start construction of the project by giving the PCB the customary check for any track shorts or other problems. Check particularly for shorts between tracks that run close to each other, and any track breaks. Check also that the PCB will fit neatly inside the bottom of the case. Trim the board if necessary.

Next decide if the PCB is to be separated into two sections (detector section and interface) or if it is to be enclosed in the one case. The prototype is shown as two separate modules, and if the whole PCB is to be enclosed in the same case, a larger size than that shown will be needed.

If you decide to construct the unit as two separate modules, cut the PCB as shown in the layout diagram. This can be done with either a guillotine or a hacksaw. Draw a line across the PCB before cutting to ensure it is cut correctly.

Next insert all resistors and capacitors, taking care to correctly orientate the electrolytics, as being polarised they will only function properly with the correct polarity of DC voltage across them. The diodes can now be placed; again pay particular attention to the polarity. Note that D6 and R18 are mounted vertically.

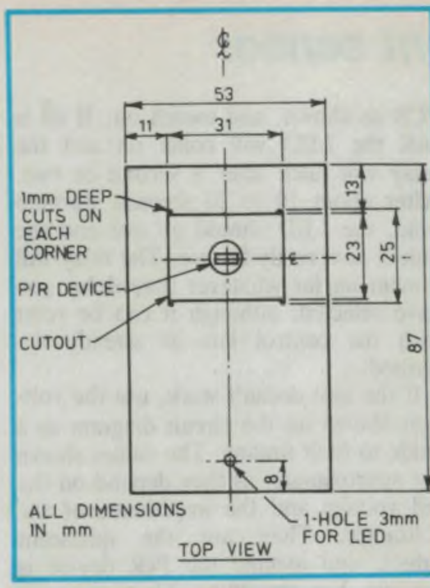


Fig.5(a): Cut the opening for the lens and the LED using the dimensions shown. These only apply to the recommended case.

Next the semiconductors can be installed. IC sockets are recommended (except for IC4), as the extra cost will soon pay off if an IC is found to be faulty. When the transistor, IC4 and the IC sockets have been soldered in place, mount the relay. The final components to install are the PIR device and the LED. However, before mounting these, the lens should be fitted to the case so the height of the PIR detector can be set for the correct focal length.

To fit the lens, cut a rectangle in the top of the case as shown in Fig.5. Note that the dimensions shown are for the recommended case only; other cases can be used, but you will need to determine the relative position of the cutout. The case has tapered sides, and the dimensions shown are relative to the top, and all are outside measurements.

Be careful when cutting the opening, as the plastic case is fairly fragile. First mark the rectangle on the case, then drill (carefully) inside the markings to eventually remove the cutout required. File the rectangle to get the correct sized opening. Then, using a hacksaw, cut 1mm deep nicks in each corner as shown in Fig.5, at an angle of around 45°. Also, drill a 3mm hole for the LED indicator, along the centre line of the case, 8mm from the bottom.

Then form the Fresnel lens into a semicircle and fit it into the four corner cuts. The smooth side should face out, and the 4 sector section should be at the bottom. The lens is 25mm wide, and the cuts should allow the lens to be held reasonably firmly. Next adjust the apex of the lens so that it is about 10mm above the top of the case. Once you are happy with the result, apply adhesive to the underside of the case and the lens as shown in Fig.5. Nail polish will hold the lens quite well, although we used a silicone-based adhesive.

PARTS LIST

1 PCB coded OEPIR88
1 Case, 53 x 87 x 30mm
1 PCB mount 12V relay
1 PIR sensor type RPY97 with Fresnel lens

Semiconductors

3 TL071 op amps
1 7805 5 volt regulator
1 4011 quad NAND gate
1 BC558 transistor
6 1N914 diodes
2 EM401 diodes
1 3mm Red LED

Resistors

All 1/4 watt:
2 x 2.2M, 1 x 1.5M, 1 x 1M, 1 x 270k, 6 x 100k, 2 x 47k, 1 x 33k, 1 x 15k, 4 x 10k, 1 x 8.2k, 1 x 4.7k, 1 x 2.2k, 2 x 1k, 1 x 220, 1 x 150.
1 4.7k trimpot.

Capacitors

3 100uF electrolytic
6 10uF electrolytic
3 0.1uF monolithic
2 47nF ceramic
1 680pF ceramic

Miscellaneous

Hook up wire, 3 x 8 pin IC sockets, 1 x 14 pin IC socket.

Now proceed with installing the PIR device. Exercise great care with it, and solder it into the PCB as quickly as possible. Insert the device into the PCB and adjust the lead length so that it is approximately 18mm from the apex of the lens. This dimension is not particularly critical; in fact we achieved excellent results with a focal length of 25mm. Also, fit the LED indicator, and adjust its height so that it fits neatly into the hole in the top of the case, sufficiently proud of the top of the case to be visible when lit.

The time delay should now be decided on, and the link either used or deleted. Finally, the interconnecting wires can be soldered to link both PCBs, unless you have elected to keep the board as a complete unit. Finally, once everything is complete, recheck your work to ensure that there are no problems with soldering and that all components are in properly and the correct way round.

Testing

Once you're convinced that all is ready, apply 12V DC to the interface PCB as shown, and switch on. If all is well the LED will come on and the relay will latch after a second or two. After about 10 to 20 seconds warmup time, the LED should go out and the unit is now ready for use. The relay will remain on for whatever time delay you have selected, although it can be reset with the control line as already described.

If the unit doesn't work, use the voltages shown on the circuit diagram as a guide to fault finding. The values shown are approximate, as they depend on the rail voltage and the impedance of the voltmeter. They are the quiescent values, and assume the PIR device is inactive. You should be able to measure values that are consistent, if not exactly the same. Look particularly for incorrectly polarised electrolytic capacitors, or capacitors that are leaky. The circuit is relatively simple, and you can be assured that it works as described if built correctly.

Installation

Installing the completed project is really up to the requirements of the user. The sensor should be about two metres above the ground and focused towards an entrance. Don't try and make the one sensor perform everything; you may need to build two or more to get the kind of protection you want.

Once installation has been completed the sensitivity should be adjusted to suit the particular installation. Test the sensitivity by actually moving around, rather than merely waving your hand. Adjust it to give reliable indication of a person in the room, but not so sensitive that it reacts to the cat!

For the prototype, we obtained a range of above 10 metres with a field of view of approximately 70° at maximum sensitivity. At minimum sensitivity a range of about 4 metres was obtained with the same field of view. This may vary between units, however.

The three wires connecting the detector module to the interface should be run away from any other wiring to minimise noise pickup. Hopefully, with one or more of these detectors, you won't become part of the robbery statistics or disturbed by false alarms.

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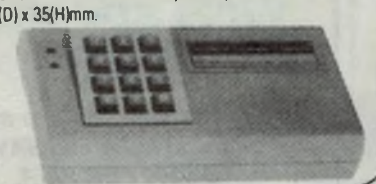

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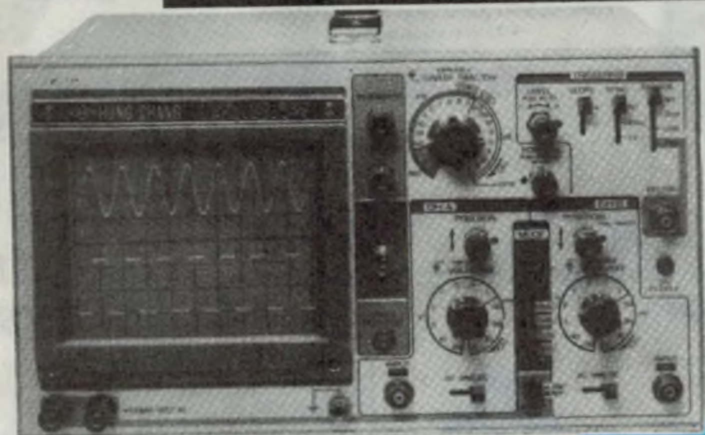

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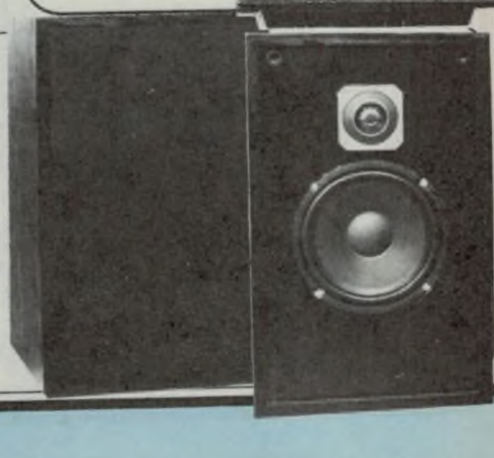

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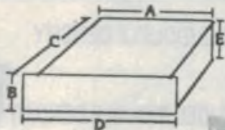

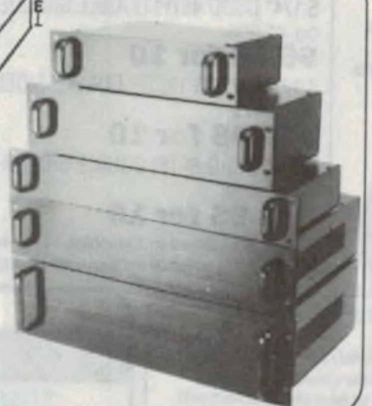

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HB-5382	429	62	203	481	69	**$49.50**	**$46.00**
HB-5383	429	95	292	481	100	**$65.00**	**$61.00**
HB-5384	429	122	292	481	126	**$75.00**	**$70.00**

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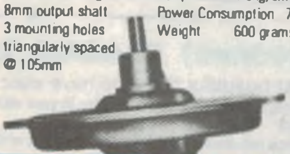
Powerful 12V DC Motor!

This motor, as used in automotive thermatic type fans, has incredible torque. It is a 'pancake' style unit with a 8mm diameter output shaft (with flat). We have scooped up a smallish quantity of these at a great price! Grab one now for an incredible $25. Worth over $60!!

Cat. YM-2706 **$25**

Dimensions 130 (approx) dia
40(approx) deep
20mm shaft length
8mm output shaft
3 mounting holes triangularly spaced @ 105mm

SPECS
Speed 1800 RPM @ 12V
Torque 1.5kg/cm @ 1800 RPM
Power Consumption 70W @ 12V
Weight 600 grams



JAYCAR DIGITAL MULTIMETER

(With almost everything - SAVE $50 over others)

LOOK AT THESE FEATURES

- 34 ranges - 3.5 digit LCD display
- High impact yellow case
- Small size - only 133 x 70 x 30mm
- 10 amp AC and DC. DCV > 1% worst
- Diode tester - continuity buzzer
- Frequency counter 10Hz - 200kHz
- Built-in 20MHz logic probe
- Capacitance tester 1pF - 20µF
- Tilting Bail - Safety test leads
- One hand operation with unique feature where probes can mount into either side of the case
- 3 month warranty

Cat. QM-1400

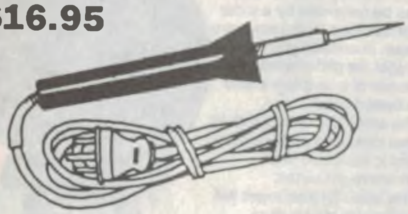
$99.95

Jaycar Soldering Iron

Ideal for the hobbyist and handyman. Our lowest price 240 volt quality iron has a stainless steel barrel. 30 watt

Cat. TS-1450

$16.95



Ultrasonic Air Humidifier

CREATE YOUR OWN CLIMATE IN YOUR OFFICE OR HOME

Features

- Cutout switch when water runs out
- Generous 6.75 litre water tank
- Ultra quiet operation
- Adjustable intensity control
- Adjustable humidity control
- Air filter included
- Humidifies up to 4,000 cubic feet

Specifications

- 40 watts
- 240V AC power source
- Humidity control 30 - 90%
- Dimensions 375(L) x 150(W) x 290(H)mm

Cat. YH-5500

WAS SELLING FOR $149 in 1986

NOW ONLY $99.50

NEW FOR 89

ECONOMY DIGITAL MULTIMETER

Digital multimeter at an analog price!

- 3.5 digit LCD display
- 20 ranges
- Diode checker
- DC 10 amp, 1000V, 0-20M ohm, etc
- 1500 hour battery life
- One hand operation with unique feature where probes can mount into either side of the case
- Tilting bail
- Safety test leads
- 3 month warranty

Cat. QM-1410

$59.95

NEW FOR 89

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Let Jaycar tempt you into making that decision NOW and SAVE UP TO $200 PER PAIR.

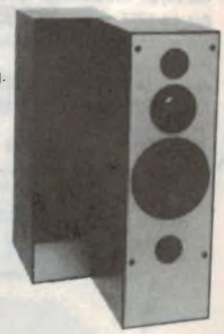
All our stores have the new upgraded Vifa kits on demonstration so drop in and have a listen. Remember, you will pay about twice as much for similar pre-built, imported speakers when, in fact, they will probably have Vifa speakers in them anyway. See our 1989 catalogue for full details. (Demonstration speakers are not at Concord).

SA-130 3-way kit

complete with cabinets and crossovers.
130W RMS power handling.
Cat. CS-2485/CB-2467

SAVE $200

ONLY $999 A PAIR

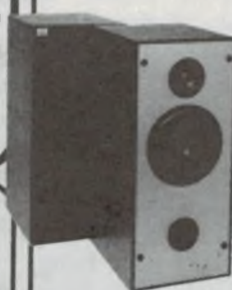


SA-100 2-way kit

complete with cabinets and crossovers.
100W RMS power handling.
Cat. CS-2460/CB-2482

SAVE $100

ONLY $699



SA-70 2-way kit

complete with cabinets and crossovers.
70W RMS power handling.
Cat. CS-2471/CB2472

SAVE $50

ONLY $449 A PAIR

SA-50 2-way bookshelf

kit with cabinets and crossovers.
30W RMS power handling.
Cat. CS-2450/CS-2452

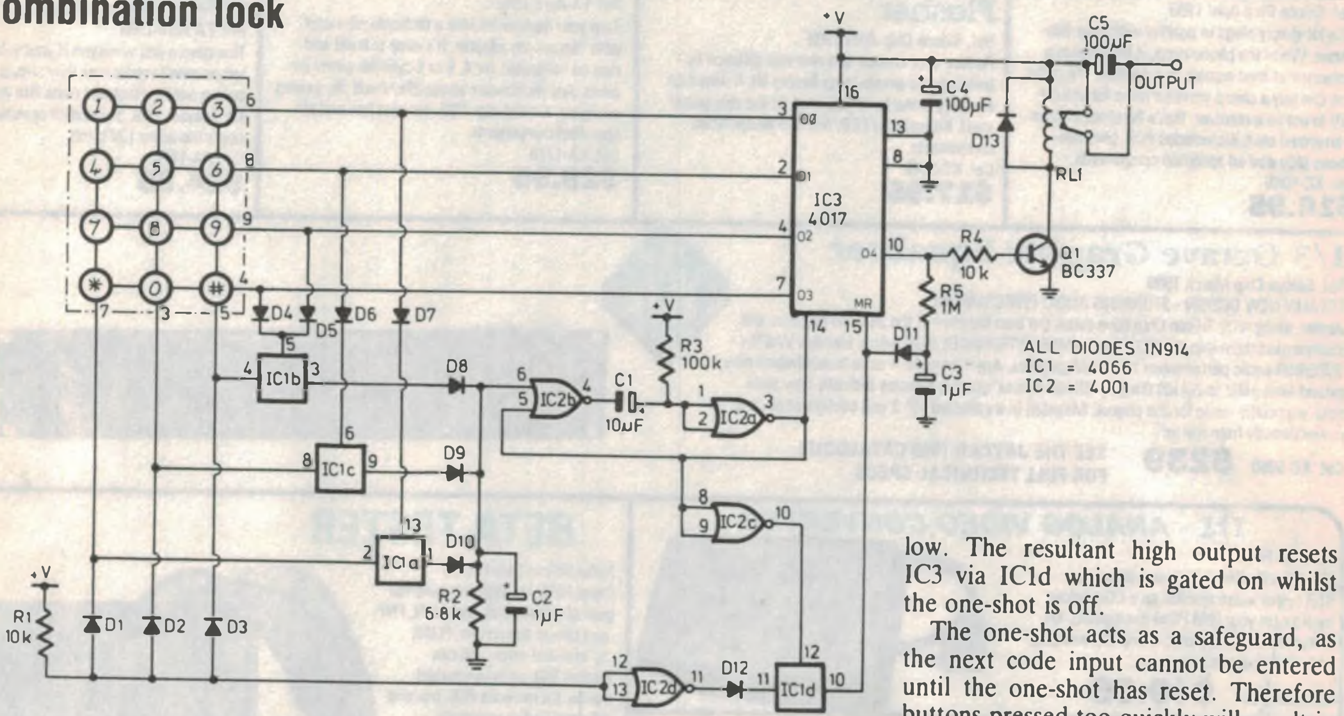
SAVE $30

ONLY $369 A PAIR

Circuit & Design Ideas

Interesting circuit ideas from readers and technical literature. While this material has been checked as far as possible for feasibility, the circuits have not been built and tested by us. As a consequence, we cannot accept responsibility, enter into correspondence or provide constructional details.

Combination lock



The aim of this project was to build a cheap but secure keypad activated switch using readily available parts. Estimated cost of parts including keypad but excluding relay and circuit board is approximately $10.00.

The main advantages of this circuit are:

1. 'Code' buttons pressed out of sequence will reset circuit.
2. Buttons pressed too quickly will not access code.
3. Code easily changed.
4. Latched or momentary output.

IC3 is a decade counter with the '0' output high in the reset condition and all others low. When four correct code numbers are entered in correct sequence IC3 is clocked four times and the resultant high '4' output drives Q1 which in turn drives the relay. R5 & C3 form a RC network which resets IC3 via D11 after approximately 1.5 seconds. Omission of R5 gives a 'latched' output.

IC2a&b and R3 and C1 form a one-shot of short duration. This one-shot is triggered by the transfer of a 'high' through IC1a,b or c. This can only be achieved if the correct code number is pressed, as only one row of the keypad has a high input from IC3 and thus only one switch is gated on by any of diodes D4-7. The one-shot, when triggered, clocks IC3 and simultaneously disables the reset circuit. No other code number can be accepted until the one-shot has reset.

If an incorrect number is pressed a low is transfered via the keypad and any of D1-3 and this pulls the input of IC2d low. The resultant high output resets IC3 via IC1d which is gated on whilst the one-shot is off.

The one-shot acts as a safeguard, as the next code input cannot be entered until the one-shot has reset. Therefore buttons pressed too quickly will result in a reset.

The code can be changed by the relocation of diodes D4-7, or the relocation of the column connections of the keypad.

'KRL'
Toowoomba, Qld.

Slave flash unit

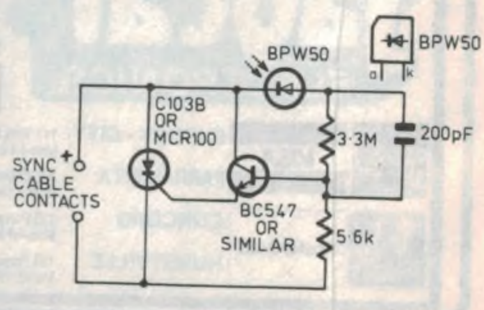
Some time ago a friend of mine purchased a second underwater flash and wanted to convert the first unit to a slave flash. He asked me to convert it for him. I searched around the market and the only slave attachment available is a NISSIN brand unit, which is a self contained light sensor and SCR firing circuit, set into a plastic mould about the size of an index finger to the first joint. Unfortunately there was no way that it could be connected inside an underwater strobe. The other solution was an *EA* flash unit using a solar cell and step-up transformer, but the solar cells are no longer available, so it was a design from scratch project.

The result is as shown, which can be constructed for under $10.00 and can be used both underwater and on land. The BPW50 is only available in some electronics outlets but there is no shortage of supply.

In this circuit the only critical component is the 5.6k resistor which must be a fraction above the resistance of the BPW50 at maximum light level – otherwise the unit will trigger sporadically. I have found that 5.6k is about optimum. The advantage of these slaves is that the BPW50 can be mounted remote from the rest of the firing circuit.

A. Lukevich,
Floreat Park, WA

$40



Decimal display of binary numbers

Displaying a binary code in decimal is not as simple as first appears. Although there are chips available for this purpose (BCD-7 segment decoders), most are only suited to decimal values up to 9. While it possible to incorporate additional logic supporting these ICs to enable them to display digits beyond 9, (or beyond 15 for a hex device), it becomes impractical when the range of values to be decoded is much greater than 15.

The circuit shown uses a 74C926, (4 digit-7 segment display counter/latch device) and three 4029 presettable up/-down counters. The idea is to display the binary code in decimal form by simultaneously counting down the binary input counter towards zero while clocking the 74C926 up towards the original binary input.

The binary input value is loaded into each of the 4029 counters (IC1 to IC3), forcing the carry out terminals of at least one of the counters to go high, depending on the input value. These counters are connected in cascade, giving, in effect, a 12 bit counter. When a carry-out terminal goes high, the output of the NOR gate IC4a goes low, causing the outputs of AND gates IC5a and b to go low also. This inhibits the latch in IC6, and also prevents it from resetting. IC5b also prevents the counters from reloading the binary number.

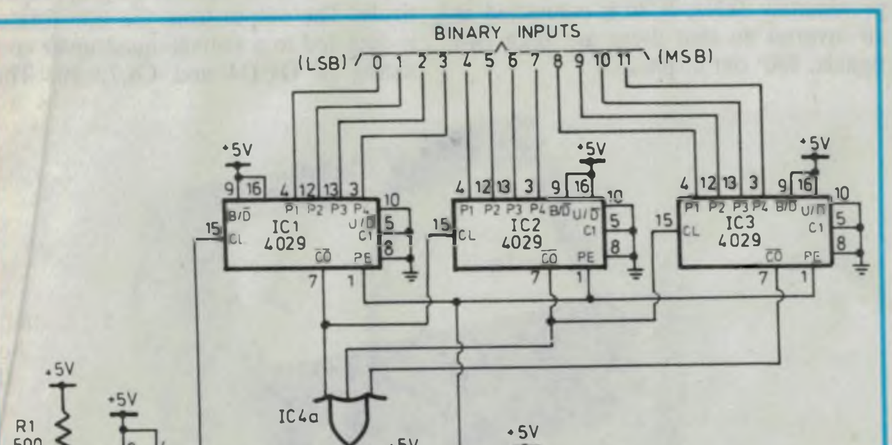
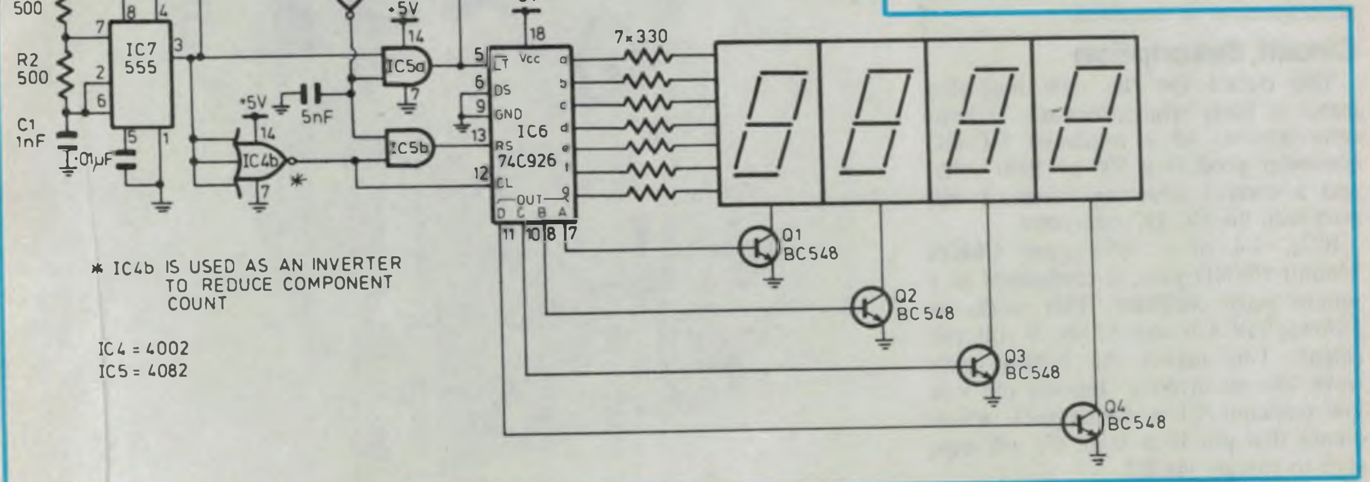
Under these conditions, the counter in the 74C926 and the input counter, IC1-3 are able to count in the required directions, driven by the clock oscillator of IC7. The input counter is clocked towards zero, and the counter in IC6 is clocked up from zero. When the input counter has reached zero, the output of IC4a will go high (on the positive edge of the clock pulse) as all carry-out terminals are reset to zero.

Because the clock is still high, the latch section of IC6 will be enabled, storing the internal counter's contents for subsequent display. When the clock signal goes low, the counter is reset and the binary number at the input is again loaded into the input counter to restart the whole process.

The capacitor from the output of IC4a to ground is included to prevent glitches occurring – for example, when the carry-out terminal of IC2 goes high while that of IC1 goes low. The circuit speed is limited only by that of the ICs, (around 3MHz), and it could be expanded to allow the decoding of even larger inputs by including more input counters and display drivers.

The use of TTL equivalents would increase the available speed, although the circuit complexity would also increase. One possible use, in conjunction with an appropriate 12 bit A to D converter would be a 4-digit multimeter.

David Burchell,
Pascoe Vale South, Vic **$50**

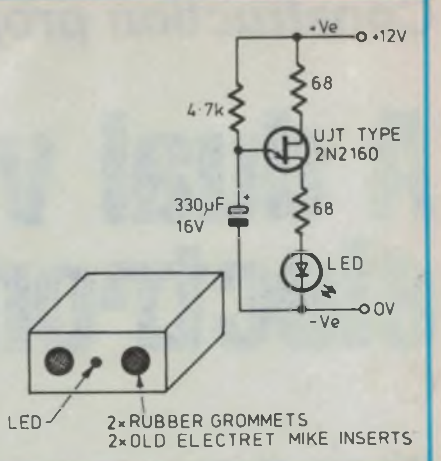



Claytons car alarm

This simple 'Claytons' car alarm flasher has been operating reliably for over three years, and consists of a modified UJT relaxation oscillator circuit. It pulses at approximately 1Hz.

To complete the deception, I mounted the oscillator in a small metal box, complete with two old electret mike inserts, to give the appearance of ultrasonic transducers. I then turn the device on or off with a hidden switch, and so far – the car hasn't been stolen.

Lindsay Franklin,
Woodville Gardens, SA. **$15**



Construction project:

A dual voltage electronic 'megger'

This new design for an electronic meg-ohm meter features a choice of two testing voltages – 500V or 1000V – and a large easy to read meter. It can resolve resistances from 1 to 200 megohms, which makes it very suitable for insulation testing.

by PETER HARRIS

The most common types of megohm meter measure at a single voltage. This is adequate for a go/no-go test, but will not conform to some electrical wiring regulations. A dual voltage unit will however cover all wiring insulation test specifications (for house and industrial wiring).

The unit described here provides 500V range which is used for testing wiring up to 250V AC, while the higher 1000V range is for testing wiring up to 440V AC. The usual measurement is to measure the insulation resistance between active and earth on wiring installations and to measure between active-earth and neutral-earth on appliances.

Incidentally the design of this project has been carried out by the R&D department of Altronics, in Perth. As a result the design itself and the PCB pattern, etc., are proprietary and cannot be reproduced commercially. However full kits of parts for the project are available from Altronics – please see the firm's advertisement in this issue.

Circuit description

The circuit for the new meg-ohm meter is fairly straightforward. It basically consists of a regulated DC-DC converter producing 500 or 1000 volts, and a current metering circuit. I will start with the DC-DC converter.

IC2c, 1/4 of a 4093 quad CMOS Schmitt NAND gate, is configured as a square wave oscillator. This works as follows. Pin 8 is tied to the 9 volt rail (high). This makes the NAND gate work like an inverter. Initially pin 9 is low (capitor C1 is discharged), which means that pin 10 is high. C1 will now start to charge, via R1.

When the voltage on pin 9 reaches the upper threshold level of the Schmitt input, the output will change state. When this happens the capacitor will start to discharge, via R1, until the lower threshold level is reached, whereupon the output will change state again. The whole process is repeated at a rate determined by R1 and C1 – here approximately 3kHz. IC2d is connected as an inverter so that there are then two signals, 180° out of phase.

The two out of phase signals are then fed to two further NAND gates, IC2a and IC2b. Assume for the moment that pins 2 and 5 are high, thus gates a and b will act like inverters. These gates then drive transistors Q1 and Q2 alternately, so that 9 volts is applied to each half of the transformer primary. This simulates an 18 volt square wave applied to the primary of the transformer.

The transformer then steps up this primary voltage to 400V across the full secondary and 200V at the centre-tap – allowing for losses. Switch S1a is used to select these voltages for the 500V and 1000V measurement ranges, respectively. The output from the transformer is then fed to a voltage quadrupler consisting of D1-D4 and C6,7,9,10. This

gives 800V and 1600V DC respectively for the two settings, provided that the inverter runs continuously. This is where the regulator part of the circuit comes into the picture, based around IC1c.

The voltage at the cathode of D1 is divided down via the string of 3.3M resistors R9-13, and R14 (or R15). The voltage at pin 9 of IC1c for the 500V setting of S1 is thus 150k/(150k+16.5M) x 500V = 4.5 volts. The same feedback voltage is also produced for the 1000V range, by switching in R15 (75k) instead of R14 via S1b (75k/(75k+16.5M) x 1000V = 4.5volts).

This voltage is compared to a reference voltage at pin 10 of IC1c, formed by R6 and zener diode ZD1, together with trimpot RV2, R7 and C4. RV2 is adjusted to give 4.5 volts at pin 10.

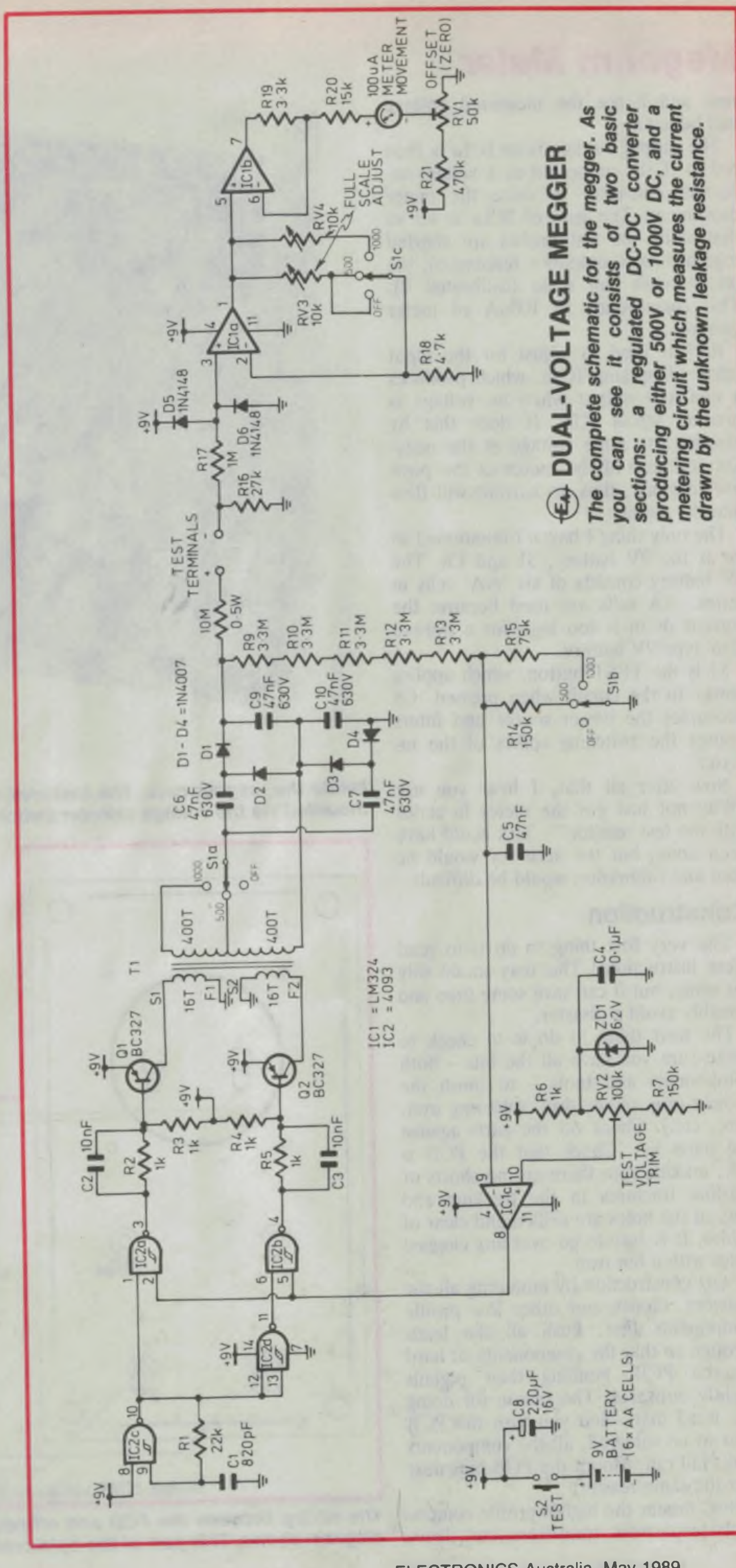
If the voltage at pin 9 starts to go higher (i.e., the output goes higher), pin 8 of IC1c will go low. This shuts off the drive to Q1 and Q2, so the output of the DC-DC converter falls. This makes pin 9 go lower and hence pin 8 goes high again, and the inverter restarts. It's in this way that the DC output from the converter is regulated, at either 500V or 1000V.

At the cathode of D1 is also a series 10M resistor R8, which limits the current to the test terminals to 100uA. So much for the DC-DC converter or 'high voltage power supply' section of the circuit.

Now comes the relatively easy part – measuring the unknown resistance. The theory here is that you have a known resistor (R16) connected in series with the test resistance, connected across the known output voltage of our DC-DC converter.

By measuring the voltage developed across the known resistor, you can therefore find the current flowing through the two resistors – by Ohm's law. Then, because the two resistors are connected across a known voltage, you can work out the voltage across the unknown resistor and hence its resistance. This is easy to do here, because everything (except the unknown resistor) is kept constant – allowing the meter to be calibrated directly in terms of resistance across the test terminals.

The metering circuit consists of IC1a, IC1b, the 100uA meter movement and associated components. Resistor R16 in this case is the 'known' resistor. The voltage across R16, proportional to current, is then amplified by IC1a, with gain set by RV3 or RV4, depending on which range is selected. The gain will be higher for the 500V range, as the cur-



DUAL-VOLTAGE MEGGER

The complete schematic for the megger. As you can see it consists of two basic sections: a regulated DC-DC converter producing either 500V or 1000V DC, and a metering circuit which measures the current drawn by the unknown leakage resistance.

rent and hence the measured voltage will be lower.

The output voltage from IC1a is then fed to IC1b, connected as a voltage-to-current converter to drive the meter movement. The gain of IC1a is set so that when the test probes are shorted together (zero unknown resistance), the meter reads full scale (calibrated 0). This corresponds to 100uA of meter current.

RV1 is used to adjust for the input offset of op-amp IC1a, which produces a non-zero output when no voltage is present across R16. It does this by creating the same voltage at the negative terminal of the meter as the positive terminal, thus no current will flow into the meter.

The only thing I haven't mentioned so far is the 9V battery, S1 and C8. The 9V battery consists of six 'AA' cells in series. AA cells are used because the current drain is too high for a normal '216' type 9V battery.

S1 is the TEST button, which applies power to the circuit when pressed. C8 decouples the power source and filters against the switching spikes of the inverter.

Now after all that, I hear you ask "Why not just put the meter in series with the test resistor?". This could have been done, but the accuracy would be poor and calibration would be difficult.

Construction

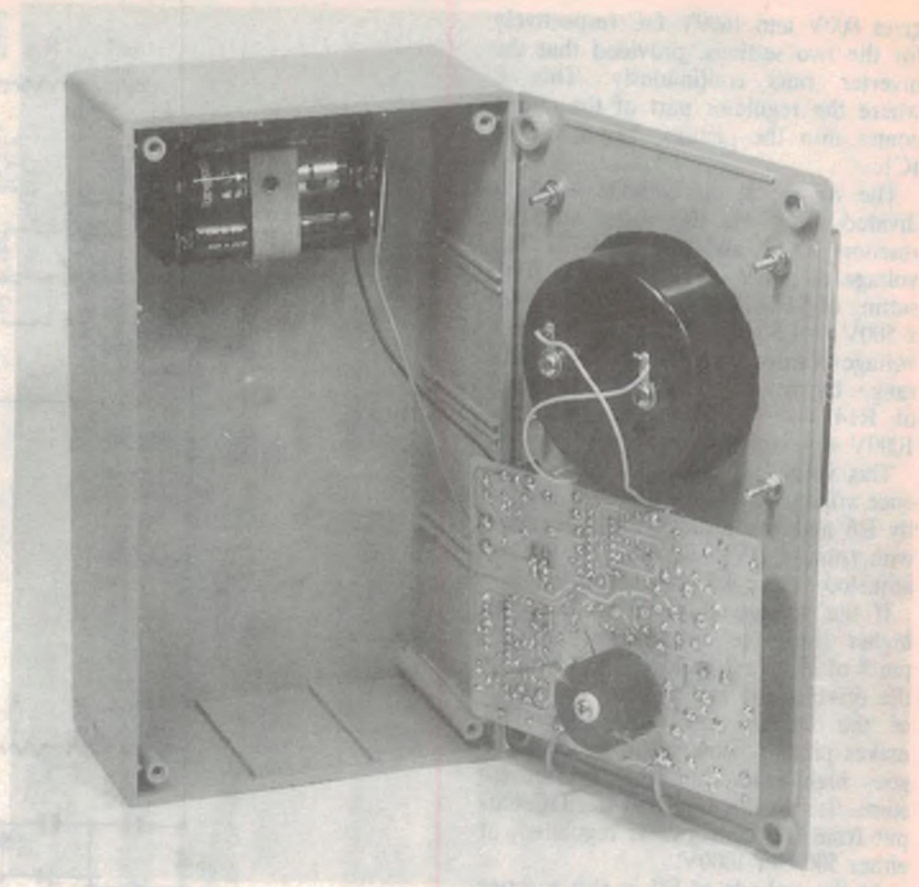
The very first thing to do is to read these instructions! This may sound silly for some, but it can save some time and possibly avoid a disaster.

The next thing to do is to check to make sure you have all the bits – both components and tools – to finish the project (e.g. pliers, drill, soldering iron, wire, etc.). Check off the parts against the parts list. Check that the PCB is OK, making sure there are no shorts or hairline fractures in the tracking and that all the holes are drilled and clear of solder. It is easy to go over any clogged holes with a hot iron.

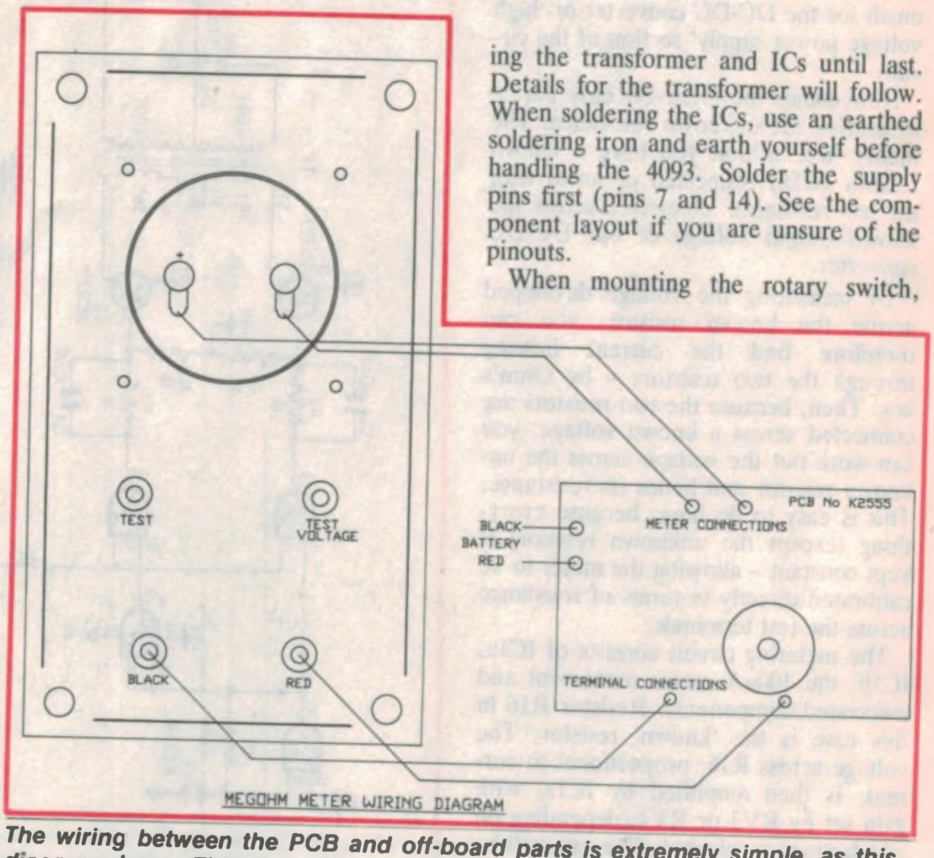
Start construction by mounting all the resistors, diodes and other low profile components first. Push all the leads through so that the components sit hard on the PCB, bending their pigtails slightly outwards. The reason for doing this is so that when you turn the PCB over to be soldered, all the components don't fall out. Mount the PCB pins next (for the same reason).

Next mount the higher profile components (capacitors, transistors, etc), leaving the transformer and ICs until last. Details for the transformer will follow. When soldering the ICs, use an earthed soldering iron and earth yourself before handling the 4093. Solder the supply pins first (pins 7 and 14). See the component layout if you are unsure of the pinouts.

When mounting the rotary switch,



Inside the megger case. The batteries mount in the rear with the circuit PCB mounted via the voltage selector switch and pushbutton.



The wiring between the PCB and off-board parts is extremely simple, as this diagram shows. This part of the construction should be easy!

position it such that all the holes line up properly and then solder it. Next take the nut, shakeproof washer and 'position' lock washer off the switch, and rotate the shaft fully anti-clockwise. Then put the position lock washer back on, with its spigot in the number '3' hole. Refit the shakeproof washer and nut again by hand, to hold things in place until you mount the PCB in the case.

Now to the transformer. You will note that the hard work has already been done. The secondary of the transformer has been wound. All you have to do is determine the connections of the secondary and wind on the 16 primary turns.

Note that there are four wires for the secondary – two 400 turn windings. The windings are wound in series, i.e., one winding on top of the other. The two 'starts' will come out on one side of the bobbin, and the two 'finishes' on the other side. Try not to handle these thin wires too much, as the acids on your fingers will eat through the insulation and eventually the copper itself, in time to come.

Make sure the secondary is fully insulated before winding the primary, using PVC tape. The transformer produces some pretty high voltages which will arc across any badly insulated wires.

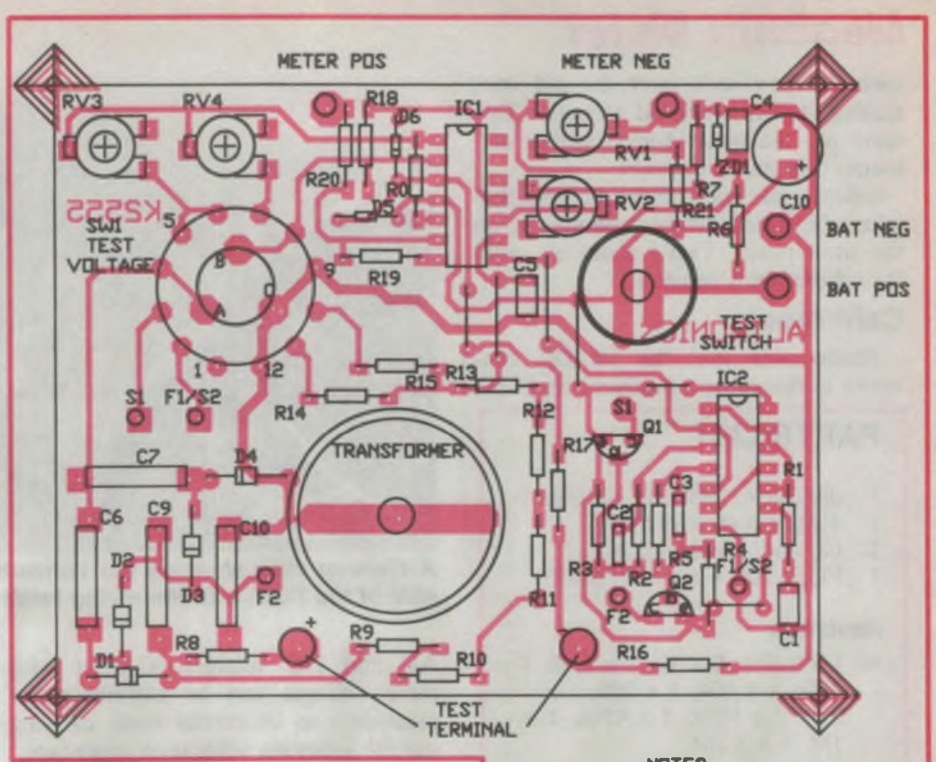
The primary is wound in *bifilar* form. This means that the two half-windings are wound together.

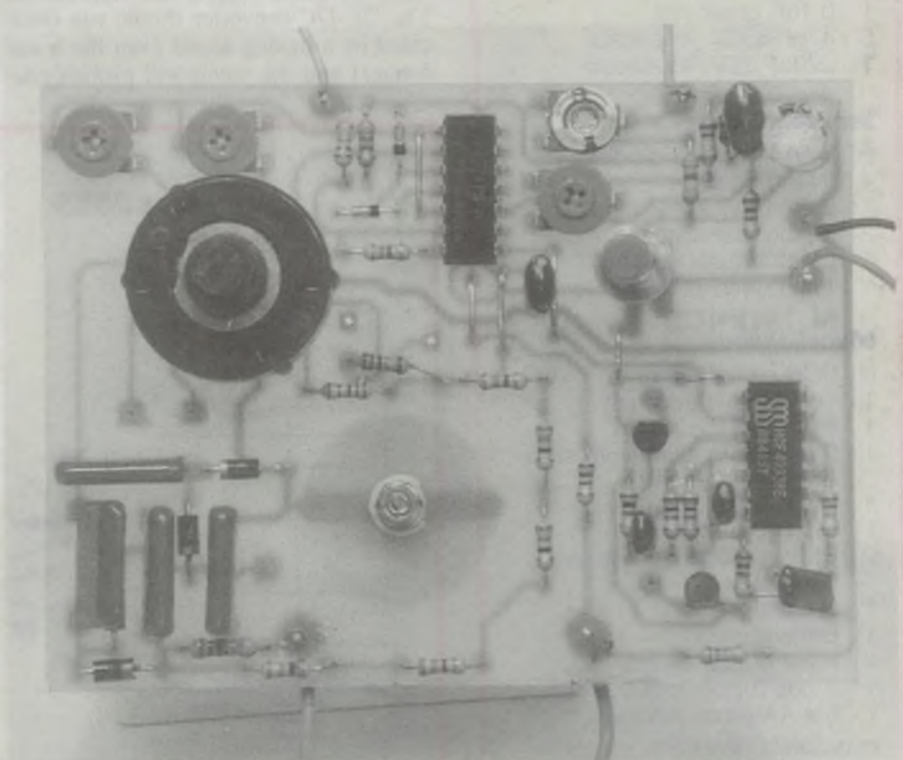
Divide the copper wire supplied into two equal lengths and label the starts of each winding (S1, S2) and the ends (F1, F2). This makes life easier when connecting the potcore up. Then place the two 'starts' so that they come out of the bobbin in the same radial location as the secondary starts, but at the other end cheek. Leave about 75mm of each free, and then handling both together – as if they were a single wire – carefully and evenly wind 16 full turns over the insulated secondary. Bring the ends out again in the same position as the starts, and apply a small layer of PVC tape to hold everything in place.

Finally cut the wires to length and strip and tin the ends. Be very careful when taking the insulation off the fine wire as it is very easy to break. Now mount the complete potcore assembly on the PCB, using the bolt and plastic washers and using the small assembly diagram as a guide.

Don't tighten the bolt up too tightly, as the ferrite core may break. To finish the job secure the nut with some nail varnish or similar to stop it from coming undone. Note that the assembly mounts on the copper side of the PCB (so it will fit in the case!). Wire up the connections according to the overlay.

Now your attention can be turned to the meter. Carefully remove the meter cover and unscrew the scale, being very careful not to bend the pointer. Now





At top is the PCB overlay diagram, showing the location and orientation of the on-board parts. These are also shown in the photo above.

stick the new scale over the old one, making sure it is aligned properly. This done put the meter back together and mount it in the front panel.

Solder some leads to the PCB so that it can be tested before mounting it on the front panel. That's about all, until the calibration is complete.

Calibration

Please note that the DC-DC converter in this project produces very high AC and DC voltages. Contact with these voltages can be extremely unpleasant – so be careful when carrying out the following calibration procedure.

Before firing up the megohm meter make sure everything seems to be OK according to the diagram. Check all your solder connections for bridges and dry joints. Follow the wiring exactly – all the usual sort of stuff.

Now set all the trimpots at mid position, turn the selector switch to 500V, apply power and press the test button. The DC-DC converter should run (indicated by a hissing sound from the transformer) and the meter will probably indicate something. If nothing happens at all, then check the connections to the transformer and the connections to the battery and meter.

If all seems well, then connect a voltmeter (to read 500/1000V) between the cathode of D1 and 0V. Press the test button and adjust RV2 for a reading of 500V, although a few volts either side won't make a lot of difference. Now switch to the 1000V range and check the voltmeter for a reading of 1000V.

Note that RV2 will affect both the 500 volt and 1000 volt ranges, so if necessary adjust RV2 for a compromise between the two.

PARTS LIST

- 1 Jiffy box, 198 x 113 x 63mm
- 1 100uA meter MU 65
- 1 Custom meter scale
- 1 PCB, 102 x 78mm, K2555

Resistors

All 1/4W 5%: 5 x 1k, 1 x 3.3k, 1 x 4.7k, 1 x 15k, 1 x 22k, 1 x 27k, 2 x 150k, 1 x 470k, 1 x 1M, 5 x 3.3M

- 1 10M 1/2W
- 1 75k 1% metal film
- 2 10k horizontal mount trimpot
- 1 50k horizontal mount trimpot
- 1 100k horizontal mount trimpot

Capacitors

- 1 820pF greencap
- 2 10nF greencap
- 1 0.1uF greencap
- 5 47nF 630V greencap
- 1 220uF 16V RB electro

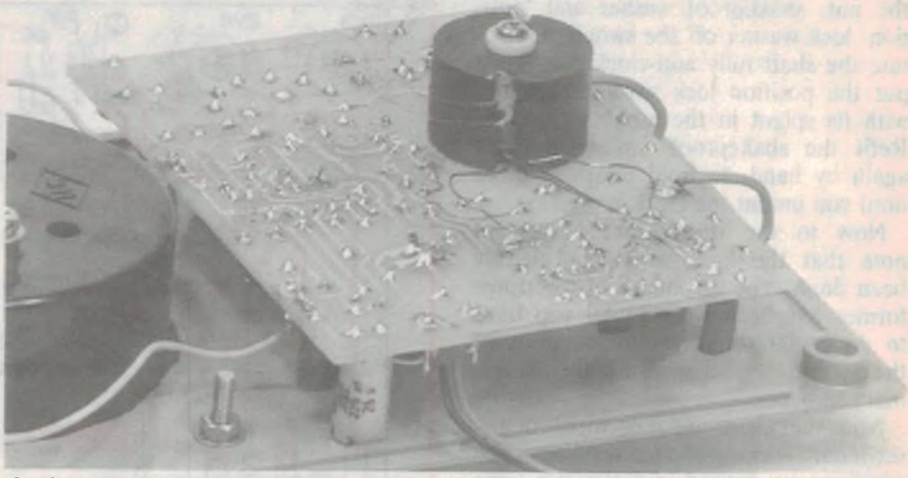
Semiconductors

- 2 IN914/1N4148 diodes
- 4 IN4007 diodes
- 1 6.2V 1/2W zener
- 2 BC327 transistor
- 1 LM324 quad op-amp
- 1 4093 quad NAND gate

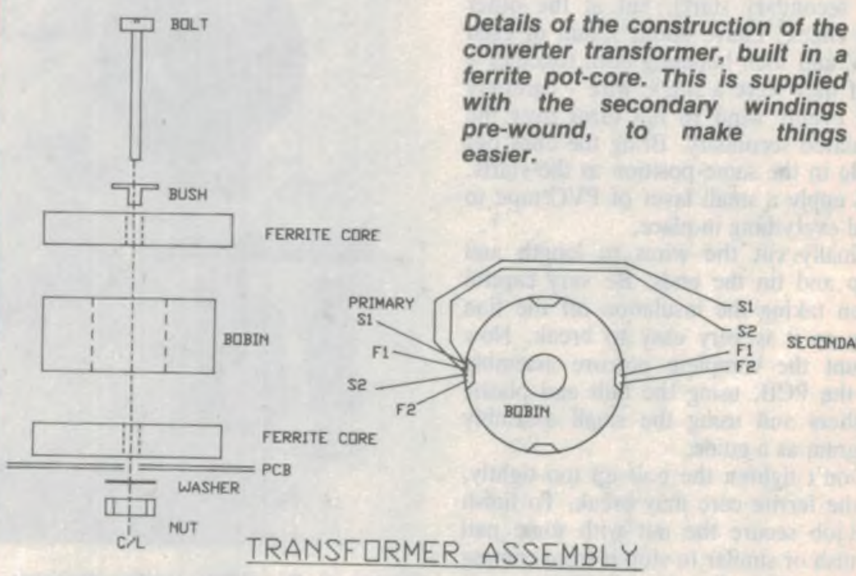
Miscellaneous

- 6 PCB pins, 0.9mm
- 1 TO-3 insulated bush
- 1 Fluted knob, 20mm
- 1 25 x 60mm aluminium strip (for battery clamp)
- 1 Pre wound bobbin
- 1 FX2240 pot core
- 2 Banana sockets; one red, one black
- 1 Set test leads
- 1 Battery snap
- 1 Push button switch
- 1 3 pos 3 pole rotary switch
- 1 6 x AA battery holder

nuts, bolts, washers, solder, medium wire and 0.5mm enamelled copper wire



A closeup view showing the converter transformer mounted on the copper side of the PCB, with the wiring leads taken to the appropriate pads.



Details of the construction of the converter transformer, built in a ferrite pot-core. This is supplied with the secondary windings pre-wound, to make things easier.

Now disconnect the voltmeter and adjust RV1 for a reading of infinity on the meter. Select the 500V range again and short the probes out. Adjust RV3 for a reading of zero. Finally switch to the 1000V range and adjust RV4 for zero reading. And that's it! Now you can assemble the PCB onto the front panel, put the clip on the battery, screw the thing together and give it a final test.

Note that if you try and measure the voltage at the test terminals, you will get a substantually lower reading due to the internal resistance of the meter. For example if you use a digital meter with 10M ohms input, the voltage on the 1000V range will fall to 500V (due to R8) and the megohm meter will read 10M.

Note also that when the meter is switched off and the test button is pressed the inverter will still run, but there will be no voltage at the test terminals.

If it doesn't work

If the meter doesn't spring into life when you first turned it on, don't despair. Be assured the design will work, and the problem will probably turn out to be something simple – like a diode wired in reverse polarity, or bad soldering, etc.

The first thing to do if it doesn't work is to determine the main area of the circuit where the trouble lies. This will make it a lot easier to track down using logical deduction.

Say, for example, that the inverter does not function. Firstly determine if the oscillator is working. Check at pin 10 and pin 11 of the 4093 – with a multimeter, these should read about 1/2 supply voltage, while a CRO should show square waves at about 3kHz. Pins 2 and 5 of the 4093 should both be high, and therefore pins 3 and 4 should read virtually the same as pin 10/11.

If all that is OK, then make sure that there is 9V at the emitters of Q1 and Q2. If these transistors get hot or fail, then the transformer is probably the problem (make sure that all the starts and finishes go to the right place).

If pins 2 and 5 of the 4093 are low, then check that ZD1 is in the right way. There should be approximately 6V across ZD1, and 4.5V at pin 10 of IC1c (LM324). Check that the 9V supply is getting to pin 4 of the LM324.

The idea is to try all of these things in methodical fashion, and sooner or later you must find the problem. The same applies if the DC-DC converter is working correctly, and the fault seems to be in the metering circuit. EA

Altronics For Quality Electronic Products & Australia's Fastest Delivery Service Bar None - says Jack O'Donnell M/Director

● BANKCARD ● VISA ● MASTERCARD ● PHONE TOLL FREE 008 999 007
● NEXT DAY JETSERVICE DELIVERY
Country clients please allow an additional 48-72 hours

Fantastic New HEAVY DUTY NIBBLER

Cuts any shape cut out in steel, aluminium or plastic. Very easy to use. Capacity steel 1mm aluminium 1.6mm

T 2355
Normally $19.95
ONLY $14.95
SAVE $5.00

TOROID POWER TRANSFORMERS

As used in EA and Silicon Chip Projects
All Primaries 240V

160VA (Watt) Models ~~$85~~ NOW $60

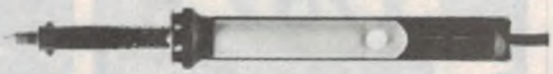
M 3050	12V +12V
M 3055	18 + 18
M 3060	25 + 25
M 3065	30 + 30
M 3070	35 + 35
M 3075	40 + 40
M 3080	45+ 45

300VA (Watt) Models ~~$79~~ NOW $75

M 3085	12 + 12
M 3086	18 + 18
M 3088	25 + 25
M 3090	30 + 30
M 3092	35 + 35
M 3100	40 + 40
M 3105	45 + 45

SOLDERING SPECIALS IN '89

De-Solder Iron SPECIAL $49.95



Ideal for the service technician and hobbyist alike. Allows components to be quickly and cleanly removed with one hand. Comes with a cleaning wand.
240V AC 50Hz 30W SEC Approval W/22281 Easy single handed action Simple cleaning action.

NEW FOR '89 T 1250 Normally $59.95

Temperature Adjustable 250°C to 450°C

Excellent new iron, screwdriver temperature adjustable between 250oC and 450oC enabling very delicate soldering on low settings with surprising heat energy reserve on maximum setting.
Relative temperature is indicated by LED lamp brightness.

Much lower cost than a soldering station.
T2445 Great Value at $37.95
Fantastic Value at only $29.95

Audio Purists This is For You!
VIFA 2 Way 100 Watt Weatherproof Speaker

Look for product review feature in Electronics Australia Magazine April/May '89
The heart of the system is the now famous 5" VIFA Woofer/Midrange, computer optimised for use in a 5 litre Bass reflex cabinet.
The classic VIFA 19mm ferro fluid Dome Tweeter is incorporated with the crossover network as employed with the SA-50 bookshelf system.
Has unique overdrive protection enabling amplifier input of up to 100 Watts without damage.
Overall performance and appearance is superior to any competitive weatherproof speaker on the Australian market.
Each speaker is supplied complete with mounting brackets.

C 0970 Black, C 0972 White, ONLY **$399.00 pr**
OR $199.50ea

Toggle Switch Bargain

SAVE 50%

S 1010 SPDT 250V 3A $1.90
1-9 $1.20 10-24 $1.10 25+ $1.00
S 1020 DPDT 250V 3A $2.50
1-9 $1.50 10-24 $1.40 25+ $1.25

16 Way Parts Drawer Set

See through acrylic parts drawer. Slide-in Ident card fronted drawers. Ident. cards supplied. Sturdy steel construction. Value Plus!

H 0240 WAS $29.95 NOW ONLY $20 SAVE $9.95

Utility Parts Case

Featuring a clear plastic lid so you can tell contents at a glance. Simple slide lock. 48 partition combinations. Very sturdy ABS plastic.

H 0249 WAS $23.95 NOW ONLY $20.00 SPECIAL

Mylar Stereo Phones With Dynamic Mic

Simply brilliant Mylar Stereo headsets &dynamic mic combination.
Headphone: 20Hz - 20,000Hz, 32Ohm, 3.5mm stereo jack, 6.35mm stereo jack, adaptor.
Microphone: Dynamic type, 300Ohm, 100Hz-15,000Hz, 3.5mm mono jack.

C 9055 **$29.95 VALUE!**

TOP PRODUCT FOR '89 - FANTASTIC ULTRASONIC CLEANER

PIN POINT ULTRASONIC CLEANER

Awarded the Good Product Design Award for CETDC in 1987. This fantastic Ultrasonic cleaner can earn its cost a hundred times over in cleaning Computer Connectors, PCB's Switches, Relays, Jewellery, Glasses, Watches, etc.

Pin Point Ultrasonic Cleaner uses a transducer generator to produce millions of activated microscopic cleansing bubbles, which blow dirt, grease & grime off surfaces, and deep into cracks and holes. Pop your dirty watches, glasses, connectors etc into the cleaners stainless steel basin, add a cup of tap water, and three minutes later see the difference. The results are instantly revealing.

A 0100 $199

Nicad Rechargeable Batteries

Premium Grade - Good for up to 1000 re-charges.
Charge Rate 45-50mA for AA, 20mA for AAA, 10-15mA for 9V 120mA

Cat.No.	NORMALLY 1-9	10-99
S 5020 AA 1.2V 500mAh	$ 3.99	$ 3.25
THIS MONTH'S SPECIALS	$ 3.50	$ 2.80
S 5021 AAA 1.2V 180mAH	$ 4.50	$ 3.95
THIS MONTH'S SPECIALS	$ 4.00	$ 3.00

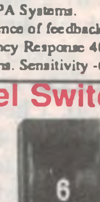
Noise Cancelling Microphone

C 0304 $29.80
NOW $19

For Professional 2 way Radios on Aircraft, Boats, Vehicles & also Industrial PA Systems.
Fantastic voice clarity, absence of feedback and background noise. Frequency Response 400-8KHz. Impedance 160 Ohms. Sensitivity -65db

Thumbwheel Switch

BCD 0-9



Panel mount BCD coded units that simply slot together to produce switches of required size.
PCB's are gold plated copper on epoxy fibreglass, continuous load 1A max. Panel cutout for one unit 16mm x 30mm. Allow further 8mm per extra

S 3300 NORMALLY $6.95 ea NOW $5
S 3305 End Caps/pr $1.75 10 up $1.60 ea.

Famous Goldstar Brand 20 Meg Dual Trace Cro Sensation

Available from Altronics or Altronics Mail Order Department Only
Sorry Not Available From Dealers.

$300 Off Last Years Price

12 Only At A Never To Be Repeated Price of $599

★ ★ BE QUICK BE QUICK BE QUICK ★ ★

Phone Order To Reserve Yours Now

OUR TOP SELLER!

PROFESSIONAL STEREO CONSOLE MIXER

Ideal for "live" recording, our NEW Audio Mixing Console has truly sophisticated features:

- PA mixing
- Fantastic tape recording
- Stereo/mono VCR recording
- R/L 5 band graphic equalisers
- Talkover facility
- Separate headphone level control
- Patch switch bank
- Individual controls for Microphone, Phono 1&2, Aux. line 1&2, and Master slide level controls.

Blend up to two magnetic or crystal turntables, two tape decks and two microphones - all at once!!

FULLY PROFESSIONAL SPECS:

. Input - Mic 1: 0.5mV, 600 Ohms, Mic 2: 0.5mV, 600 Ohms (Low imp.), 2.5mV, 10kOhms (low imp.); Phono 1&2 (Mag.) 3mV, 50kOhms; Phono 1&2 (Cry.), 150mV, 100kOhms; Tape/Tuner 1&2 150mV, 100kOhms Equaliser - 5 frequency bands: 60Hz, 250Hz, 1kHz, 4kHz, 12kHz - Boost Cut Range, plus or minus 12db @

A 2570 240V Mains Operated

Normally $499

This Month $399

You Save $100.00

VALUE Increase YOUR SECURITY! VALUE

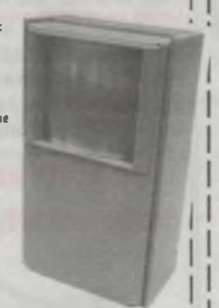
Infra Red Movement Detector

Pulse Count Type

Our 1989 Model IRD now includes pulse count circuitry with a specific time delay between pulse sensing. Three pulses of IR radiation are required to trigger the detector. Providing the detectors are sensibly positioned false triggering is completely eliminated.

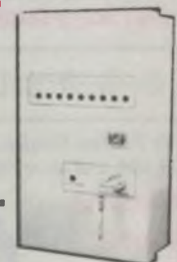
Features:

- •Lens simply 'snaps' to either wide angle (range 40ft) for normal use or Narrow angle (and 80ft plus) for corridor applications.
- •Snazzy integral mounting bracket allows corner 90o mounting.
- •12V DC Powered
- •Built-in test lamp.
- •Relay output SPST 30V 1a max.
- •9-18V DC



S 5301 Excellent value *at $79.00*

Multi Sector Burglar Alarm



Protect your Home or Business from Intruders with this "State of the Art" Burglar Alarm System

Over the last few years, House Break-Ins have increased dramatically. The recovery rate of stolen goods is very low. Now more than ever before, it makes extremely good sense to build and install this ingenious Multi-Sector System. This unique Alarm System incorporates the features of the more expensive commercial models - at a fraction of the price.

Features:

• 8 sectors can be monitored independently • Each input circuit is provided with an indicator LED and a sector On/Off switch • Individual sector isolation • Inputs accept both normally closed and normally open sensors • Two inputs provided with an entry delay • Alarm is disabled by frontpanel key switch • Internal trip warning buzzer • Unique circuit detects tampering • Automatic muting of the siren driver when under test • Fully variable exit delay • Will drive external horn speaker • Alarm output variable between 1 & 15 minutes • When triggered, gives a connection to external devices e.g. Bells, TV Camera etc • Switched output can be used to send a silent alarm • Full battery back up • Alarm will operate for approx. 2 days with mains disconnected • Supplied in an attractive functional security case. (See EA Jan/Feb'85)

Kit(Less Battery Back Up) K 1900 $149.50

Back Up Battery 12V 1.2AH S 5065 $24.95

Passive Infra-Red Lite Guard Floodlight Control

How often have you thought there could be a prowler outside your door?

Install a Lite Guard & (once armed) any "guest" will be floodlit when detected by this highly sensitive Infra-Red Detector.

The Lite Guard detects a moving person or vehicle by comparing the background temperature with a rapid change of temperature across the detection beams. So when Lite Guard detects movement across the coverage area it will turn on the floodlight(s) for 1-20 minutes as preadjusted.

Security: Prowlers are startled by an unexpected blast of light.

Convenience: Lite Guard will detect your arrival & turn light on to welcome you home.

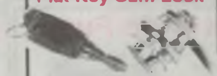
Energy Saving: Built-in photo cell deactivates unit in daylight.

S 5350 was $135.00 SPECIAL ONLY $99.00

Please note: Floodlamps & holders not supplied

More TOP VALUE SECURITY KITS on our 2nd DPS

Flat Key Cam Lock



Zinc alloy die cast housing with stainless steel cap. Key removable in either position. 2 solid brass keys supplied.

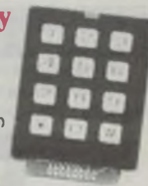
S 2550 WERE $4.95

NOW ONLY $4.00ea

S 2552 Spare Key Blanks $1.20 ea.

Telephone or Security Keyboard Switch

Matrix Type



Specifications: Contact Conductive rubber. Rating DC 24V 5mA. Contact Resistance 200 Ohms . Max. Withstand Voltage 250V AC. Bounce 5m sec. max.

S 5380 WERE $9.90ea

10 up $8.90ea NOW ONLY $7.50ea

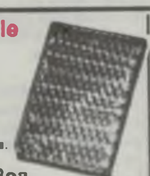
2 Amp Regulated Power Supply Save!

Input Voltage: 240V AC -50Hz
Output Voltage: 12V DC +/-0.5V
Output Current: 2A DC
Dimensions: 84 x 68 x 200mm
Weight: 1.2kgs

M 9050 Normally $69.95

Now only $50.00

Solar Cell Module



.4V at 450mA

Great experiments Solar Module. Connect in parallel or series as you wish. Terminal strap enables easy interconnection to other cells.

A 0210 previously $5.98ea

NOW ONLY $5.00ea

10 Cells or more $4.00ea

★ ★ ★ ★ ★ ★ ★ ★

Transformer Bargains

M 2165 240V to 9,12,15,18,21, 24V @ 60VA (60W)

Normally **26.50** NOW **$19.00** 10 Up **$15.00ea**

M 2175 240V to 12,15,24,30V @ 120VA (120W)

Normally **$39.95** NOW **$30** 10 Up **$26.00ea**

TEST EQUIPMENT

Portable Multimeter With Bench Stand

Includes Continuity Buzzer
20,000 Ohms/Volt DC • 8,000 Ohms/Volts AC, Mirror backed scale • Overload protected. 10 amp DC current range. Unique carry handle doubles as a bench stand.

Q 1080 ~~$39.00~~
NOW $29.95

RF Signal Generator

Specifications:
Frequency Range 100Hz - 150MHz, in 6 ranges
RF Output Level 100mV RMS **Accuracy** +/-3%
Modulation:- Internal (30% depth) **1KHz** • External **50Hz - 20KHz** • Crystal Locked Oscillator

Q 1550 **$225.00**

USEFUL, INTERESTING, PRACTICAL - FABULOUS KITS

House Guard Alarm System

Fantastic New Alarm Project - Easy to Build as it all assembles on a single PCB.
Includes 12V 1.2 amp hour inbuilt lead calcium backup battery.
(See EA April '89)

Features: Delayed and instant input • Entry and exit delay • Panic alarm input • Battery backup • Line monitoring • Soft alarm start • Lamp telltale ouput • Auxiliary relay for external siren etc. • Key switch operation • Operates on virtually any type of sensor.

K 1910 **$89.00**

Digital Multimeter *With Built-In Capacitance Meter*

All the normal ranges of current, resistance and voltage plus a convenient and simple to use capacitance meter in five ranges, plus transistor tester. Check the features of this top quality digital multimeter from the Labtech range.: • Continuity Test • Buzzer Sound: Less than 200 ohm • Capacitance: 5 Ranges 2000pF - 20uF • Transistor Tester

DC Voltage	.2, 2, 20, 200, 1000V
DC Current	200uA, 2mA, 20mA, 200mA, 2A, 10A
AC Voltage	.2, 2, 20, 200, 750V
AC Current	200uA,2mA, 20mA, 200mA, 2A, 10A
Resistance	200, 2K, 20K, 200K, 2M, 20M

General: Display: 3 1/2 digit LCD, 0.5" height, with polarity and LO-BAT indication • Overrange Indication
Maximum Common Mode Voltage: 500V peak
Power: 9V alkaline or carbon-zinc battery.
Dimensions, Weight: 170mm x 87mm x 42mm, 350 grams

Specifications: Input Impedance: 10M on all ranges
Normal Mode Noise Rejection: 46db at 60Hz (1K unbalanced)
Common Mode Noise Rejection: 100db at 60Hz
Overload Protection: 1000V dc or peak on all ranges
Response Time: less than 1 Second.

Q 1065 USUALLY **$139.00**
SPECIAL PRICE $99.00
SAVE

Audio Frequency Generator

In testing audio circuitry it is necessary to have an accurate audio signal source. It even allows you to test 455KHz IF stages!

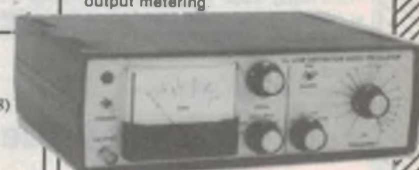
Specifications:
Frequency Range 10Hz 1MHz
Accuracy +/- 3% +2Hz
Output Waveforms: Sine: 8V RMS
Square: 10V P-P
Output Attenuator: -20db, -40db and fine adjust.

SAVE $50

Q1540 was $249.00 NOW $199

Audio Oscillator & Function Generator

This Ultra low distortion oscillator is comparable with the very best laboratory standard sine wave oscillators. As well as having very low distortion it has excellent envelope stability, square wave output and output metering.



(See EA Dec'86)
• Frequency range 10Hz-100KHz in 4 ranges • Output level 3V RMS max adjustable • Attenuator 0db - 10db, -20db, -30db, -40db, -50db plus fine adjustment. • Output impedance — 600 Ohms unbalanced • Output waveforms — sine and square • Sinewave harmonic distortion (typical) - 1KHz less than .01% — 100Kz less than .02% • Square wave rise and fall times .50nS

Save $200 and More by Building This Fine Kit Project

K 2540 **$155.00**

❋ ❋ ❋ ❋ LIGHT UP YOUR LIFE! ❋ ❋ ❋ ❋

We have lots of specials we couldn't fit. Come in and look around and make sure you have our NEW 1989 Catalogue

Up To Now Similar Lamps Sold For $1,000 And More **NEW FOR '89**

Plasma Lamp Display

Fantastic pulsating high voltage Plasma discharge continually changes shape and direction. Mode selectable to either fingertip control or sound activated e.g. from voice or sound system. Provides endless fascination as it sizzles and arcs. Supplied complete with AC Mains Adaptor.

Price Breakthrough for '89
A 0120 $199.00 NOW PRICE
SLASHED TO $150

Beat Triggered Strobe (See AEM July'85)

Add More Life To Your Next Party Flashes in time to your music, or as normal strobe. Exclusively customised by Altronics into our H 0480 Instrument Case. Includes silk screened panel.

K 5790 $79.95 NOW $75.00
For Increased Power Two Tube Option
K 5795 $16.50 NOW $15.00

Line Filter and Conditioner (See EA July '88)

Smooth power for stereo, TV & computers. Altronics customised version housed in strong Jiffy Box. Nickel sprayed for EMI shielding.

K 6040 **was $39.50**
NOW ONLY $35.00

Machined Pin Sockets

Gold Plated Sockets
For applications demanding 100% long life contact reliability.

All 30% OFF!

			Now
P 0530	8 Pin	$1.10	.79
P 0532	14 Pin	$1.45	$1.00
P 0534	16 Pin	$1.65	$1.15
P 0536	18 Pin	$1.80	$1.25
P 0538	20 Pin	$1.99	$1.39
P 0540	24 Pin	$2.45	$1.70
P 0542	28 Pin	$2.80	$1.95
P 0544	40 Pin	$3.25	$2.25

DC Electronic Fuse

(See EA Nov'87)

Simply clips across the DC Fuse holder, Offers protection adjustable from 0-10A in 2 ranges.
Features:
• Fast blow - slow blow setting.
• Manual reset button.
• LED fuse tripped indicator.
• Operates off 1 single 9V battery (not supplied)
• Two current Settings easily adjustable via a pot and calibrated scale.
• Housed in a rugged Jiffy Box.

A must for prototyping and service work. No Electronic workshop should be without one.

K 2535 **GREAT VALUE AT $39.50**

Active Direct Injection Box

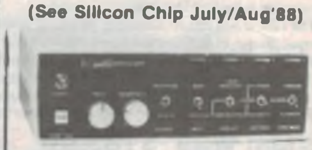
(See EA Oct '87)
Converts high impedance unbalanced inputs to low impedance balanced outputs. Dozens of studio/PA uses.

Features:
- **Sturdy diecast box**
- **Black tough indust. powder coat finish**
- **Professionally screen printed.**
- **Earth isolate switch.**
- **+5db pad.**
- **Phantom powering plus internal 9V bat.**

K 5550 **$45.00 NOW $39.00**

Discolite

(See Silicon Chip July/Aug'88)



Add Some Colour To Your Next Party - Great For Parties, Shop Displays & Special Lighting Effects

The Discolite flashes party lights on & off in beat with music from your amplifier. • 4 light channels controlled by 4 separate audio channels • Forward reverse & auto-reversing chaser patterns • Simultaneous strobe on all four channels • Alternating light patterns • Music modulation available on chaser strobe & alternate patterns.

K 5805 **$159.50**

Utility Timer

(See E.A. March'88)
Time your STD calls and Save Money. Timing is adjustable from 10 seconds to 15 minutes. It features a ten way count down LED display and buzzer. Altronics Kit features full kit and silk screened front panel.

K1425 was $28.50 NOW $25.00 SAVE

50MHZ Digital Frequency Meter

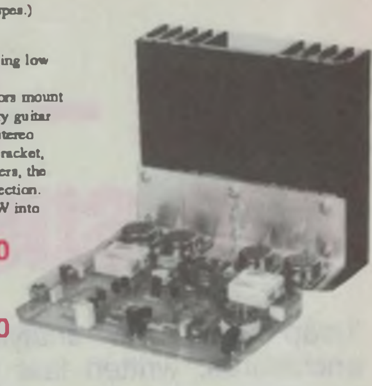
(See EA May '88)
Fantastic for Work Bench & Tool Box For Less Than $100
Easy to build. Over 50MHz in 5 ranges.
I Features high input impedance overflow LED indicator. KHz & MHz LED Indicators.
All components mount onto a single PCB.
Complete with pre-punched & silk screened front panel. Ideal for use in testing CB radios, TV's & AM Radios etc.

K 2510 $99.00 VALUE

Universal High Power Amplifier Module

(See SC Dec'87 or our '89 Cat for full spes.)

High power rugged reliable design featuring low distortion and inbuilt speaker protection.
All components, including output tranistors mount on a single PCB. Suitable for high quality guitar amp. public address or in a high fidelity stereo amplifier. Kit includes angled heatsink bracket, main heatsink and unlike other kit suppliers, the In-Built Polyswitch for loudspeaker protection.
Output Power: 100W into 4 Ohms 150W into 4 Ohms



100W Version K 5140 ~~$69.00~~
NOW $65.00
150W Version K 5150 ~~$99.00~~
NOW $95.00

Capacitance Meter Adaptor

(See SC Nov'87)
Great for hand selecting exact values e.g. exact values for timer circuits etc.
This clever add-on adaptor increases the range of your digital multimeter. It allows measurements up to 2.2uF. Plugs directly into your meter via inbuilt banana plugs. Kit includes pre-punched silk screened front panel.
Suits Labtech Q 1075

K 2520 was $24.99
NOW $20.00 SAVE!!!

12/240V Inverter for Small Appliances

(See EA Aug'85)

Doubles as Battery charger under normal mains conditions

K 6705
$89.00

This inverter is ideally suited to powering low wattage mains appliances from the car battery while camping. Similarly, it has uses in boating. Typically, it can be used to power an electric shaver, electric blanket, electric can opener or a 40W light bulb.

Megger Meter

See EA April/May 89
Checks electrical wiring and appliances for insulation breakdown.
Insulation breakdown can be determined by the use of this dual range megohm meter.
Ideally suited for checking breakdown in electrical wiring, appliances transformers, automtive generators and alternators etc.
Breakdown can be measured at either 500V or 1000V depending on the required situation.
Would suit electricians or technicians work van, tool box or work bench.

K 2555
REAL VALUE $79.00

Car Parking Proximity Detector

(See Silicon Chip Jan'89)
Ever reversed into a parking spot and hit the car behind you?
Well this proximity detector is the answer. A buzzer starts beeping and just before you hit the object the buzzing becomes continuous. Connects to your reversing light circuit, so it comes on automatically every time you reverse. Effective range of about 1 metre. Complete with all parts, boxes and cable.

K4310 *MOST USEFUL KIT $34.50 NEW FOR '89*

Desk Mounted Magnifier Lamp

Find Circuit Faults In A Jiffy
This unit magnifies any object under a clear, cool fluorescent light
A 0980 **$229** Normally $270

ALTRONICS

Manufacturers, Contractors and Bulk Users
Please Contact Our Wholesale Sales Dept.
Sydney (NSW Only) Colin Fobister (02) 437 4077
Melbourne (Vic/Tas Only) Brian Sorensen (03) 811 9967
Perth (W.A., S.A., QLD., N.T.) (09) 328 2199

174 Roe St. Perth W.A. 6000
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STANDARD DELIVERY & PACKING CHARGE $4.00 to 1Kg $7 over 1Kg AUSTRALIA WIDE — We process your order the day received and despatch via. Australia Post. Allow approx 7 days from day you post order to when you receive goods

$7.00 OVERNIGHT JETSERVICE — We process your order the day received and despatch via. **Overnight Jetservice Courier** for delivery next day Country areas please allow additional 24-48 hours. Weight limit 3Kgs (3Kgs covers 95% of Orders).

$10.00 HEAVY HEAVY SERVICE — All orders of 10Kgs or more must travel Express Road - Please allow 7 days for delivery.

INSURANCE — As with virtually every other Australian supplier, we send goods at consignees risk. Should you require comprehensive insurance cover against loss or damage please add 1% to order value (minimum charge $1). When phone ordering please request "Insurance".

TOLL FREE PHONE ORDER — Bankcard, Visa, Mastercard Holders can phone order toll free up to 6pm Eastern Standard Time. Remember with our **Overnight Jetservice** we deliver next day.

ALTRONICS RESELLERS

Chances are there is an Altronics Reseller right near you - check this list or phone us for details of the nearest dealer. **Please Note:** Resellers have to pay the cost of freight and insurance and therefore the prices charged by individual Dealers may vary slightly from this Catalogue - in many cases, however, Dealer prices will still represent a significant cost saving from prices charged by Altronics Competitors.

Don't forget our Express Mail and Phone Order Service - for the cost of a local call, Bankcard, Visa or Mastercard holders can phone order for same day despatch.
Blue Ribbon Dealers are highlighted with a ■ These Dealers generally carry a comprehensive range of Altronic products & kits or will order any required item for you.

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Leap – before you look into speaker enclosures

'Leap' is a new analysis/design package for loudspeaker enclosures, written last year in the USA. It is considerably more powerful than earlier packages, and has been well received overseas by professional enclosure designers. EA was given the opportunity to try out the first sample to reach Australia, and here's what we found.

by JIM ROWE

When I studied audio engineering at uni, back in the dim dark days of the late 1950's, the design of loudspeaker enclosures seemed to be pretty crude. You measured the speaker's resonant frequency in free air, and designed the enclosure to resonate at the same frequency. Hopefully the two would act like a pair of over-coupled tuned circuits, and you'd get a 'double-humped' response which extended down lower than the speaker by itself. That was about it.

Of course some boxes seemed to end up sounding pretty peaky and 'boomy', and if this happened you had to put fill up the box with sufficient 'bullswool' or acoustic resistance material to damp the peaks, and make it all sound smoother – more or less.

I remember it all seemed a lot more like an art than a science, with not much of an attempt to analyse what was really going on.

But then in August 1961, Australian engineer Neville Thiele published a paper in the *Proceedings of the IRE Australia*, with the unassuming title 'Loudspeakers in Vented Boxes'. In it he analysed the behaviour of the complete loudspeaker-enclosure system, and showed that its performance could be analysed and manipulated reliably and accurately knowing a small number of basic parameters. He even showed how these parameters could be easily and reliably measured.

Theile's paper was to become a landmark in the design of loudspeaker enclosures around the world, acknowledged as the first to provide a complete, comprehensive and practical understanding of vented-box systems on a quantitative level. But strangely enough it took 10 years before this achievement was widely recognised.

In May 1971, the paper was reprinted in the US *Journal of the Audio Engineering Society*. Then in the June-October issues of the same *JAES*, four further papers were published by Dr Richard Small of the University of Sydney. These built upon and extended the work of Neville Thiele, hitting the world's audio engineers with a kind of 'double whammy' that they couldn't ignore.

From that point onwards, there were no excuses. Theile and Small had shown that the design of loudspeaker enclosures could be done properly, using science – art could be kept for other things.

Since then, of course, the Thiele/Small model and design technique have become not only an established part of speaker enclosure design engineering, but a prominent feature of the advertising copy used by marketing people throughout the world, when flogging almost any kind of loudspeaker box. Such is the price of fame!

All of the foregoing is by way of introduction, of course. Suffice to say that since 1973, and with the growth of personal computers, inventive programmers have produced various software programs designed to make it easier for people designing speaker systems to perform the necessary calculations, and in many cases plot out a graph showing the predicted response. The package reviewed here is the latest of these loudspeaker system CAD packages to be produced.

'Leap' is its name, really an acronym standing for 'Loudspeaker Enclosure Analysis Program'. It was written last year by Chris Strahm, of Portland Oregon, in the USA, and is marketed by his company CNS Electronics. It seems to have quite a big impact in both the USA and Europe, by all accounts, and now it is being marketed in Australia by exclusive distributor Speaker Technologies – a subsidiary of amplifier designer Peter Stein's company ME Sound.

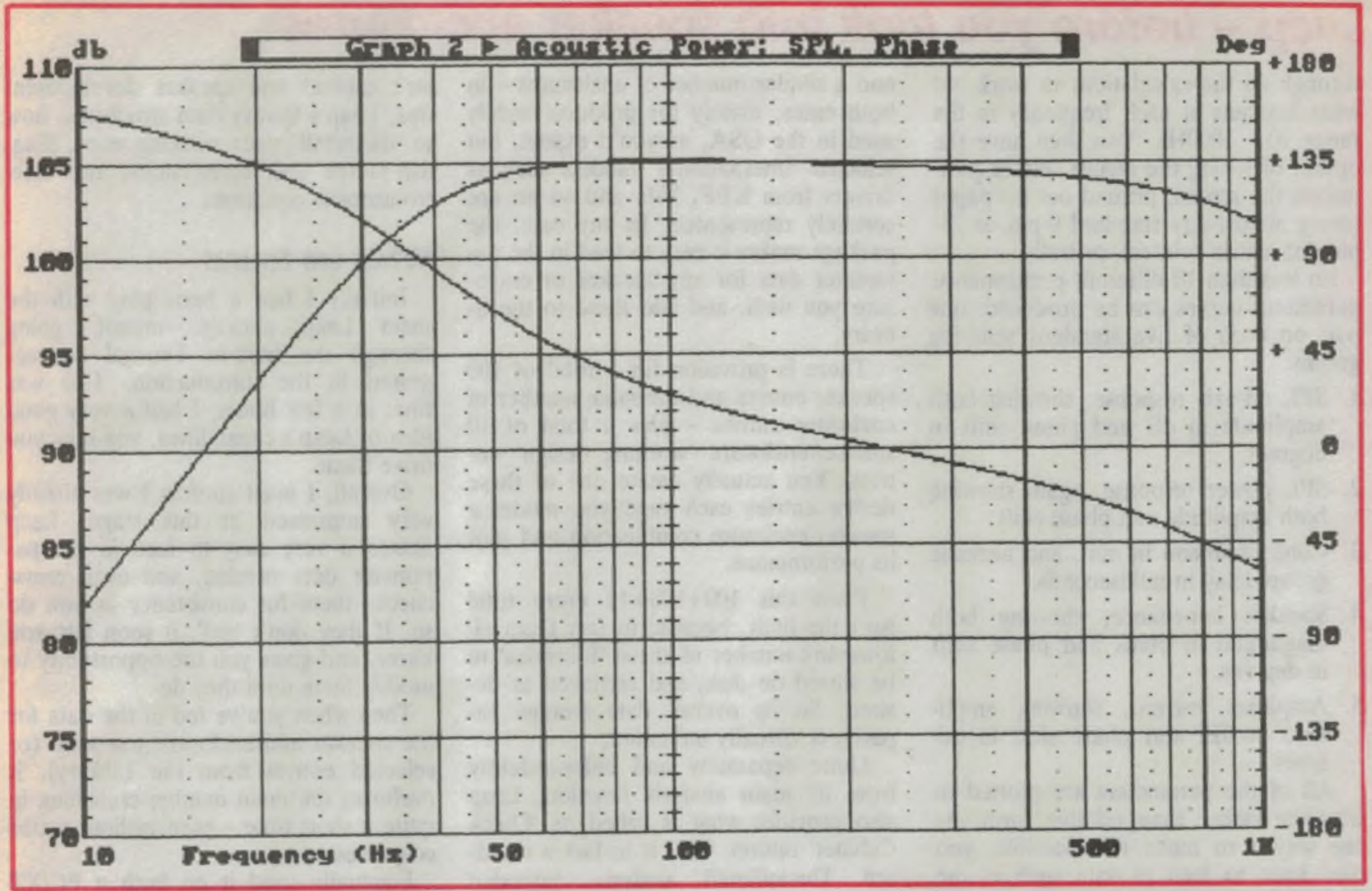
Peter and his colleague Trevor Wilson were kind enough to let me try out the first sample of the package brought into the country, along with a stripped-down version which will also be sold (rather more cheaply) as a 'Demo' program. Needless to say, I was very interested to try out both, although I freely admit I'm anything but an experienced loudspeaker system designer.

Leap's features

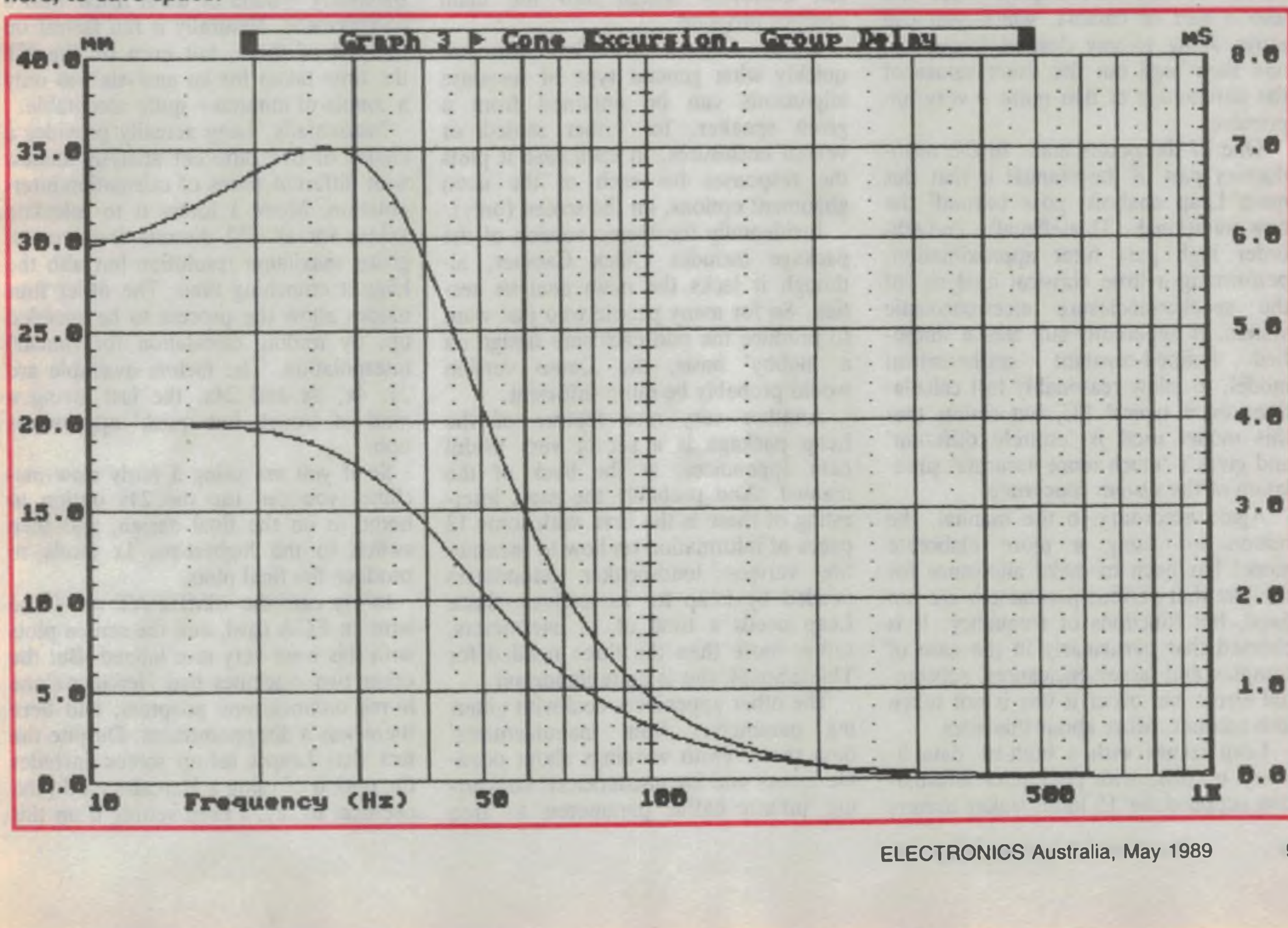
Leap is claimed to be the most sophisticated and powerful package of its kind available, and it's certainly more impressive than others I've seen. The main package consists of an A4 ring binder packed with about 20mm of manual, plus the software itself on both 5-1/4" (three disks) and 3-1/2" (two disks) floppies. The stripped-down demo version is simply a single 5-1/4" floppy with some basic notes.

The main software itself is copy protected, incidentally, and will only let you make two working copies on a hard disk or other floppies. If you change machines or whatever, you have to 'de-install' it back onto the master disks, and then re-install it. A bit irritating, but I guess the software involved a big investment and Mr Strahm is entitled to make sure he isn't ripped off. The demo version is not copy protected.

Like other speaker enclosure CAD packages, Leap essentially allows you to feed in the appropriate parameters for both the loudspeaker 'driver' itself, and the enclosure. It then plugs these values into its system model and crunches



Above and below: samples of two of the graphs produced by Leap, the acoustic SPL amplitude and phase and the cone excursion and group delay time. Note that all calibrations are absolute. The normal title area has not been reproduced here, to save space.



through all the calculations to work out what happens at each frequency in the range 10 – 1000Hz. You then have the option of seeing the results, either plotted on the screen, printed out on paper (using almost any standard 9-pin or 24-pin dot-matrix printer), or both.

No less than 10 different performance parameter curves can be produced, one pair on each of five standard semi-log graphs:

1. SPL on-axis response, showing both amplitude in dB and phase shift in degrees.
2. SPL power response, again showing both amplitude and phase shift.
3. Cone excursion in mm, and acoustic group delay in milliseconds.
4. Speaker impedance, showing both magnitude in ohms and phase shift in degrees.
5. Amplifier current, showing amplitude in dBi and phase shift in degrees.

All of the parameters are plotted in *absolute* rather than relative form, by the way – to make this possible, you also have to feed in data such as the power input level and the distance at which the simulated SPL is to be measured. On the screen plots there are also a pair of cursors, which you can move along to any desired frequency, and then read out the exact values of the parameters at that point – very impressive!

One of the points made in the introductory part of the manual is that this main Leap analysis 'goes beyond' the now-traditional Thiele/Small 2nd/4th-order high pass filter approximation, performing a 'true classical analysis' of the speaker-enclosure electroacoustic system. It apparently still uses a simplified lumped-constant mathematical model, to allow reasonably fast calculations on a typical PC, but claims that this model used is 'entirely different' and gives a 'much more accurate' simulation of the system concerned.

Again according to the manual, the reason for using a more elaborate model has been to make allowance for the fact that various parameters are not fixed, but functions of frequency. It is claimed that particularly in the case of complex and larger enclosures, substantial errors can occur if this is not taken into account. More about this later.

Leap comes with a built-in 'data library' on disk, with parameter information supplied for 15 loudspeaker drivers and a similar number of enclosures – in both cases, mainly for products widely used in the USA, as you'd expect, but selected 'international' models such as drivers from KEF, Vifa and so on are certainly represented. In any case, the package makes it easy to feed in the parameter data for any speaker or enclosure you wish, and add these to the library.

There is provision for a total of 100 speaker entries and the same number of enclosure entries – plus a total of 10 speaker/enclosure 'working design' entries. You actually create one of these design entries each time you model a speaker/enclosure combination and plot its performance.

Even this 100+100+10 entry total isn't the limit, because in fact Leap allows any number of these 'Libraries' to be stored on disk, and retrieved as desired. So its overall data storage capacity is virtually unlimited.

Quite separately and independently from its main analysis function, Leap also provides what is called its 'Quick Cabinet' option. This is in fact a standard Thiele/Small analysis, intended mainly to allow 'ball-park' evaluation of Vab and Fb figures before entering a full enclosure design into the main analysis program.

Quick Cabinet also lets you see quickly what general type of response alignments can be obtained from a given speaker, for either sealed or vented enclosures. In each case it plots the responses for each of the main alignment options, on the screen (only).

Incidentally the Demo version of the package includes Quick Cabinet, although it lacks the main analysis section. So for many people who just want to produce the odd enclosure design on a 'hobby' basis, the Demo version would probably be quite sufficient.

Another very nice feature of the Leap package is a set of very useful data appendices, at the back of the manual. And probably the most interesting of these is the first, with some 12 pages of information on how to measure the various loudspeaker parameters needed by Leap for its analysis. Since Leap needs a total of 15 parameters, rather more than the three needed for Thiele/Small, this is quite important.

The other appendices deal with entering parameters from manufacturers' data sheets (with warnings about possible errors and inconsistencies); converting 'infinite baffle' parameters to 'free air'; cabinet and speaker development tips; Leap's library data structures; how to 'de-install' your working copy; English-Metric unit conversions; and electro-acoustic equations.

What we found

Initially I had a basic play with the main Leap package myself, going through the built-in Tutorial as suggested in the introduction. This was fine; in a few hours, I had a very good idea of Leap's capabilities, and how you drive them.

Overall, I must confess I was already very impressed at this stage. Leap makes it very easy to feed in the parameter data needed, and even cross-checks them for consistency as you do so. If they don't 'gel', it soon lets you know, and gives you the opportunity to modify them until they do.

Then when you've fed in the data for the speaker and enclosure you want (or selected entries from the Library), it performs the main number-crunching in quite a short time – even without maths co-processor.

I actually tried it on both a PC/XT running at 8MHz, and two different PC-AT's running at 10MHz and 12MHz respectively – none of them fitted with a co-processor. Naturally it ran fastest on the last of these, but even on the XT the time taken for an analysis was only a couple of minutes – quite acceptable.

Incidentally, Leap actually provides a choice of five different analysis modes, with different ratios of calculation/interpolation. Mode 1 forces it to calculate values for all 552 discrete frequencies, giving maximum resolution but also the longest crunching time. The other four modes allow the process to be speeded up, by trading calculation for (linear) interpolation. The factors available are 2x, 4x, 8x and 24x, the last giving a kind of 'rough but quick' approximation.

So if you are using a fairly slow machine, you can use the 24x option to home in on the final design, and then switch to the highest-res 1x mode to produce the final plots.

In my case the 10MHz AT was fitted with an EGA card, and the screen plots with this were very nice indeed. But the other two machines had Hercules-clone hi-res monochrome adaptors, and here there was a disappointment. Despite the fact that Leap's set-up screen includes the option of using a Hercules card (and needless to say, I tried setting it up this way), it simply wouldn't produce screen plots at all. Whenever you tried to get a plot, the screen dropped out of synch into a pattern of moving horizontal lines.

You could still get the curves plotted out on the printer, though, so all was not lost.

Actually Leap's printing function is quite flexible. You can produce either a quick 'draft' plot, or a full-resolution plot – the latter tending to take rather longer, especially with a 9-pin printer where it has to make multiple passes to achieve the full resolution. And for the full resolution plots you have the choice of either 'across' or 'sideways' orientations, and even the ability to specify the overall width and height. So you can produce plots of almost any size and aspect ratio you wish.

Samples of some of the printed plots are reproduced here, and as you can see Leap does a very nice job. They're fully labelled, and of course calibrated in absolute units. Printout of a full-resolution plot takes around 7 minutes.

In addition to trying out the full package, I also tried out the Demo version. As noted before this is essentially a stripped-down version of the main package, packed into a single floppy disk and primarily intended to 'sell' the main package. Although it lacks the main analysis routine and has a subset of the speaker/enclosure data library, with some library management functions disabled, it will still plot out sample curves on both the screen and printer, and give you a good idea of how it all works.

More importantly, perhaps, it still has Quick Cabinet in full working order, so you can actually do basic Thiele/Small alignments for any speaker in the Demo disk's library, or for a speaker of your own if you have measured the three main parameters. And although Quick Cabinet doesn't print out the response for the various alignments, it plots them quite happily on the screen. It lives up to its name, too, giving you three suggested alignments for either a vented or sealed box in a very short time (around 20 seconds on a 10MHz AT).

All in all, then, my impression of Leap in both the full and Demo versions was that it is excellent – apart from the hassle with getting screen plots on a machine with a Hercules-type video card. But what about those claims that Leap goes where no speaker CAD package has gone before, 'way beyond' Theile/Small?

Never having gone all that deeply into the theory of loudspeakers in enclosures, I decided that the best way to tackle this aspect would be to seek help from someone who had. And who better than the great Mr Neville Thiele himself, who happens to reside in our own fair city of Sydney – and also happens to be one of nature's gentlemen, as I've found to my great pleasure on previous occasions.

In response to my call, he confirmed that yes, he would be delighted to have a look at Leap, and give me his reactions. So a couple of days later I found myself in the founder of modern speaker design's very own office, installing Leap on his PC-XT while he looked through the manual.

As luck would have it, Neville's machine also happened to be fitted with a Hercules card – so again we couldn't show any of Leap's impressive curves on the screen. But we could print them out on the printer, and at least this gave him a good idea of its capabilities.

It was no trouble at all to feed in the parameters for a speaker that Neville knew well, and compare Leap's calculated alignments with those he would have worked out the official Thiele way. We did this using both Quick Cabinet and the full analysis routine, and there was close agreement.

He seemed to be very happy with the way Leap guides you through the overall process; the way it cross-checks the speaker parameters for inconsistencies, when you're feeding them in; the absolute scaling of the SPL response and other parameters; and the use of the constant-voltage technique of measuring speaker parameters.

One thing he *wasn't* quite so happy about was the use of a *sealed* test enclosure to measure the moving mass and compliance of the speaker cone. Even though this approach was suggested in his own original 1961 paper, he would nowadays recommend doing these measurements with a *vented* test enclosure, because of the difficulty in ensuring that it really is sealed and airtight. In fact the vented-box approach was noted in the 1961 paper, and in his second paper in the November 1973 issue of *Proc. IREE Aust.* he emphasised that it was rather less prone to error. Better to have a box with a deliberate and known vent, rather than a nominally sealed box that mightn't be!

Apart from this, Mr Thiele's basic reaction to Leap was much the same as mine (whew!) – he was quite impressed. It seems capable of doing pretty well everything one would want, and with more than sufficient resolution and accuracy.

But what of that claim about Leap's going way beyond Thiele/Small?

Neville admitted that he was inevitably a *little* biased here, but he was quite happy to agree that (a) some of the speaker/enclosure parameters (such as voice coil inductance and resistance) may well be, and probably are, frequency dependent rather than fixed; and (b) the original Thiele/Small model doesn't allow for this.

On the other hand, he points out that even if you allow in the system model for the frequency dependence of these parameters, you're still faced with a problem: at which frequency do you measure the parameters, and which value do you feed into the program?

Leap solves this by measuring voice coil resistance at DC and inductance at 1kHz, and presumably makes the appropriate allowances. This is not necessarily wrong, according to Thiele, but not necessarily right either.

As I understand it, things boil down to this. There's still a lot of debate in speaker system design circles, as to the exact 'no holds barred' model to be used, if you do indeed want to go that far. Chris Strahm's approach as embodied in Leap certainly seems to be a credible one, although there are also others.

For the present, Neville Thiele and apparently quite a few other experts seem to hold that there really isn't a great deal of point in trying to go 'further' than the original model.

Either way, of course, Leap will do what you want – because it gives you a choice of either the Thiele/Small model or the fancier one complete with bells and whistles.

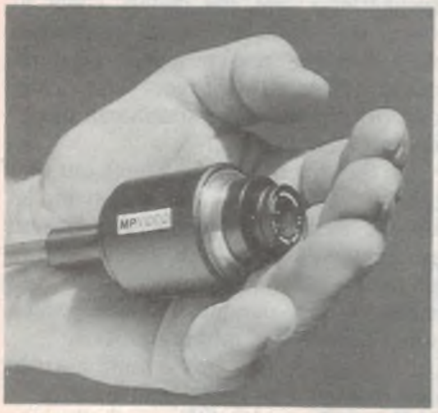
Quoted price for the full Leap package is $339.00, plus sales tax if applicable and $10 for shipping. Price of the Demo version is a very attractive $29, again plus tax if applicable.

It's available from Speaker Technologies, PO Box 50, Dyers Crossing NSW 2429 or phone (065) 50 2254, or alternatively PO Box 368, Hurstville NSW 2220, phone (02) 57 5605.

Finally, a postscript regarding the problem with Leap's screen plots, on machines with Hercules-type video cards. Speaker Technologies has checked this out with CNS Electronics, who advise that there does seem to be a problem with Hercules cards in countries like Australia with 50Hz power mains. Currently they're looking into it, and hope to come up with a solution soon.

But for the moment, you'll need a CGA or preferably an EGA to see Leap's beaut curves on the screen.

New Products



Miniature colour TV camera

A new, miniature, colour TV camera originally developed for medical applications in the USA by MP Video comes in a 44 x 43mm package weighing only 71 grams.

The RP-7 industrial version of the camera can be used as a stand-alone system for use in awkward or cramped places, or its RGB output can be integrated with computer programs for image processing. It is shielded against EM and RF interference, and has a high resolution, 420 line, 2/3rd inch CCD image sensor. Being all solid-state the RP-7 is robust and impervious to shock and vibration.

The camera has push-button white balance, a built-in colour bar generator for accurate monitor adjustment, multiple video outlets, and an optional alphanumeric character generator.

Further information is available from Industrial Television Services, 15 Coolaroo Road, Lane Cove 2066 or phone (02) 427 0294.

Handheld 'multiscope'

The new Multiscope 100/120 is a multi-purpose portable instrument designed for use by service technicians in field work. Features of the 100 or 120 include:

- Dual-channel storage oscilloscope.
- 10MHz analog bandwidth with a maximum sampling rate at 20MHz.
- Small size (260 x 105 x 39mm).
- Multimeter functions which calculate true-RMS or average values, frequency and period measurements.
- Automatic analysis of signal with optimisation of the timebase, trigger and trace cursor positions.
- Storage capability and auto calibrate.

The Multiscope uses flat panel LCD and digital technology to achieve the portability and performance of a full size digital oscilloscope and multimeter.

For further information contact University Paton Instruments, 106 Belmore Road North, Riverwood 2210 or telephone (02) 53 0644.

Metrix digital multimeters

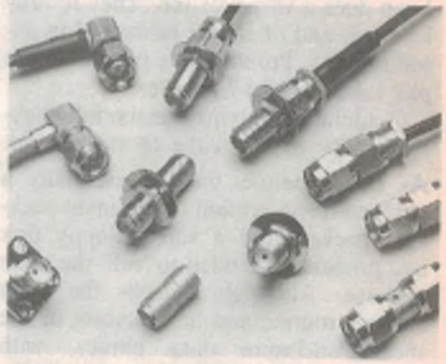
The Metrix 40 Series DMMs are intended for the most difficult areas of production, service and maintenance. Their rugged construction allows them to be used on the test bench, in the plant or out in the field.

All models feature 4000 count resolution, autorange with manual override, memory function, very fast peak hold (5ms response), waterproofing on models MX43, MX45 and MX47, diode test and audible continuity. They also come with a four-year warranty.

The Metrix 40 Series measures voltage ranges from 0-400mV to 0-1000-VDC (750AC), current from 0-400uA up to 10A AC and DC, and resistance up to 20M.

The full-function Model 47 also features direct temperature measurement, using a K type thermocouple plus true-RMS AC or AC & DC. This last feature is especially useful in applications where AC components are superimposed on a DC value, for example, the output of a thyristor, However, in applications where only the AC component is of interest, such as noise level in a power supply, advantage can be taken of the AC-only coupling feature – which has a bandwidth greater than 20kHz.

The Metrix 40 Series with 4 year warranty is available from a wide network of Elmeasco authorised distributors or Elmeasco offices around Australia.



Greenpar SMA connectors

Greenpar SMA Series connectors feature the BS 9210 N0006 mating face and are fully compatible with all the requirements of MIL-C-39012 intermating with all the SMA series connectors.

These connectors are suitable for use on both flexible and semi-rigid cables, optimum results being achieved with RG-402/u semi-rigid cable with excellent VSWR performance to 18GHz.

Bodies, pins and contacts are gold plated. Passivated stainless steel bodies are also available.

For additional information contact ACME Electronics, 205 Middleborough Road, Box Hill 3128 or phone (03) 890 0900

500W & 1.2kW sinewave inverters

Power Conversions have released the latest in their range of sine wave DC-AC ultralightweight inverters; a true 500 watt continuous (1000 watt peak) output and a true 1200 watt continuous (2000 watt peak) output model.

Using a technique patented by Power Conversions, these inverters are ultra lightweight (5kg and 11kg respectively), compact, quiet, efficient (up to 87% and 90% respectively, 72% and 78% at 10% load) and very competitively priced.

Features include: High efficiency (documentation available), crystal locked 50Hz frequency, sinewave output (less than 2% distortion), output voltage regulation ±1% from 5% to 100% load, full current limiting, full transient protection, input over and under voltage protection, over temperature cutout, ±0.9 power factor loads, 19" rack mount (3U for 1200 watt unit, 2U for 500 watt unit), foolproof operation, fully isolated to 2kV, reverse polarity protection.

The 1200 watt MODULAR power converter also features an autostart selector switch, external synchronisation facility and full opto-coupled alarm/status I/O. This model has a preferred input voltage of 42-58V DC, while the 500 watt SLIMLINE model has a preferred input voltage of 21-28V DC.

For further information contact Power Conversions, 4 Shamouni Court, Frankston, 3199 or phone (03) 789 7354.

Miniature DC/DC converters

Ericsson Components is now releasing a new series of 0.3-6W hybridised DC/DC converters named Power Industries, offering single or dual 5, 9, 12 and 15V outputs from 5, 12, 24 and 48V inputs.

All units have isolation between input and output (500-2500V DC) and are protected against short circuit. A high switching frequency (80-120kHz), an efficient thermal management and high efficiency result in higher power densities than conventional converters using the same footprints.

The units come in DIL 16, DIL 24 and other standard packages like 31 x 31 x 10mm and 51 x 51 x 10mm. The case material is self extinguishing and the potting is approved for aeronautical applications. The technical specifications make these DC/DC converters ideal for professional industrial, computer and telecom applications.

For further information contact Ericsson Components (RIFA), 202 Bell Street, Preston 3072 or phone (03) 480 1211.

Desoldering tool/iron

The new Altronics T1250 desoldering iron is designed for fast and efficient servicing of PCB's, being both sturdy and easy to use.

The tool combines a snap action, plunger operated solder extractor with a 30 watt earthed soldering iron. It is SEC approved, simply cleaned, and spare tips are available.

Further information is available from Altronics Distributors, 174 Roe Street, Perth 6000 or (09) 328 1599.

Locally made rocker switch

The new 52 Series (double pole) and 44 Series (single pole) rocker switches spearhead Swann's 'Third Generation' switch range. Many innovations combine to make the new 52 and 44 Series switches superior to those which have gone before.

Tamper resistant ports allow gasses to escape the switch body, whilst still maintaining suitability for strict SECV and Australian Approvals, unlike some opposition switches which expose the internal switching mechanism to both environmental contamination and dangerous tampering. Barrel resistors have been utilised, allowing modern resistor technology to push the mechanical design of switch illumination systems to a new level of simplicity and reliability. Spring actuation of gullwing contacts has been designed into these switches, to provide ultra-positive detent in both OFF and ON positions, and more constant contact pressure resulting in higher performance under load.

For further information on these items please contact Swann Electronics Group, 5 Dunlop Road, Mulgrave 3170 or phone (03) 560 7555.

Long life axial fans

Canon has released a series of axial fans available in both 12V and 24V DC. The are long life axial fans with brushless motors and two ball bearings. Specially designed fan blades ensure particularly low noise.

The product's safety design minimises flux leakage. The motor is protected against faulty power-supply connections and mechanical locking, ensuring safe operation. Finger-guard protectors are provided for all models.

Further information is available from Crusader Electronic Components, 81 Princes Highway, St Peters 2044 or phone(02) 516 3855.

Coaxial cable stripper

Warren & Brown & Staff, established and respected tool makers to Australian industry since 1921, were requested by a major telecommunications company to develop a coaxial cable stripper that, unlike all previously employed, would meet the requirements of efficiency and longevity of cutting blades.

After investigation into the shortcomings of existing products and drawing on the experience of long serving staff, the W & B TC155/6 high quality, reliable and easy to use strippers and associated cutter cassettes were developed in response to this challenge.

The unique feature of the TC155/6 is in the patented rotary blade cutting action, which when rotating forward around the cable, establishes a rolling and skiving action necessary to cut through the outer braid and foil: then in reverse the blades lock to slice through the dielectric, leaving the cable cleanly prepared for connector fitting.

The TC156 stripper adjusts to varying cable diameters from 5mm up to 7mm and will accommodate the ten presently developed cutter assemblies for popular cable/connector combinations. More will be developed in response to user needs.

Further information is available from Australian distributor Mijell Enterprises, 5 Barriedale Gve, Frankston 3199 or phone (059) 711 853.

Construction Project:

Build your own etching tank for PCBs

The fast and elegant way to etch your one-off printed circuit boards is with a vertical etching tank, using air bubbles to keep things moving. Here's how you can build your own tank, using less than $40 worth of materials.

by DAVID EATHER

This project comes from the desire for a better way to etch printed circuit boards. Like most hobbyists, I used to sit watching etchant wash over PCB's in a plastic tub until all hours of the morning. After wrecking one more shirt, I decided there had to be a better way.

A bit of research showed there are three main ways to etch a PCB. It can be placed in a bath of etchant and agitated periodically. This is the lowest cost method, but is also the slowest.

The fastest method is spraying the etchant onto the PCB. It is unfortunately also the most expensive method.

A middle of the road approach is bubble etching. This is nearly as fast as spray etching, while being cheap and simple to make at home. A bubble etching tank can save you one half to three quarters of the time used to etch a PCB.

And the cost? Even if you have to buy everything including the tools, the bubble etching tank will still cost you under $40.

Construction

Most of the commercial etching tanks are either moulded PVC or acrylic. Another suitable material is glass, and this is the material I have chosen. Glass is cheap, readily available, needs no exotic tools and is easier to work with than semi-molten lumps of acrylic.

The first step is to decide what is the maximum size of PCB's you want to etch. Mine were all smaller than 125 x 150mm, so if this suits your needs you can use my measurements directly.

I have called the longer side of the PCB its 'width' and the shorter side its 'height'. None of the measurements are critical, but I suggest you use the clearance specified.

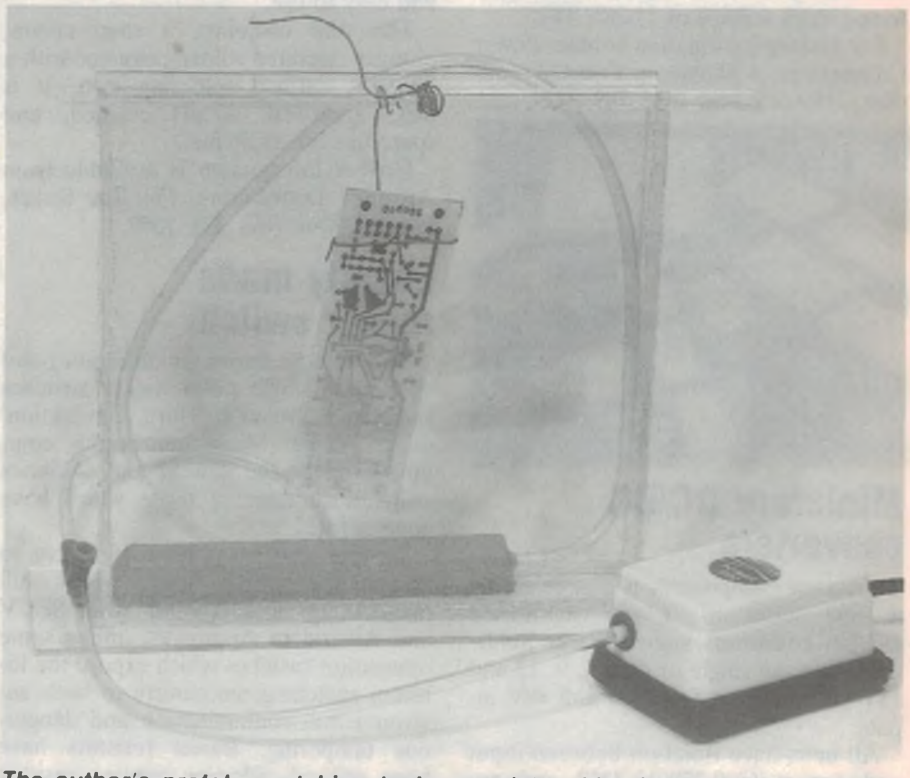
Calculate the required sizes for all the pieces of glass (see table 1 for the recommended clearances). Having done that, the next step is to draw a cutting diagram. Draw each piece of glass. Keep in mind the need for best use of a single sheet, and also try to minimise the number of cuts.

It is important to remember you can't stop a cut in glass half way along. Also larger pieces are easier to cut off than small bits. Mark on the drawing the order in which the cuts will be made (see Fig.1).

Place the glass on a smooth hard surface, covered with a cloth such as a tea towel. The dining room table generally makes an ideal surface for this, if you are a bachelor. Mark out the cuts one at a time.

Glass is cut by scoring the upper surface with the glass cutter, then flexing the glass away from the scored line (the same way as cutting ferrite).

For large pieces this is best done by placing the cut uppermost over a straight edge and snapping by pressing down on either side of the cut. Smaller



The author's prototype etching tank, complete with 'air stone' and fish-tank air pump. It gives very speedy PCB etching.

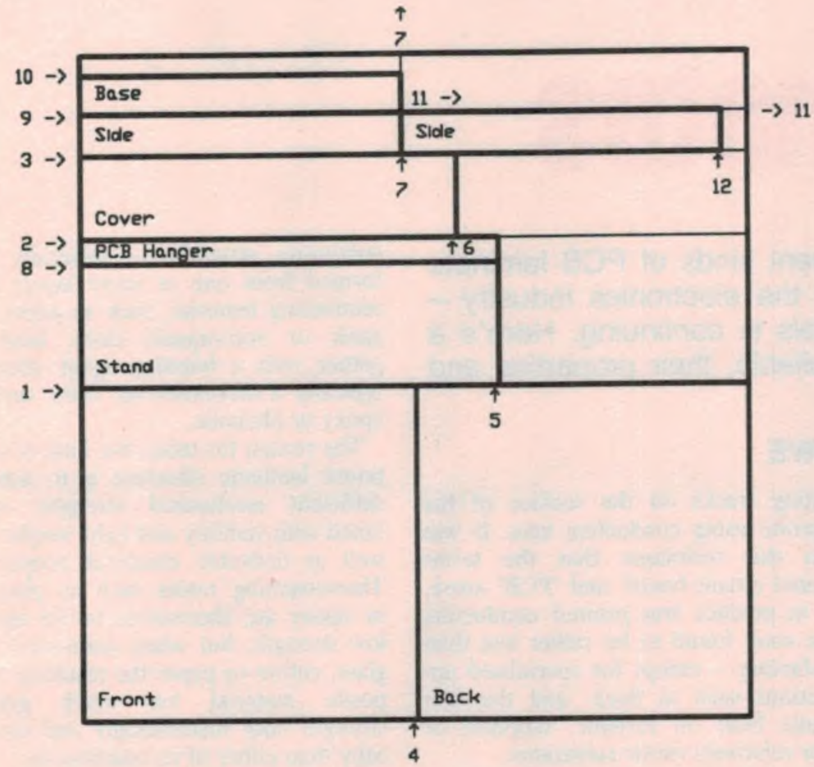


Fig.1: How to cut all of the pieces for a tank the same size as the author's, from a single sheet of glass 400mm square. The cuts are numbered in order.

PARTS LIST

Sheet glass – all 3mm thick:

Front/back of tank: 200 x 200mm, or (PCB width + 50mm) x (PCB height + 75mm)

Sides (2 off): 192 x 25mm, or (PCB height + 67mm) x 25mm

Base: 192 x 23mm, or (PCB width + 43mm) x 23mm

Stand: 250 x 75mm, or (PCB width + 100mm) x 75mm

Cover: 225 x 50mm, or (PCB width + 75mm) x 50mm

PCB hanger: 250 x 15mm, or (PCB width + 100mm) x 15mm

N.B. All of the above pieces can be cut from a single sheet of glass 400mm x 400mm – see Fig.1.

Miscellaneous

Fish tank aerator pump and tubing to match

'Air stone' aerator block (approximately the length of your PCB)

Silicone Sealant (silastic)

Super glue

Fishing line to suspend PCB

pieces can be snapped by grasping either side of the cut and snapping by hand. Make sure you snap the glass immediately after scoring.

For those unsure, many glass cutters come with instructions and the hardware salesmen are happy to explain how they work. It really is easy.

When finished cutting, find the stand and the base. The base is cemented on to the centre of the stand. 'Super Glue' is suitable.

When the glue has set run a thick bead of silicone sealant (silastic) around the base. This is for setting the front, back and sides into. Run a thin bead of sealant up the long edges of both side pieces. Place these to one side.

Put the back in place, making sure it overlaps the base by an even amount on each side. Take one of the sides and put the lower edge in place. Then join the long edge to the back. Repeat for the other side. Finally put the front in place. One person can do this, but an extra pair of hands will help.

Place a couple of rubber bands around the etching tank and square up the sides. Leave the etching tank until the silastic has dried, then trim off the excess and test for leaks. Remember neatness counts – but on this job not as much as the water proofing!

An aerator pump and 'air-stone' block of the type, used to aerate fish tanks are used to provide the air bubbles which provide etchant circulation and aeration, to promote rapid etching.

Connect the air-stone to the pump and place the air stone in the bottom of the tank. Lastly, make a way to support the PCB in the tank. You can hang it via a couple of holes discreetly drilled in the PCB itself, or use fishing line to make a sling to hang from the piece of glass cut for the purpose. I sit the PCB directly on the air stone, but this makes removing it a little more difficult.

Etching tips

This bubble etching tank can be used with either ferric chloride or ammonium persulphate. However I strongly recommend ammonium persulphate.

Many hobbyists are under the impression that ammonium persulphate is difficult to use. This is not true. The only trick is that ammonium persulphate will not etch at all until heated to over 30-40ºC, and works best at 60-70ºC.

In practice this is easy to achieve by mixing the ammonium persulphate with hot tap water. Ammonium persulphate etches faster, is cleaner and easier to handle than ferric chloride. In the dry state ammonium persulphate will not stain and should an accident happen after the etchant is mixed, the stains are less noticeable.

To use this tank with ammonium persulphate, first pre-heat the tank by filling with hot tap water (about as hot as you can stand without discomfort). Leave this for a minute or two and empty.

Refill the tank with hot water so it will cover the PCB, then add the appropriate amount of dry etchant. As a starting point, I suggest using about a quarter of a cup of etchant for each 100 square centimetres of copper to be etched.

Lower the PCB into the tank and turn on the bubbles. You should now be able to fully etch a PCB in five to ten minutes. It's as simple as that!

PCB laminates

Over the years, a number of different kinds of PCB laminate material have been developed for the electronics industry – and development of further materials is continuing. Here's a rundown on the types that are available, their properties and their uses.

by JIM ROWE

Printed circuit technology was first developed in the 1940's, during World War II. The initial impetus was to produce circuit assemblies that were light in weight but at the same time strong and ruggedised, for airborne military use. However as the technology developed, it was soon realised that because the copper conductor pattern on printed circuit boards or 'PCB's' effectively performed most of the wiring between components, the potential saving in manual labour made the technology equally attractive for mass-produced consumer equipment.

Of course further development subsequently took place, resulting in techniques for automated 'pick and place' assembly of components on the PCB's – using either 'inserter' machinery for conventional leaded components, or more recently the 'onserter' machinery for surface-mounted parts. And for bulk soldering of the components into circuit, once they are assembled, using either wave soldering, or reheating of solder paste using the vapour-phase or infrared distributed heating techniques.

As a result, PCB technology has become very close to universal in most areas of today's electronics industry. Open up almost any kind of electronic equipment, and with rare exceptions (such as microwave gear or very high-powered equipment) you'll find the circuitry based on one or more PCB's.

Essentially a PCB consists of a *substrate* or base, formed from a sheet (or sheets) of insulating material, providing mechanical support for one or more relatively thin layers of conducting material (usually copper) which are formed into a pattern of thin conductors to becomethe actual circuit wiring.

In the first, relatively crude PCB's, the conductors were indeed formed by printing tracks on the surface of the substrate using conducting inks. It was from this technique that the terms 'printed circuit board' and 'PCB' arose, but in practice true *printed* conductors were soon found to be rather less than satisfactory – except for specialised applications such as thick- and thin-film circuits built on ceramic, sapphire or other relatively exotic substrates.

The technique which rapidly became almost universal for producing the conducting tracks was the *subtractive process*, otherwise known as *chemical foil etching*. Here a continuous sheet of copper film is first bonded to the surface(s) of the substrate, to form a *metal-clad laminate*. Then the desired conductor pattern is formed on the surface of the copper film, in *resist* form – i.e., in a material which will protect the copper against chemical action. Following this the laminate is placed in an etching bath, where a chemical agent such as ammonium persulphate, ferric chloride, cupric chloride or chromic and sulphuric acids is used to etch away all of the copper other than that protected by the resist. The boards are then washed, and the resist removed to leave the desired pattern of copper conductors.

There is an alternative technique, known as the *additive process*, where the desired pattern of conductors is formed directly on the substrate surface by selective metal plating. However this is not nearly as widely used as the etching method.

Whichever kind of technique is used to form the actual conducting tracks, however, there is always the need for the substrate material itself – either with or without a bonded layer or layers of metal cladding. And in most cases the substrate is itself formed as a laminated composite structure – generally one formed from one or more layers of a reinforcing material, such as paper, organic or non-organic cloth, held together with a bonding agent which is typically a *thermosetting resin* such as epoxy or phenolic.

The reason for using this kind of composite laminate structure is to achieve sufficient mechanical strength, combined with stability and light weight – as well as desirable electrical properties. Thermosetting resins such as phenolic or epoxy are themselves brittle and of low strength, but when reinforced with glass, cotton or paper the resulting composite material has much greater strength both mechanically and electrically than either of its constituents.

The first PCB's to appear were generally based on a substrate of phenolic-bonded paper laminate. Phenolic is a thermosetting resin formed by catalysing phenol or creosol, and as a result these PCB's were often described as being made from 'SRBP' (synthetic resin-bonded paper).

Phenolic-bonded paper laminate is low in cost, but still relatively weak and brittle mechanically. It also tends to have relatively poor resistance to moisture, causing its electrical performance as an insulator to deteriorate under

Fig.1: The 'glass' reinforcing in an epoxy-fibreglass PCB laminate is generally a plain weave of 'E' glass fibre.

conditions of high humidity.

Substituting cotton cloth for the paper gives better mechanical strength and moisture resistance, but poorer performance as a dielectric. As a result, other kinds of laminate were developed – in particular, the so-called *epoxy fibreglass* type which uses one or more layers of woven glass cloth, bonded with an epoxy resin.

The glass used as the reinforcing in this type of laminate is usually what is called 'E-glass', consisting mainly of 50-55% silicon dioxide, 8-13% boric oxide, 15-20% calcium oxide and 10-15% aluminium oxide. This is drawn into a filament and then woven into a plain-weave cloth, as shown in Fig.1.

The woven glass cloth is then passed through through a tank of resin (usually epoxy), then through a set of rollers or 'doctor' blades to remove the excess resin. It is then passed through an oven at a controlled rate, to produce partial curing and make it 'tack-free'. This produces a material called *pre-preg* (short for 'pre-impregnated').

To minimise further curing the pre-preg material is usually kept under refrigerated conditions, until it is to be used to make either normal single-layer copper-clad laminate, or for making multi-layer boards.

To make normal single-layer copper-clad laminate, a number of layers of pre-preg sheet are sandwiched together, with a final layer of copper foil on the outside – or outsides, if double-sided board is to be produced. The number of sheets of pre-preg used in the 'book' will depend upon the thickness of the laminate to be produced. Then the assembled 'books' are placed in a heated hydraulic press, and subjected to both heat and pressure for about three hours.

The pressure and temperature profiles of the press are carefuly adjusted so that the resin first flows, and then fully cures, to bond all of the layers – including the copper foil(s) – into a single strong laminated sheet.

Epoxy fibreglass laminates have been available for some time in various grades, and currently form the most widely used substrates for PCBs. However in recent years various other laminate materials have been developed, generally for specialised applications involving operation at ultra high frequencies, high temperatures or high voltages. Examples of these more specialised laminates are those using nylon fabric reinforcing, or bonded using thermosetting/thermoplastic resins such as polytetrafluoroethylene (PTFE), silicone, polysulphone, polyester, polyimide and bismaleimide/triazine or 'BT'.

TABLE 1: Typical characteristics for NEMA-grade PCB laminates

Property	XXXPC	FR-2	FR-3	FR-4	FR-5	FR-6	CEM-1	G-10/11	G-30	G-60
Volume resistivity, min. (ohm-cm 1/16"-1/8")	10^7	10^7	10^8	10^9	10^9	10^9	10^9	10^9	10^9	—
Surface resistance, minimum, ohms	10^6	10^6	10^7	10^7	10^7	10^7	10^7	10^7	10^8	—
Dielectric breakdown, min. kV, parallel to lam.	15	15	30	40	40	30	40	40	40	—
Dielectric constant at 1MHz	4.6	4.6	4.6	5.2	5.2	4.2	4.6	5.2	4.35	3.1
Dissipation factor at 1MHz	.035	.035	.035	.025	.025	.017	.035	.015	.014	.006
Coefficient of thermal expansion, cm/cm/°C x 10^{-5}	2	2	2	0.9	0.9	1	—	0.9	0.3	0.7
Water absorption, max (% over 24h—1/16")	0.75	0.75	0.65	0.25	0.25	0.18	0.3	0.25	0.75	0.29
Flexural strength, min. psi—lengthwise	12k	12k	20k	60k	60k	15k	50k	60k	60k	24k
Flexual strength, min. psi—crosswise	10k	10k	16k	50k	50k	15k	40k	50k	50k	16k
Peel Strength, min. (lbs/in width, 1-oz Cu.)	6	6	8	8	8	7	7	8	9	8

Some of the main physical and electrical parameters of PCB laminates, compared for the main grades currently available.

How many different kinds of PCB laminate are there? The American National Electronic Manufacturer's Association (NEMA) specifies around 30 different types of laminate material, although of these only about 10 are commonly used for PCB fabrication. Let's look at these briefly in turn:

Grade XXXPC: This is a phenolic resin bonded paper laminate, reasonably moisture resistant compared with earlier types. It is suitable for use at radio frequencies, and designed for easy *punching* at relatively low temperatures. As a result, this laminate is still used for a lot of equipment made in very large volumes, where punching is cost-effective as opposed to drilling.

Grade FR-2: This is also a phenolic resin bonded paper laminate, similar to XXXPC but less flammable.

Grade FR-3: An epoxy resin bonded paper laminate, with superior mechanical strength and dielectric characteristics to FR2 and XXXPC. Suitable for punching at room temperature.

Grade FR-4: An epoxy resin bonded glass fabric laminate, the most widely used type for general-purpose PCBs. Excellent mechanical and good dielectric properties, under both dry and humid conditions. Reduced burning rate compared with grades G-10/G-11.

Grade FR-5: An improved epoxy resin bonded glass fabric laminate, similar to

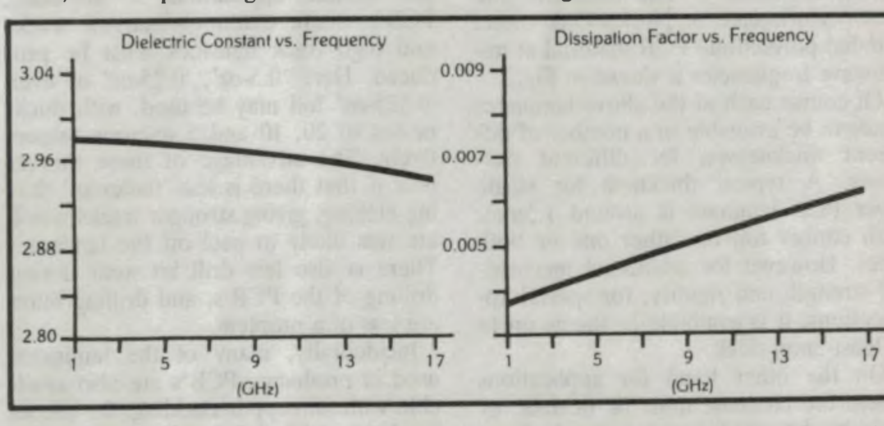


Fig.2: The dielectric constant (left) and dissipation factor of Norplex-Oak 'Polysulfone' direct bond PCB laminate, as a function of microwave frequency.

FR-4 but with improved flexural strength. Excellent mechanical and dielectric properties, moisture resistance and low burning rate.

Grade FR-6: A thermosetting polyester bonded glass mat laminate. Lower dielectric constant than FR-4 or FR-5 laminate, also improved dissipation factor and water absorption characteristics. However it has poorer mechanical strength.

Grade CEM-1: An epoxy resin bonded laminate with glass fabric surfaces and a cellulose paper core, making it suitable for punching. Not as moisture resistant as FR-4, FR-5 or FR-6.

Grade G-10: An epoxy resin bonded glass fabric laminate, with excellent mechanical and good dielectric properties. Similar to type FR-4, but slightly more flammable.

To these common laminate materials can be added the newer and more exotic laminates, such as these:

Grade G-30: A high-temperature polyimide-resin bonded glass fabric laminate. This has very high dimensional stability, high moisture resistance and outstanding electrical characteristics. No volatiles are generated during the final polymerising stage, so the pressed laminates are void-free. This makes it very suitable for making multi-layer PCB's.

Grade G-60: A laminate produced by Norplex-Oak, and using Union Carbide 'Polysulfone' thermoplastic as its substrate material. The main feature of this material is a very low dielectric loss and closely controlled dielectric properties, making it suitable for use at gigahertz frequencies for microstrip lines, etc.

A summary of the main characteristics of each of these types of laminate is shown in Table 1. The dielectric and loss performance of Norlex-Oak direct bonded polysulfone PCB material at microwave frequencies is shown in Fig.2.

Of course each of the above laminates tends to be available in a number of different thicknesses, for different purposes. A typical thickness for single layer PCB laminate is around 1.5mm, with copper foil on either one or both sides. However for additional mechanical strength and rigidity, for special applications, it is available in sheets up to at least 3mm thick.

On the other hand for applications where the laminate must be flexible, or it is to be used to make multi-layer boards, many grades are available in thicknesses down to 0.1mm.

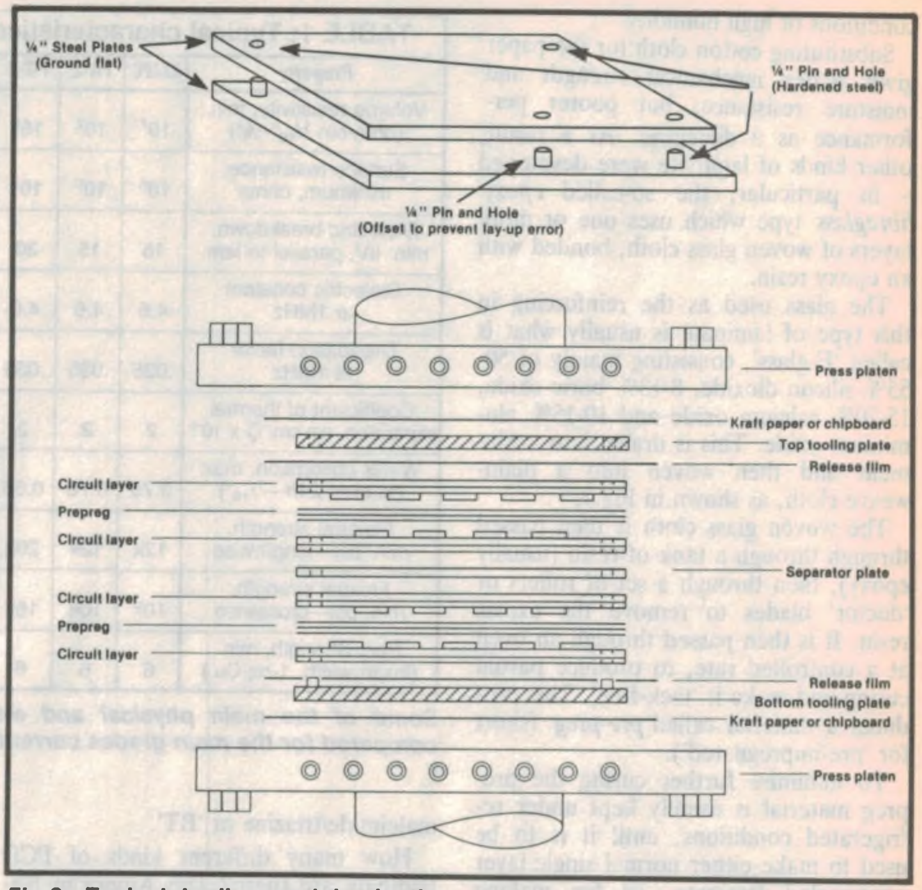


Fig.3: Typical tooling and laminating press make-up for multilayer PCB's, showing the alternate layers of pre-etched thin laminate and bonding/insulating layers of 'pre-preg' material.

A similar range of choice is typically available in terms of copper foil thickness. The foil thickness most commonly used is 35 microns (.035mm, or .0014"), commonly called '1-oz' foil because one square foot weighs one ounce. However '2-oz' or 70 micron thick foil is available for making PCB's where the conductors must carry high currents, or need to be thicker to minimise losses due to skin effect, etc.

Much thinner foils are also available, for special applications – including PCB's where extremely narrow tracks and high track densities must be produced. Here '0.5-oz', '0.25-oz' or even '0.125-oz' foil may be used, with thicknesses of 20, 10 and 5 microns respectively. The advantage of these thinner foils is that there is less 'undercut' during etching, giving stronger tracks which are less likely to peel off the laminate. There is also less drill bit wear during drilling of the PCB's, and drilling burrs are less of a problem.

Incidentally, many of the laminates used in producing PCB's are also available without copper cladding, for use as insulating and lightweight construction materials both elsewhere in electronics, and in other fields.

Multi-layer PCB's

So far, we have been talking mainly about the laminates used for single-layer PCB's, which are produced by etching copper-clad laminates that are fully processed. Let us now look briefly at the more elaborate multi-layer PCB's.

These are made using a combination of *very thin* standard copper-clad laminates, with layers of the partially-cured unclad *prepreg* material used for bonding layers. The reason being, of course, that the copper patterns destined to be 'inside' a multi-layer board must be etched *before* it is finally laminated.

The first stage of manufacture of a multi-layer PCB is to etch the various layer patterns into suitable very thin sheets of standard fully-cured standard copper-clad laminate. If necessary, these are also drilled and plated to produce any through-board 'via' connections that will ultimately become hidden once the full multi-layer PCB is assembled.

The etched individual layer boards are then treated to produce an oxide layer on the surface of the etched copper, to provide a good surface for final bonding. Then the boards are very carefully cleaned, to remove all traces of etching resist and other contaminants. Finally they are baked for a period of about 30 minutes at about 100°C, to remove all moisture and trapped solvents.

The various layers are then assembled, together with layers of pre-preg laminate to provide the additional insulating and bonding layers. Many of these identical board sandwiches or 'packages' are stacked, and placed between steel 'tooling plates' top and bottom with pins for accurate registration. The complete assembly is then placed in a heated hydraulic press, and heated for around 45-60 minutes at a temperature of 150-230°C and a pressure of about 250psi (for epoxy/glass).

What happens during this operation is that the resin in the pre-preg layers first flows and then cures, bonding the various layers together to form the final multi-layer assembly. The final boards are usually allowed to cool down to around 50-65°C, under full pressure, and then baked for 3-4 hours at about 148°C for stress relief.

The tooling plates and arrangement of layers in a laminating press are shown in Fig.3.

Most multi-layer PCB's are made from epoxy-glass laminate, typically FR-4 or similar material for the etched layers and matching pre-preg material for the bonding layers. However for applications where dimensional stability is critical, the newer polyimide materials may be used.

Multi-layer PCB's with up to 40 different layers are technically possible, and have been used for specialised applications. However most multi-layer boards have between 4 and 18 layers.

For satisfactory multi-layer boards, the etching, drilling and laminating operations must be carried out with great accuracy of registration. The platens of the laminating press must also be maintained in very accurate parallel alignment, and the press pressure/temperature profile adjusted very carefully to ensure correct flow of the resin during the curing.

I hope the foregoing gives you a reasonable insight into the various laminate materials used for PCB manufacture, and how they are used. It's a specialised field, but an understanding of the basics can be worthwhile when you are trying to select the most appropriate material for a particular job, or trying to track down the cause of a subtle electrical or mechanical problem.

My thanks to Mr Leenders, of the O.H. O'Brien division of Anitech, Australian distributors for Norplex-Oak, for his courteous help in preparing this article.

State of the PCB art in Australia

Alcatel STC is Australia's largest designer and manufacturer of communications equipment. Here's a rundown on the company's PCB manufacturing and assembly facilities, which employ the very latest world-class technology to process over a million boards a year.

by J.M. HAMILTON

Industry sectors always have a base technology – a fundamental process without which the higher levels of those industries cannot exist. With a national electronics, computers and communications industry, the base level of these technologies is its capacity to design, produce and assemble the latest in printed circuit boards (PCBs).

Australia can buy components cheaply overseas, but if we are to retain a healthy electronics manufacturing sector we have got to make and assemble printed circuit boards in our own backyard – and to a standard equal to any in the world.

Electronics is a fast-changing business with new designs and new components arriving on the scene every day, and board manufacture and assembly techniques must keep pace. Fortunately in Australia, this is an area in which we now excel.

It is now quite apparent that surface mounted component (SMC) technology is the way to go, unless the circuit is designed to carry heavy current loads. Surface mounting was invented in the late 1970's and has been gradually introduced into production over the last decade.

The delays came about because of the need to design small components to fine electronic tolerances, and the long hard battle which had to be fought just to get standards in place for component geometry. Size and shape become of critical importance when these miniaturised items need to be positioned with little spatial tolerance.

In Australia, the electronics industry's acceptance of SMC followed the lead of the Europeans in waiting for the component industry to get its house in order. This cautious approach has meant that Australia avoided many of the mistakes made by other countries during the early SMC years.

"By waiting, we have been able to choose the best methods of assembly available, culminating in one of the country's largest and most advanced SMC installations at the Alcatel STC Commander Telephone System plant at Liverpool, which opened in late 1987," states the company's manufacturing director, Graham Tonkin.

"The initial advantage for us with SMC technology came from the size reduction, which allowed us to put more functions on the one board", he explains. "The SM components were about a quarter the size of the older 'through-hole' components, and for the Commander, this meant that we could more effectively package the electronics to allow more flexible designs within the same overall-sized product."

Electronics companies around the world are finding that the higher board packing densities also lead to simplified circuit designs with multifunction VLSI, greater reliability and robustness of components and connections, and in many cases higher-speed operations because circuit distances are compressed.

Not everything in the garden comes up rosy, however. As components get smaller the distance between contacts on ICs and VLSIs become much finer, and so the placement of components – and the soldering methods used – become critical. Most surface-mounted boards now in production are based on ICs with contact leads designed around 50-mil (.05") centres, but as VLSI chips increasingly pack in more devices, lead counts rise. New families of components are emerging, with leads on extremely tight contact pitches of 25, 20 and even 15 mils (.015") – which places even more pressure on the accuracy of board manufacture, design, and component placement.

Alcatel STC is Australia's largest designer and manufacturer of communications equipment. Its printed boards are designed on the company's CAE/CAD system, which both generates the photographic artwork to make the printed circuit boards and provides the information need to control the automatic machinery. The boards are screened and etched at the company's Alexandria facility, which produces 1.2 million boards a year for a wide range of products made in Australia: from telephones to line and power equipment, to AXE exchanges and optical fibre links.

Communications has now become the world's first truly internationalised industry – the central manufacturing business of our emerging 'global village'. So no advanced country can afford to be left behind in communications manufacture – or it will soon become a client state of its more advanced neighbours. As Graham Tonkin says, Alcatel STC's ability to manufacture such an extensive range of communications equipment in Australia is enhanced by his company's links to Alcatel NV's Advanced Manufacturing Technology Centre (AMTC), based in Belgium.

"The AMTC has become a central clearing-house for industry knowledge acquired from our associated Alcatel companies worldwide", he explains. "The Centre's major task at the present moment is in rationalising and standardising manufacturing techniques – and we monitor this constantly."

"They are always researching new production methods, and we can go to them for advice on new processes or for help in the purchase of any type of automated assembly equipment or compo-

Alcatel STC's surface mount technology produces miniaturised printed circuit control panels for the Commander Telephone System.

nents. We often send our people over to Europe to keep up with the latest developments."

As a result of these training and knowledge links to the world's No.1 communications equipment manufacturer, the company's Liverpool SMC installation is a world-class facility utilising up-to-date assembly and soldering techniques.

The SMC process, despite its complexity, is accurate and highly productive. The blank boards are held in a magazine and after a solder paste has been silk-screened onto the surface, they are fed, one at a time, onto the line. The first step is a Dispenser Module, where a programmable syringe dots the board with epoxy adhesives to hold the components during the soldering process. A special sensing feature controls the positional accuracy of the dots to within 0.1mm, while still achieving a throughput of 12,000 dots per hour.

The board then enters the 'Onserter', which selects resistors, capacitors and LEDs before placing them on the surface of the PCB with a positional accuracy of nearly 0.05mm. The Onserter uses a vacuum pick-up nozzle to handle the components and it is able to orientate and lay them accurately at a rate of 6,000 per hour.

An infra-red glue cure and reflow solder system firstly cures the adhesive so that nothing can shift during the following reflow soldering operation, which utilises infra-red heating to melt the tiny particles of solder within the solder paste previously screened onto the board.

It takes about five minutes to reprogram the Onserter for the second run. The boards can then be returned for the second pass through the machine, to mount components on their 'other' sides.

The second side is glued and components laid using the Onserter, and the adhesive cured in the IR process. They are then put through an in-line flow solder machine, to solder the components in place without dislodging those already mounted on the first side.

Occasionally a vapour-phase soldering machine is also used. This process immerses the boards in the heated vapour of Flourinert, which is a totally inert liquid that boils at 215°C. As the vapour condenses on the contacts of the board, the heat transfers to the contact points, reflowing the solder and completing the soldering operation.

These soldering processes are the key to the reliability of the SMC boards, since they largely eliminate problems of thermal mismatch. Early SMC techniques often faced problems caused by the lack of flexibility inherent in component leads – which, in through-the-hole techniques, take up any expansion and contraction differences between the substrate and the components reasonably uniformly, so thermal mismatch is minimised.

The progress of surface mounting techniques increasingly demands that board laminates have better dimensional stability and a controlled co-efficient of thermal expansion. A lot of work is going on around the world to discover new resins and laminates suitable for board manufacture.

The present epoxy-glass substrates will probably give way to boards using the new BT (bismaleimide and triazine) thermosetting resins which, when mixed with epoxy, help maintain dimensional stability while substantially reducing the dielectric constant of the board. Dissipation factors can be reduced by up to a third.

Australian manufacturers are also fixing their sights on tomorrow's highly automated factory, where in-circuit and functional testing will be pushed to the limits by elaborate on-board VLSI chips. Testability will need to be designed into the boards to cope with the increased complexity – especially where analog and digital components co-exist side by side.

PCB Technology – News & Products

Vapour-phase soldering medium

Unlike many of the soldering options available for mass production, vapour phase reflow soldering assures precise temperature control in a clean, non-oxidising, non-flammable soldering environment. And 3M Australia claims that its 'Fluorinert' liquid is the key to effective use of the vapour phase soldering process.

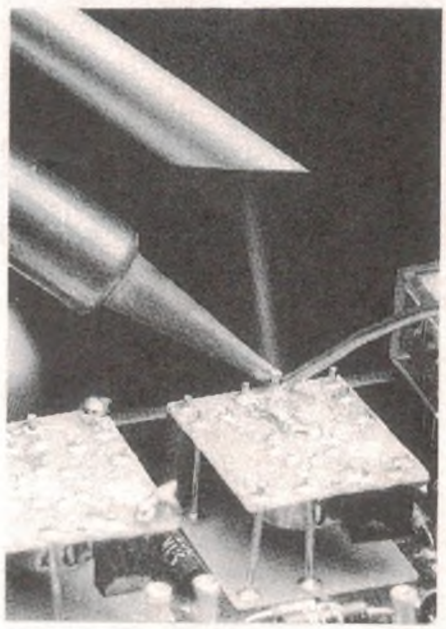
When one of the 'Fluorinert' liquids is heated to its boiling point, a saturated primary vapour zone is created. The workpiece or component to be reflow soldered is lowered into the primary vapour zone. The vapours condense, transferring heat to the workpiece and causing the solder to reflow. (The component can also enter the vapour zone on a continuous belt for an in-line system).

Since every surface is covered by condensing vapour, the entire workpiece is uniformly heated, regardless of the product's size or shape – making the vapour phase reflow process essentially independent of the product geometry.

Applications that can capitalise on high production/low cost vapour phase soldering with 3M's 'Fluorinert' liquids include surface mounted leaded or leadless components, wire-wrap pins and through-hole leads, attachment of edge clip/terminals and reflow of the electroplate on PCBs.

For more information on Fluorinert and the vapour phase condensation reflow soldering method contact 3M Australia at 950 Pacific Highway, Pymble 2073 or phone (02) 498 9292.

Fume extraction for hand soldering



Are you worried about what your hand soldering operative breathes in? The George Brown Group has announced a new concept in hand soldering which is already used in overseas factories, and has now been tested in an Australian production line.

The Weller Fume Extraction Soldering Station is the result of close co-operation between The George Brown Group, Cooper Tools, Neographics and a prominent communication manufacturer. It is quite obvious when viewing the flux residues drawn in by the system that these noxious by-products would otherwise have been breathed in by the operator.

Removing the flux 'smoke' has a much wider effect than just making the operator's job more pleasant. It allows for more concentration on the item being soldered, thus improving quality. Health problems due to flux inhalation will decrease, thus reducing the amount of sick time taken.

Systems are available to suit from 1 up to 20 work stations. Installation is simple and can be carried out to suit any production layout.

For further information contact your local George Brown Group office or George Brown Group Marketing Division, 456 Spencer Street, West Melbourne 3003 or phone (03) 329 7500.

PCB design, photoplotting

A new company has been established in Melbourne to provide a full range of services in printed circuit board (PCB) design, high precision photoplotting and prototyping.

PCB Resources, based in the Melbourne suburb of Mount Waverley, was formed by Martin Gregory and Andrew Kluchareff who between them, have more than 40 years experience in all aspects of quality PCB design, including multilayer and surface mount board design techniques. The company offers accurate PCB design, precision photoplotting, fast turnaround and competitive pricing.

Additional PCB design services offered include schematic design, electromechanical design (ACAD), blank PCB sourcing, multicolour artwork checkplots (Protel PCB or Autotrax); and prototype PCB loading and testing.

For further information contact PCB Resources, Suite 9/417 Ferntree Gully Road, Mount Waverley 3149 or phone (03) 544 6955.

Flexible PCB technology

Email Electronics has recently been awarded the exclusive distribution agency in Australia and New Zealand for an exciting new PCB manufacturing technology. The technology, developed by Bayer in Germany and marketed by Wilde MIT, is a revolutionary process where copper tracks can be deposited directly onto plastic substrates such as polycarbonate, polyimide and polyester. This offers significant advantages over conventional etching technology in regards to cost, performance and design flexibility.

The main application of the process known as 'Bayprint' will be for membrane keyboards and flexible PCB's. Current membrane keyboards use conductive inks, which are prone to field failure as a result of contact tarnishing and silver migration. The 'Bayprint' process however can be used to produce gold plated contacts, giving reliability while remaining very cost competitive.

Future developments are for the production of three dimensional circuit boards deposited directly onto injection moulded substrates.

While production of 'Bayprint' substrates will initially take place at Wilde's manufacturing plant in Germany, a local facility is planned for installation at Email Electronics' Huntingdale plant in 1990.

For further information regarding the applications of 'Bayprint' contact Alan Fancke at Email Electronics, 15-17 Hume Street, Huntingdale 3166.

Pen 'draws' PCB tracks

Planned Products of Los Gatos, California has introduced a low cost pen that makes applying solderable conductive electronic traces to most surfaces as easy as writing. Through advances in valved pen and polymer ink technologies, the pen writes with highly conductive silver ink. Electronics hobbyists will find hundreds of uses for the Circuit Works pen, including PCB fabrication and repair, electromagnetic shielding and conductive point to point traces. The pen incorporates a valved tip to allow the smooth application of the liquid silver conductor. Normal writing pressure opens the valved tip and the liquid conductor flows easily.

When not in use the pen's spring loaded tip closes to prevent drying. Traces as narrow as 1/16" are easily drawn, and the pen comes filled with enough silver conductor to make 150 feet of conductive traces.

Circuit Works polymer ink dries in minutes at room temperature and is several times more conductive than solder. Solderable terminations are possible using a 250°F cure for 10-15 minutes after application.

Individual Circuit Works Conductive Pens sell for US$9.95 plus $2.00 for postage outside the USA, and handling. To order send a cheque or money order to Planned Products, 21105 Santa Cruz Highway, Brush Road, Dept. FEA, Los Gatos, CA 95030, phone (408) 353 4251 or (408) 354 4818.

AutoCAD photoplotting

Printed circuit board design and photoplotting company PCB Resources can now offer fine resolution photoplotting services from AutoCAD drawings.

The company can now offer a comprehensive service of PCB design from start to finish, or photoplotting, even from a client-supplied AutoCAD file. The ability to provide photoplot positives from AutoCAD files also allows reduced scale drawings for inclusion in manuals or other publications.

PCB Resources, a Victorian-based company, provides an extensive range of services or consultancy, in PCB design and surface mount technology.

For additional information contact PCB Resources, Unit 9/417 Ferntree Gully Road, Mount Waverley 3194 or phone (03) 544 6955.

Vintage Radio

by PETER LANKSHEAR

MATE – A handy accessory

Recent comments from vintage radio collectors indicate that there is a need for an alternative programme source, for times when there is an absence of suitable transmissions. If you enjoy demonstrating or listening to your vintage radios, you will find this 'Mate' useful – as well as deriving satisfaction from building some working equipment.

Tapes of the old classic radio shows are becoming very popular, and reproducing them through a radio of the era enhances their entertainment value. Furthermore, increasing numbers of existing AM medium frequency stations are being lost to vintage radio, as they transfer to the FM VHF bands.

A specification was drawn up and some experimental work was done, to see if it would be practical to produce what is in effect a miniature AM broadcast transmitter. The criteria it had to meet were these:

1. Construction should be simple and use components that are readily available and inexpensive.
2. Power and range should be strictly limited.
3. A multimeter should be the only test equipment necessary for setting up.
4. It should accept either monaural or stereo programme input from the headphone or extension speaker sockets of receivers, cassette, CD or record players.
5. Have 90% modulation capability, with no audible degradation of the programme material.
6. Use a minimum of current so that it could be powered from a receiver.

The result was the MATE (Micro Amplitude – modulation Transmitting Equipment). Like radio controlled toys and wireless microphones, it is a limited radiation device transmitting a very low powered signal, sufficient to cover a room or display area. Appropriately, it uses techniques frequently found in early broadcasting transmitters.

At this stage, I would suggest that readers not familiar with the workings of broadcast transmitters should study the article in the October 1988 issue of *EA*, Part 4 of the 'Basics of Radio Transmission'.

Early AM transmitters

Fortunately for early broadcasters, and this project, a class-C valve oscillator is easy to amplitude modulate, as the relationship between its HT voltage and power output is very linear.

Modulated oscillators can be simple and effective transmitters, and were used by some 'B class' AM broadcasting stations well into the 1930's. They have limitations, which are somewhat academic in the case of the MATE. These are lack of crystal frequency control and frequency shift with modulation, both of which can create problems for adjacent transmissions.

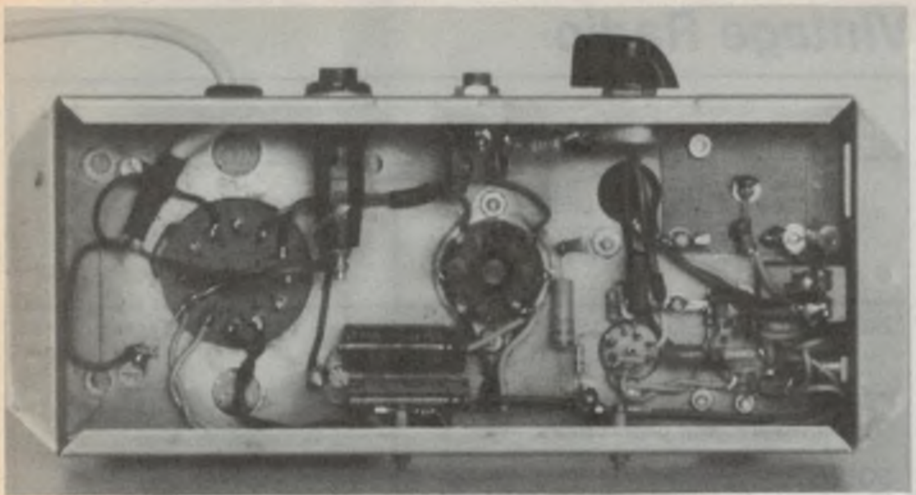
Heising or choke modulation was general, but during the 1930's, series modulation which needed no expensive choke or transformer was popular – and this seemed to be an attractive proposition for the MATE.

Experiments were promising, and resulted in a single valve oscillator and modulator capable of using common types of double triode. A triode amplifier was added to increase audio gain, and the overall result is a very simple but effective little transmitter.

Why use valves?

No excuses are offered for using valves. Apart from being appropriate for a vintage radio project, valve equip-

The author's prototype for the 'MATE' mini-transmitter, built on a disused power supply chassis.



Underneath the chassis of the prototype, which also includes the power supply circuitry.

ment in this case is far less complex and is easier to adjust than a semiconductor unit. The MATE uses only two valves, and a handful of components.

Operation is very simple, and construction and layout are not at all critical. One half of the double triode (V2a) is a classic tuned anode oscillator, with tickler feedback to the grid. The other section (V2b) is the series modulator, which is driven in turn by a resistance-capacitance coupled triode voltage amplifier (V1). The HT current of about 4 milliamps and filament requirement of 6.3V (AC) at 0.6A can easily be supplied by any medium-sized valve radio – or alternatively, a self contained power supply can be used.

Housing for the MATE can be as simple or as elaborate as the builder wishes. The prototype was built on a disused power supply chassis, but a utility box would make a more attractive unit. However, if appearance is not important, there is no reason why it should not be built on an old receiver chassis.

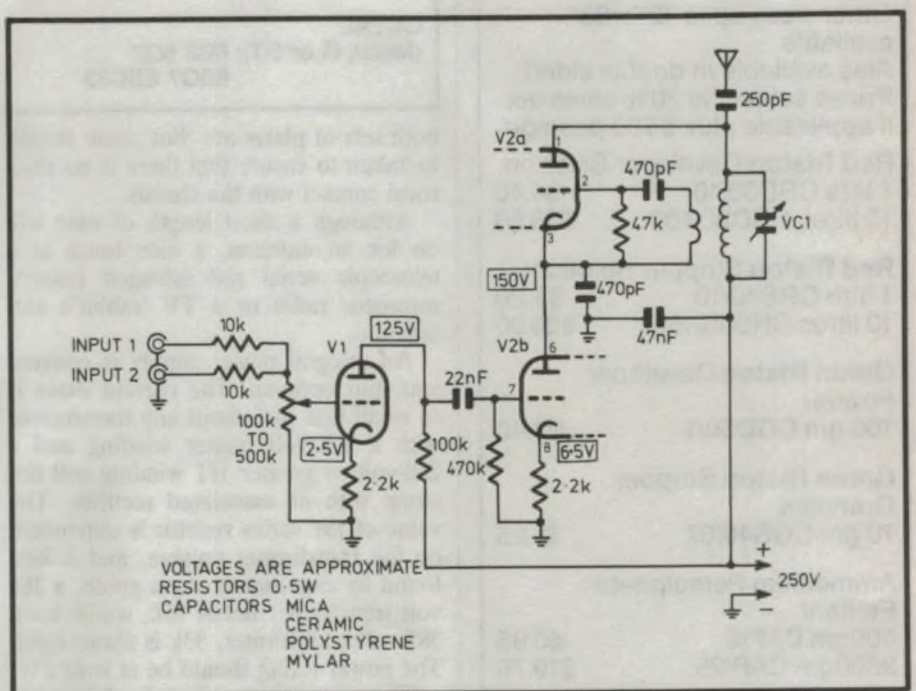
The audio input socket is connected to the modulation level control by a pair of 10k resistors, used to combine stereo signals, with one input being ignored for monaural sources. If the lead from the control to the voltage amplifier grid is longer than a few centimetres, it should be shielded by using a piece of thin coax or screened cable.

The voltage amplifier can be just about any small triode or triode-connected sharp cutoff pentode. Some suitable types are listed in the table. The oscillator/modulator can be a 12AU7/ECC82, 12BH7 or 6CG7. These valves were popular in black and white TV receivers, and if necessary can still be purchased at reasonable prices.

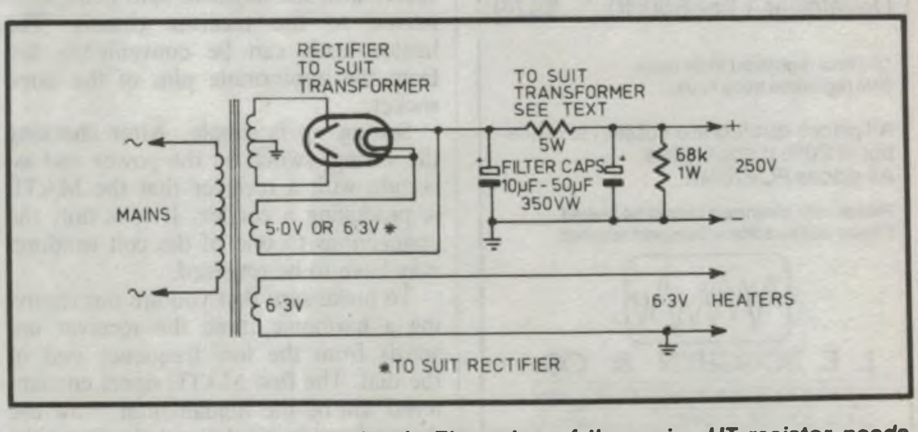
The oscillator is quite similar to a standard anode-tuned superhet oscillator, except that it is series rather than shunt fed. A receiver oscillator coil is suitable, or one can be readily wound on a piece of broom handle using enamelled winding wire of about 36 SWG or 0.2mm diameter. The tuned anode (plate) winding has 100 turns, while the tickler/grid winding has 25 turns. Small plated nails can be used to provide terminations for the windings.

As the coil is connected to HT voltage it should be kept away from fingers, and if used, a shielding can should have a minimum of twice the coil diameter.

Tuning is controlled by variable capacitor VC1. This can be an old oscillator padder, from a valve set, or even a transistor receiver tuning capacitor. As



The circuit for the 'MATE' – effectively a very low powered AM transmitter, using a triode RF oscillator V2a series modulated by V2b. Incoming audio is amplified by V1.



The matching power supply circuit. The value of the series HT resistor needs to be selected to suit the transformer secondary voltage – see text.

SUITABLE VALVE TYPES

V1 AUDIO AMPLIFIER Ignore unused sections of multiple valves	V2 OSCILLATOR/ MODULATOR
DIODE TRIODES: 6AV6 6AT6 EBC81 EBC91 PENTODE (Triode Connected): 6AU 6 EF94 DOUBLE TRIODES (One Section): 12AX7 12AT7 ECC83 ECC81 OCTAL (Metal, G or GT): 6B6 6Q7 6SQ7 EBC33	NOVAL: 12AU7 12BH7 6CG7 ECC82 OCTAL: 6SN7

both sets of plates are 'hot', care should be taken to ensure that there is no electrical contact with the chassis.

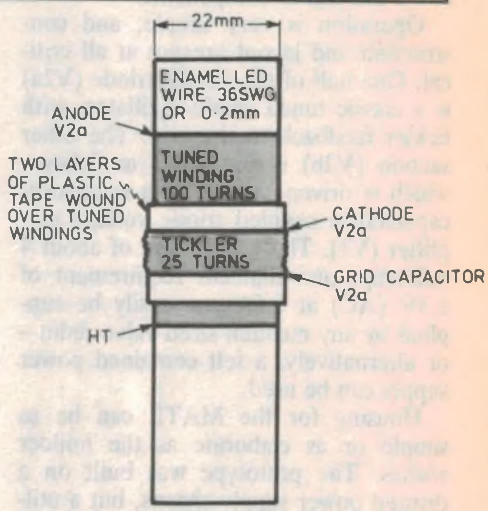
Although a short length of wire will do for an antenna, a nice touch is a telescopic aerial rod salvaged from a transistor radio or a TV 'rabbit's ear' antenna.

An integral power supply is convenient, but optional. The current drain is so small that just about any transformer with a 6.3 volt heater winding and a 200-volt or greater HT winding will do, along with its associated rectifier. The value of the series resistor is dependent on the transformer voltage, and is best found by experiment. As a guide, a 285 volt transformer needs 15k, whilst for a 385 volt transformer, 33k is about right. The power rating should be at least 5W.

The alternative approach of borrowing power from an existing valve receiver is simple. HT can be picked up from the screen grid pin of the output valve, with the negative lead being connected to the receiver chassis. The heater leads can be conveniently fed from the appropriate pins of the same socket.

Setting up is simple. After checking the wiring, switch on the power and ascertain with a receiver that the MATE is producing a carrier. If it is not, the connections to one of the coil windings may have to be reversed.

To make sure that you are not receiving a harmonic, tune the receiver upwards from the low frequency end of the dial. The first MATE signal encountered will be the fundamental. Now use the tuning capacitor to set the transmission frequency to a section of the



If you want to wind your own oscillator coil, here are the details. The wire should be enamelled copper, or 36 SWG or 0.2mm diameter.

broadcast band that is vacant in your area. Connect your programme source, and adjust the gain control to produce a modulation level that does not cause audible distortion on programme peaks. If you can check with an oscilloscope, limit modulation to 90%.

An unexpected and successful use has been found for my own prototype MATE, shown in the photographs. On a couple of occasions, I have provided background music for functions held in a medium-sized hall. Receivers tuned to the MATE were placed at strategic places around the hall, and volume levels set individually. Much favourable comment resulted from people intrigued by old 'cathedral' radios supplying their entertainment!

Solid State Update

KEEPING YOU INFORMED ON THE LATEST DEVELOPMENTS IN SEMICONDUCTOR TECHNOLOGY

Toshiba develops 45ns 16Mb DRAM, 8ns 1Mb SRAM

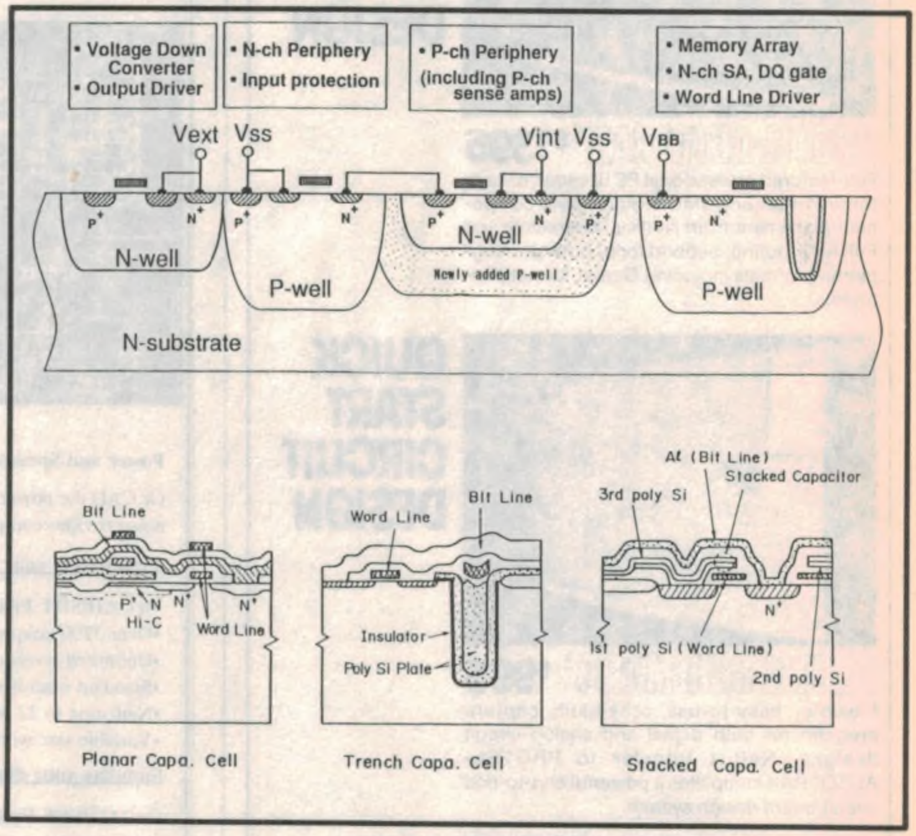
Researchers at Toshiba Corporation in Japan have succeeded in developing a new prototype 16-megabit CMOS (complementary metal oxide semiconductor) dynamic random access memory (DRAM) chip. The new 16M-DRAM features a typical access time of 45 nanoseconds – the world's fastest, and low power consumption of 65mA at a cycle time of 150 nanoseconds.

In order to shorten access time, Toshiba researchers have used a 0.6-micron design rule; the new device integrates approximately 35 million transistors and capacitors on a 7.87mm x 17.4mm chip – compared with the 2.2 million elements of a 1-megabit DRAM chip. This reduction in chip size contributed to the fast operating speed.

Also, the new 16M-DRAM is fabricated on an N-type substrate, while to date almost all DRAMs have traditionally used P-type substrates. This is because the historical stream of DRAM development originates from the period when N-channel MOS DRAMs, which used P-type substrates, were dominant. Toshiba researchers have completely overthrown this tradition, and also added a new 'third' P-well (an area diffused by impurities) to the conventional double-well to create a 'triple-well' structure.

The newly added P-well enables most N-wells to be electrically separated from the N-type substrate, thus eliminating the invasion of electrons from the substrate to the circuits fabricated in N-wells. This enables engineers to attain the optimum distribution of electrons between P-well and N-well in order to achieve the best performance of transistors. This improves the reliability of the device, and at the same time, realises faster access time.

Another design characteristic facilitating the faster access time is that triple polysilicon/double metal technology is fully utilized in the chip layout. Most peripheral circuits are placed in the central part of the chip, to shorten address/data paths and to minimize wiring.



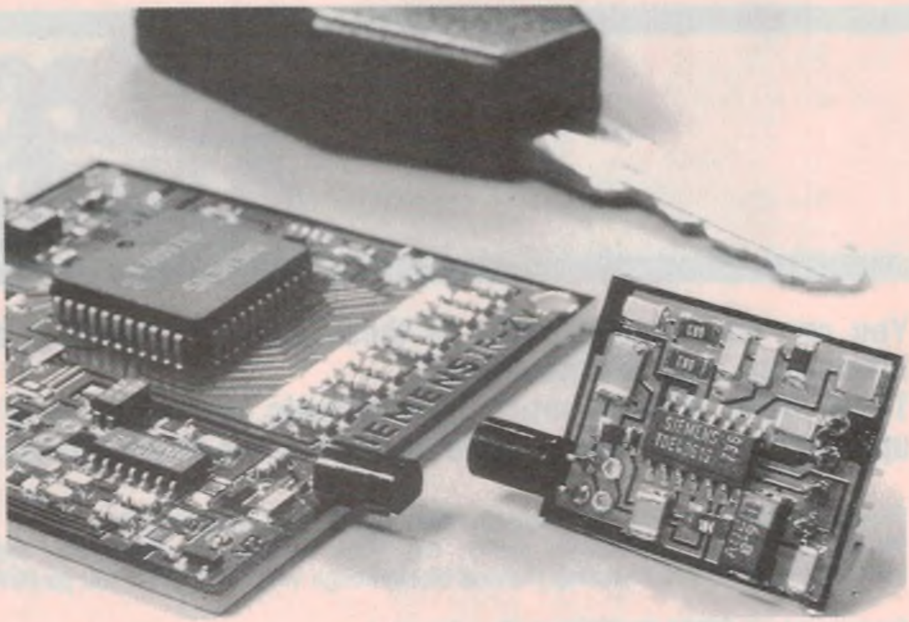
Researchers developed and applied an advanced trench capacitor by improving technology established in the company's development of 4M-DRAM. An additional polysilicon layer was formed on the side walls of the trench, through which the doping of impurities is carried out. The polysilicon layer makes it possible to diffuse impurities thinly and evenly, and this eliminates current leakage between capacitors, despite their closer proximity in the highly integrated circuits. The new trench structure has great advantages in terms of suitability for mass-production, due to structural simplicity and a smooth transition path from 4M-DRAM.

Toshiba researchers have also succeeded in developing the world's first prototype of a 1-megabit BiCMOS static RAM, compatible with emitter-coupled logic ICs, which are increasingly used in high-end engineering workstations and other high-speed office automation equipment. The new device, fabricated with a 0.8 micron design rule – the finest rule used in BiCMOS circuits, features a typical access time of 8 nanoseconds – the world's fastest. Power consumption is 500 milliwatts at 50MHz cycle time.

BiCMOS is a structure which combines two types of widely-used silicon technologies on a single silicon substrate: CMOS (Complementary Metal Oxide Semiconductor) and bipolar. CMOS devices feature lower power consumption, less heat dissipation and higher integration density than bipolar devices, but are not as fast. On the other hand, bipolar devices generally operate faster than CMOS devices, and also have superior output drive capability.

By blending the merits of both structures, the new BiCMOS SRAM achieves faster access time than CMOS SRAMs, and higher integration and lower power consumption than bipolar SRAMs. Until now, the world's largest capacity bipolar SRAM has been 64-kilobit, and access time of the fastest CMOS SRAMs has been around 15 nanoseconds.

IR preamp has current sink for extraneous light



Infrared remote control circuits tend to be susceptible to interference, as the infrared diode on the input side normally receives the infrared spectrum of impinging daylight in addition to the useful signal. Additional interference is caused by the 100Hz ripple of incandescent bulbs and frequency components from the spectrum of fluorescent lamps.

The new Siemens TDE 4061 infrared preamp circuit integrates a low-noise preamplifier with parallel current sink which serves to discharge the undesired, low-frequency diode currents. The current sink also stabilizes the operating point at the input of the preamplifier, to 1.4V. A bandpass filter which follows improves the signal-to-noise ratio. There is also a demodulator.

The TDE 4060 amplifier is available as a variant without the demodulator, but is otherwise identical. An AGC circuit over the current sink prevents the interference amplitude from overdriving the amplifier and obliterating the useful signals.

For further information contact the Communications Equipment Department of Siemens, 544 Church Street, Richmond 3121 or phone (03) 420 7314.

Surface-mount zeners

After the successful introduction of the Minimelf diodes, ITI Intermetall has now also made available zener diodes for surface mounting, in the well known rectangular Jedec TO-236 plastic package.

The BZX84 series with a rating of 350mW are supplied on 178mm diameter reels of 3000 pieces, and will compliment the SMD Transistors already available from ITT Intermetall in the same package.

For further information contact Crusader Electronic Components, 73-81 Princes Highway, St Peters 2044 or phone (02) 516 3855.

Controller for 32 ISDN subscribers

Using CMOS technology, Siemens has succeeded in producing a single chip capable of switching both the B and D channels from up to 32 ISDN subscribers onto internal PCM highways. The PEB 2055 extended PCM interface controller (EPIC) is a successor to the PEB 2050 NMOS chip – a peripheral board controller which serves eight ISDN subscribers.

The PEB 2055 is suitable for applications in digital subscriber modules and for switching functions in PCM systems. With its quadrupled B channel capacity, the new chip is on a par with the PEB 2075 ISDN D channel exchange controller (IDEC) for the D channels, whose capacity has now also been quadrupled with respect to the PEB 2070 (for one D channel).

The D channels (16kbit/s each) mainly transport the control and switching data between subscribers; and the B channels (64kbit/s each) carry the actual flow of data.

For further details contact the Communications Equipment Department of Siemens, 544 Church Street, Richmond, 3121 or phone (03) 420 7314.

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Basic Principles of VCRs – Part 5

Playback Circuitry

This month we'll examine the playback circuitry of a typical video cassette recorder. We'll also look at picture 'drop out' correction and noise cancelling circuitry, together with long play operation in the newer VCRs.

by DAVID BOTTO

In practice, most of the circuitry shown as small sections in this chapter is contained in a few large scale integrated circuits. Also it should be understood that circuitry can vary in different VCRs. However the schematics shown will serve to illustrate the basic principles of the playback circuitry.

Fig.1 is a simplified block schematic showing how the recorded magnetic information on the video cassette tape is supplied to the early stages of the circuitry.

As the head drum rotates each video head in turn 'scans' a single tape 'track'. Each track, you'll recall, contains one field of picture information.

On playback this induces a signal voltage in each head as that head detects one 'field' of picture. From channel 1's head the first field of picture data is fed first to rotary transformer T1, and then to the channel 1 preamplifier. Channel 2's head scans the next picture field feeding the signal via rotary transformer T2 to channel 2 preamplifier.

Transistors Q1 and Q2 are cut off in the playback mode. In the record mode 9V DC+ is applied to point X, switching Q1 and Q2 on and effectively shorting points A and B to chassis. Electronic switch SW1 is closed in the playback mode, open in the record mode.

At point C in Fig.1 the signal waveform from channel 1 pre-amplifier – as viewed on a suitable oscilloscope – appears as in Fig.2(a). At point D the signal appears as in Fig.2(b). The two signals now enter the switching amplifier. Fig.2(c) shows the 25Hz signal, obtained from the head drum, that enters this amplifier at point E.

You'll remember that the video head drum speed and phase is accurately controlled by the servo circuitry. (See part 3 of this series). This ensures that the 25Hz signal generated by the head drum will correctly control the switching amplifier so that each two recorded fields of the picture are properly synchronized.

The 25Hz signal controls the internal circuitry of the switching amplifier so that it amplifies the signals from the channel 1 and channel 2 preamplifiers in turn. The output signal from electronic play/record switch SW2 at point F appears as in Fig.2(d). Notice that the ends of the waveforms in Figs.2(a) and 2(b) have been slightly clipped.

The waveforms of Fig.2(a-c) are useful in servicing, when checking the video heads of a VCR for wear or damage. In older VCRs using discrete cir-

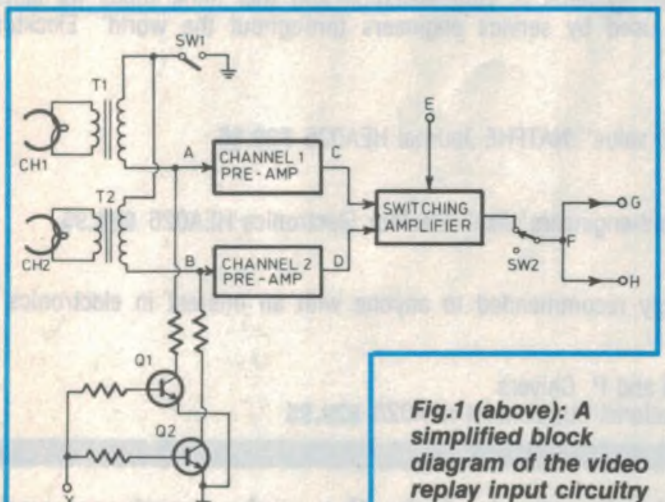


Fig.1 (above): A simplified block diagram of the video replay input circuitry of a typical VCR.

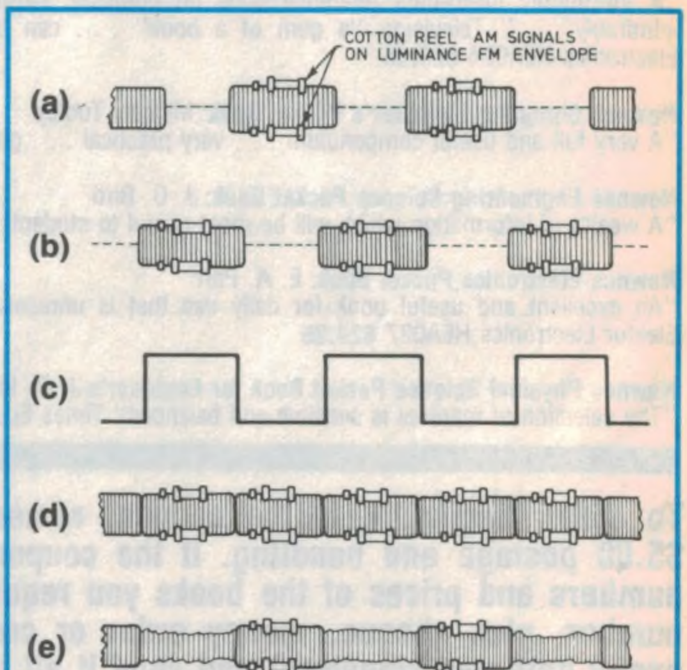
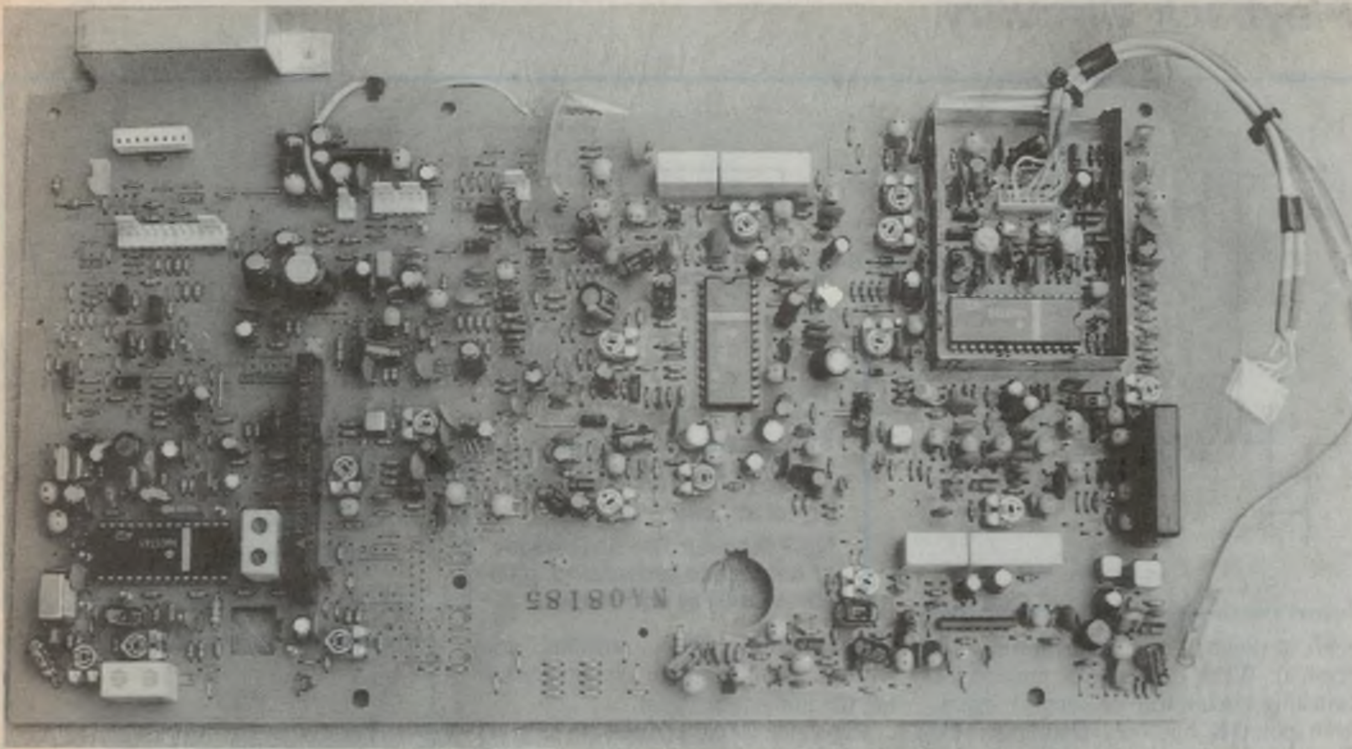


Fig.2 (right): Showing the way the replay signals from the two heads (a,b) are combined in the switching amplifier, controlled by switching signal (c), to produce the combined signal (d). Waveform (e) shows the effect of a faulty head.



This photo shows a printed circuit board housing VCR circuitry very similar (though not identical) to the VHS colour schematic described in the text. Three ICs contain most of the circuitry.

cuitry the waveforms can all be seen separately. In a newer VCR where most of the circuitry shown in Fig.(1) is contained within a single integrated circuit, the waveform of Fig.2(d) can usually be viewed.

Fig.2(e) shows a typical waveform (point F) produced by a VCR with one good head and one faulty head. For this test the circuitry must be in good order, and the heads clean.

At point F the signal includes both the playback frequency modulated luminance signal and also the down converted 627kHz colour signal. Point G feeds to the playback luminance circuitry, and point H to the playback chroma circuitry.

Luminance processing

The signal at point G feeds to point G1 in Fig.(3). The high pass filter removes the 627kHz colour signal, so that only the luminance FM signal enters the FM amplifier at point I. This amplifier is designed so that its maximum gain is at 4.8MHz – the *white peak* area of the signal.

From the FM amplifier (point J) the signal feeds to the input of the FM AGC (automatic gain control) amplifier. The AGC circuit now corrects any changes in the strength of the FM signal that might be caused by variations in the video head to tape contact.

Signal 'drop-out' may be present, due to possible faults on the magnetic cassette tape, spoiling the quality of the picture as shown in Fig.4(a).

From the output of the AGC amplifier (point K) the signal is supplied to the switching circuit. It's also fed to the drop-out detector circuit. This circuit detects any drop-outs in the signal.

If signal dropout is present in a line of signal, the drop-out detector generates a narrow square wave signal during the period of drop-out only. This pulse ap-

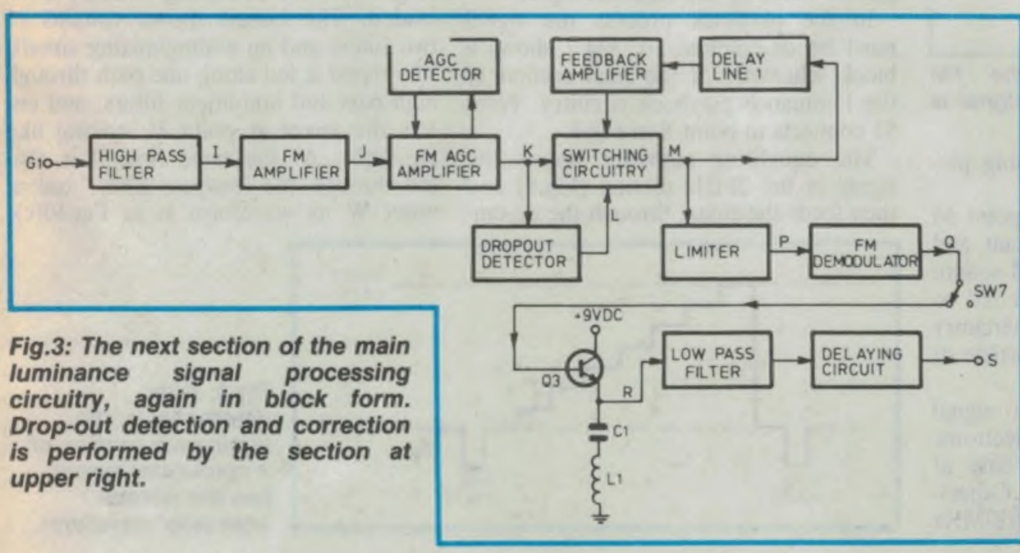


Fig.3: The next section of the main luminance signal processing circuitry, again in block form. Drop-out detection and correction is performed by the section at upper right.

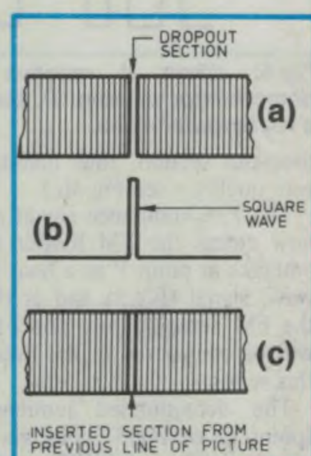
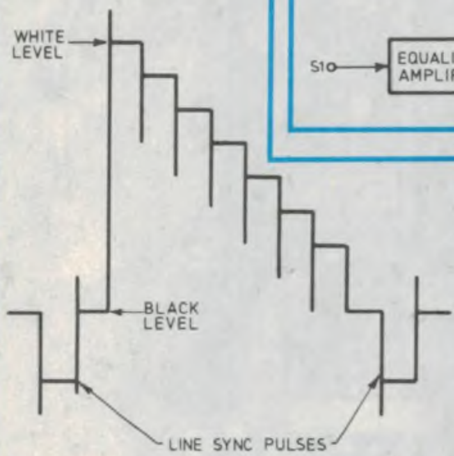


Fig.4: Waveforms for the dropout correction circuit.

Playback Circuitry



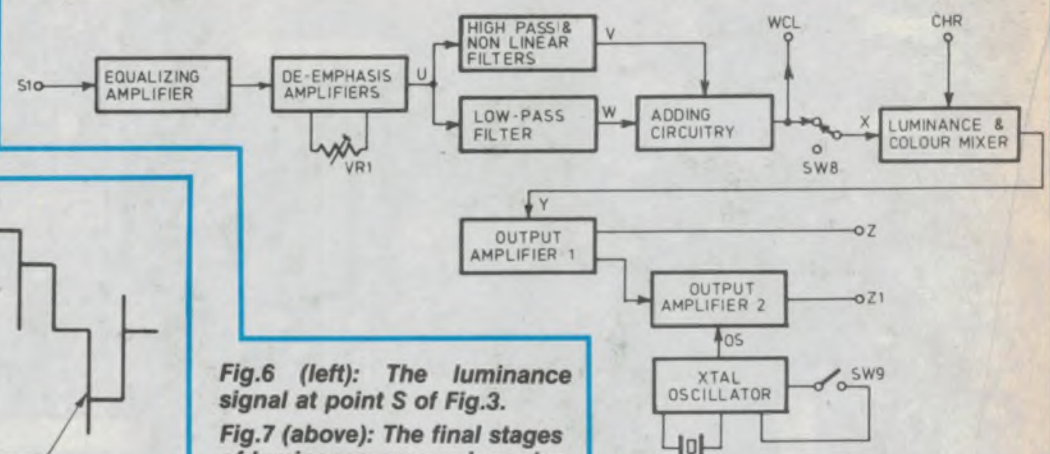


Fig.6 (left): The luminance signal at point S of Fig.3.

Fig.7 (above): The final stages of luminance processing, plus colour mixing and output.

pears at point L, with a waveform as in Fig.4(b). When this pulse is present the switching circuit will not accept signals from point K but only from point N. The signal output from the switching circuit is fed back to the switching amplifier via delay line 1, which delays the signal by one exactly line of picture, and through the feedback amplifier to point N.

The signal at point N cannot re-enter the switching circuit unless the narrow square wave pulse from the drop-out detector appears at point L, during the drop-out period. The switching circuit now blocks the original signal input from point K so that the signal from the previous line is accepted at point N for as long as the dropout persists.

The nett result is that signal from the previous line is inserted into the missing

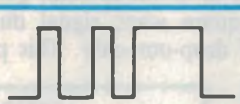


Fig.5: When it reaches the FM demodulator at point P, the signal is a rectangular wave.

drop-out section, thus maintaining picture quality – see Fig.4(c).

The FM luminance signal at point M now enters the FM limiter circuit and emerges at point P as a neat FM square wave signal (Fig.5) and is then fed to the FM demodulator. The FM circuitry will be considered in the final article of this series.

The demodulated luminance signal (point Q of Fig.3) goes via electronic play/record switch SW7 to the base of emitter follower transistor Q3. Capacitor C1 and coil L1 form a 4.433619MHz acceptor trap which prevents stray pickup from the colour circuitry affecting the luminance signal.

The signal at the emitter of Q3 is supplied to the low pass filter (point R) and then to a delaying circuit, which delays the luminance signal by approximately 600 nanoseconds to ensure that the luminance and colour signals arrive together at the luminance and colour mixer (see Fig.7). The reason for this delay of the luminance is that the colour signal will be slightly delayed by the chroma playback circuitry. At point S (assuming that a colour bar signal is recorded on the magnetic tape) the signal appears as in Fig.6.

Part 4 of this series explained how, during the recording process, the signal levels of the high frequency parts of the video signals are boosted, particularly on low level signals. This prevents interference at low signal levels from causing picture noise on the recorded signal.

In the playback process the signal must be de-emphasized. Fig.7 shows a block schematic of the final section of the luminance playback circuitry. Point S1 connects to point S in Fig.3.

The equalising amplifier boosts the signal in the 2MHz section (Fig.8) and then feeds the signal through the de-emphasis amplifiers. The signal emerges at point U with the spikes removed, and now appears as a normal 'staircase' luminance waveform (Fig.9) – assuming that the recording is of a colour-bar signal.

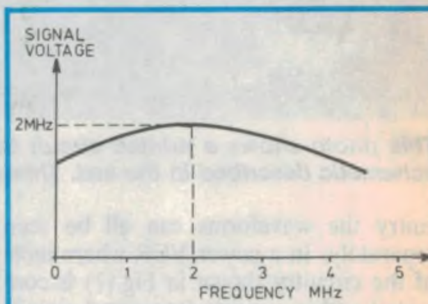


Fig.8: The response of the luminance equalising amplifier, with a broad peak at 2MHz.

Because high frequency noise may be present on the signal at point U (Fig.10a) noise cancelling circuitry is included. The circuit shown consists of two filters and an adding/mixing circuit. The signal is fed along one path through high pass and non-linear filters, and enters the mixer at point V looking like Fig.10(b). At the same time it is also fed through the low-pass filter, and at point W its waveform is as Fig.10(c).

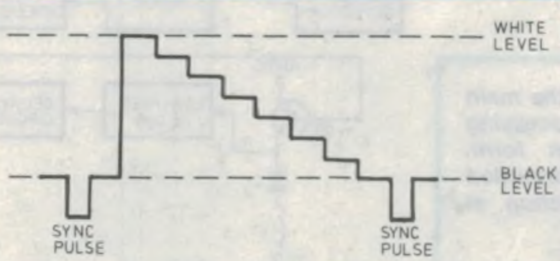


Fig.9: After de-emphasis, the luminance portion of a colour-bar signal has the normal 'staircase' waveform.

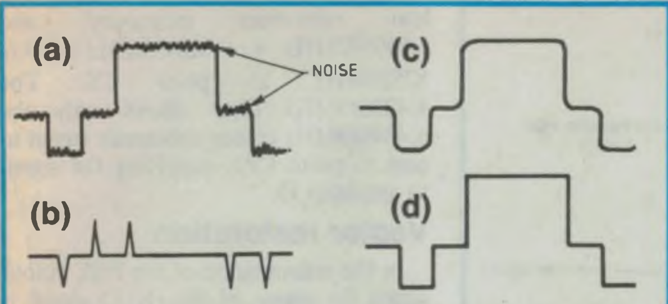


Fig.10: Operation of the noise cancelling circuitry, with (d) the output signal.

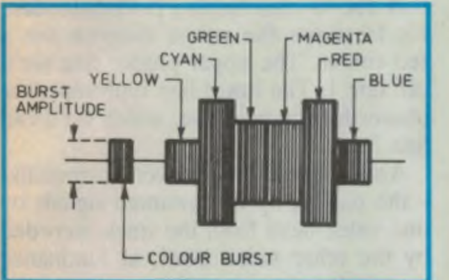


Fig.11 (left): The 'cotton-reel' colour signal, before adding to the luminance signal.

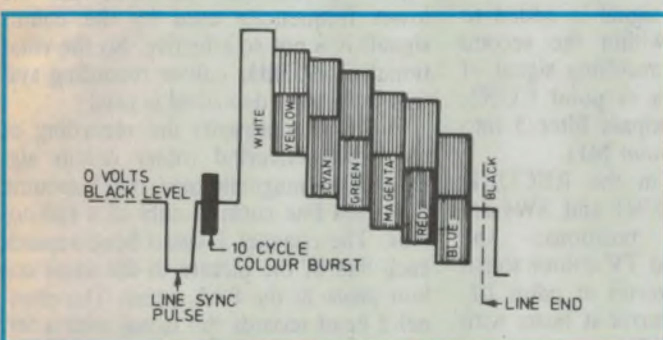


Fig.12 (above): The full composite colour signal, containing both luminance and colour components.

The signals at points V and W are then added or mixed together to produce an interference free signal – Fig.10(d).

SW8 is an electronic play/record switch, shown in the playback position. In the luminance and colour mixer section the colour signal (Fig.11) fed in at point CHR is mixed with the luminance signal from point X. Fig.12 shows the resulting signal at point Y.

Output amplifier 1 supplies output to point Z, for direct connection to a video monitor or to another VCR etc. Output amplifier 2 further amplifies the signal supplying the RF (VHF or UHF) modulator that connects to the TV antenna socket of the TV used to view the recorded programme (point Z1).

The crystal oscillator that feeds into output amplifier 2 at point OS is controlled by switch SW9. Closing SW9 produces a monochrome test signal at point Z1 which appears at the RF out socket of the VCR. One channel of a TV receiver is then tuned to receive this pattern. For normal viewing SW5 is switched to its 'open' position.

Colour playback

Block schematic Fig.13 shows the play/record colour circuitry of a typical VHS machine. It's the same diagram shown in the last chapter, but with the playback sections of the circuitry added (shaded areas). Electronic play/record select switches SW3-SW6 and SW10-SW12 are shown switched to the playback position.

Point H in Fig.1 is taken to point CP1

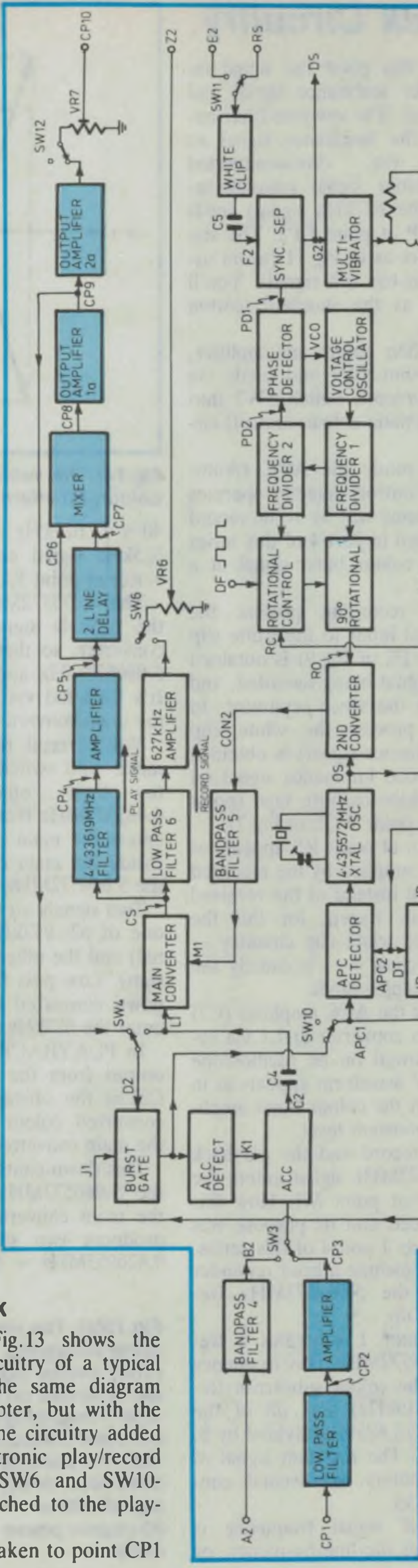


Fig.13: Block diagram of the play-record colour circuitry of a typical VHS machine. The sections used for playback are shown with blue shading.

Playback Circuitry

in Fig.13. At this point the signal includes both the luminance signal and the colour signal. The low pass filter circuit removes the luminance signal so that only the down-converted 626.953kHz colour signal (usually referred to as the 627kHz signal) feeds into amplifier P at point CP2. The signal now appears as in Fig.11 (again assuming a colour-bar test signal). You'll recognise this as the standard 'cotton reel' waveform.

The signal then enters an amplifier, emerging at point CP3 and feeds via electronic play/record switch SW3 into the ACC (automatic colour control) circuitry.

In the play mode the ACC (Automatic Colour Control) detector operates in exactly the same way as in the record mode – described in part 4 of this series – keeping the colour burst signal at a constant level.

During the recording process the luminance signal input to the white clip circuitry (point E2 of Fig.9) is obtained from the TV signal being recorded, and passed through the synch separator. In the playback process the white clip input (the luminance signal) is obtained from the recorded luminance signal on the magnetic video cassette tape (point RS connects to point WCL in Fig.7).

The waveform at point RS appears as in Fig.9, but is supplied by the recorded luminance signal instead of the received television signal. Except for this the operation of the white clip circuitry — described in section 4 — is exactly the same as in the replay mode.

The output of the ACC amplifier (C2) enters the main converter at L1 via capacitor C4. Viewed on an oscilloscope the 'cotton reel' waveform appears as in Fig.11, but with the colour burst amplitude held at a constant level.

In both the record and the playback mode a 5.060572MHz signal enters the main converter at point M1. How this signal is produced and its purpose was discussed in parts 1 and 4 of this series. However, we'll include a brief reminder here of how the 5.060572MHz frequency is made up.

Crystal oscillator 1 generates a frequency of 4.435572MHz This frequency is the sum of the colour subcarrier frequency (4.433619kHz) and 1/8 of the line frequency (15.625kHz divided by 8, or 1953.125Hz). The resultant signal of 4.435572MHz enters the second converter at point OS.

The rotational signal frequency is equal to 40 times the line frequency, or

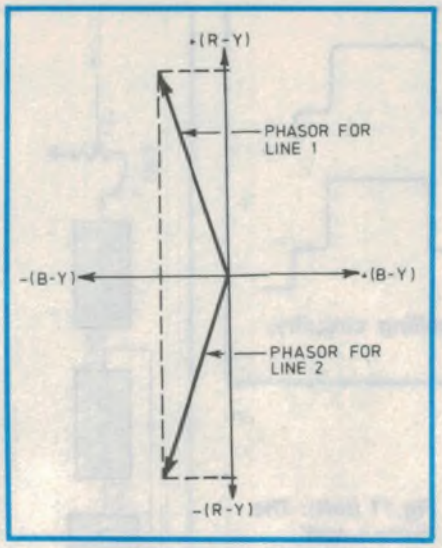


Fig.14: The vector diagram for a red colour, on alternate lines.

40 x 15.625kHz which is 625kHz. This 625kHz signal enters the second converter at point RO.

The 4.435572MHz signal is added to the 625kHz signal within the second converter, so that a resulting signal of 5.060572MHz appears at point CON2. It's then fed via bandpass filter 5 into the main converter (point M1).

You'll recall that in the RECORD mode with switches SW3 and SW4 set to their other positions, the 4.433619MHz received TV colour signal enters the main converter at point L1. Inside the main converter it beats with the 5.060572MHz signal.

Two signals are produced at point CS, one of 626.953kHz (the difference signal) and the other of 9.494191MHz (the sum). Low pass filter 6 allows only the down converted 626.953KHz signal to enter the 627kHz amplifier.

In PLAYBACK mode as shown, the output from the ACC circuitry (point C2) is the off-tape 626.953kHz down-converted colour signal, which enters the main converter at point L1.

This down-converted signal beats with the 5.060572MHz signal which enters the main converter at M1. This again produces two signals, of 5.060572 - 0.626953MHz = 4.433619MHz (the colour subcarrier frequency) and 5.060572MHz + 0.626953MHz = 5.687525MHz, at point CS. The 4.433619MHz filter allows only the 4.434619MHz colour subcarrier signal to pass to point CP4, supplying the signal to amplifier Q.

Vector restoration

In the transmission of the PAL colour signal the phase of the (R-Y) signal is reversed by 180° as alternate lines of the picture are transmitted. This is done in order to cancel out colour phase errors due to transmission path distortion. Fig.14 shows the vector diagram for a red colour. The upper phasor line we'll call line 1. The lower line represents the phasor for the next line, which we'll call line 2.

Azimuth recording prevents 'crosstalk' – the picking up of unwanted signals by one video head from the track recorded by the other video head, at luminance signal frequencies. However at the lower frequencies used by the colour signals it is not so effective. So the rotational 626.953kHz colour recording system previously described is used.

Fig.15(a) represents the recording of the down-converted rotary colour signals on the magnetic tape. We'll assume that each line consists only of a red colour. The channel 1 video head records each line of the picture in the same colour phase as the PAL signal. The channel 2 head records the signal with a 90° phase delay for each line.

In the playback process, the colour signals recorded by the channel 2 head are returned to their correct phase by the rotational circuitry. Otherwise, the colours viewed on the displayed picture would be incorrect. This is known as *vector restoration*.

When the VCR is in the playback mode each head tends to pick up a little of the colour signal from the other track. For example channel 1's head responds to part of the channel 2 track signal. The small arrows in Fig.15(a) represent the crosstalk interference picked up by channel 1's head from the channel 2 track.

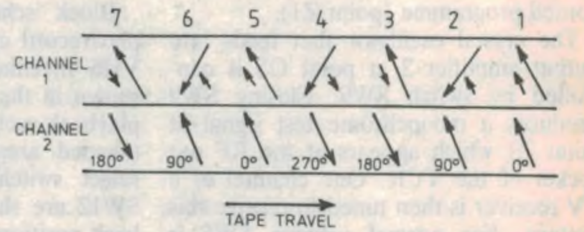


Fig.15(a): The way down-converted rotary colour signals are recorded on the tape – assuming a constant colour, say red. The channel 2 head records the signal with a 90-degree phase delay.

When the signals arrive at point CP5, the colour vectors for the channel 2 signal have been corrected by the rotary circuitry. However the crosstalk vectors remain on the channel 1 track signal.

This signal appears at the output of amplifier Q, and goes directly to the mixer input at point CP6. The signal also passes through the two-line delay circuit, so that the signal at point CP7 is

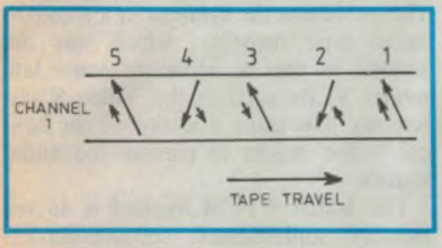


Fig.15(b): Inside the replay colour mixer, delayed signals at CP7 are used to cancel crosstalk.

delayed by two lines. Inside the mixer line 3 (Fig.15a) is combined with delayed line 1 (Fig.15b), line 4 is combined with delayed line 2, and line 5 with delayed line 3 and so on.

You can see that the small crosstalk vector arrows in Fig. (15b) exactly cancel out those in Fig.(15a), so that the colour signal at point CP8 is free from crosstalk.

The signals are then amplified by output amplifiers 1a and 2a and feed via switch SW12 to preset control VR7, the playback colour gain control. The signal at point CP10 is supplied to point CHR on Fig.7. Here the 'cotton reel' colour signal of Fig.11 is combined with the luminance signal (Fig.9) to produce the output signal of Fig.12.

Because of slight variations in the tape and video drum rotation speed, and possible 'stretch' in the magnetic tape, frequency and phase errors occur in the playback colour signal entering the main converter at point L1. We'll call this variation Fv. To compensate for Fv, tiny changes in phase and frequency must be made in the signal entering the converter at point M1.

APC circuitry

The APC (Automatic Picture Control or Automatic Phase Control) circuit operates only in the playback mode. The colour signal (Fig.11) is taken from point CP9 and fed through switch SW4 into the burst gate (D2). The burst gate, controlled by the off-tape line sync pulses fed in at J1, allows only the colour burst signal to pass to point J2.

The 4.433619MHz colour burst signal is taken via electronic switch SW10 to the APC detector (APC1). The signal from the 4.433619MHz crystal oscillator is supplied to the APC detector at point APC2, via switch SW5. Within the APC detector the phase and frequency of the burst and crystal oscillator signals are compared (Fig.16).

Any differences in the two signals cause a corrective voltage (APC3) to be sent to the 4.435572MHz oscillator, slightly changing its phase and frequency to compensate for Fv.

The ID detector

In the record mode the ID (identification) pulse detector obtains its input via switch SW5 (other position) from point OS. In the playback mode its input comes from the 4.433619MHz crystal oscillator.

Inside the ID detector the burst signal is compared with the 4.433619MHz crystal oscillator signal. If a difference between the two is detected, then the ID detector output (ID to RC) via the rotational control circuitry slightly changes the phase of the output (point RO) of the 90° rotational circuitry. This provides further correction for Fv.

Colour killer

When recording or playing back monochrome pictures, a colour killer circuit may be used. These circuits operate by switching or biasing off the chroma circuitry in the absence of a colour burst. This prevents 'colour splash' spoiling the displayed picture.

However many TV stations now continue to transmit the colour burst even when the programme is in monochrome. For this reason, instead of colour killer circuitry modern VCRs have a user operated B/W (black and white) switch which turns off the colour circuitry.

'E to E' facility

During recording or when tuning the VCR to the desired TV channels the *E to E* (Electronics to Electronics) facility is used. The complete video picture signal and the audio signals being recorded are taken to the RF modulator, which converts these signals into a TV signal that may be viewed on the user's TV receiver.

Betamax colour playback

The Betamax system uses principles basically similar to the VHS system – but with some significant differences which we'll briefly consider. A simplified section of the colour replay arrangement is shown in Fig.16. It's helpful to compare this diagram with the Betamax diagram in part 4.

The signal at point K has a frequency of 5.1230721MHz for one field of the picture. With the succeeding field the signal frequency changes to 5.1191659MHz, returning to 5.1230721MHz for the third field, and so on. The circuitry producing these two frequencies was explained in part 4.

In the replay mode the two down-converted off-tape colour subcarriers recorded on the cassette magnetic tape (685.5469kHz for channel 1's video head, and 689.4531kHz for the channel 2 head) feed into point A through the ACC amplifier into the second mixer (B).

The channel 1 off-tape signal is phase shifted by +45° each line, and the channel 2 signal by -45° for each line.

The 685.5469kHz signal beats with the 5.1191659MHz signal, producing sum and difference signals of 4.433619MHz and 5.8047128MHz. The 689.4531kHz signal similarly beats with the 5.1230721MHz signal, to produce 4.433619MHz and 5.8125252MHz. These signals appear at L.

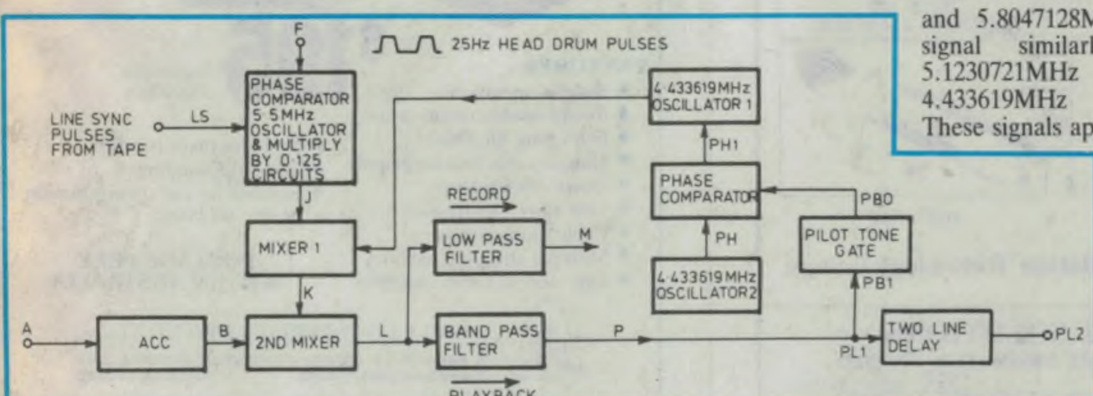


Fig.16: The colour replay circuitry of a Betamax machine.

Playback Circuitry

Bandpass filter 1 allows only the 4.433619MHz signals to reach point P. At point PB1 the pilot tone gate allows only the special pilot tone signal that was recorded on the tape to pass to point PBO into phase comparator B. Here the signal at point PH is compared with the pilot burst signal. The output at point PH1 controls the phase of oscillator 1, compensating for variations in tape and video drum rotation speed and any 'stretch' in the tape.

After reaching point PL1 the chroma signal enters a two-line delay circuit. It's then taken (PL2) to phase correction circuitry (not shown) and finally arrives at the luminance and colour mixing amplifier.

LP operation

Many of the newer VCRs have a 'long play' mode, involving two speed operation. This makes it possible to have as much as eight hours of recording on a single video cassette.

The normal tape speed of a VHS machine is 23.39mm per second. For long play operation it runs at half speed, or 11.695mm per second. Two additional video heads are incorporated in the head drum.

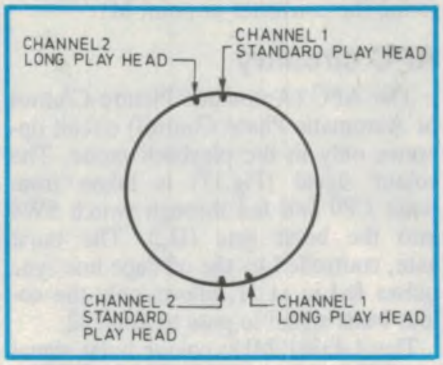


Fig.17: An additional pair of heads are mounted on the head drum, for VCRs offering a 'long play' mode.

Fig.17 shows the relative positions of the video heads in a typical head drum. The long play heads are slightly thicker than the standard play heads. Electronic switching selects the required heads as standard or long-play modes are required. Because luminance crosstalk increases at the lower tape speed, additional circuitry is included to overcome this.

Audio circuitry

In a standard VHS recorder the magnetic audio track or tracks are located at the top edge of the cassette magnetic tape, as explained in part 2.

In the recording process the audio tracks are first 'wiped clean' by the audio erase head, which has a bias oscillator signal supplied to it. Then the audio signals to be recorded (which may be mono or stereo) are applied to the audio record head(s) proper, together with a suitable ultrasonic biasing signal. The process is the same as in a standard audio tape recorder, which was described in part 1. However some late model VCRs such as the Video 8 system are now using a section of the helical 'video' tracks to contain the audio signals.

The Video 8 PCM method is an extremely sophisticated compression/expansion analog to digital recording process.

In the final part in this series we'll consider the complete VHS machine, including the power supplies and timer/clock assembly. The operation of the video head rotary transformers will also be explained, with the aid of diagrams and photographs. In addition there will be a discussion of VHS-C compact cassettes, the new S-VHS system and a look at possible future VCR developments.

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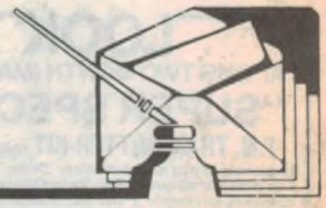


Copyright, valves and suggestions

Anxious to make your fortune in electronics? Perhaps you might be able to plagiarise an idea from EA to help you on your way. But is it legal? That's one of the topics this month. There's also a short dissertation on TTL to CMOS interfacing, with a few reader comments on how we should check circuits presented to us for publication.

It's funny how projects from the past keep cropping up. This month it seems the emphasis is on the older projects, even as far back as 1951! Still, regardless of when the project, or circuit, was published, it's fair game for this section.

We generally seem to get more mail concerning older projects compared to that for the more recent ones, which suggests one of two possibilities: the new ones don't give any problems, or the new ones aren't being built. I suspect there is a combination of the two, with readers taking a conservative approach towards the latest projects by waiting to see how much errata is generated.

And that's the function of this section – to alert you to any difficulties that other constructors have encountered. But we need a *few* pioneers to feed us with the bad (or good) news. So don't keep your problems to yourself, share them with us and all the other readers. That is, your *technical* problems anyway...

Are projects patented?

The question of whether magazine projects, or sections thereof are subject to copyright is an interesting one and has been prompted by a letter from a reader who wishes to remain anonymous. Fair enough, it's an issue that seems to evoke an air of secrecy. The letter, duly edited to retain the anonymity requested is as follows:

I am interested in developing a marketable item that uses a certain section of a project described in EA. Are magazine projects subject to copyright, or may I use any or all of the ideas contained within them? (anon)

The short answer is that the circuit techniques used in Electronics Australia are effectively 'Public Domain', once they have been published. However, let's just expand on that, because there are some things that you *aren't* free to use.

For example, the text and diagrams associated with a project or any article are subject to copyright, and may only be used with the publisher's permission. This applies whether you intend to use the material to make money or otherwise. We are often quite happy to give permission to individuals wishing to use material in the magazine, but we need a written request and you need our written reply.

Some projects are presented with certain sections withheld, for example the PCB artwork. Projects of this kind are usually offered to the magazine by a kit supplier, who is keen to retain sole rights to the project. If a third party decides to sell such a kit he runs the possible risk of legal action by the original developer, although the magazine would not be involved.

This sometimes raises the vexing question of whether a developer would do better marketing his project without publishing it. It may be that the idea is so good a fortune could be realised by marketing it privately. A magazine such as *EA* will only pay a fixed amount, whereas a good project might catch on and be a commercial winner. Then again it may not.

There's one more thing. If you plan to market kits or assembled units for projects such as our 'Playmaster' series of amplifiers, you must use the parts and circuit configuration specified, if you are to use our 'Playmaster' name. Otherwise you'll have to sell it under your own name, if you make changes.

But apart from these qualifications, if you think our projects have circuit ideas that could make you a million then go for it. Just don't tell us when you buy your own island in the South Seas – we might get a little jealous!

A bad design?

The next correspondent raises quite a few points in a letter that has a fairly severe tone to it. The letter is in response to a previous letter concerning problems with a VZ-300 RAM expansion circuit, presented as long ago as May 1987 in our 'Circuit and Design Ideas' section. Although the circuit in question is now somewhat dated, the points raised are interesting. Here's the letter, in reduced form.

The VZ-300 RAM expansion circuit presented in the Circuit and Design Ideas (EA May 1987) section has two glaring faults. The first is that the Z80 CPU, as used in the VZ-300 has TTL level output voltages, that is, less than 0.8V (low) and greater than 2.4V (high), whereas the CMOS logic gates used in the circuit have CMOS level inputs less than 1V (low) and greater than 4V (high). Because of the incompatibility of the logic families used, it is probable the circuit will not operate correctly.

Secondly, the propagation delay of 300ns for the 4008 adder would be likely to create problems, due to the access time of the VZ-300.

Might I suggest that when checking computer circuits for feasibility, you check particularly the following points.

1. *Correct pinouts of ICs.*
2. *Correct Boolean logic.*
3. *Logic family compatibility.*
4. *Propagation delays.*

Clearly, the third and fourth points have been overlooked in the circuit, and I doubt if the designer ever actually tested his design or perhaps he got lucky with a very fast 4008 in his prototype.

Might I also suggest that you request a *declaration from contributors stating that they have tried the circuit presented to save problems such as these. (M.S., Clarence Park A)*

OK, the circuit referred to by M.S. is now over two years old, and delving back to it is not really going to prove anything. The reason I have published the letter is to be able to air the technical aspects of interfacing logic families, and to answer the suggestions by the correspondent on how we should check circuits presented for our Circuit and Design Ideas (CDI) section.

Examining various data books on the subject, I have to agree with M.S. concerning the likely incompatibility problems with interfacing a TTL-compatible IC to a CMOS type. The problems will arise when the TTL device goes high, and it is usual to include a pull-up resistor from the output to the 5V rail to get as high an output level from the TTL device as possible.

However, my own experience has demonstrated that most TTL compatible ICs (such as the Z80) will produce an unloaded output level of around 3.5V when the output is high. Most CMOS inputs will also recognise an input voltage of 2.5V or more as being a logic 1. So while the data books state certain limits, in practice one can often get away with interfacing TTL directly to CMOS. The simple answer is to add the pull-up resistors, which can be any value from 1k to 10k, although 2.2k is a typical value.

Propagation delays are another variable, and the times specified by manufacturers are always worst case. It often happens that CMOS ICs from one manufacturer will have different specifications to those from another, and generalising is often very misleading. For example, the Fairchild manual gives a typical propagation delay for the 4008 (at 5V) as 150ns, and 300ns as the maximum.

What I am trying to say is that I believe the circuit referred to by M.S. has every chance of working, although it does break 'good design' rules. So if I had applied the criteria suggested by M.S., this circuit would have passed my inspection, on the basis that I would not be prepared to reject it as technically inoperable because it breaks a few rules.

Then again, how on earth would we have the time to analyse all circuits presented by contributors for our CDI section, using the criteria suggested by M.S.? These circuits are presented with the disclaimer that we have not tested them – a sort of 'buyer beware' clause. Our main concern is whether the circuit is likely to be of interest to other readers. Sorry M.S., we cannot abide by your suggestions as many excellent circuit ideas would never be printed.

Finally, I doubt if a signed declaration by contributors confirming that they have tested their circuit would solve anything. All the signing in the world simply means the prototype worked, which may be the result of good luck, or it may mean considerable research to ensure repeatability has been undertaken – who knows? Also, I question whether contributors would bother to dream up a circuit that they never actually built and submit it for publication anyway. We take the attitude that most contributors are honest, and our disclaimer takes care of the rest.

Vocal canceller

This project goes back a few years, but a reader who has recently built it seems to be having a few problems. His letter is as follows:

I recently completed the Vocal Canceller project described in EA April 1982. Although everything else works, it does not seem to cancel the voice as described in the magazine. I have changed various components, including IC1, but when tested from a tape recorder, as described in the article, the voice is not cancelled.

Our resident audio expert Rob Evans has provided me with the following response:

To test the operation of the vocal canceller, short the left and right inputs to ensure that a true mono signal is applied to IC1. Then apply an audio signal or test tone to one of the inputs, and adjust the 'null' control RV1. Since the unit cancels any common mode signal, you should be able to eliminate the sound at the output or reduce it to a very low level.

If this is not the case, remove the input short and check the components between the input connections and pins 2 and 3 of the IC. Also, double check that both inputs are arriving from your amplifier, by switching the canceller to 'normal' mode and verifying that both the left and right outputs are present.

Valve suppliers

We occasionally get letters asking us where valves might be purchased. The following letter is typical, and the reply may be useful if your trusty valve amplifier or transmitter has finally died.

Could you advise me where I could obtain an 807 beam power valve. I have a

SBS RADIO & TV LISTING.

In the January 1989 issue of *Electronics Australia* we published a listing of all the Radio and Television stations in Australia. However, the Special Broadcasting Services' listing (better known as SBS TV & Radio), was inadvertently left out. It is as follows. We will also be publishing an updated version of *all* Radio and Television stations in the January 1990 issue.

SBS TV-STATIONS

Call	Location	Freq. (MHz)	Power Watts
ACT			
SBS28	Canberra	527.260	200K
SBS/54	Tuggeranong	709.250	400
SBS/58	Tuggeranong	737.250	750
NSW			
SBS28	Sydney	527.250	300K
SBS/32	Wollong. Nth	555.250	2.5K
SBS45	Newcastle	646.250	300K
SBS53	Illawarra	702.224	600K
SBS/58	Cooma	737.260	100
SBS/58	Gosford	737.198	200
SBS/58	Goulburn	737.260	500
SBS/58	Kings Cross	737.250	1K
VIC			
SBS28	Melbourne	527.250	300K
SBS/51	Upwey	688.224	160
SBS/58	Marysville	737.250	10
SBS/58	Warburton	737.250	150
SBS/68	Ferntree Gully	807.224	350
SBS/69	Selby	814.198	500
QLD			
SBS28	Brisbane	527.224	300K
SBS/48	Currumbin	667.250	2K
SBS/61	Gold Coast	758.250	50K
SA			
SBS28	Adelaide	527.224	300K
SBS/43	Adl. Foothills	634.224	2K
WA			
SBS28	Perth	527.198	300K
TAS			
SBS28	Hobart	527.224	225K

SBS RADIO

Call	Location	Freq. (kHz)	Power Watts
NSW			
2EA	Sydney	1386	5000
2EA	Newcastle	1584	150
2EA	Wollongong	1485	150
VIC			
3EA	Melbourne	1224	5000

Information centre

Playmaster No 1, designed I believe by John Moyle in Radio and Hobbies in 1951, that uses these valves. The amplifier has worked excellently over the years, and still does, but is overdue for some new valves. (A.F., Aitkenvale Qld).

Valves are not exactly freely available these days, but the following sources are some that we know of.

Resurrection Radios, 53 Lang Street, South Yarra 3141 or phone (03) 820 1315;

Orpheus Radio, RSD B98, Ballarat 3352 or phone (053) 34 2513;

Waltham Dan, 96 Oxford Street Darlinghurst NSW or phone (02) 331 3360.

You could also try Dick Smith Electronics and other large parts suppliers, as they occasionally hold some valves in stock without advertising them in their catalogs.

You could also try a small advertisement in the Marketplace section in *EA*, as other readers may have spare valves they would be willing to part with. As a final suggestion, there are several companies in England or the US that specialise in selling valves. Their addresses are best obtained by referring to an imported electronics magazine.

Bipolar electrolytics

The following letter was addressed to retired EA editor-in-chief and regular contributor Neville Williams, whose answer is printed immediately after it. Neville originally referred to the use of bipolar electrolytic capacitors in his series 'An Introduction to Hifi – 21' in EA, Oct.'88. The correspondent questions the notion of using two standard polarised electrolytic capacitors of twice the required value, connected in series to make a bipolar electrolytic.

It would seem to me that making an 11uF bipolar electrolytic by connecting two 22uF electrolytic capacitors in series is the wrong way of going about it. I propose that an 11uF bipolar should be made from two 11uF electros connected in series.

I suggest that under the conditions of applying an AC signal, the electrolytic capacitor that is 'reverse biased' would appear as a resistor in series with the other capacitor. Because the resistance value would be small, the total effective capacitance would be 11uF, for either polarity of the applied voltage. If I am correct, then connecting two 22uF electrolytics in series would end up giving a total capacitance of 22uF, although two non-polarised capacitors (e.g., paper) would give the 11uF value. (B.G., Korumburra, 3950)

• Years ago, when bipolar electrolytics were not always available, it was common practice to use polarised types back-to-back, as in the article referred to, each capacitor being twice the specified value. I cannot remember this practice ever being challenged before.

Without being able to quote chapter and verse, I simply assume that most modern electrolytics will retain something like their rated value for long periods, provided they are not subjected to DC voltages and currents which are likely to de-form or re-form the electrolytically based dielectric.

While the measured leakage may vary with the polarity of the applied voltage, I do not go along with the idea that the capacitors would change dynamically from capacitor to resistor and vice versa, from one half-cycle to the next of the applied audio voltage. By connecting them back-to-back, they tend to protect each other from any DC component that might be present.

NOTES & ERRATA

PC-DRIVEN FUNCTION GENERATOR (January 1989): The identification of capacitors C2 and C5 is transposed on the PCB overlay diagram. Also the pin numbers for pins 3 and 16 of IC2 are transposed on the circuit schematic. The -12V rail connects to pin 3, not pin 16 – the PCB is correct.

FAN CONTROLLER (Circuit and Design Ideas February 1989): The circuit diagram should show a 150k resistor connected between the 'inside sensor' input (LHS of the 2.2k resistor), and the +12V rail. Also, the resisitor feeding the base of T4 should be 3.3k rather than 3.3M, and the emitter of T3 should be connected to earth.

Playmaster 60-60

The Playmaster 60-60 amplifier has featured in these pages before. The following letter is from a reader who has had some experience with this project. He offers a solution to a problem that is possibly fairly common with this amplifier:

I am writing to hopefully help others who have constructed the Playmaster 60-60 stereo amp, with all suggested errata and modifications, only to find they cannot set the quiescent current.

I recently had occasion to look at such an amplifier constructed by a friend. After ensuring that my friend had constructed the amplifier correctly, I checked and found the amplifier was oscillating supersonically. The oscillation commenced at the point where the voltage across the fuse resistor reached approximately 7 volts, as VR1 was being adjusted, and then rapidly raced to almost rail voltage.

Both channels exhibited the same symptoms. The 68pF compensation capacitors were replaced with known values but the symptoms remained. A fix was found by soldering a 68pF capacitor across the 4.7k resistor between the base of Q10 and the -50 volt rail for each channel. The oscillation completely disappeared allowing the voltage to be adjusted to the required 11.2 volts. I hope this can be of assistance. (E.M., Cambridge Park NSW)

Why??

It is said the sine wave is the fundamental waveform from which all other waveforms can be constructed. How then does a square wave relate to a sine wave? Both waveforms look and sound totally different, yet are related quite closely.

Answer to last month's Why??

Last month we asked why the input capacitance of a transistor seems to be higher than its specified value when used as a common-emitter amplifier.

The answer lies with Miller's theorem. This theorem states that the capacitance between the collector and base (or gate and drain for a FET) will appear across the input terminals, (base-emitter) but multiplied by $(1 + A_v)$, where A_v is the gain of the amplifier.

In other words, if C_{bc} and C_{be} are both 6pF, and the gain of the amplifier is 100, the total capacitance that will be present across the input terminals of the amplifier is $(C_{bc} \times 101) + C_{be}$, which equals 612pF. Considerably more than the 12pF you may have expected.

If the resistance of the signal source is high, say around 100k, the upper cut-off frequency (-3dB point) will be around 2.6kHz, using the equation of 1/6.28RC. If Miller's theorem didn't apply, this frequency would be over 132kHz. Quite a difference!

Letters

Continued from page 5

rads was written mf and it is only comparatively recently that uF has been generally accepted, as an alternative to (Greek letter) mu-F. Neither of these changes involved any alteration of values, only of name. And please note: your use of mF is dreadfully confusing to us older users.

Your new policy of nanofarads and millifarads is an attempt to introduce new values into the range. As you have argued in the case of the symbols, I have not yet seen a good and valid reason for the introduction of these new values. The old values were quite adequate in the UK, USA, Japan and Australia, until the Europeans decided to try to impose their ideas on us all.

Nanofarads was a European standard, yet in the symbols case you vehemently oppose the European standard. (Millifarads you've conjured up from I don't know where.)

If your arguments are going to carry any weight, they must be consistent. What's it to be? Rectangles and nanofarads? Or zig-zags and uF?

Jim Lawler
Geilston Bay, Tas.

Comment: Thanks for your views, Jim. I guess during this transitional era it's inevitable that we're going to be accused of either being 'old fashioned', 'confusing' or 'inconsistent' – but at least we're not boring! Incidentally I would scarcely describe the few changes we have made as 'desperate'.

Anniversary message

I was delighted to learn that *Electronics Australia* has reached its golden fiftieth year – an accomplishment that most magazines never attain.

As a reader of *Electronics Australia* for the past twenty years, I find that the last two decades culminate a half-century of faithful service to emerging engineers and scientists who are practising hobbies based on the information your inspiring articles provide. Additionally, *Electronics Australia* offers a pleasant respite from the turmoil of everyday travail that professionals and electronics technicians endure on the job.

The measured accomplishments of *Electronics Australia* give to our industry an elevated bench mark of quality performance that must be achieved if we are to serve our readers faithfully and endure the test of time.

Continue your worthy efforts and fulfill the destiny of truth and education that our worthy industry expects from all of us.

Julian S. Martin, Editor
Popular Electronics
Farmingdale, New York

50 and 25 years ago...

"Electronics Australia" is one of the longest running technical publications in the world. We started as "Wireless Weekly" in August 1922 and became "Radio and Hobbies in Australia" in April 1939. The title was changed to "Radio, Television and Hobbies" in February 1955 and finally, to "Electronics Australia" in April 1965. Below we feature some items from past issues.

RADIO AND HOBBIES IN AUSTRALIA

May 1939

Remote control units for pick-ups: The latest craze in the USA is for remote control units which will allow records to be played through a radio set, but without a connecting wire.

The devices are, in fact, small transmitters. An oscillating receiver valve is modulated by the output from the pick-up, and the signal that results is picked up by the set, and heard via the loudspeaker.

The idea is quite a workable one, and we have carried out some experiments in the past with such units. The attitude of the PMG towards them in Australia, however, is rather hard to gauge. They are actually unlicensed transmitters, and could be picked up some distance from the set. In the event of interference with the neighbour's programme, trouble might start.

RADIO, TELEVISION and HOBBIES

May 1964

Translator TV: A recent amendment to the Wireless Telegraphy Act in Australia has opened the way to the use of television 'translators'. By picking up television signals in favourable locations and re-directing them into 'shadowed' areas, translators can bring TV programs to communities, which local topography robs of a normal service.

Operating in the VHF band, between 45 and 222Mc, the coverage of television transmitters is limited to an area which is commonly described as 'slightly beyond the visual horizon'. While the use of tall transmitting masts, prominently sited, can yield surprising coverage, some signals may skim right over the top of communities hidden from the transmitter by intervening high ground.

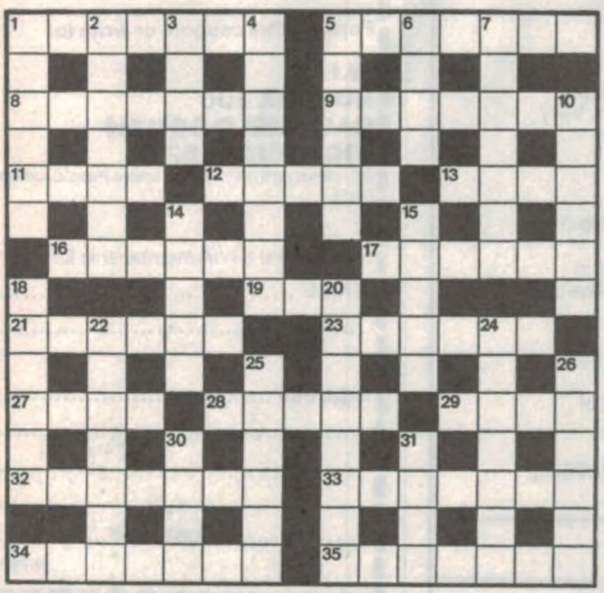
Translators can serve these communitites by automatically rebroadcasting the television signals into the shaded area. The translator is located on a hill or tower where it can receive the original television signal to best advantage. The signal is then amplified, converted in frequency to another standard television channel and transmitted to the area below. Here it is picked up by normal domestic TV receivers tuned to the second channel.

Translator systems with one watt of RF power output or less can typically provide good service to about 30 miles. Yagi type antennas are commonly used to direct the limited power for most effective coverage of the desired area. EA

MAY CROSSWORD

ACROSS

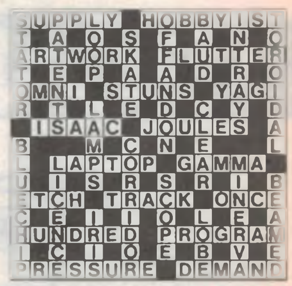
1. Intermittent eye-catcher. (7)
5. Rank serviceman? (7)
8. Concerned with light and sight. (7)
9. State of electrical equilibrium. (7)
11. Mode of tape deck. (4)
12. Brand of rechargeable battery. (5)
13. Rectification form, ---- wave. (4)
16. Manifestation of lightning. (6)
17. Sound of interference. (6)
19. Australian standards authority. (1,1,1)
21. Small unit of length. (6)
23. Period preceding 5 down. (6)
27. Having a boundary somewhat like 35 across. (4)
28. Particle detector, ---- chamber. (5)
29. Effect of excess radiation. (4)
32. Maximum. (7)
33. Consequence of 16 across. (7)
34. Computer bugs. (7)
35. A Lissajous figure. (7)



DOWN

1. Kind of disk. (6)
2. Parallel currents do it. (7)
3. Break into computer system. (4)
4. New recordings. (8)
5. Paths of satellites. (6)
6. Collection of data. (4)
7. Part of a switch. (7)
10. Physical phenomenon. (6)
14. Vertical oscillators with digital loop support! (5)
15. Play series of quitar notes. (5)
18. Remove ripple. (6)
20. First Canadian satellite. (8)
22. Device for battery maintenance. (7)
24. Said of knowledgeable crossword solver? (5-2)
25. Anodesin thermionic valves. (5)
26. False. (6)
30. Morse senders. (4)
31. Term describing method of current balancing. (4)

SOLUTION FOR MARCH



EA marketplace EA marketplace

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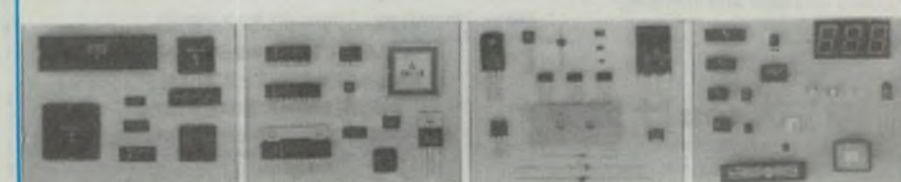

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KEY TO CODING
A Kits & modules
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C PC boards and supplies
D Components
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F Test & measuring instruments
G Reference books

Note that the above list is based on our understanding of the products sold by the firms concerned. If there are any errors or omissions, please let us know.

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PROJECT QUERIES: Advice on projects is limited to postal correspondence only, and to projects less than five years old. Price: $5. Please note that we cannot undertake special research or advise on project modifications. Members of our technical staff are not available to discuss technical problems by telephone.

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