SEPTEMBER 1976 $1.00*
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# electronics TODAY INTERNATIONAL

Electronics Today International is Australian owned & produced

## Special Section
## Microprocessors!

## Biofeedback build your own Heartrate Monitor!

SPECIAL OFFER


$14·99

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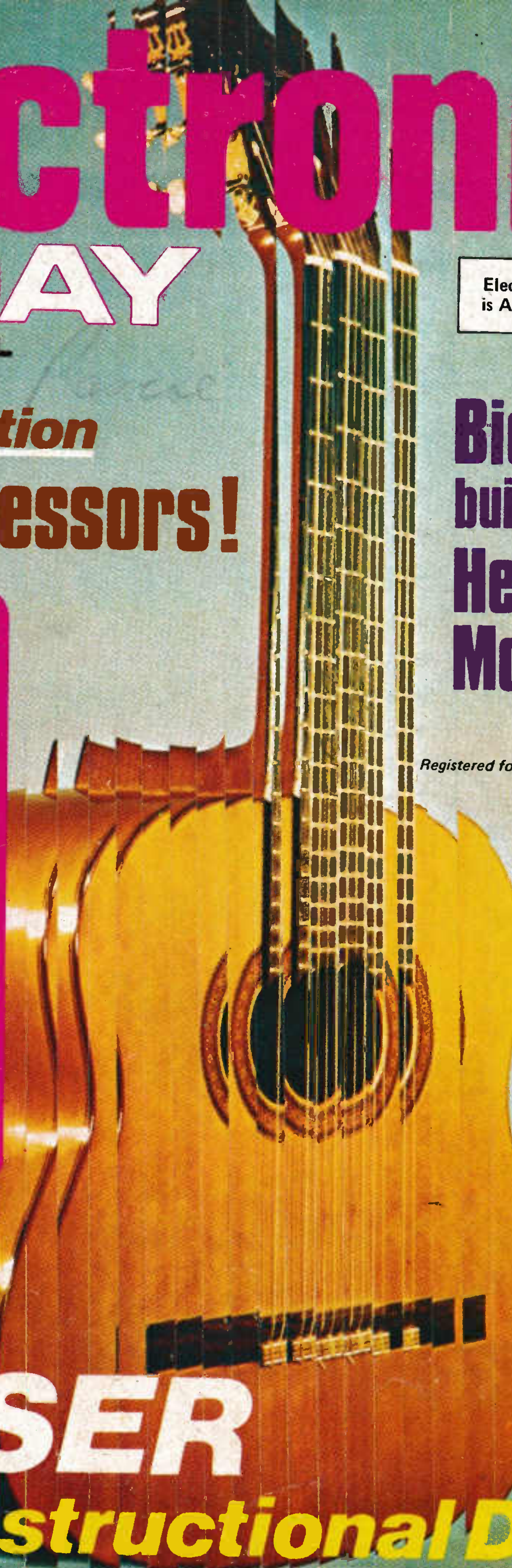

## PHASER
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# A turntable with features you'd expect only on a more expensive unit

One feature you'll notice is the price; in fact we believe it to be 'the best buy' turntable available today.

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- ☐ illuminated stroboscope
- ☐ elliptical stylus
- ☐ completely automatic tone arm return
- ☐ viscous-damped cueing lever
- ☐ anti-skating dial scale control
- ☐ CD4 ready
- ☐ audio insulated legs

and the list just goes on.

Any way you want to look at it, you'll agree the Technics SL23 is a sound buy, with appearance and performance to match.

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# electronics TODAY

INTERNATIONAL

A MODERN MAGAZINES PUBLICATION

September 1976, Vol. 6 No. 9



Electronics Today International is Australian owned and produced. It is published both in Australia and Britain and is the fastest growing electronics magazine in each country.

## PROJECTS



## MICROPROCESSORS



## FEATURES



## DATA SHEET



## NEWS & INFORMATION



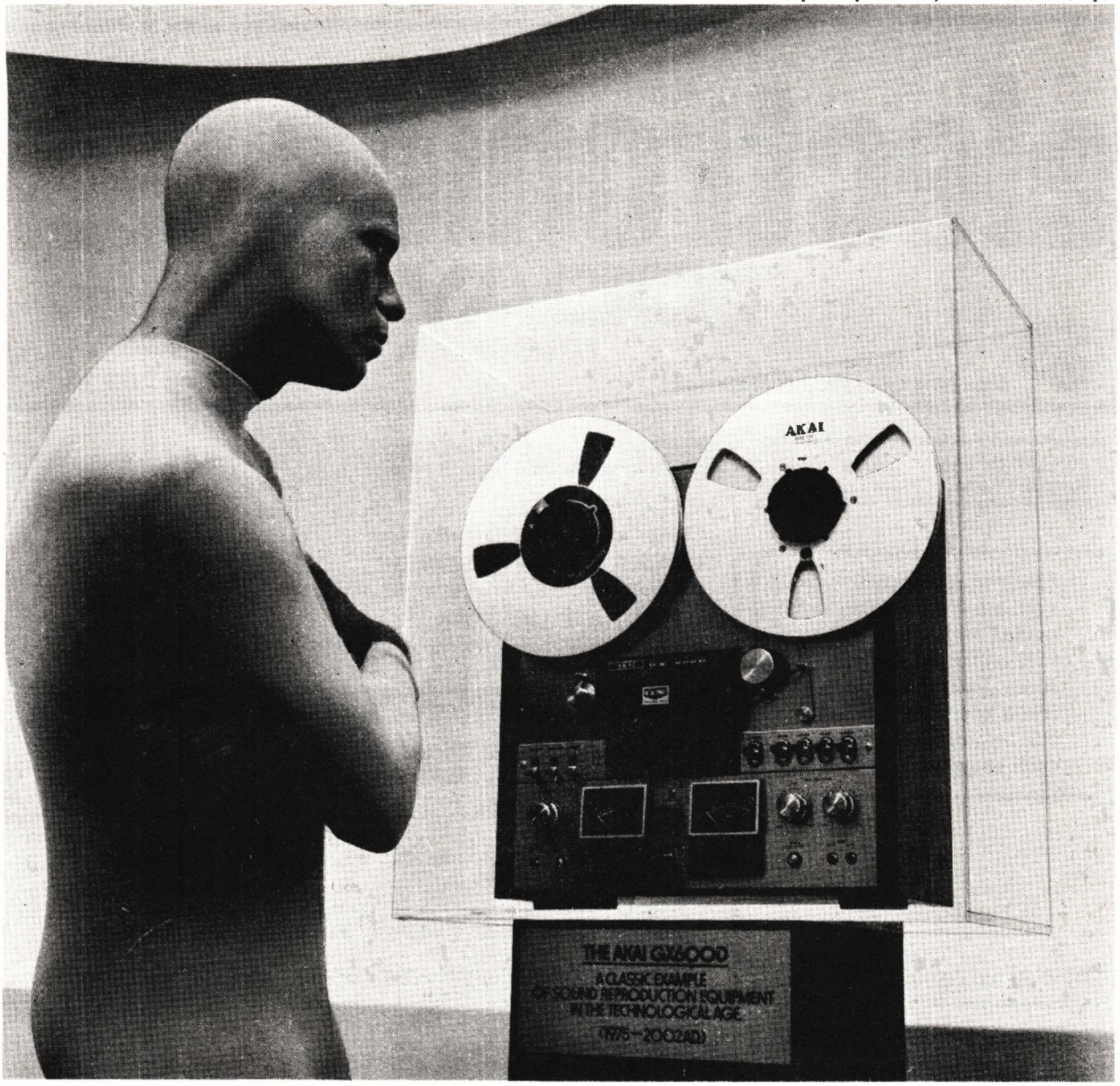
## Special offer

A Scientific Calculator for $14.99!

*COVER: Distortion can be interesting. The ETI Audio Phaser can be used to get 'atmospheric', outer-space, or surf-like sounds when used with guitar, piano, drums, or any instrument. Photo by George Hofsteters.*

*Recommended retail price only

For optimum performance, we recommend BASF tapes.




# Its rewards might be in another place and time, but yours are here and now.

The 630D tape deck is one of our top models. It retails around $656†. That's a lot. But the 630D is a lot of tape deck. It's totally professional in every function. Recording, dubbing, mixing, playback.

Yet the controls are beautifully simple. After all, we want to give you good times. Not hard times.

It comes, like all AKAI hi-fi equipment distributed by AKAI Australia, with our Complete Protection Plan*. Which simply means 12 months full parts and labour warranty on all Tape Equipment, 2 years full parts and labour warranty on all Amplifiers, Turntables and Speakers and a lifetime warranty on all GX Tape Heads.

If you're still thinking about the price, think about this: sure, we could have compromised and saved a hundred. But we can't see any future in that.

The AKAI Hi-Fi Professionals are: **NEW SOUTH WALES — SYDNEY CITY AND METROPOLITAN. Sydney:** Douglas Hi-Fi, 338 George Street; Duty Free Travellers Supplies, 400 Kent Street; European Electronics, 187 Clarence Street; Instrol Hi Fi, Cnr. Pitt & King Streets; Magnetic Sound Industries, 32 York Street; Jack Stein Audio, 275 Clarence Street. **Bankstown:** Selsound Hi Fi, Cnr. North Terrace & Apian Way. **Burwood:** Electronic Enterprises, 11 Burwood Road; Edge Electrix, 31 Burwood Road. **Concord:** Sonarta Music Services, 24 Cabarita Road. **Cremorne:** Photo Art & Sound, 287 Military Road. **Crows Nest:** Allied Hi Fi, 330 Pacific Highway. **Hurstville:** Hi Fi House, 127 Forest Road. **Liverpool:** Miranda Stereo & Hi Fi Centre, 166 Macquarie Street. **Miranda Fair:** Miranda Hi Fi & Stereo Centre, Shop 67, Top Level. **Mona Vale:** Warringah Hi Fi, Shop 5, Mona Vale Court. **Parramatta:** Gramophone Shop, Shop 151, Westfield Shoppingtown; Selsound Hi Fi, 27 Darcey Street. **Roselands:** Roselands Hi Fi, Gallery Level. **South Hurstville:** Selsound Hi Fi, 803 King George's Road. **Summer Hill:** Fidela Sound Centre, 93B Liverpool Street. **Sutherland:** Sutherland Hi Fi, 5 Boyle Street. **Waitara:** Hornsby Hi Fi, 71 Pacific Highway. **Westleigh:** Sound Incorporated, 16 Westleigh Shopping Centre. **NEW SOUTH WALES COUNTRY. Albury:** Haberecht's Radio & TV, 610 Dean Street. **Bega:** Easdowns, 187-191 Carp Street. **Bowral:** Fred Hayes, 293 Bong Bong Street. **Broken Hill:** Pee Jay Sound Centre, 364 Argent Street. **Gosford:** Gosford Hi Fi, 163 Mann Street; Miranda Stereo & Hi Fi Centre, Cnr. Donnison & Baker Streets. **Moss Vale:** Bourne's Merchandising, 1 White Street. **Newcastle:** Ron Chapman Hi Fi, 880 Hunter Street; Eastern Hi Fi, 519 Hunter Street. **Nowra:** Nowra Hi Fi, Shoalhaven Arcade. **Taree:** Taree Photographics, Graphic House, 105 Victoria Street. **Wagga Wagga:** Haberecht's Radio & TV, 128 Baylis Street. **Wollongong:** Hi Fi House, 268 Keira Street; Selsound Hi Fi, 2-6 Crown Lane. **A.C.T. Civic:** Allied Hi Fi, 122 Bunda Street. **Fyshwick:** Allied Hi Fi, 3 Paragon Mall, Gladstone Street. **QUEENSLAND. Brisbane:** Chandler's, 120 Edward Street; Chandler's, 399 Montague Road, West End; Stereo Supplies, 95 Turbot Street; Tel Air Electronics, 187 George Street. **Nambour:** Custom Sound, Currie Street. **Mt. Isa:** The Sound Centre, West Street. **Rockhampton:** Chandler's, 144 Alma Street. **Southport:** Stokes Electronics, Scarborough Street. **SOUTH AUSTRALIA. Adelaide:** Ernsmiths, 48-50 King William Street; Flinders Trading Co., 55 Flinders Street; J B Electronics, 115 Gouger Street. **Blackwood:** Blackwood Sound Centre, 4 Coromandel Parade. **Glenside:** Steiner Electronics, Conygham Street. **Moana:** Bob Carmen, 185 Commercial Road. **VICTORIA. Melbourne:** Douglas Hi Fi, 191 Bourke Street; **Warrnambool:** A. G. Smith, 159 Liebig Street. **WESTERN AUSTRALIA. Perth:** The Audio Centre, 883 Wellington Street. **Calista:** Hub Hi Fi, Kwinana Hub, Gilmore Avenue. **East Victoria Park:** Japan Hi Fi, 889 Albany Highway. **Nedlands:** Audio Distributors, Broadway Shopping Centre, Broadway. **Midland:** Midland Audio, 16B Great Northern Highway. **Mosman Park:** Audio Distributors, 14 Glyde Street. **W.A. COUNTRY. Bunbury:** Aabel Music, 130 Victoria Street. **Kalgoorlie:** Hambley's Hi Fi, Shop 13, Central Arcade, Hannan Street. **TASMANIA. Burnie:** James Loughran & Sons, 29-31 Wilmot Street. **Hobart:** Quantum Electronics, 181 Collins Street. **Launceston:** Wills & Co., 7 Quadrant. **NORTHERN TERRITORY. Darwin:** Pfitzners Music House, Smith Street.

**AKAI**

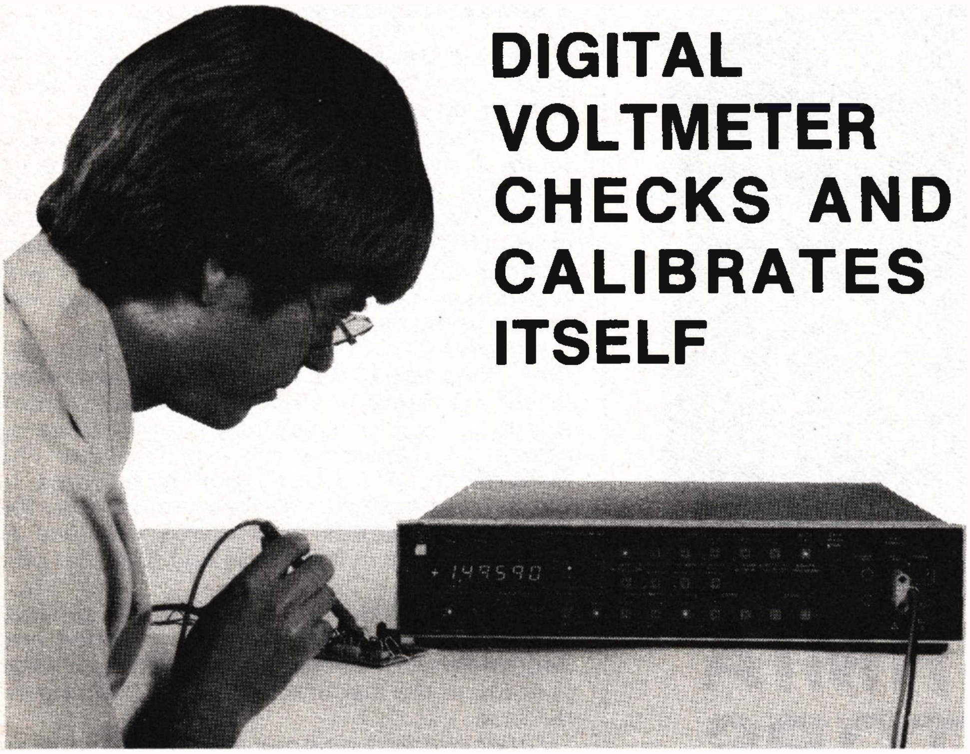
**The name you don't have to justify to your friends.**

*The Complete Protection Plan does not cover equipment purchased outside Australia. †Recommended retail price only.

70621R

# NEWS DIGEST

## DIGITAL VOLTMETER CHECKS AND CALIBRATES ITSELF




Several new test instruments incorporate microprocessors — this new digital voltmeter from Hewlett-Packard has two of them — one for measurement control, and the other for computation and remote programming. The new fully-guarded, integrating Hewlett-Packard Model 3455A digital voltmeter is a high-performance unit designed for bench or systems use. It measures dc from 1 microvolt to 1000 volts, true rms from 10 micro-volts to 1000 volts, or with an optional average ac converter, from 10 microvolts to 1000 volts average. Resistance measurements cover 1 milliohm to 15 megohms in six ranges, either two or four wire. A high-resolution mode uses 6½ digits, but for faster reading, 5½ digits are used.

A plug-in precision reference enables the instrument to check itself against the reference and under control of the Microprocessor, to make its own corrections. A self-test feature verifies operation of the dc circuits. If a problem is found, it is easily analysed using the front panel display. Mathematical functions built into the 3455A let the user off-set, take ratios, or scale readings so that readouts are in physical units. A '% ERROR' mode converts readings into percent change compared to a predetermined reference.

DC measurements are made at 22 readings per second with 1 microvolt sensitivity. Greater than 60 dB normal mode noise rejection is obtained on all dc ranges. DC accuracy is ⅛ 0.0023% at full scale.

True rms measurements are made to 13 readings per second at frequencies above 300 Hz. True rms is measured with best accuracy of 0.1% over a 30 Hz to 1 MHz bandwidth.

Average ac measurements (optional) are also made up to 13 readings per second at frequencies above 300 Hz. Average ac is measured with best accuracy of 0.1% over a 30 Hz to 250 kHz bandwidth from 1 to 1000 volts in four ranges with 50% overranging. The Model 3455A can be ordered with Option 001, which provides average ac instead of true rms, at a reduced price.

Resistance is measured in six ranges from 100 ohms to 10 megohms full scale with best accuracy of 0.0025% at full scale. Maximum current through the unknown is less than 1 milliampere. Internal circuits are protected against overvoltage.

Standard on the 3455A is an HP-IB (Hewlett-Packard's implementation of IEEE-488) I/0 for systems operation. The front panel indicators on the 3455A display range, function and HP-IB status during remote operation.

Fur further information contact Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn, Vic, 3130.

## This month's ETI

This issue is special because we have more than 30 pages devoted to microprocessors (that's editorial plus advertising). We have good reasons for doing this but it does mean the normal balance of the magazine is upset slightly. Apologies to those awaiting part three of our CMOS article, we will bring this to you as soon as possible. Another repercussion of our 'microprocessors special' is ETI Data Sheet being down to one device this month. Again we will return to normal as soon as possible.

Another interesting field of electronics covered in this issue is biofeedback. Read about it on page 68 and have a go with our Heart-rate Monitor project. We hope to publish more projects in this field in future ETIs.

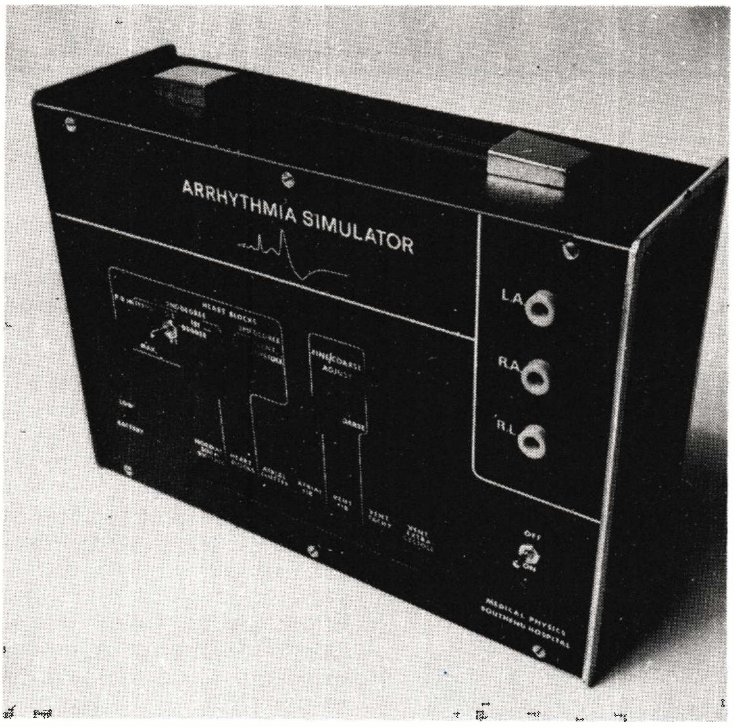
## CB expansion approved

The FCC has expanded the number of CB channels to 40 by allocating 17 new channels in the 27.230 to 27.410 MHz range. The channels will be shared between AM and SSB users. Marketing of new equipment will not begin until January 1 next year.

## Easy pcbs

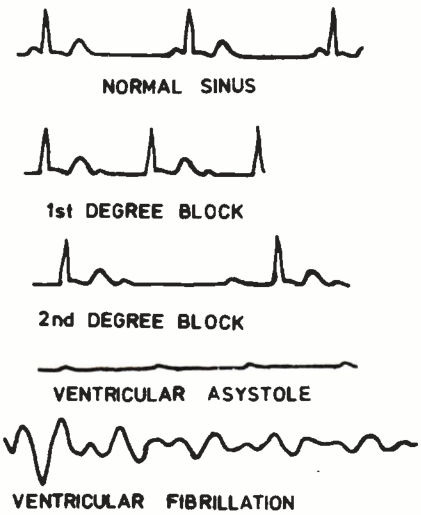
Cirtek are offering the home constructor an easy way to make his own pcbs. The Riston kit contains five 10 x 8 boards coated with dry-film photoresist and all the chemicals needed for processing them. Because the boards are ready-coated it is quite easy for an unskilled person to make a pcb.

Cirtek also offer a kit for professional laboratories. Send SAE for free flyer to P.O. Box 57, Rozelle, NSW.




# ARRHYTHMIA SIMULATORS

A wide range of heart malfunctions can be simulated by the Brandenburg electronic arrhythmia simulator developed by the Medical Physics Department of Southend Hospital, (UK). The device is designed to be used in conjunction with an electrocardiograph display. The simulator, which incorporates a series of oscillators and filter networks that can be controlled to produce a variety of waveforms including random patterns, is self-contained, battery powered and portable.




The simulator is intended as a teaching device for use in medical education centres, or as a 'refresher' in treatment units where the quick, positive recognition of arythmias is vital.

The waveforms that can be selected by a series of pushbutton switches include normal sinus rhythm, first-degree heart block, second-degree heart block, atrial flutter, atrial fibrillation, ventricular fibrillation (fine or coarse), ventricular tachycardia and ventricular extrasystole. For further information, please conduct Peter Bush, Bush Steadman & Partners Limited, 4 Gold Street, Saffron Walden, Essex, UK.

## *National Seminars on Practical Measurement Techniques*

*Improved productivity through better measurement – this is the theme of national seminars being planned for the near future.*

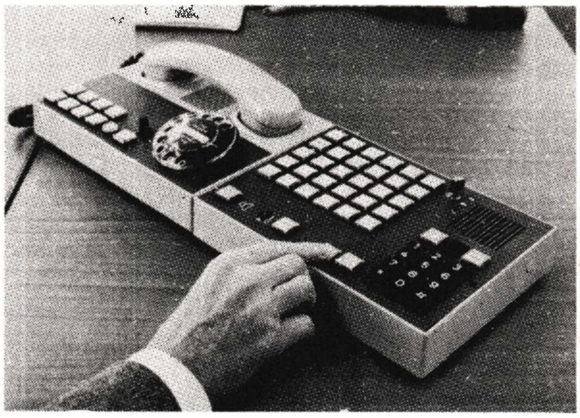
*"Increase productivity" is the demand made on all of the industries. Few people, however, spell out practical ways of meeting this demand. Many existing processes can be made more efficient through adoption of different techniques, techniques that have been well proven yet have not yet found their way into common practice.*

*A series of one-day seminars dealing with these techniques is currently being organised for the Institute of Instrumentation and Control Australia, by the Department of Continuing Education, University of New England. The Department of Industry and Commerce in Canberra is assisting this venture because the adoption of various techniques will lead to large increases in individual and National productivity.*

*The first of these one-day duration seminar clinics will concentrate on the practice and implementation of reliable and efficient laser gauging in the manufacturing and building industries.*

*Other subjects planned include linear gauging in parts inspection, digital readout on machinery, surface finish inspection, moisture measurement,large-scale industrial metrology industrial temperature measurement and numerical control of machine tools. Coordinator of the lecuturing team is ETI's special correspondent Dr Peter Sydenham.*

*Further details and enrolment forms are available from "Productivity Seminars", Department of Continuing Education, University of New England, Armidale. 2351 (Phone 067) 72.2911, Ext. 2442.*



*Thirty telephone numbers —of up to 20 digits each— can be dialled automatically by this new unit from Siemens. A dynamic read/write memory (RAM) stores the call numbers. Provision is made to store the numbers for at least two days in the event of a power shotage.*

- ☐ - 80 dB rumble
- ☐ 0.04% wow and flutter
- ☐ continuously variable speed range through a servo controlled d.c. motor...

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P.S. If this isn't the ultimate turntable, we'd like to know why.

* Measurements taken from authoritative U.S. "F.M. Guide" May 1976.

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| 22/63V | .35 | 470/63V | .95 |
| 33/16V | .26 | 1000/16V | .75 |
| 33/25V | .28 | 1000/25V | .95 |
| 47/16V | .26 | 1000/35V | 1.20 |
| 47/25V | .30 | 1000/63V | 1.80 |
| 47/63V | .45 | 2500/16V | .98 |
| 47/350 | 1.10 | 2500/25V | 1.40 |
| 100/16V | .28 | 2500/35V | 1.65 |
| 100/25V | .33 | 2500/50V | 1.98 |
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11106

# *for the love of music*


# dynamic range enhancer dbx 117

The dbx 117 is an incredible piece of equipment that will give you greater listening pleasure than you ever thought possible to achieve.

It does this in two extremely efficient ways; by literally expanding the material deliberately compressed in the recording studio, so that full dynamic range is restored, and by effectively limiting the background noise inherent in most recorded product to the extent that it becomes, in most cases, totally inaudible.

This is what Electronics Today said. *"We first used the dbx unit by playing ordinary records with average background noise . . . and the background noise all but vanished. The music sounded far cleaner with a presence that was unquestionably better than the original unexpanded record."*

*"Our next evaluation involved a piece of newly recorded orchestral music . . . when played in the normal manner, tape hiss was quite prominent . . . when played through the dbx 117 . . . the problem all but completely disappeared . . . the music had a quality which could genuinely be described as sounding comparable with the original."*

Australian Hi-Fi discusses the remarkable dbx 117 in detail. Here are a few direct quotes. *"And it does work well, giving back a 'sparkle' to some recordings which have always sounded over-compressed. Its action is particularly impressive during pauses—the disc's surface noise and any tape hiss disappear completely."*

*"The dbx 117 uses true RMS level sensors which respond to the overall level in* ***both*** *stereo channels even though the signal paths themselves are separate. This technique is necessary for dynamic range enhancement or there would be a wandering of the stereo image."*

Hi-Fi Review expressed their findings of the dbx 117 this way: *"Yet another way of 'quieting' noisy records is to use a clever little device called the dbx 117, dynamic range enhancer.*

*This device 'expands' the program material so it sounds more like the real thing, and reduces background noise so effectively, that it all but disappears. It's particularly effective with old or antique records."*

dbx 117 restores up to 20 dB of the dynamic range missing from records, tapes and FM broadcasts.

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# MS Components in Redfern

M.S. COMPONENTS (Electronics) Pty Ltd have moved into new modern premises, occupying the entire corner block at 164-166 Redfern Street, Redfern, (telephone 69-5922 – 69 6912).The premises cover two floors.

The shop gives increased display area for the Company's Hi-Fi products such as KEF, Denon, Sherwood, Ultralinear, Apan, Expo, Tannoy & Pioneer.

As previously, the large range of components, which this company has always carried features IC's to transistors — motor driven oil-less compressors to cassette tapes — data & handbooks, test equipment and speaker kits. The vast range of components will be increased dramatically within a short time.

Mike and Barry Sheridan and staff are naturally enthusiastic about their new shop — and with good reason.

## *National second-source the 8080*

National Semiconductor announce that they have stocks of the famous 8080 microprocessor. This is the device developed by Intel which currently leads the 8-bit microprocessor charts in the United States. The National device, the INS8080A, is pin-for-pin and function-for-function compatible with the Intel microprocessor. Samples are now available in Australia and orders are being accepted. For 100-off the price is $16.25 each.

National are planning to come out with support chips too: the 8224 clock and 8228 controller and data bus buffer.

## GAMES FOR HIRE

Later this year Fairchild Semiconductors, who have recently taken a hand in digital watches, will be introducing their long awaited TV games chips into Europe. These are based on the F8 microprocessor, and according to Fairchild's UK division, can handle teletext as well. In order to assure themselves of a market, the company plans to do a deal with a TV rental company so that games could be hired with the set. The cost to the user would be about one pound sterling extra on top of a colour rental.

## Fibre TV

TelePrompTer Manhattan Cable Television Inc. is using a 250 metre fibre-optic link to carry TV signals from the microwave equipment on the roof of their building to their cable equipment 34 floors below.

## Bright TV

Hitachi will be marketing sets later this year which incorporate colour picture tubes twice as bright as current types. A high potential is set up between mask and screen and the guns fire almost twice as many electrons as before.

## Fluorescent globes shaped like ordinary incandescent lamps

A fluorescent lamp that will replace ordinary electric lights but will use only a third of the power and will last for up to ten years is being developed in America. The common construction of a fluorescent lamp is a long tube with a phosphor coating on the inside surface and filled with mercury vapour. The phosphor emits visible light when hit by UV photons, which are emitted by the electrically-excited mercury atoms.

The electrical discharge is initiated and controlled by starters and ballasts.

To fit the starting and controlling electrics for the discharge into a small package would not be possible, so the inventor of the new globe has taken another approach. He uses radio-frequency excitation, produced by a transistoried circuit in the base of the globe and radiated by a coil in the centre. The lamp uses mercury vapour and phosphor in the same way as previous designs.

## Thirty secret registers on the Texas SR52!

The SR52 programmable calculator has thirty extra data registers, over and above the facilities publicised by the manufacturer, Texas Instruments. An American engineer, Philip R. Geffe, made the discovery that locations 70 to 99 can be used to store information when the machine is in the calculator mode.

## The politics of DBS

John Eger, before resigning as acting director of the White House Office of Telecommunications Policy, put to the Supranational Association for Communications research a proposal favouring the use of direct broadcast satellites (DBS). Eger sees DBS as attractive because they can spread information and knowledge easily into other nations, crossing cultural and political boundaries.
Noting that DBS are under study in countries outside the US, (countries like Canada, Japan and the USSR) and noting that the USSR has plans for an 11-satellite system capable of linking up the entire communist world, Eger has called for a meeting of the free peoples of the world to establish a consensus as to the form and role this "inevitable" revolution will take: "I believe that the democracies, in making our telecommunications technology fully serve mankind, must take the lead. For not to take the lead may be to lose it — and to lose the lead is to lose man's oldest hope, man's basic right, his basic need to make life better, to improve the quality of life on earth for everyone. But more, to lose the lead may be to lose the thing we most cherish — freedom."

*Throws a whole new light on why America exports programmes like "I Love Lucy" doesn't it?*

## WIN A UNITREX CALCULATOR!

Unitrex are offering a scientific calculator as a prize in this month's contest. The 90SC is a reverse Polish machine with a red display. To enter the contest just answer the puzzle below and send your entry to ETI/Unitrex Calculator contest, 15 Boundary Street, Rushcutters Bay, NSW 2011. The closing date is October 8th, 1976. The winner will be the sender of the first correct entry picked from a barrel after that date.

### Result of July's contest

The contest in ETI July was based on a microcomputer-generated maze drawn from a program written at the Royal Melbourne Institute of Technology. Most entrants solved the maze but less than half answered the question correctly. The nearest answer was 10500, and the first-drawn correct entry belongs to Peter James of ACT.

### The puzzle

Find the number which gives a remainder of 8 when divided by 9, a remainder of 7 when divided by 8, and so on down to giving a remainder of zero when divided by one.

**Permit number TC7578**

## SOFTLY SOFTLY 741

Motorola has introduced new ultra-low noise versions of the MC1741 and MC1458 (dual) op-amp. Many users of op-amps have trouble with 'burst' noise, and these new devices are guaranteed to have less than 20uV peak noise referred to the input.
Special tests are run to identify burst noise. The devices are distinguished by the N suffix.

## New Function Oscillator

The NF Ltd model E-1011 is a new function oscillator which has the low distortion characteristic of RC oscillators but maintains the wide frequency range, high stability and multi-waveform capability of function generators.

Distortion in the range 2 Hz to 20 kHz is claimed to be typically 0.5% which equals some high quality RC oscillators, and stability is maintained down to ultra low frequencies providing excellent settling time. Synchronising output is also provided.

Enquiries to Electro Technics Pty Ltd, 36 Park Street, South Melbourne, 3205.

## Multi-Million dollar tape recorders

**Three multi-million dollar tape recorders have played a vital part in the recent Viking Space probes to Mars.**

Many times during the mission, the lander acquired data faster than the data could be transmitted to earth. For example, television photos and readings from the instruments of the spacecraft were converted to electrical pulses and stored on the recorder until the data could be transmitted (at times via the Orbiter) to earth, at a slower rate, where it was electronically reconstructed. The slower transmission rate also required less electrical energy.
The Lander recorder weighed less than 9 kg, recorded at either 16 000 or 4000 bits per second.

Upon command, the recorder reproduced data at any of its five selectable speeds including 16 000, 4000, 1000, 500, or 250 bits per second.

The 300 mm long, 228 mm wide, and 152 mm high reel-to-reel recorder used dry lubricants, a special magnetic head, and a metal recording tape.

A nickel cobalt coated phosphor bronze tape was used as the recording medium rather than the standard iron-oxide coated mylar tape used in prior spacecraft recorders. Because sterilization, by subjecting the recorder to dry heat temperatures more than 20 degrees above the boiling point of water for a minimum of 30 hours, was required to prevent the contamination of the Martian surface, metal tape had to be used. Similarly, a powdered graphite-like lubricant was employed for the bearings because liquid type lubricants would boil off during sterilization.

To keep power consumption to a minimum, the recorder had only one motor to turn both reels and move the 215 metres of 12 mm wide tape back and forth from reel-to-reel. Four passes of the tape, one for each of four channels, were needed to fill the recorder's 400 million bit capacity.
A pair of nine-track Lockheed reel-to-reel recorders aboard the Orbiter recorded and played back more than 640 million bits (one electrical pulse equals one bit) of photographic and other scientific information each.

Weighing about 8 kg each Orbiter recorder contained a specially designed seamless peripheral belt used to move the 420 metres of recording tape back and forth from reel-to-reel. The belt also maintained tape tension and tape tracking integrity required to withstand shock and attitude manoeuvres encountered during launch and throughout the long flight profile.

Information was received from a number of scientific investigations including stereoscopic black and white, colour, and infrared photos; facsimile cameras with an inorganic mineral analysis, using an x-ray fluorescence spectrometer; pressure, wind velocity, wind direction, and temperature sensors; three-axis seismometer; and molecular analysis, using a gas chromatograph mass spectrometer.

# Electronics hobbyist develops biofeedback pacemaker

Dr Hermann Funke, a German surgeon and life-long electronics hobbyist, has developed a novel cardiac pacemaker incorporating a respiration rate monitor. The device is the first to satisfy the need for a faster heartbeat when the patient is undergoing physical exertion.

Previous pacemakers have been of fixed frequency, about 70 beats per minute, and they give pulses on demand, when the heart is too weak to beat. Dr Funke's pacemaker gives a heart-rate that's related to respiratory rate in the ratio four to one. The range is limited to 60 — 146 pulses per minute.

The respiratory information is obtained by a piezo-electric sensor in the pleura of the lung. There is then a response lag of about a minute before the device acts to change frequency. The German doctor makes the prototype entirely on his own — from design through soldering. Now an electronic firm is working on miniaturisation of the device before implanted trials (initially on dogs).

# NEW SPACE PROBE

**A radiotelescope which will search the depths of space for complex organic molecules was officially inaugurated last month by the Minister for Science, Senator J.J. Webster. The radiotelescope, with a dish diameter of four metres, will be operated by CSIRO's Division of Radiophysics at its headquarters in the Sydney suburb of Epping.**

Senator Webster said the instrument would be primarily involved in the study of how new stars form from the dense, cold clouds of molecules at distances of about 30 000 light years from earth.
"Scientists speculate that the evolution of organic matter is intimately associated with the formation of new stars and planets. The new radiotelescope will be an important reserach tool in CSIRO's efforts to understand cosmic evolutionary processes and continue their search for molecules which could form living organisms," Senator Webster said.
The radiotelescope, which is designed to monitor the radio signals transmitted to earth by molecules which radiate on millimetre wavelengths, will open up a new field for Australian radioastronomers.
Until now, Australian radiotelescopes have only been able to monitor the longer wavelength signals — thereby severely limiting the range of molecules which could be detected.

## Big demand for electronic engineers and microprogrammers

Where there is a high concentration of electronic companies, like Silicon Valley and Orange County in California, and in cities like Boston, there is now a shortage of skilled staff to design microprogrammed logic systems. Several companies are offering bounties to the present employers so they will recruit new people. Fairchild is issuing "Fairchild needs you" T-shirts and badges and is offering rewards like clocks, watches, games and $50 for every engineer hired.

## CCD spot remover

CCD imaging arrays produce TV pictures well below the standard of present cameras; one trouble being white spots caused by dark currents in individual cells. The BBC research department has found a way of overcoming this problem using electrically-erasable ROMs and circuitry to interpolate the value at the faulty location. There is still quite a way to go before CCD arrays are good enough to be used in studio colour cameras.



## *The microprocessor boom hits Australia*

You don't have to be clairvoyant to see the number of companies getting into microprocessors — look at the advertisers in this issue — and to predict their domination of the Australian electronics industry in the next couple of years. Companies we have approached report they are currently inundated with enquiries and custom from individuals and companies wanting microprocessors. Sadly these sources also report that most of the people they are dealing with don't know what is involved in getting a system going; many believe that they can spend a hundred or so dollars on an evaluatiŏn kit and get it running when they take it home!

The articles in this issue of ETI are designed to put the hobbyist in the picture so he doesn't get lumbered with a pcb he can't use. Dr. Tim Hendtlass of the Royal Melbourne Institute of Technology concludes his introductory article on page 43 of this issue and all the other articles on microprocessors form part of a carefully planned ETI guide for the amateur. The laboratory work for this guide was done by Kevin Barnes and the planning, writing, and presentation was done by Kevin and ETI's Assistant Editor, Steve Braidwood.

Although the initial users of these devices are likely to be companies we decided to present the material at amateur level for two reasons. First to make it clear to amateurs that this is not an easy field to get into, and second because few professionals understand microcomputers anyway.

This issue is very much oriented to evaluation kit systems; in future ETI will be dealing with more advanced microcomputing equipment — complete computers (with everything from power supply to terminal), development systems, applications, etc. The photo on page 32 of last month's ETI was taken at the Royal Melbourne Institute of Technology and although it didn't appear in his article it was sent in by Dr. Hendtlass.

## The ultimate microprocessor application

For Motorola it was traffic control and engine diagnosis, the Fairchild F8 is going into a travelling chess game, and there have been supermarket checkouts, electronic forecourts, and a host of creative applications for microprocessors. But RCA have the application to put an end to all the others — the thermonuclear bomb.

The first nuclear bomb for missile warheads to be developed in 15 years will be controlled by RCA's Cosmac 8-bit microprocessor. The makers of the megaton-range bomb, Sandia Laboratories, chose the microprocessor because it offers compact, cost-effective decision-making.

## ERRATA

There is an error in Fig.12 on page 88 of the July issue.The captions RIGHT and WRONG should be transposed. See Please Explain (p115) for errata on that column.

# ADVANCED SCIENTIFIC CALCULATOR


# Full Scientific Notation

This must surely be the greatest calculator offer yet made. Unitrex's advanced scientific calculator has full scientific notation enabling problems solving with numbers from $10^{99}$ to $10^{99}$ – yet the special offer price is so low that everyone who possibly needs one can afford one.

The offer is open until October 25.

*We regret that we must limit the offer to not more than three units per person (schools etc excepted).*

## $14·99

## (Plus $1.50 p&p)

**SPECIFICATION**

- ☐ 8 digit digitron display and 9 character LED display – 5 digit mantissa, 2 digit exponent, 2 signs when answer is in scientific notation
- ☐ Scientific notation permits solving problems from $10^{99}$ to $10.^{99}$
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- ☐ Automatic change sign and pi keys
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- ☐ Complete with carrying case. Operates on a 9 volt battery.

**WARRANTY**

Ninety days – parts and labour. Please return faulty units to Unitrex Pty Ltd 414 Collins St., Melbourne 4000.

**The articles in this issue are all concerned with special microprocessor packages:**

# EVALUATION KITS

## Basic Microcomputer Boards

All the manufacturers offer these introductory packages to familiarise customers with their microprocessors and the way they operate. These kits are available for prices as low as $80, but they need other equipment before they can be used.

IT HAS BEEN SAID THAT A journey of 1000 miles begins with the first step, but sometimes that first step can be so difficult that the journey never starts. This has turned out to be very true for some people who would like to own their own computer. In the past, the cost and complexity of the computer have limited the personal computer to science fiction.

Now, thanks to LSI and microprocessor evaluation kits the situation is changed, and presented here is the information you need to enable you to buy your own evaluation kit and join that growing band of people who operate their own computer.

To start, let's see where these kits come from and what they allow you to do.

### Where evaluation kits started

Evaluation kits were originally introduced by IC manufacturers as a means of getting logic design engineers in the industry started on the new microprocessor chips. The idea was that the designer could use the kit to learn about the microprocessor and even build a small system prototype. Then, having had his appetite whetted, he would move on to a more sophisticated development system.

The evaluation kits are a great success because they overcome one great difficulty — getting the microprocessor to run. MPU chips are complicated devices and their operation can not be described adequately by simple data sheets or truth tables, the traditional way of supplying information to the user.

For a working system (a microcomputer) you must add memory and interface circuits to the microprocessor and you must be able to load programs. That is what the evaluation board does. It provides the buyer with the MPU and the required minimum of support ICs to turn it into a workable microcomputer, and furthermore it provides a pc board with all the interconnections worked out. To further reduce costs, most are available in unassembled kit form. To turn an evaluation module into a working microcomputer, then, all you have to do is provide a power supply and a terminal to load and run your programs.

### The other half — the terminal

It's here that you the home user will find the big difficulty, because you don't have a suitable terminal and for all but the most enthusiastic or wealthy they are too expensive to buy.

You must make the decision whether to buy an evaluation board and find some way of overcoming the problem of driving the microcomputer or you must use some other method of getting your own computer. To help you with this decision, a summary of what can be done with evaluation boards has been included in this issue of ETI.

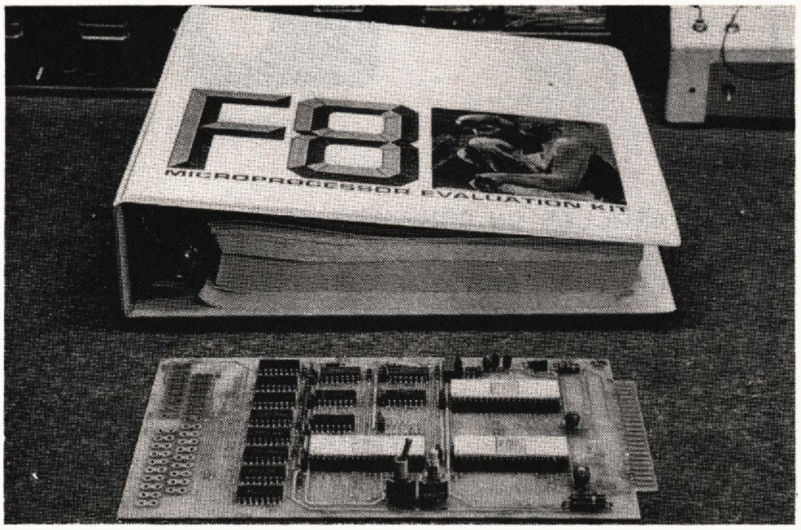
As you will see, the summary mentions alternative methods of interfacing with the microcomputer: terminal substitution or non-terminal interfacing.

Although the second method is cheaper and generally quicker to get going, it loses the use and convenience of the monitor program. This program, which counts as part of the cost of the kit, is included in all kits. It gives the operator effective control of the computer.

Many people believe that such a program is essential to getting the best out of the computer. But its very difficult for those who are unfamiliar with monitors to appreciate the value. Consequently, we have also included an explanation of monitor programs. So before you commit yourself to not using a terminal, and losing the monitor, read this section to find out just what you are giving away.

### Value

In terms of components supplied for cash outlaid, evaluation kits are excellent value. Most IC manufacturers are taking the view that each evaluation kit sold could result in large sales later on, so they have kept their profit margin to a minimum. Of course each manufacturer's kit offered for sale is




*This is typical of what you get in an evalualticn kit — enough hardware and enough literature to enable you to build a system and make it go.*

# EVALUATION KITS

different from his competitors – each manufacturer has his own ideas about what people will want.

This means you are offered a number of MPU systems with a wide diversity of architecture and support chips and each one claiming to be the system that will do the best job.

So where does this leave the average guy?

At home, with piles of data and looking very crosseyed. Well, to un-crosseye you and help you choose a microcomputer for your application, we got hold of as many kits as were locally available and got them going. Also we have pruned through the mountains of data and sales talk available and tabulated the main points for easy appraisal.

This month we look at evaluation modules from Intel, Motorola, National Semiconductor and Fairchild. Next month we will look at other evaluation modules, such as those from Signetics and RCA.

## USING OUR DATA

Be careful when you make direct comparisons between boards. Try to get an overall impression of the kit and what it can do. No two MPUs work in exactly the same way.

An example of the difficulty comes to light if we compare the number of instructions available for each chip. To say chip A is better than chip B because A has 48 instructions and B only 47 is ridiculous, B might have relative addressing capability and A not, giving A a possible edge.

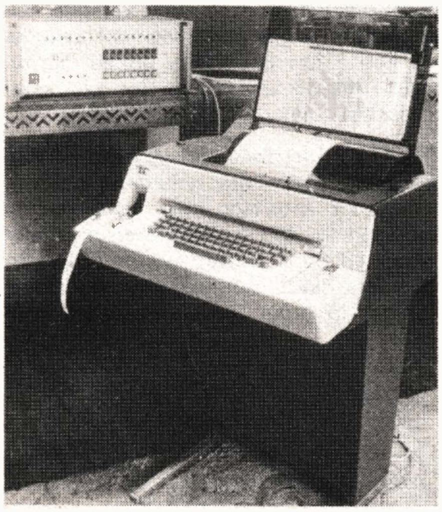
Not all kits are supplied with all the parts required to get them going, so check out what extra is required and how much it will cost. It is also worth your while to fit IC sockets to the board supplied to allow you to plug in the ICs.

The tracks on the PC boards are quite fine and are easily damaged. At some later date you might decide to expand your system and this is easier to do via sockets and interchanging ICs rather than working on the pcb tracks. Believe me, you'll feel very sorry for yourself if you damage a $30 IC while desoldering it. ●

# TERMINALS

**The way to get data into & out of your computer**

In this article we look at the minimum requirements for getting a simple microprocessor board (such as an evaluation module) to perform. Apart from power supplies all that's needed is a way to put programs and data into the memory, a way to initiate the commands built into the monitor program, and some way of getting information back after execution of the program.



*The terminal. This is the first big obstacle for the amateur computer-owner. The terminal here is an ASR38, which costs well over $1000. To the left of the keyboard you can see the paper-tape reader for loading programs into the computer.*

## The Teletypewriter

Manufacturers of evaluation kits have universally designed their kits to interface with a teletypewriter terminal. Together the monitor program and terminal provide an easy and convenient way of developing, loading and running programs. But if you don't have a terminal and can't afford to buy a new one, (they cost over $1000), what options if any are available to you?

Well, there are a number of options we can suggest and this article looks at four methods of tackling the problem.

## 1. Teletype

Try for a second-hand teletype, ideally an ASR33, as this can be connected to any of the evaluation boards with the least amount of effort. The ASR33 comes in various configurations, so try for one that includes a keyboard and a paper punch and reader.

Some ASR33 s were sold as printers only, but these are still very useful (a printer can give you permanent copy, the most difficult feature to duplicate in your own workshop). A reader-only ASR33 can be configured as a line printer.

## 2.Teleprinters and Typewriters

The second method is to modify one of the older-style teleprinters. These are used by hams to send and receive RTTY and this has created an active second-hand market in teleprinters, so check out the electronic disposal stores.

Although they are serial devices, these older teleprinters do not use the ASCII code expected by all the monitor programs, so you will have to construct a suitable code converter. Most IC manufacturers offer pre-programmed ROMs to convert the Baudot code to ASCII, but converting ASCII to Baudot is difficult and not to be tackled by the uninitiated.

If you do manage to pick up an old teleprinter, try for a set of engineering manuals as well. These will give you the required information on the code it uses.

**Typewriters** If you don't mind extra work there are always second-hand electric typewriters. There are many different models and the conversion technique for each will depend on how that model works, but the overall principle is to parallel the switches on the keyboard with your own switches.

However, not all electric typewriters have such switches, some have the keys operating mechanical interlocks and use the electrical part of the typewriter to provide only the muscle. So examine the machine offered carefully before you buy it.

Others, like IBM's Selectric models, offer an electrical interface to drive other devices. A code converter as well

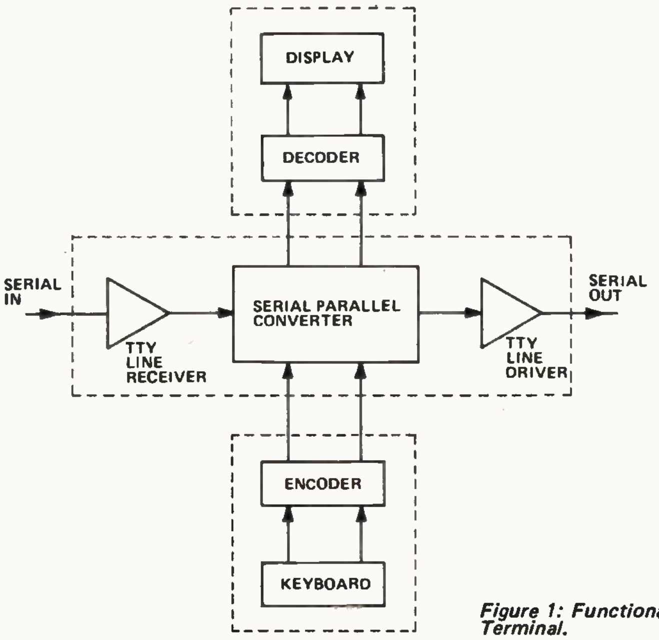



*Figure 1: Functional block diagram of a Terminal.*

as a parallel-to-serial data converter are needed, but these are available in ROM for this model.

### 3. Homebrew

The third alternative is to build your own terminal from scratch. Ideally this would imitate a teletypewriter so the computer won't know the difference. Such a terminal would consist of three parts (1) the keyboard to input data, (2) the display to output data and (3) the serial/parallel converter to produce the teletype interface signals. See Figure 1.

Recently a number of ICs have become available to dramatically reduce the parts-count in such a terminal. For the keyboard there's special encoder ICs that scan a keyboard to detect a depressed key and then give out the appropriate 8-bit ASCII code. Chips are available for use with full alphanumeric or 16-key hex keyboards.

For displays there are chips that display hex and character generator chips to display a full set of alphanumeric characters over several rows.

### Hex terminal

Since most of the monitor programs use less than 20 out of the possible 128 ASCII characters, the cheapest way to make a keyboard is to use 20 push buttons and enough diodes to make a 6 x 20 matrix, see Figure 2.

**The display** section will need to consist of a memory, of minimum size 12 characters, and a readout capable of displaying the characters 0-9, A-F, and 4 or 5 unique shapes to represent the other characters the monitor will output. To make sense out of this output, all 12 characters need to be displayed at once.

Now available are some interesting 16-character plasma displays. These can be purchased ready made-up, just apply dc power and the least significant six bits of the ASCII code of the character you want to display. The module will store the character in its own memory, decode it, and display it in a 5 x 7 dot matrix. But these modules are expensive, costing around $200 each.

A cheaper alternative is to build your own out of seven segment LED displays. Selective lighting of the seven segments (plus decimal point) gives each display 128 unique states, more than enough for the 20 characters used by most monitor programs. Just pick twenty distinct shapes that are easily remembered. Since all the monitors use hex, 16 of the shapes will represent 0-9 and A-F, something a seven segment display does quite well. The remaining symbols are used by the monitor to prompt the operator and so do not need to be identical to the shapes used in the ASCII set, just distinct enough to be remembered.

A decoder to drive such a display can be built using a seven-segment decoder IC and a few gates. For added clarity, light the decimal point for character other than hex.

**The TTY interface and serial-to-parallel converter** form the remaining section. The TTY interface does a conversion between the 0/1 current levels normally expected by a teletypewriter (TTY) to the 0/1 level required by the logic family in your serial-to-parallel con-

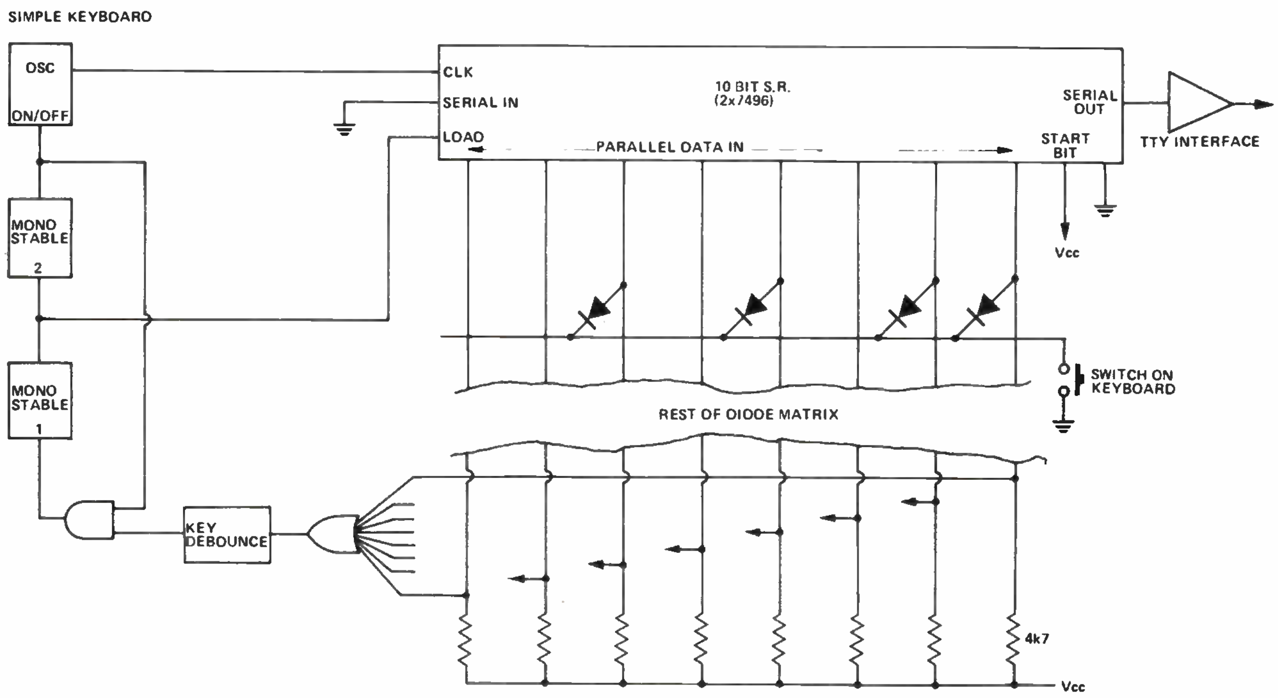



*Figure 2: A simple keyboard. The circuit shows how pressing one key sets up a parallel code and instigates operation of the serial code generator. This circuit outputs an eleven-bit serial code: first a start bit (logical zero), then eight bits taken from the ASCII code, then two stop bits (logical one). To do this the shift register needs 11 clock cycles but if it gets more it doesn't matter with this circuit, it just gives out more ones. See figure 3.*

verter. See Figure 3.

The converter is a shift register of 11 bits. Added to the eight ASCII bits of data is one bit at the beginning called the start bit. It's always a logic zero and it tells the receiving unit it's about to receive another 10 bits (8 bits of data followed by two bits called stop bits). The stop bits are logical ones.

The process is asynchronous so once started the receiver expects a new bit every 9.09 milliseconds. To make life simpler, several manufacturers now offer an IC called a UART (Universal Asynchronous Receiver/Transmitter) that has all the logic included in the IC to handle this serial-to-parallel conversion for receiving, as well as the parallel to serial conversion for transmitting. Internal logic will also check the parity and generate flag signals to say data available and data sent.

There is insufficient space available to describe the complete operation of the UART, but should you decide to use one it is definitely worthwhile getting an applications note about it.

**Bulk Storage:** A magnetic tape cassette recorder can be used with your home-made terminal in place of a paper-type punch and reader. The string of serial 1s and 0s can be stored on magnetic tape by tone and no tone or by two tones of different frequencies. A tone of around 2 kHz will do, since the data bit-rate is a low 110 bits/second (see Figure 3).

For better noise rejection use a stereo recorder and record the 1s on one channel and the 0s on the other. A 30 minute cassette will hold some 18 000 words of data. This is equivalent to a length of paper tape 50 metres long and unlike paper tape you don't have to roll it up by hand if you drop it.

## 4. The Front Panel

The last method of driving your microcomputer is not to use a terminal, but instead to use what is generally called an 'operating panel' or 'front panel'. With such a panel you lose the use of the monitor program. The operator has to use more tedious operating procedures.

But you do gain a fairly inexpensive way of driving your microcomputer. Such a panel is generally quicker to get working then building your own terminal and about half as expensive. A very simple one can be built for around $60 (excluding power supply and case). Adding refinements like incrementng address counters will take the cost to around $80 to $100.

In this method then, program execution in the microcomputer is halted and data is loaded into read-write memory one word at a time. The word comes from a row of toggle switches mounted on the front panel. The location in memory is selected by the value set up on another row of switches also mounted on the front panel.

To examine the contents of a memory location, the word comes back from memory to a row of LEDs on the front panel. In effect the front panel takes control of the microcomputer's buses and the microprocessor chip disconnects itself from the circuit by disenabling its output from driving the buses. This mode of operation is sometimes referred to as DMA mode (Direct Memory Access).

Likewise the switches on the front panel must be disconnected from the buses when the microcomputer is running. The logic to do this has to be built by you and included on the front panel. To this you should also add logic to allow the microcomputer to be single-stepped by the operator. Single-stepping is executing one instruction or cycle at a time and then going back to the halt mode. This allows the operator to step through his program an instruction at a time, and check as he goes that what ought to happen, does actually happen.

This mode of operation is essential to debugging a program without too much difficulty. Application information included with most, but not all evaluation boards, shows how this is done.

One disadvantage of the simple front panel is it cannot directly load the display with the contents of the microprocessor internal working registers, it can only work on memory locations and consequently I/O devices seen as memory locations. The feasibility of adding hardware to overcome this depends on each microprocessor chip and is complicated. Fortunately it can be done with a simple software routine loaded by the operator when the microcomputer is first switched on.

A suitable front panel then consists of the following functional sections:

1. A row of toggle switches to set up addresses and input data.
2. A display to output data (say a row of LEDs driven by CMOS buffers, (e.g. 4009 s).
3. Buffers between the microcomputers buses and the front panel switches. Buffers must have three state outputs, such as 74LS365 or CMOS transmission gates like the 4016, where suitable.
4. Control logic to halt the microcomputer, enabling the buffers to single-step the microcomputer.

*(Continued on page 24)*

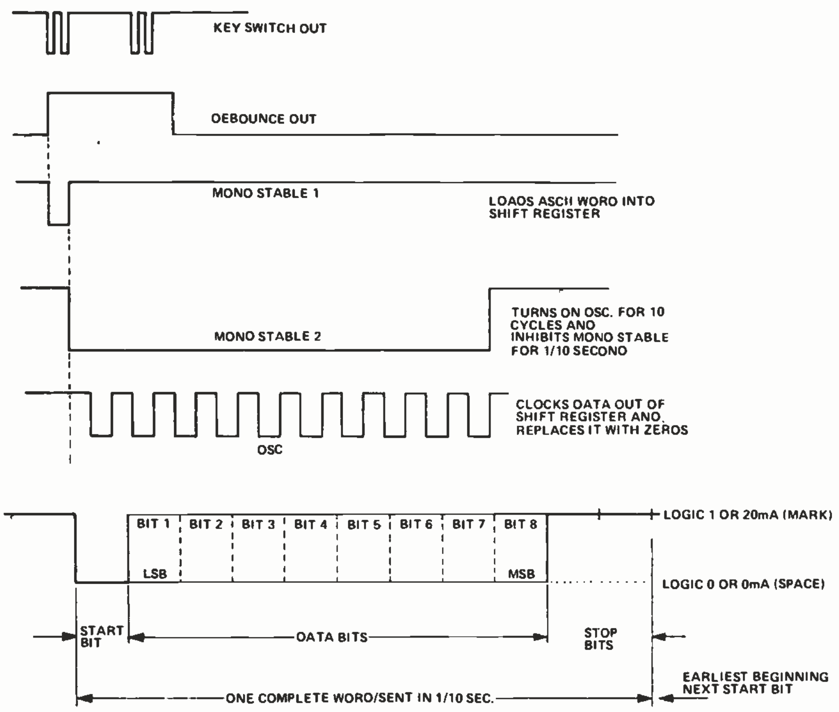



*Figure 3: These waveforms show how the circuit in figure 2 works. The final waveform is that expected by the interface and monitor programs of the evaluation kits — it is the format used by a teleprinter to send and receive in ASCII.*

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# HOBBY NEWS

ETI September, 1976

# MICROPROCESSORS:

## The Ultimate Toys?

With the hobby computer market booming overseas it now seems obvious that the same situation is about to occur in Australia. We have stocks available of the lowest cost microprocessor kit ever: the SC/MP INTROKIT by National Semiconductor. This kit is complete in every detail including all components, assembly manual and full technical documentation. After assembly and power is applied you are ready to explore the capabilities of the SC/MP microprocessors. A pre-programmed ROM is supplied so that you can enter your own program using a teletype or similar ASCI I machine.

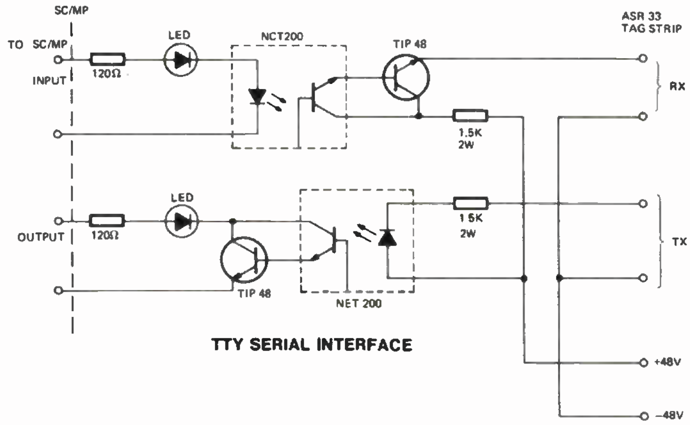
SC/MP offers many advantages to the home hobbyist particularly because of its low price, simple interfacing and static clock and a major magazine project using SC/MP is scheduled shortly.

We have a wide range of components associated with microprocessors now in stock.

# APPLICATIONS NOTE:

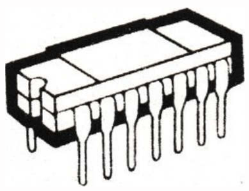
## Teletype Interface for SC/MP

Many thanks to Alan Mason of Asquith for this suggested circuit for a general purpose teletype interface for SC/MP microprocessors. This circuit utilises the ± 48V available from the teletype and is fully isolated from the microprocessor voltage rails using opto couplers.



TTY SERIAL INTERFACE

# I.C. SOCKETS



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|---|---|---|
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| 325 | (± 15V 100mA) Regulator (DIP) | 3.25 |
| 320–12 | (-12V 1A) Negative Regulator | 2.75 |
| 340–5 | (+5V 1A) Regulator (TO220) | 2.00 |
| 340–6 | (+6V 1A) Regulator (TO220) | 2.00 |
| 340–8 | (+8V 1A) Regulator (TO220) | 2.00 |
| 340–12 | (+12V 1A) Regulator (TO220) | 2.00 |
| 340–15 | (+15V 1A) Regulator (TO220) | 2.00 |
| 340–18 | (+18V 1A) Regulator (TO220) | 2.00 |
| 340–24 | (+24V 1A) Regulator (TO220) | 2.00 |
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| 78L12 | (+12V 100mA) Economy Regulator (TO92) | .85 |
| 78L15 | (+15V 100mA) Economy Regulator (TO92) | .85 |
| 79L05 | (-5V 100mA) Economy Negative Regulator (TO92) | .95 |
| 79L12 | (-12V 100mA) Economy Negative Regulator (TO92) | .95 |
| 79L15 | (-15V 100mA) Economy Negative Regulator (TO92) | .95 |
| 723 | (2-37V) General Purpose Regulator (DIP) | .90 |

* All prices include postage.

# MICROPROCESSORS

| | | |
|---|---|---|
| SC/MP KE | Introkit with sales tax exemption certificate. | $79.50 F |
| SC/MP K | Introkit including sales tax. | $89.50 F |

# RAMS

| | | |
|---|---|---|
| 2101 | 256 x 4 STATIC | $ 6.95 M |
| 2102 | 1024 x 1 STATIC | $ 3.25 M |
| 2112 | 256 x 4 STATIC | $ 6.95 M |

# E PROMS

| | | |
|---|---|---|
| 1702A | 256 x 8 UV ERASIBLE | $19.75 M |
| 5203 | 2512 x 4 (256 x 8) UV ERASIBLE | $20.50 M |
| 5204 | 512 x 8 UV ERASIBLE | $40.00 M |

# ROMS

| | | |
|---|---|---|
| 2513 | CHARACTER GENERATOR | $15.75 M |
| 5240 | CHARACTER GENERATOR | $17.50 M |

# UARTS

| | | |
|---|---|---|
| 51883 | 10 K BAUD UART | $ 9.50 M |
| 5303 | 30 K BAUD UART | $ 9.50 M |

Note: SC/MP kits will be sent freight forward. All other items are mailable and prices include postage.

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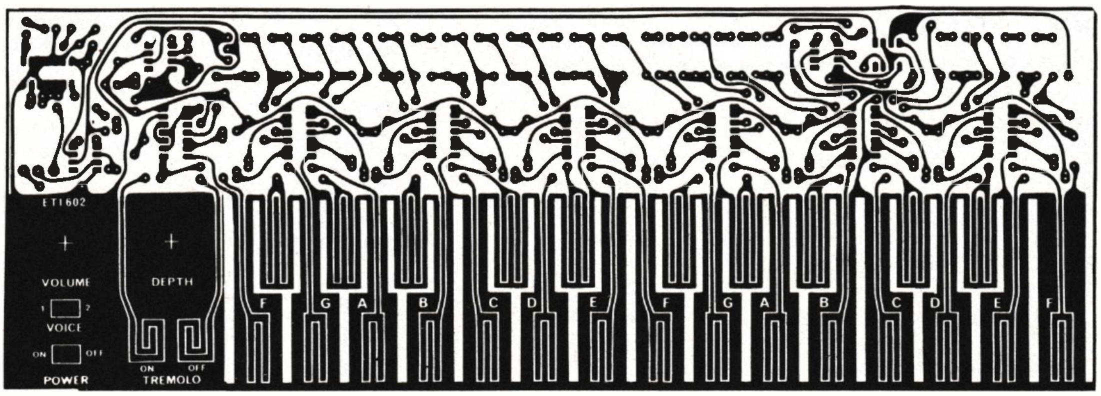


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# TERMINALS

*(Continued from page 21)*

Care must be exercised not to exceed the loading rules on the microprocessors and memory outputs. These outputs can only sink a small current and drive a small amount of capacitance.

Those who decide to use the front panel method will also have to address the read/write memory to be able to run programs. All evaluation boards come configured so that pressing the reset button starts the microprocessor executing the program in ROM. If you do not use the ROM then the address of ROM and RAM must be changed so that pressing the reset forces the microprocessor to take its first instruction from RAM. This is where you put the beginning of any program you write, or at least the beginning of any software routine that allows you to jump to some part of RAM. ●

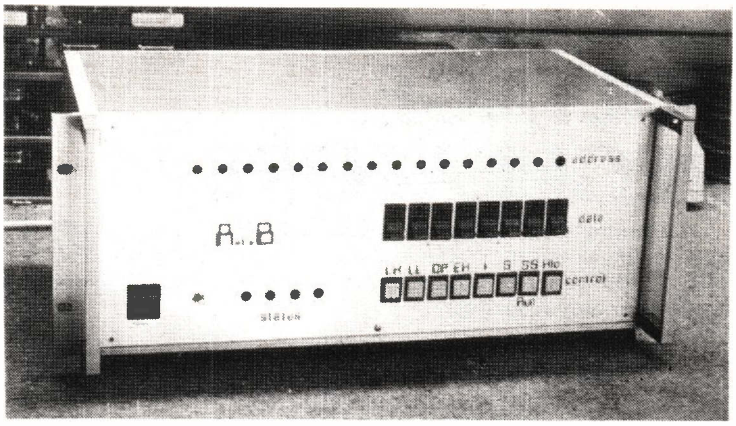


*Photo 2*

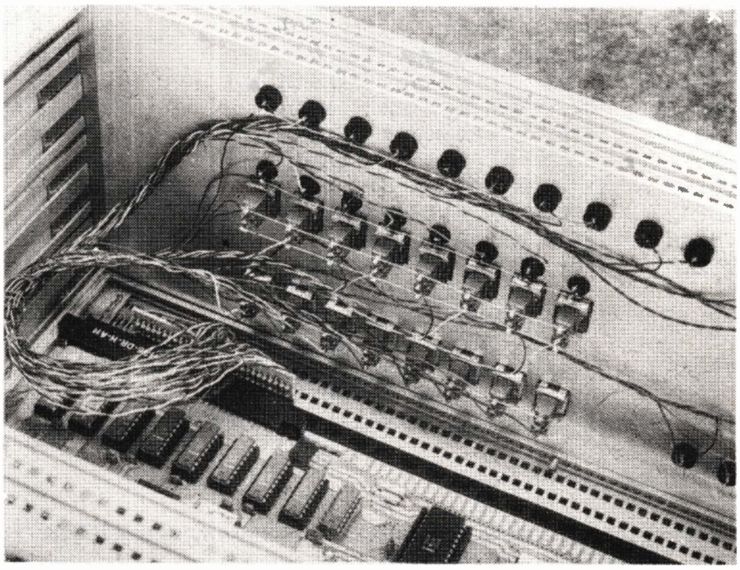


*Photo 3*

*How we used the front panel idea to drive the Intel 8080. These photos show what is involved in making your own front panel. Photo 3 shows the switches and photo 4 (opposite page) shows the ICs we added to the board. These are the ICs fitted to the breadboard area at the top left corner of the picture.*

## SUGGESTED CHIPS

For those who decide to build their own interface, here are a few ICs worth checking out:

### Displays

| | | |
|---|---|---|
| DL57 | Alphanumeric | Litronix |
| MAN 2 | " | Monsanto |
| MAN1002 | " | " |
| TIL305 | " | Texas |
| TIL311 | Hexadecimal | " |
| 5082-7340 | " | HP |
| Plasma Displays | Alphanumeric | WHK, CEMA |
| 9368 | Hexadecimal Decoder (7 segments) | Fairchild |

### UARTs

| | | |
|---|---|---|
| SI883 | Distributed by | CEMA |
| AY-5-1012 | " | GES |
| 2536 | " | Texas Instruments |

### Keyboard encoder

| | |
|---|---|
| MM5740 AAE | Distributed by National Semiconductor |
| HD0165 | Distributed by CEMA |

### 3 State Bus Drivers

| | |
|---|---|
| 74LS365 | Fairchild, George Brown |
| 74LS366 | " " |
| 74LS367 | " " |
| 74LS368 | " " |

8T26
8095
8096

### CMOS

40097
40098
4016
4066
MM80C95
MM80C96
MM80C97
MM80C98

*A simpler approach to getting an evaluation board going, but this way you will need a terminal. Picture 5 shows the Scamp computer fitted in a box with a breadboard on top. The circuit under development is to enable single-stepping of the computer. Photo 6 shows what is inside the box: the pcb, the power supply and the TTY connector.*

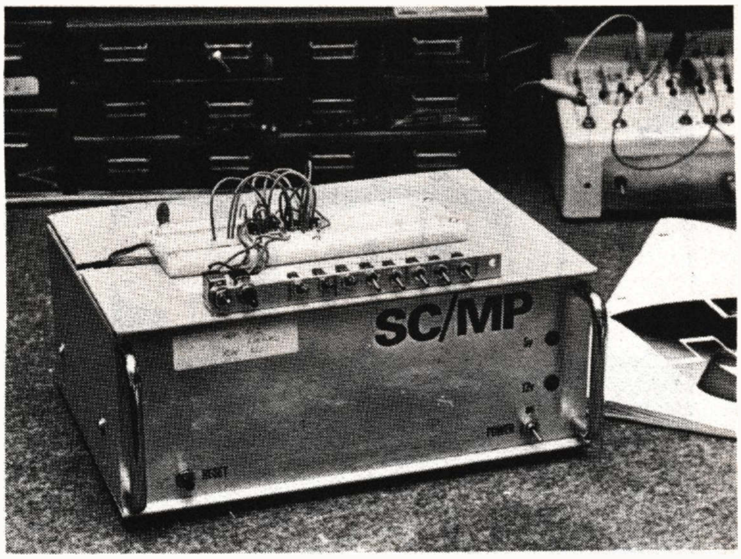



Photo 5

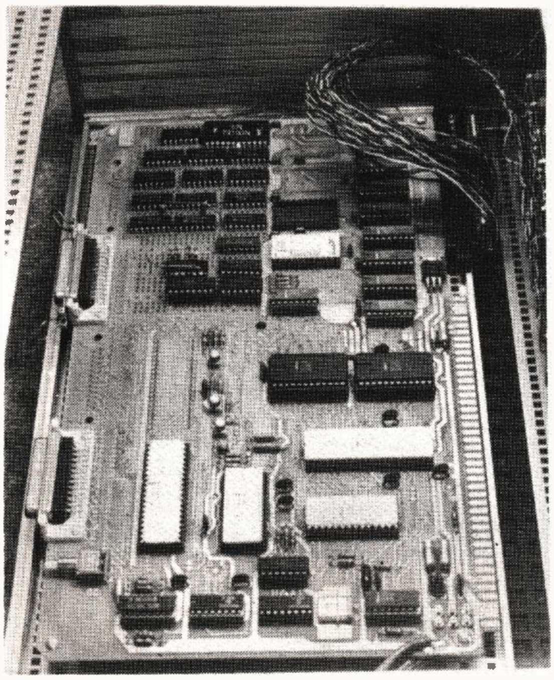


Photo 4

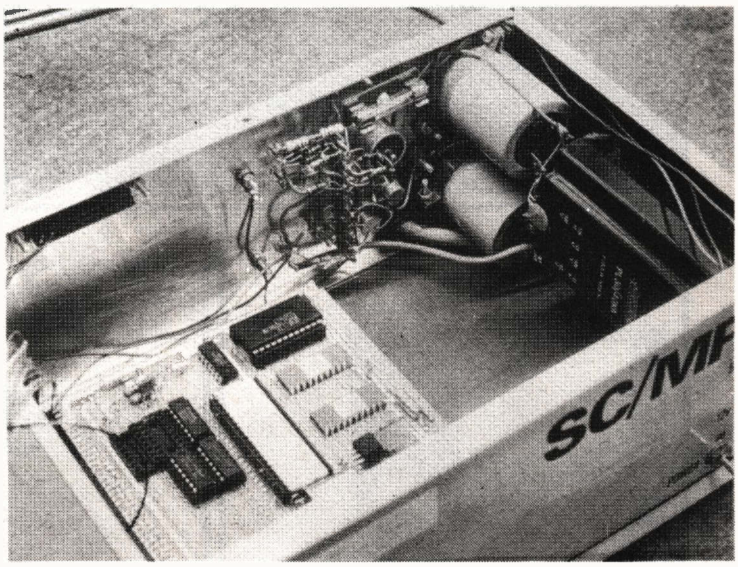



Photo 6

*This is what we did with the Motorola board. Photo 7 shows the power supply, mounting the board and the connectors, the connector at the top of the picture is for the teletype, the connectors at the bottom bring out the address, data and control busses. For these we have used mini breadboards. Photo 8 shows how we used these to prototype a front panel. The eight switches on the left set up the address and allow data to be inputted. The other three switches are run/halt, single-step, and load/examine.*

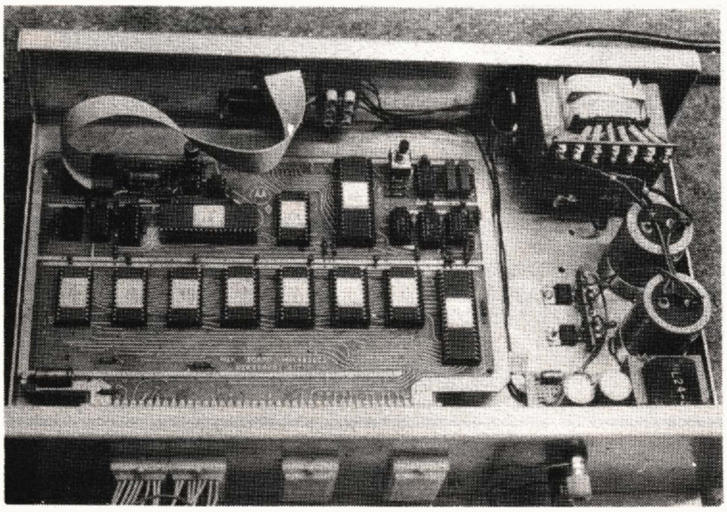


Photo 7

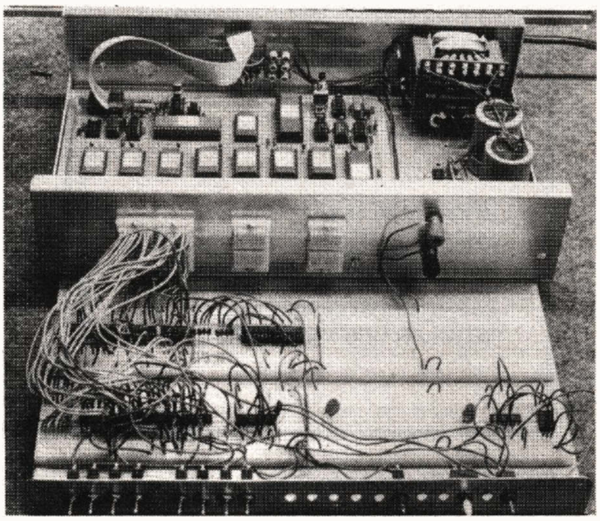
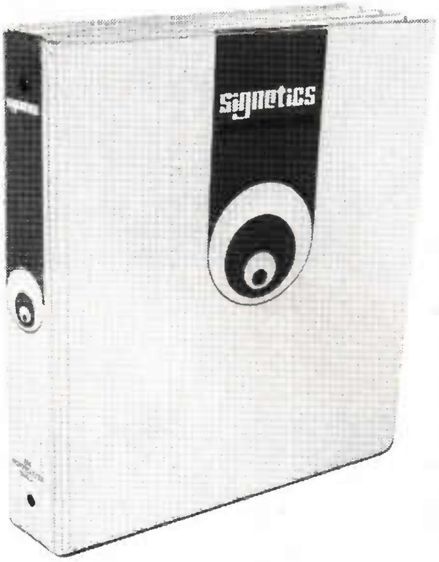


Photo 8

# SIGNETICS 2650 MICROPROCESSOR

## Designer's Choice




**2650 BM1000**
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**SOFTWARE:** FORTRAN IV ASSEMBLER AND SIMULATOR 16-bit & 32-bit TAPES.

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**An "evaluation kit" is not just a convenient package of computer chips and a pcb — there is also a special ingredient:**



# THE MONITOR PROGRAM

It's unlikely you'll be able to get your microprocessor to do anything useful until you've put in quite a few hours of frustration and despair. But if it wasn't for the monitor program chances are you'd never get your system going at all.

FROM THE INSTANT YOU SET OUT in the computer game you are buying software (In this context "software" should really be called "firmware". As long as the ROM containing the monitor program is plugged in, its facilities are permanently available.) and you're not ready to start until you appreciate the value of this intangible commodity.

Because you can't see it, you have to know quite a bit about microcomputing before you can evaluate this software, and this article will introduce you to the basic concepts.

## The ROM

When you buy your evaluation module one of the ICs will be a 'read only memory' or ROM. This ROM will have been factory encoded with a set of software routines for the particular microprocessor in the system. Each manufacturer gives his program a unique name (Kitbug, Mikbug, etc.), but we will use the general name of monitor program or "monitor".

Like the supervising monitors in large-scale computers, these monitors are there to make operating the microcomputer as simple and convenient as possible.

## What the Monitor does

A monitor should allow you, the operator, to do three things:

1. To load and run your programs.
2. To find faults in your program and determine the nature of these faults (whether they are coding errors or logical errors). It will also enable you to correct these faults.
3. Handle the interface between codes familiar to the operator and the binary "machine code" which the microcomputer needs.

## Commands

To achieve these three aims the monitor comes with a set of commands, all of which are available to the operator via the keyboard of ther terminal. To see what a monitor can do, let's look at a cross section of what the various commands actually do.

**The Load Command** loads a string of words into sequential memory locations. The words may be data or instructions. The starting location (in memory) is usually keyed in by the operator. The list of words can come from holes punched in paper tape, from a cassette player, or the operator can input these words through the keyboard as he reads off a listing of the program.

**The Go Command** allows the operator to start his program running. Having used the load command to place the program in memory, the go command is used to shift control of the microcomputer from the monitor program to the program you have just loaded. The execution begins at the starting location specified by the operator as part of the go command.

**Set Break Point Command** allows the operator to specify certain locations in the program as break points. When the microcomputer reaches one of these points its control is moved from the currently running program back to the monitor program. This is a very powerful tool for fault finding. When you run a program for the first time it is easy to locate errors if you break the program into small segments of say five to ten instructions each, and execute each segment as a separate program.

The Go command is used to enter at the beginning of a program segment and the Break Point command is used to exit at the end. The contents of the microprocessor working registers are then examined to see if the program segment is producing expected or unexpected results.

A good monitor also saves the contents of the working registers when it exits a segment and restores them when it enters the next segment, thereby allowing execution of the program to continue without disruption by corrupted data.

**The Print on Display Command** displays the contents of consecutive memory locations. The list so produced can be checked for error or filed as a record for later use. By engaging the paper punch (available on most terminals) a permanent copy is produced. This can be reloaded using the Load command. On some monitors the format of the punched tape will be unsuitable for use with the simple Load command, but it is quite simple to write a small program of your own to do this.

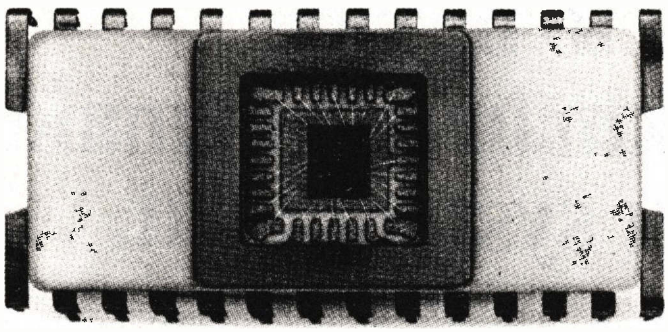
**The Examine Command** displays the contents of individual operator selected memory locations, and then gives the operator the option of changing the contents. Useful when you want to correct an instruction or change a data constant.

**Examine Registers Command** allows the operator to display the values stored in the internal working registers of the microprocessor and change them if necessary. Because of the nature of the microprocessor design and the limited number of pins on the LSI chip, this feature is difficult to do with hardware.

## Interfacing

Included in the monitor are software

# THE MONITOR PROGRAM



*If your monitor program comes in a package like this you are lucky. It means you don't have to throw away the chip if you don't want the monitor. These ROMs with windows in the top are eraseable by UV light — so you can have them erased and re-programmed with your own program.*

routines that translate between the characters used by the operator at the terminal and the binary codes used inside the microprocessor and the memory. Since the monitor can do the work involved in the translation, the operator can immediately talk to the microcomputer in hex characters and a few selected alphabetic characters.

Hex is convenient to use since two selected hex characters can specify any 8-bit binary word. Contrast trying to remember A6 rather than 1010 0110.

The alphabetical characters (other than A to F, which are hex) are used in the various commands available with the monitor. For example, G 02A6 means (to one monitor program) execute the program in memory starting at location 0000 0010 1010 0110 (the G is the Go command, 02A6 is the location).

### First the good news . . .

One great convenience of having the monitor program stored in ROM is its ability to be used immediately the power is turned on; it is not lost when the computer is turned off.

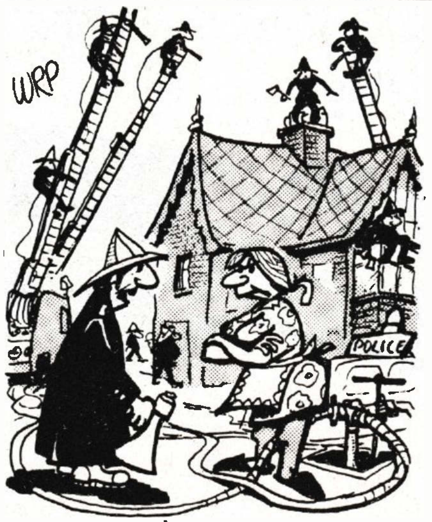
It can not be destroyed by a faulty program over-writing it, and should the operator lose control of the micro-computer he can recover by just pressing the reset button.

### And now the problems . . .

The big disadvantage of the monitor is needing a terminal to drive it. These are usually expensive — costing over $1000 when new. Even if you get hold of a terminal, you will have to spend a lot of effort learning the correct operating procedure, but I have yet to find anyone who has found this impossible.

The ROMs included in evaluation modules are limited in size, the largest containing some 1024 locations. They can do only so much and each manufacturer has his own ideas on what features he thinks are important.

So if you decide to use the monitor check out what features each monitor has, and don't be swayed because one type has more commands than another.●




*ANY MINUTE NOW LADY — THESE NEW AUTOMATIC MONITOR SYSTEMS ARE PRETTY CUTE AT PREDICTING MAJOR FIRES*

# Introducing Lux's new L30 amp. and its stablemate the T33 tuner. Now you don't have to be rich to use Lux workmanship to make the heart of your system beat.

The reputation of Stradivarius as a maker of fine violins remains unequalled. Although other violin-makers tried to imitate him, an expert can always tell the imitations from the Master's own violins. Somehow, no-one succeeded in matching the Stradivarius workmanship, which gave his violins a special timbre and clarity of their own.

In these days of mass-production and corner-cutting techniques, workmanship is a rare commodity.

Yet the Lux reputation, like that of Stradivarius, is based on those exceptional tonal characteristics which nothing but great attention to detail can bring about.

**A word about Lux:**

For more than fifty years, Lux has concentrated on making superlative amplifiers, and is probably the oldest established amplifier manufacturer in the world.

Very early, the company concerned itself with the problems of tube output transformers and the degradation they tended to impose on otherwise excellent designs. Lux transformers are highly-regarded. Recently, the company developed two new vacuum tubes, the G 6240G and 8045G, which are now being used in an advanced breed of Lux vacuum state amplifiers.

The company's equipment is aimed at the audiophile who wants perfection and is prepared to pay for it.

**Luxman's L30 integrated (32w RMS per channel) amplifier** brings the benefit of the company's experience to serious audiophiles who do not require unusually high power output or special facilities.

The L30's specifications demonstrate this was done without compromising performance: The output stage consists of pure complementary circuitry with a combination of PNP and NPN transistors. Crossover distortion is kept extremely low while high reliability is realized by the use of TO-3 transistors with good heat-dissipation . . . Transistors of high cut-off frequency at the driver stages suppress distortion in the treble range.

**A tuner developed to match: the T33.**

A superior tuner can significantly enrich audio life and provide an endless supply of material to add to your personal tape library. It should come as close as possible to connecting the studio to the amplifier. Thus it should eliminate noise, interference and distortion inherent in transmission.

The (PPL) Phase Locked Loop MPX 1C automatically locks the phase of the subcarrier generator with that of the incoming pilot signal. Similarly, each of the tuner sections (front-end, detector, I.F. circuit, AM section) have been given the usual Lux attention to detail.

**We would like you to know more about the Lux L30 and T33.**

Feel free to write to us. We'll give you all the help we can.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I/LUX/3002
Creative Load

# THE I/O INTERFACE

## How the computer can drive external circuits

A computer doesn't just handle information, it doesn't simply communicate with the operator. In most applications it is required to control devices directly, to automatically act in real time on input signals to produce programmed effects in some external system.
And this machine-to-machine communication is done via the I/O interface.

THE I/O INTERFACE IS THE circuitry that connects the micro-computer to the equipment you want it to control or monitor. Each connection is usually referred to an input port or an output port depending on which way the data is flowing.

Since all practical uses of the computer will need I/O ports, the number available and their ease of use are important considerations for the user. Without specific knowledge of the devices you intend to connect to the evaluation board it is impossible to know how many I/O ports you will need, so try for as many as possible. Also check out the nature of the port. Is it buffered, what can it drive, what can I connect directly to it?

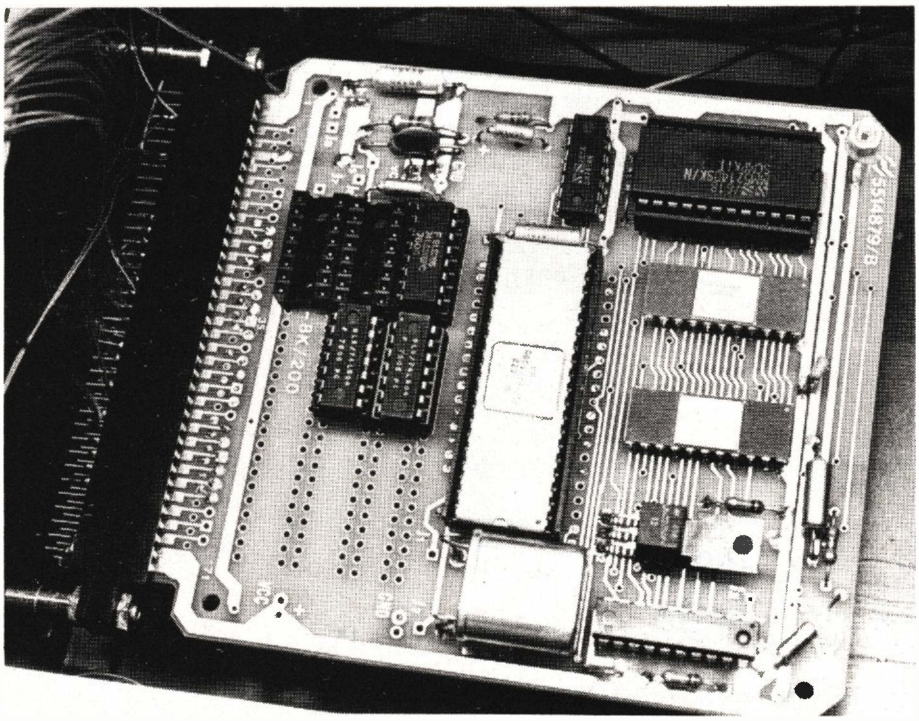
Data passing through I/O ports will (at one stage of their journey) travel via the evaluation board's data bus. To do this it will have to be time-multiplexed. In some systems this multiplexing has to be done by the circuit you have to build and add to the board. If you are unfamiliar with the techniques involved, it is definately worth your while to go for boards that include special I/O ICs called Interface Adapters.

One such IC is called the PIA (Peripheral Interface Adapter). This will interface two 8-bit bi-directional data buses and four control lines onto the evaluation board data buses. These PIAs can be programmed by the micro-processor to act as inputs or outputs depending on the requirements at that time. The outputs are also latched so that once a level has been established on a port it remains that way until new data is outputed.

The PIAs are also family-compatible with the MPU and observe the required loading rules.

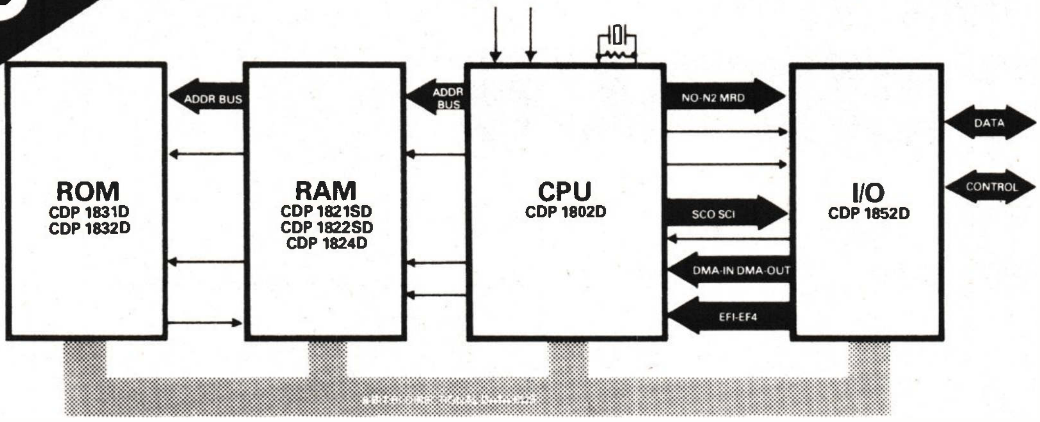
Another type of interface adapter (ACIA, for Asynchronous Communications Interface Adapter) will perform the function of serial data transmission. In this device the 8-bits sent out as a parallel word by the MPU are serialised and transferred one bit at a time. Such interfaces are handy when it comes to interfacing to tape recorders transmitting data over a single wire pair.

Generally such interface chips expand the I/O capability of the evaluation boards and make interfacing easier for you. Not all boards have them and those that do are more expensive, so think carefully about your needs before you decide. ●



*The I/O capabilities vary from kit to kit, some have it, some don't. In this example we look at the Scamp board, which comes without I/O. However if you look at the left of the board you will see the chips we have added to take care of this.*

# Announcing




# the 1-chip COSMAC μP

Now, a CMOS system that really delivers the promise of the microprocessor. It's the expanded RCA 1800 family with CDP1802, our new one-chip COSMAC CPU. And it gives you an unsurpassed combination of flexibility, performance and cost effectiveness.

Simple COSMAC architecture lowers memory costs because of 1-byte instructions and internal address pointers. It also reduces I/O costs. Plus design and learning costs.

Then you have the familiar CMOS savings. Single power supply. Single-phase clock. Less cooling and other equipment, thanks to low power and high tolerances.

For all these reasons, we believe no other microprocessor matches the RCA 1800 for system cost effectiveness. What's more, you can get the whole system from us: CPU, ROM, RAM, I/O. Everything you need including complete design support.

For further information on the above and other solid state products, please contact:

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**Amalgamated Wireless Valve Company Pty. Ltd.**
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AD81

# LITERATURE

**on the chip, the system and programs.**

Why are manufacturers putting their marketing effort into distribution of this literature?
Because before you buy an evaluation board you're going to need lots of information . . .

EACH KIT COMES WITH A PILE OF information, designed to offer assistance in three main areas:

1. Details on how to put the kit together and how to operate it.
2. Technical details on the microprocessor and the support chips supplied to make the microcomputer. Such information usually includes details on the microprocessor instruction set, timing diagrams, and loading rules as well as application information.
3. Programming manuals with detailed explanations of the software support available. These programming manuals go beyond evaluation boards and deal with commercial time sharing services and developmental systems. The cost of such systems is an order of magnitude greater than the price you pay for your evaluation kit.

To the hobbyist the first two listed above are the most important, especially the technical details and application notes. It is this information you will have to use to interface to your computer. It is strongly recommended that you at least have a look through this material before buying an evaluation board for two reasons:

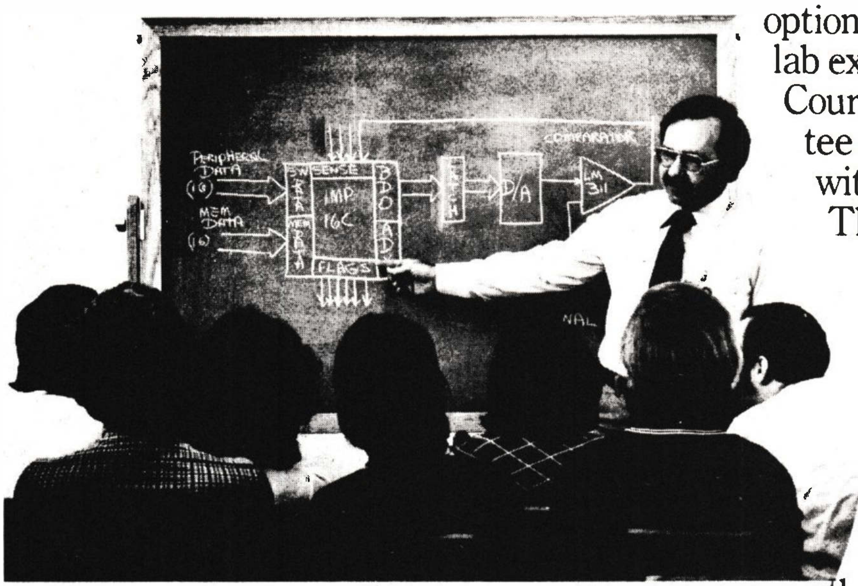
First, to give a measure of the difficulty involved in making the system work so you can decide whether your knowledge and experience is up to such a project.

And second, to learn what the evaluation board involves; this information can help you decide which system to choose. ●


*The documentation that came with the evaluation boards we are looking at this month. You can see the different amounts of information offered by each manufacturer. However, much of this information will be of little practical use to the amateur.*

# Our newest micro device is connected

## Lectures.




Introducing National's new microprocessor schools.

These aren't your sales-oriented "seminars" that various manufacturers hold on occasion at hotels. These are permanent, fully-equipped training centers dedicated to the thorough, systematic education of the engineering community to the ins and outs of microprocessing.

Located in Sydney, and Melbourne, our Training Centres will offer extensive hands-on training to reinforce class lectures. There'll be at least one lab station for every 2/3 students (consisting of a microcomputer, Disc Operating System, terminal, and experimental peripheral devices for solving class problems).

In each course we'll work your tail off for four days, with a fifth, optional day available for extra lab experience and consultation. Course prerequisites guarantee that you'll be working with others at your level.

The courses cost $395 each.

**Microprocessor Fundamentals.** Stored program concepts, logical functions, basic stuff like that.

You can be dumb as a turnip about microprocessing, but it'd help if you know something about digital design techniques, binary numbers, hexadecimal numbers, and Boolean algebra.

**Programmable Systems Design.**

An in-depth course on IMP-16, SC/MP and PACE applications and interfaces.

For this one you should either have taken our basic course or otherwise have a basic grounding in microprocessor concepts, software, programming and interfacing.

**Advanced Programming.** This one's for the guy who'll write complex applications software.

It'll cover hairy stuff like fixed frequency events, real time software design, and system timing considerations.

Prerequisites are considerable ...check with our Training Centre.

# processor input to your brain.

**Lab.**

CLASS SCHEDULE

| SCHOOL LOCATION | MICRO-PROCESSOR FUNDA-MENTALS | PROGRAM-MABLE SYSTEMS DESIGN | ADVANCED PROGRAM-MING |
|---|---|---|---|
| Melbourne | March 7-11 | Dec. 6-10<br>Oct. 4-8 | May 30-<br>June 3 |
| Sydney | | April 18-22<br>Nov. 1-5 | |

**For Further Information:** Call or write the Training Centre nearest you:

Melbourne Microprocessor Training Centre, N. S. Electronics Pty. Ltd.
Cnr. Stud Rd., & Mountain Hwy.,
Bayswater, Victoria, 3153
(03) 729 6333

Sydney Microprocessor Training
N. S. Electronics Pty. Ltd.
2-4 William Street, Brookvale,
2100. (02) 93 0481

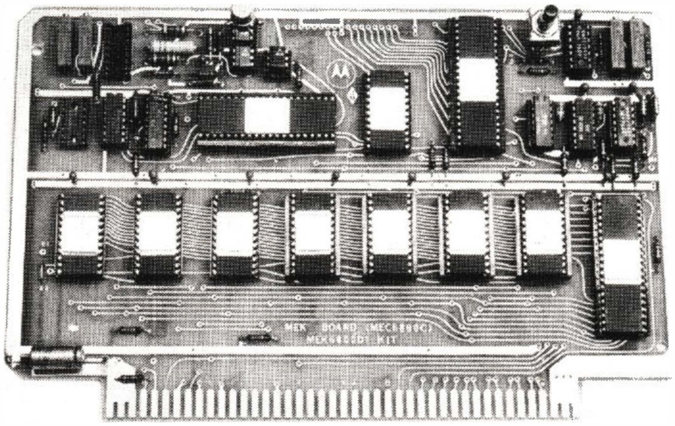
**National**

There's more to microprocessing than microprocessors.

# KIT SUMMARY

This month we look at evaluation kits from Motorola, Intel, National Semiconductor and Fairchild. Next month we will look at other kits, like those from Signetics & RCA.

## MOTOROLA



### MOTOROLA EVALUATION KIT MEK 6800 D1

| | |
|---|---|
| **Microprocessor chip —** | MC 6800 |
| **Word size —** | 8-bits |
| **Technology —** | NMOS |
| **Chip memory addressing capacity —** | 65K |
| **No. of instructions —** | 72 |
| **No. of addressing modes —** | 7 |
| **CLOCK —** | adjustable over a ten-to-one range |
| **RAM** — supplied with kit — | 256 words with room on board for expansion to 768 words. |
| **ROM —** | 1024 word, mask-programmed. Containing two monitor programs of similar functions called MIK BUG and MINI BUG. |
| **I/O —** | 2 PIA s type MC 6820<br>1 ACIA " MC 6850 |

Using MIKBUG one PIA has its connections taken to a connector at the edge of the pc board. The other PIA is used by the monitor program to interface with the terminal.

Using MINIBUG the terminal interface is the ACIA.

Maximum number of buffered I/O ports that can be utilized = 36, plus 4 interrupt lines plus 1 serial interface with 4 control lines.

The data, address and control lines connected to the MPU appear on a 86-pin edge connector. This board also has a RS232 interface along with the TTY 20MA interface. Both of these interfaces are DC-isolated from the rest of the board.

### DOCUMENTATION

| | |
|---|---|
| **Assembly Instructions —** | easy to understand and follow |
| **Technical Details —** | Vast. Plenty of details and circuits. Single step circuit included. |
| **Programming Manuals —** | Plenty of detail with most aimed at the industrial designer. |

### MONITOR PROGRAM:

**Command Types —**
(1) Memory Loader
(2) Print and Punch Memory
(3) Memory change
(4) Display working registers

(5) Go command
(6) Set Break Point with memory change

## POWER SUPPLY

**Required —** + 5V @ 1 amp
+12V @ 100 mA
−12V @ 50 mA

**Note —** ± 12V required for TTY interface only

**Size of pc board —** 248 mm x 153 mm
**Price —** $149.00 plus tax (Note the 6800 [MPU] and 6810 [RAM] chips are difficult to obtain at the moment).

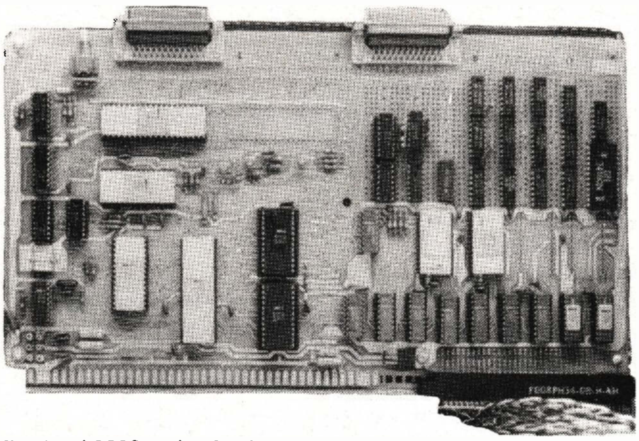
**Kit available unassembled —** yes
**Extra Components Required —** YES. Only MOS chips and pc board included (under part number MEK 6800 D1).

## DOCUMENTATION

**Assembly Instruction:** 16 pages on putting the kit together (see comments).
**Systems Reference and Data Sheets:** A 63-page run-down on each IC in the 6800 family. Rather technical in nature but essential to know. Would appear brief to a non-technical person.
**Microprocessor Programming Manual:** Ten chapters, 120 pages. The first five chapters are worth reading for the information about programming. The remaining five are concerned with more serious work with the expensive development systems. Appendix A (76 pages) is a formal description of the 6800 instruction set.
**Microprocessor Applications Manual:** Seven chapters, 640 pages. First three chapters deal with making the 6800 family of chips go. The emphasis then moves to hardware industrial applications with plenty of examples. Chapter six deals with software **systems** once again with practical examples. Chapter seven deals with the use of developmental systems and is aimed at the industrial user.
Certainly worth reading. Unfortunately most of the examples will not be of that much direct use to the guy at home, but it does demonstrate the principle of how to do things.

**COMMENTS:** The assembly of the 6800 fit was complicated by having to chase up the extra parts not supplied. In the end a number of substitutions were used in an effort to get things moving (in particular, reducing the value of the pull-up resistors on the outputs of the clock driver). This happened when the kits were first released and Motorola have since said that supply of the extra parts is no longer a problem.
Some people have also had difficulty obtaining sockets for P1, P2, P3. Ours were obtained from PYE Technico at Marrickville and CES, Crows Nest.
If you assemble a 6800 board pay particular attention to parts positioning. While it's obvious where the ICs go, many of the small components can quite easily be misplaced. The large number of plated-through holes makes it confusing. If in doubt, check on the circuit diagram.
Note also the circuit supplied with our evaluation kit shows two R2s, where only one is required. And it shows R30 and R31 going to ground when the photo shows them going to +5V. Having not used the ACIA yet, we'll leave that problem for you to sort out.
Note also that the Motorola set-up procedure calls for a CRO when first switching on to set up clock frequency. The alternative is to set the clock half-way and use trial and error.

# INTEL



*The Intel 8080 evaluation board: note the extra components in the top right corner, these we added to make a front-panel interface (see the front-panel itself in the article on terminals).*

### INTEL EVALUATION KIT SDK-80

**Chip memory address capacity —** 65K
**No. of Instructions —** 72

**Microprocessor chip —** 8080A
**Word size —** 8-bits
**Technology —** NMOS
**No. of addressing modes —** 4
**CLOCK —** crystal controlled
**RAM — supplied with kit —** 256 words with provision on board for expansion to IK words
**ROM —** 2048 words in two reusable PROMs one ROM is blank and the other contains the monitor program.
Provision on pc board for a total of four PROMs.
**I/O** 1 PIA type 8255 with 24 programmable input/output ports and provision on the pc for another 8255.
1 Serial interface type 8251 suitable for synchronous or asynchronous data transfer. The 8251 is used as the interface with the terminal over a 20 mA TTY interface, an RS 232 interface or TTL interface.
Any interface can be selected by jumper wire.

**DMA —** MPU chip has DMA, capability allowing the use of your own front panel interface.

## DOCUMENTATION

**Assembly Instruction —** easy to understand and follow
**Technical Details —** compact and technical
**Programming Manuals —** of most interest to the industrial user with plenty of money.

## MONITOR PROGRAM

**Command types —**
(1) Memory loader
(2) Print and Punch memory
(3) Memory change
(4) Display working Registers
(5) Go command
(6) Set Break Point with memory change
(7) More memory (from one location to another location)

## POWER SUPPLY

| | | Minimum System | Maximum System |
|---|---|---|---|
| **Required —** | + 5V | 1.3A | 2.1A |
| | +12V | .35A | .45A |
| | −10V<br>−12V | 100 mA | 300 mA |

**Price —** $320 plus tax
**Kit available unassembled —** Yes
**Extra components required —** Complete for most applications, you might have to buy an edge connector depending on how you mount the pc board.

**COMMENT:** The 8080 chip is probably the most common of the 8-bit microprocessors in use at this time. The way the instructions can work on the many internal registers gives the 8080 considerable flexibility when writing a program.

The pc board also has provision to take around fifteen or more DIL ICs. Sufficient room in fact for enough ICs for a front panel interface. See photo.

**COMMENT:** The things I like about the Intel module are the ~~well~~ presented assembly instructions and drawings, the fact that the overlay is stencilled on the pc board, that all components (including two I/O sockets) are supplied, and this module worked first go when power was switched on.

## DOCUMENTATION

**SDK-80 User's Guide** gives 21 pages of assembly instructions, the monitor program operating procedure (five pages), and monitor program listing.

**User's Manual:** These 200 pages are used as follows: 13 pages explaining the operation of the 8080 microprocessor chip, 6 pages on interfacing, 15 pages explaining the instruction set, and 173 pages on data sheets and explanation of the various support ICs.

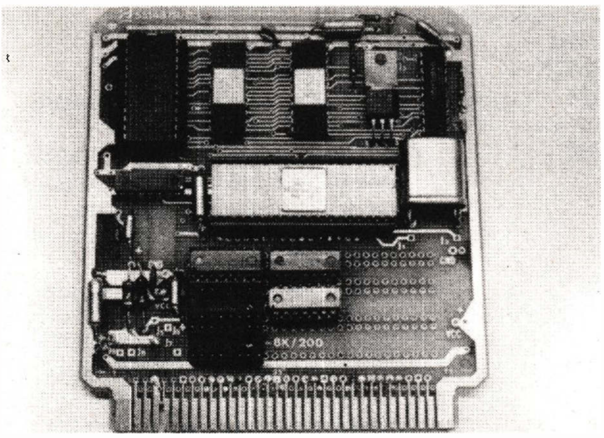
Plenty of fact, without too much explanation, and no practical application material; the guy at home will find it very dry going.

**Assembly Language Manual:** The first 41 pages explain what each instruction does and how to code it — **valuable stuff.** The next twenty pages deal with macros — valuable to the industrial engineer and those who have 'assembler' programs.

**PL/M Programming Manual** is a tutorial introduction to the PL/M language and so is of little use to the home construction.

**PC board size —** 169 x 308 mm

# NATIONAL



*The Scamp board. The five IC sockets (and the ICs in them) at the bottom of the board don't come with the evaluation module.*

## NATIONAL SC/MP MICROPROCESSOR KIT

**Microprocessor chip —** ISP-8A/500 or 'SCAMP' for short

**Word size —** 8-bits
**Technology —** PMOS
**Chip Memory Address capacity —** 65K (top 4 bits of address multiplexed via data bus).
**No. of Instructions —** 46
**No. of addressing modes —** 4
**CLOCK —** Fixed with 1 MHz crystal (supplied) (can be made variable with a capacitor).
**RAM —** 256 words supplied with kit.
**RAM —** 256 words supplied with kit.
**ROM —** 512 words. **Some** kits come with UV reusable ROM* and some don't.
**I/O —** No general purpose points. Only a driver and receiver for interface to the terminal (20 mA TTY).
**DMA —** MPU has DMA capability suitable for use with a front panel interface (but you have to build it).

**identifiable by the clear window above the chip.*

## DOCUMENTATION

**Assembly Instructions** very easy to understand and follow. Not only do the instructions tell you what to do, but also what you can not do. Assembly instructions found under the heading STUFFING PROCEDURES!

**Technical Details** comprehensive and simple presentation make these details easy to understand. Single step circuit included.

**Programming Manual** aimed at the industrial designer, however, the section on programming techniques and information in the Appendix is worth reading.

## MONITOR PROGRAM

**Commands —** (1) Print memory
(2) Memory change
(3) Display working registers
(4) Go command
(5) Set Break Point with memory change

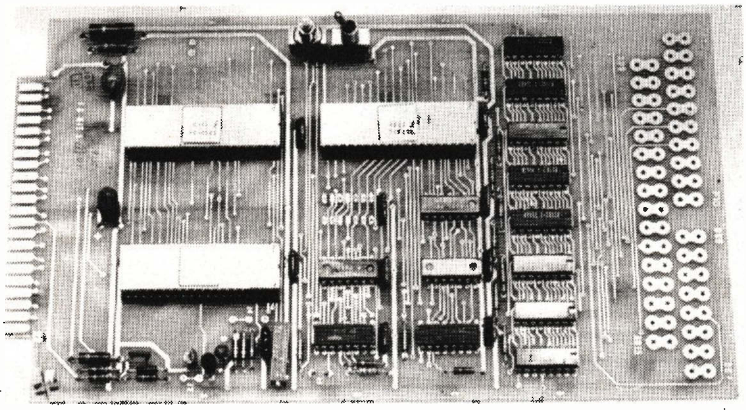
## POWER SUPPLY

**Required —** + 5V @ 350 mA
−12 V @ 200 mA

**Price —** $79.50 plus tax

**COMMENT:** Kit comes complete with all parts including edge connector. As the name says, the Simple Cost-effective Micro Processor, or SC/MP, evaluation kit is easy to learn, making it ideal for those who feel fearful of the more complicated microprocessors.

# FAIRCHILD



### FAIRCHILD F8 EVALUATION KIT

**Microprocessor —** 3850 CPU and 3851 PSU
**Word Size —** 8-bits
**Technology —** NMOS
**CLOCK —** adjustable
**RAM —** chip can address 65K. Kit supplied with 1024 words together with 64 words as part of CPU chip. No provision for on-board expansion, however the signals needed to expand memory are taken to a row of holes making interfacing to your own memory board relatively easy.
**ROM —** 1024 words and contains the monitor program FAIRBUG. The ROM is part of the 3851 chip and is factory-programmable only.
**I/O —** Board contains four 8-bit I/O ports giving 32 individual I/O ports, each capable of driving at least one TTL load. Two of the 8-bit ports are assigned to handling the monitor program's interface and are not always available for general use when the monitor program is running.

The normal monitor interface is the TTY 20 mA current loop, but provision is made on the board for a wiring change to give a RS232 interface.

**No. of Instructions —** over 70
**Addressing Mode —** 8 modes. This number is high because of the different architecture of the F8 (compared to other MPU s).
**PC Board Size —** 133 x 233 mm

## MONITOR PROGRAM

**Fairbug commands —** allow the following:
(1) to display or alter memory locations as well as the microprocessors working registers
(2) Punch paper tape
(3) Load paper tape
(4) Go command
(5) To set program break points

## POWER SUPPLY

**Required —** + 5.0V at 500 mA
+12.0V at 100 mA

## DOCUMENTATION

**Assembly Instructions** — the kit was supplied assembled, so these instructions dealt with connecting up the TTY terminal or modifying the board for an RS232 interface, and with the operating procedure for FAIRBUG.

**The Preliminary F8 Microprocessor Data Book** — gives over 130 pages of data on the F8 chip set. As well as electrical specifications, there is a functional description of each chip. In all 5 ICs are discussed in detail and 4 in short form.

**A Guide to Programming the Fairchild F8 Microcomputer** — contains 250 pages of detail on how to program the F8 system. 57 pages are spent explaining the microprocessor instruction set and 57 pages on programming techniques. The book starts off with basic concepts and ends up discussing program optimization.

**A Timeshare User's Guide** — mainly for the commercial users who can afford expensive on-line terminals, this

## KIT SUMMARY

manual uses 100 pages to explain how to use the GE time-sharing system on the National CSS time-sharing system. Too heavy for the guy at home.

**COMMENTS:** Although it was the last evaluation board to arrive in the workshop, the F8 was the one we got going in the least time, thanks to the board arriving assembled.

The first thing that became evident was the difference between the architecture of the F8 system and the architecture of the other systems tested. The F8 distributes several functions over a group of chips rather than making each chip perform one function. The 3850 CPU chip, for example, contains the arithmetic logic unit as well as two 8-bit I/O parts and a 64-word memory.

The evaluation board manages to become a versatile microcomputer with a small number of ICs. Couple this with the 1024 words of RAM that comes with the board and you get good value for an outlay of under $200. Unfortunately, it seems that only those with terminals will be able to make full use of it, because as yet we have found no **simple** way of interfacing an operator's 'front panel' and no single-step circuitry could be found in the application notes. The word 'simple' is stressed because in electronics there are always ways to do things, the trick is to find a simple way.

It should also be noted that a CRO is called for by the assembly instructions to set the clock frequency for maximum operation rate and set up the correct bit-rate for the terminal. ●

# MICROPROCESSOR AT WORK

This article, by Tim Hendtlass of the Royal Melbourne Institute of Technology, follows on from our Introduction to Microprocessors published last month.

BY NOW IT WILL BE CLEAR THAT A microprocessor can do many things other than just the logical and arithmetic operations of the hardwired logic it may replace. To be able to do all these things it has to be quite complex internally. It will consist of thousands of semiconductors which can be divided into a number of sections and Table One lists the names and features of some of the more common sections.

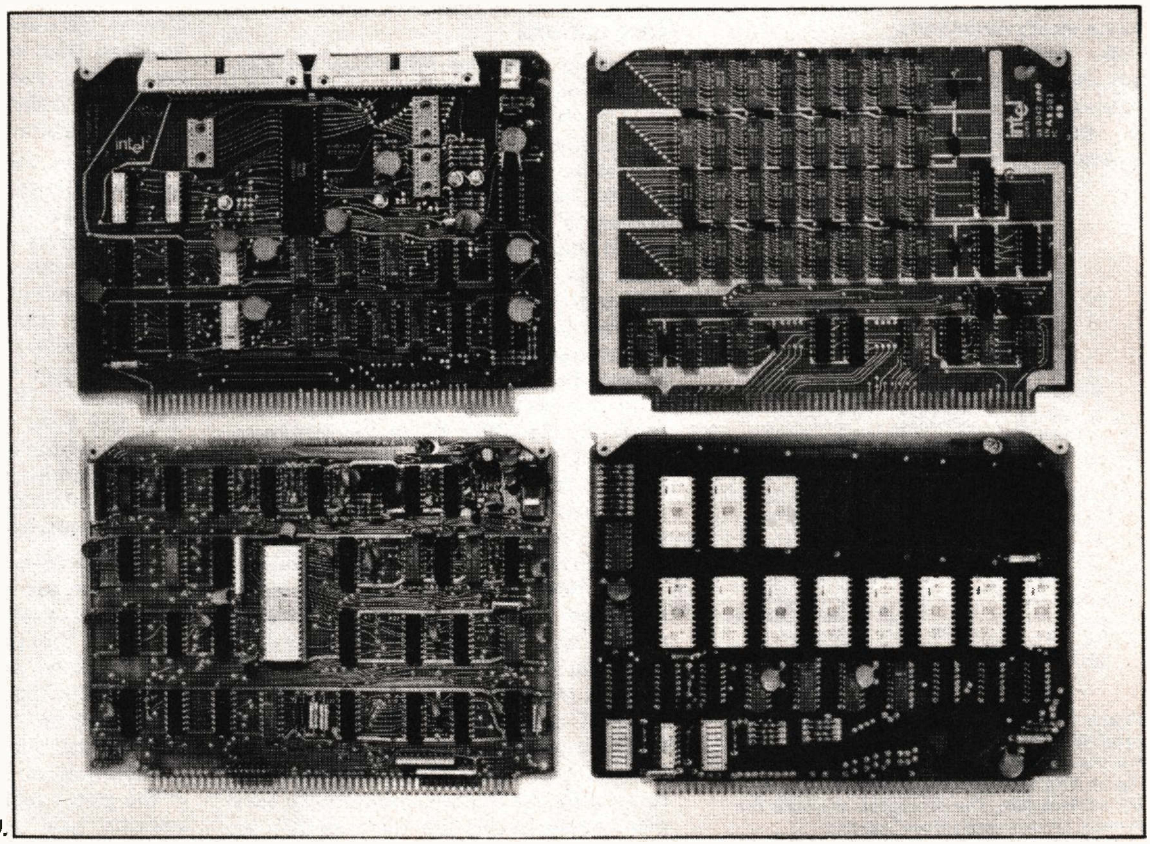
## A specific operation

To follow this example you will need to refer to Table One for explanations of new terms like accumulator, register, program counter, etc. When first used these terms will be in bold type. The example will show the step-by-step approach of the MPU and show how useful mnemonics are in programming.

## Three instructions in the program

Let us assume that the MPU is executing (running) a program and has reached a point at which it is to add a binary number stored at memory location 1000 Hex (or base 16) (this is a short way of writing the binary number 0001 0000 0000 0000) to the number in the **accumulator** and save the result in the **temporary register** C on the chip. This needs three instructions (for an Intel 8080 MPU) which are written:

*First instruction:* LXI H, 1000H;
(load the 16 bit **index register** consisting of **register** H and L together with 1000 Hex)
*Second instruction:* ADD A, M;
(add the byte found at the memory location specified by H and L to the accumulator)



*The electronic reality of a micro computer. The four boards are input (top left), CPU (bottom left), 32,768 bits of volatile RAM memory (top right) and some non-volatile memory (bottom right).*
*The eleven 1702A EPROMs on this last board can hold 22,528 bits of information indefinitely without needing power. They may be erased (cleared) at any time by shining ultra-violet light through the quartz window on each package onto the actual semi-conductor chip (the dark squares in the centre of each package). The EPROMs can be removed and reprogrammed with a special programmer (hence the socket mounting).*
*A complete micro computer will also need a power supply (not shown).*

## TABLE ONE MICROPROCESSOR MICRO-DICTIONARY

**Central Processing Unit (CPU):** A group of registers and other logic that form the arithmetic/logic unit plus another group of registers with associated decoding logic that form the control unit.

**Accumulator:** A register that adds an incoming number to its own contents and then substitutes that result for the original contents. This register is accessible to the programmer.

**Register:** Logic elements (gates, flip-flops, shift registers) that taken together, store 4, 8, 12 or 16 bit numbers. They are essentially for temporary storage in that the contents often change from one instruction cycle to the next.

**Temporary Register:** A register used for very short term storage by the CPU and over which the programmer has no direct control.

**Program Counter:** A register whose contents normally correspond to the memory address of the next instruction to be carried out. The count usually increases by one as each instruction is carried out, since program instructions are usually drawn from sequential locations. This register is accessible to the programmer.

**Instruction Register:** A register used to store the binary code for the operation to be performed. This register is not normally accessible to the programmer.

**Storage Register:** A register used for storage which is totally under the control of the programmer.

**Status Register — Flag:** The status register consists of a series of flags each of which is a flip-flop that indicates some aspect of the status of the central processor. Individual flags often occur which are not grouped together into a register.

**Stack Pointer:** A register whose contents correspond to the memory address of the top of the stack. It is under the control of the programmer.

**Index Register:** A register used to hold an address. An instruction may either use the contents of this (specified) register directly or add an offset (part of the instruction) onto the contents of the specified register to produce an effective address and then use this effective address. Useful, for example, for addressing tables.

**Address Bus:** The collective name given to a group of signal paths along which the voltage levels of the desired address are distributed throughout the system.

**Data Bus:** The collective name given to a group of signal paths along which the voltage levels that make up data words are distributed from the CPU to all points in the system or from any point in the system to the CPU (but not both ways at once).

**Direct Memory Access (DMA):** A technique by which a peripheral device enters or extracts blocks of data from the microcomputer memory without involving the CPU

*Third instruction:* MOV C, A;
(move what is the accumulator (A) to **storage register** C)
(the instruction mnemonics are in capital letters, the brackets contain explanatory comments)

You should now see why mnemonics are useful — imagine writing a program if you had to write the full description in the brackets every time. The mnemonics vary from one MPU to another, the manufacturer can provide you with a list for any particular machine.

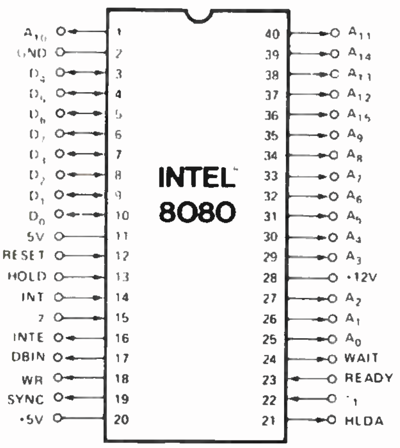



*Figure 1. This is the pin diagram of the Intel 8080 microprocessor chip. $D_0$ to $D_7$ are the eight parallel lines of the data bus. $A_0$ to $A_{15}$ are the sixteen parallel lines of the address bus. The other pins are used for timing, control and power supply.*

### How the MPU handles these instructions

Assuming that the MPU has finished processing the previous instruction and as a result the **program counter** is pointing to the start of our first instruction (in other words the program counter register contains a number which is the address of the memory in which will be found the first byte of our first instruction) the MPU does a fetch cycle. First this puts the contents of the program counter out on the **address bus.** Then the unique memory cell which has that address responds by putting its contents onto the **data bus** along which they return to the MPU. When the MPU gets the data it puts it in the **instruction register.** While the MPU was waiting for the memory to respond it incremented (added one to) the program counter so as to be ready for the next fetch cycle.

Internally the instruction register is inspected to see what kind of instruction is to be done this time and if it is complete (a one-byte instruction) or if there is more to come. In our example the first byte is the LXI H part so the MPU knows there are two more bytes to get and that when they arrive they are to go into the H and L registers. So two more fetch cycles are done similar to the instruction fetch except that when the data is received it is put into a temporary register (instead of the instruction register) and then into the final destination register. The program c counter has been incremented after each fetch so that now the first instruction has been completed the program counter is pointing to the start of the second instruction.

Again an instruction fetch is done (and the program counter then incremented) but, of course, the instruction which arrives into the instruction register is not the same. In this case when it is internally inspected it is seen that it is a complete instruction in one byte, as there is no further byte to get the MPU can start implementing the instruction. The instruction requires that the data stored in the memory location whose address is in the H and L register combined should be added to the contents of the accumulator, so first this data must be brought to the MPU.

The contents of H and L registers are put out on the address bus and the data returns as usual on the data bus and is put into the temporary register. This then is added to the accumulator. You might think that this would be the end of it, but no — one further operation takes place. Depending on the result of the addition, various **flags** are set or reset in the **status register**. If the result of the addition had been zero the zero flag would be set — if not it would be reset. If the result was too big to fit into the accumulator so that a carry out occurred then the carry flag would be set and so on.

(The main use of these flags is for those 'jump on condition' types of instructions we invented back crossing the road in the Introduction to Microprocessors article. Had the next instruction been jump if zero to 2000 H for example, as soon as the instruction had been received the zero flag would be checked. If zero the MPU would do a jump — replace the contents of the program counter with 2000 H and carry on. If the zero flag was not set, the rest of the jump instruction would be ignored and the next instruction fetched. The carry flag is also used in multibyte arithmetic — if there was a carry out then this carry is added onto the result obtained from the two next most significant bytes.)

The MPU has set the flags and finished the second instruction of our little program. The program counter is already pointing to the start of instruction three so a normal instruction fetch is done. Again, when inspected, this is recognized as a single byte instruction, and, even easier, in this case no further reference has to be made off chip at all. So the contents of the accumulator are copied into storage register C replacing whatever was there. The contents of the accumulator remain unchanged by the way.

. . . . . . END OF PROGRAM. . . . . . .

Our three-instruction program is finished — it took quite a few words to describe what happened (about 550!) but the 8080 would do this in twenty two machine cycles (little bursts of activity on the chip) and take about eleven millionths of a second over it. You don't have to understand what is going on blow by blow on the chip to use an MPU as long as you know the overall effect each instruction has (the sort of thing I wrote in brackets in the example program). The reason I took you through this example, though, is that it helps understanding to have at least a general idea of what is on the chip. The example was constructed to introduce you to almost all the "private parts" of an MPU. The only common one missed was the **stack pointer** and now that we have met flags and how they are set I would like to add one

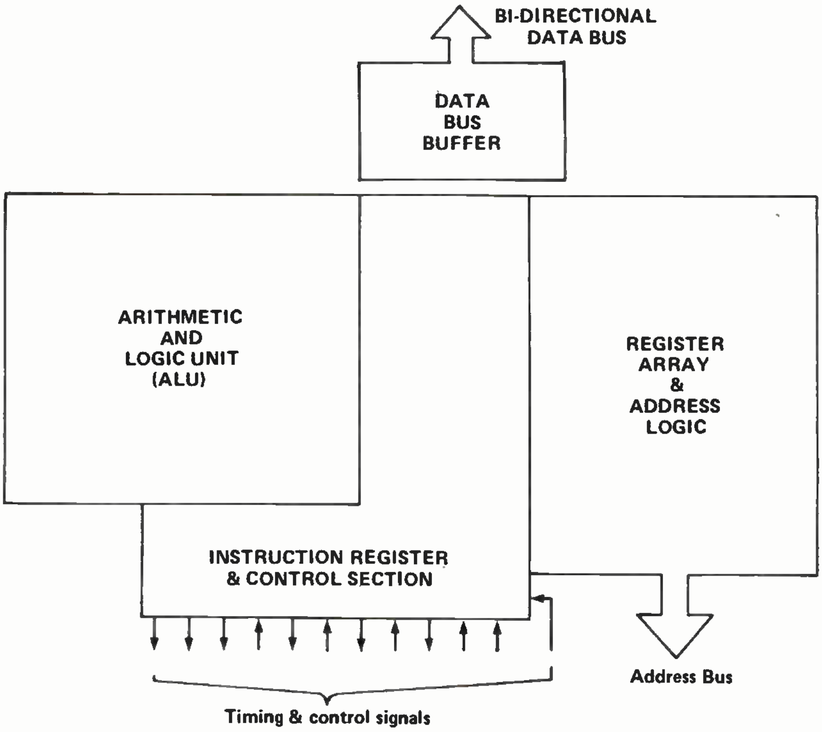



*Figure 2(a). The main functional units of the Intel 8080.*

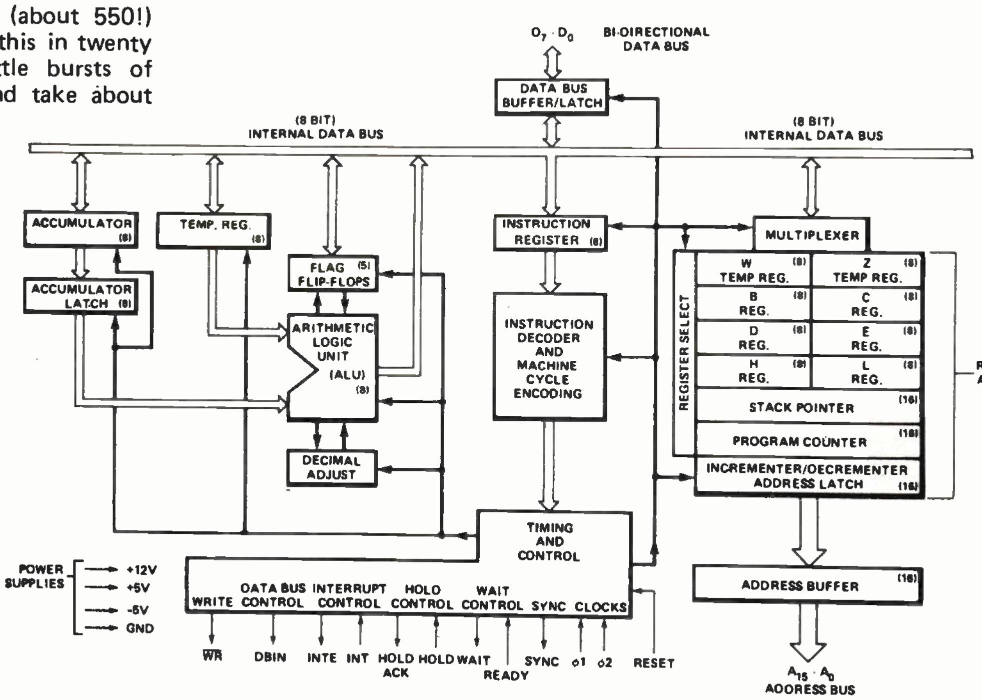



*Figure 2(b). More detail on the internal organisation of the microprocessor. All the elements described in the Microprocessor Microdictionary can be located on this diagram.*

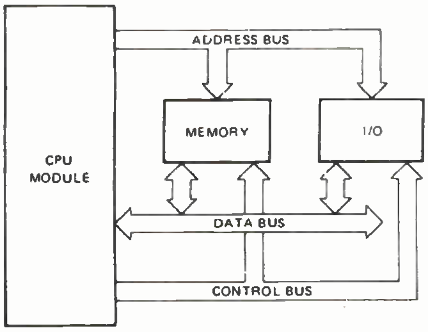



*Figure 3. How the buses connect the main parts of the computer.*

fourth instruction so you see what use a stack pointer has.

## And now a subroutine

Our fourth instruction is going to involve a subroutine, so perhaps I had better explain what a subroutine is. A subroutine is a small program that is so useful it is going to be used very frequently. An example might be a routine to multiply two numbers. In a longer main program there might be two or three hundred times when it is required to multiply two numbers together. Obviously it would be very wasteful to repeat the same block of instructions so many times so we find a way to use the one block of code in different places in the program.

This is done by jumping to the block in such a way as to enable us to come back to the next instruction in our main program when the subroutine has been finished. Instead of an ordinary jump, we first save the address of the next instruction in the main program on the top of the **stack** and then jump to the subroutine. At the end of the subroutine is a return instruction which causes a jump to the address on the top of the stack. The stack is like a pile of cards, you can vary the number in the pile but only have ready access to the card on the top.

Our fourth instruction might be:

*Fourth instruction:* CNZ 3000 H;
(Call if not zero the subroutine starting at location 3000 Hex)

meaning if the zero flag is not set, go and do the subroutine which starts at location 3000 Hex, and then come back and do the next instruction. If the zero flag is set do not bother with the subroutine but go immediately to the next instruction (after all, there is no point in multiplying by zero — we know the answer will be zero).

The fourth instruction would be processed internally as follows: An instruction fetch would get the first byte (CNZ) and put it in the instruction register. The zero flag would be checked; if it were set there is no point in fetching the next two bytes (which contain the starting address of the subroutine) and so the program counter would be incremented twice to point to the start of the next instruction and operation would continue with that instruction.

Had the zero flag not been set the sequence after testing the zero flag would be different. The next two bytes (the starting address of the subroutine) would be fetched and temporarily stored. The stack pointer (which contains the address of the top of the stack) would be consulted and the contents of the program counter (which has already been incremented by the last fetch to point to the start of the next instruction) would be put onto the top of the stack. It takes two bytes to hold an address so the stack pointer would be changed by two to point to the new "top of stack". Having saved the address to return to, the address of the start of the subroutine would be moved from temporary storage into the program counter so that program execution would continue from there.

It should be obvious that it will take longer to process this instruction if a branch to the subroutine occurs than if it does not (the actual times are about 8½ and 5½ millionths of a second respectively). At the end of the subroutine would be a return instruction which would cause the address stored on the stack to be fetched, the stack pointer returned to its original value and the saved address put in the program counter so that execution continued from instruction five (execution time of a return instruction is five millionths of a second).

## Where to from here?

Provided you have understood this article, you are now in a position to read the literature provided by the manufacturer of the microprocessor you are interested in. You have met the parts of an MPU, seen what extra is needed as well as the MPU to make a working system, and, most important, the types of instructions a microprocessor can do. Study the manufacturer's set of instruction types and you will have a fairly clear idea of what that MPU can do. You will find timing diagrams which tell you the exact order of occurence of the various small operations which together make up the execution of an instruction. They become important when you connect your MPU up to all those other components which are needed to produce a microcomputer.

If you have not quite followed this article, try re-reading it. Microprocessors are extremely logical in their organization (pun intended) and, with a little thought, all fits into place. Learning about MPUs is like learning about anything else — once you master it, it is hard to remember what it was that seemed so hard! ●

**INSTRUCTION SET**

**Summary of Processor Instructions**

| Mnemonic | Description | $D_7$ | $D_6$ | $D_5$ | $D_4$ | $D_3$ | $D_2$ | $D_1$ | $D_0$ | Clock Cycles |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Instruction Code | | | | | | | | |
| ▶ MOV r1, r2 | Move register to register | 0 | 1 | 0 | 0 | 0 | S | S | S | 5 |
| MOV M, r | Move register to memory | 0 | 1 | 1 | 1 | 0 | S | S | S | 7 |
| MOV r, M | Move memory to register | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 7 |
| HLT | Halt | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 7 |
| OUT | Output | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 10 |
| LXI B | Load immediate register Pair B & C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 |
| LXI D | Load immediate register Pair D & E | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 10 |
| ▶ LXI H | Load immediate register Pair H & L | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 10 |
| LXI SP | Load immediate stack pointer | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 10 |
| XRA r | Exclusive Or register with A | 1 | 0 | 1 | 0 | 1 | S | S | S | 4 |
| ORA r | Or register with A | 1 | 0 | 1 | 1 | 0 | S | S | S | 4 |
| CMP r | Compare register with A | 1 | 0 | 1 | 1 | 1 | S | S | S | 4 |
| ▶ ADD M | Add memory to A | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 7 |
| ADC M | Add memory to A with carry | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 7 |
| SUB M | Subtract memory from A | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 7 |
| SBB M | Subtract memory from A | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 7 |
| CC | Call on carry | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 11/17 |
| CNC | Call on no carry | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 11/17 |
| CZ | Call on zero | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 11/17 |
| ▶ CNZ | Call on no zero | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 11/17 |
| CP | Call on positive | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 11/17 |
| CM | Call on minus | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 11/17 |
| CPE | Call on parity even | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 11/17 |
| CPO | Call on parity odd | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 11/17 |

*The complete 8080 instruction set is more than four times as big as this.*

*Figure 4. The lines from the 8080 instruction set used to write the program described in the text.*

# ELECTROLUBE

REGD.

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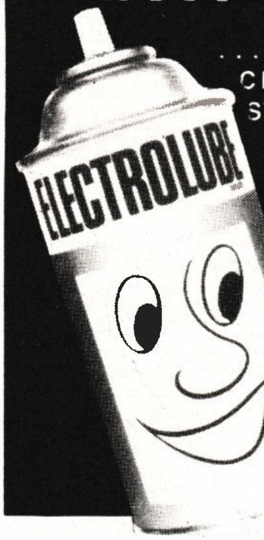


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| 4.7µF | 7c | 7c | 8c | 9c |
| 10µF | 7c | 7c | 9c | 10c |
| 22µF | 8c | 8c | 9c | 11c |
| 33µF | 8c | 9c | 10c | 13c |
| 47µF | 9c | 11c | 11c | 14c |
| 100µF | 11c | 12c | 13c | 17c |
| 220µF | 13c | 17c | 15c | 20c |
| 470µF | 18c | 23c | 21c | 32c |
| 1000µF | 24c | 37c | 31c | 40c |

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| .0033 | 7c |
| .0047 | 7c |
| .0056 | 7c |
| .0068 | 7c |
| .01 | 7c |
| .015 | 8c |
| .022 | 8c |
| .033 | 8c |
| .047 | 9c |
| .056 | 9c |
| .068 | 9c |
| .1 | 10c |
| .15 | 13c |
| .22 | 15c |
| .33 | 16c |
| .47 | 19c |

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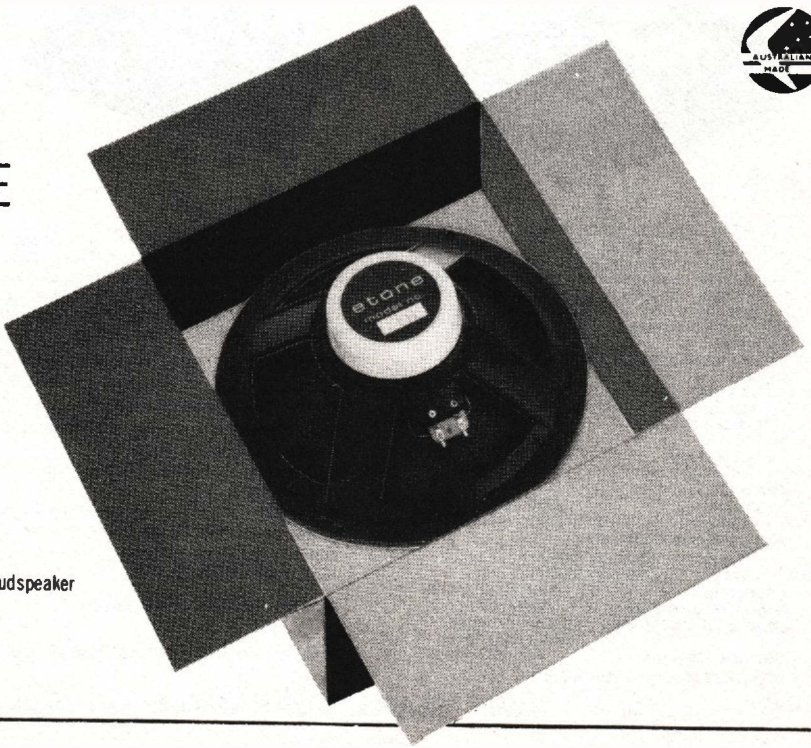


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Continuous Power Handling ........ 30 watts RMS
Recommended Amplifier Power .... 15 watts RMS
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AD82

# AUDIO PHASER

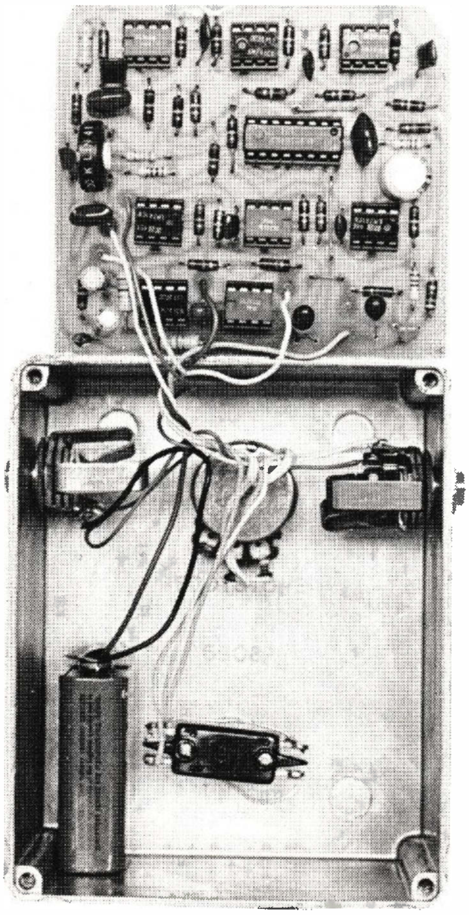
This six-stage phaser can make your electric guitar sound really spacey. And it costs less than thirty bucks to build.

THERE AREN'T MANY ELECTRONIC music accessories that we haven't published as projects in ETI and this project will make the list even shorter.

Most musicians will know what a phaser sounds like and it is going to be very difficult for us to describe the effect to readers who don't know the sound. It really has to be heard to be appreciated.

The most dramatic effect, and the easiest to describe, is that caused by feeding white noise through a phaser. The sound is similar to the sound of surf, an 'atmospheric' whooshing sound. On recordings phaser effects can be heard on electric guitars, drums, electric piano, and other instruments.

Technically the phaser acts as a filter — it phases out certain frequencies in the audio spectrum and over a period of a second or two these minima in the response curve sweep up and down the audio band. The response of the ETI phaser can be seen in Figure 3. Frequencies between 10 Hz and 4 kHz are present in varying proportions between 0 and 100% of the input signal level. As the values of the components in the phase-shift network change, the the proportions of these frequencies will change as the response curve moves up and down the audio spectrum.



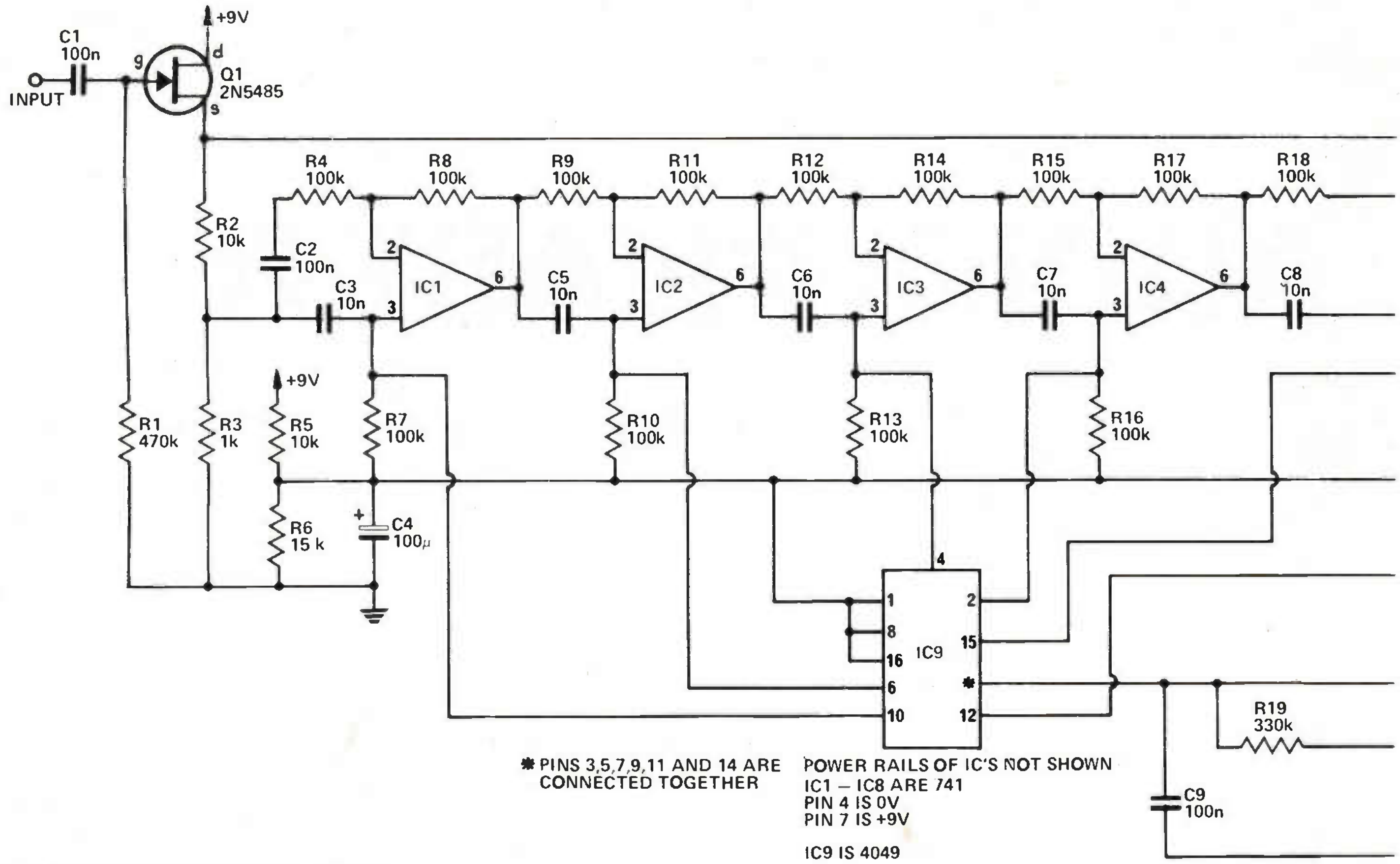



*Fig 1 Circuit diagram for the Audio Phaser*

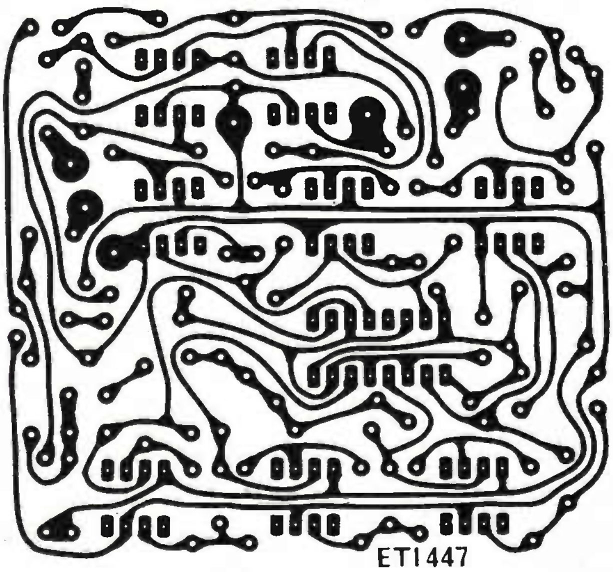



*Fig 2 Printed-Circuit Layout. Full Size 81 x 76 mm.*

### Specification ETI 447 Phaser

| | |
|---|---|
| Phase-shift stages | Six stages providing a maximum 1080 degrees phase-shift, and consequently three minima (see graph). |
| Frequency range | With 10n and 100k networks, minima at 40 Hz, 160 Hz, and 600 Hz. With 10n and 56k networks, minima at 70 Hz, 270 Hz and 1 kHz (as shown in Figure 3). With 10n and 10k networks, minima at 400 Hz, 1600 Hz and 60 kHz. In operation the resistive element of the phase-shift networks varies continuously and these minima sweep across the spectrum. |
| Input impedance | 500k. |
| Input sensitivity | 3 mV to 1 V. |
| Overall gain | unity. |

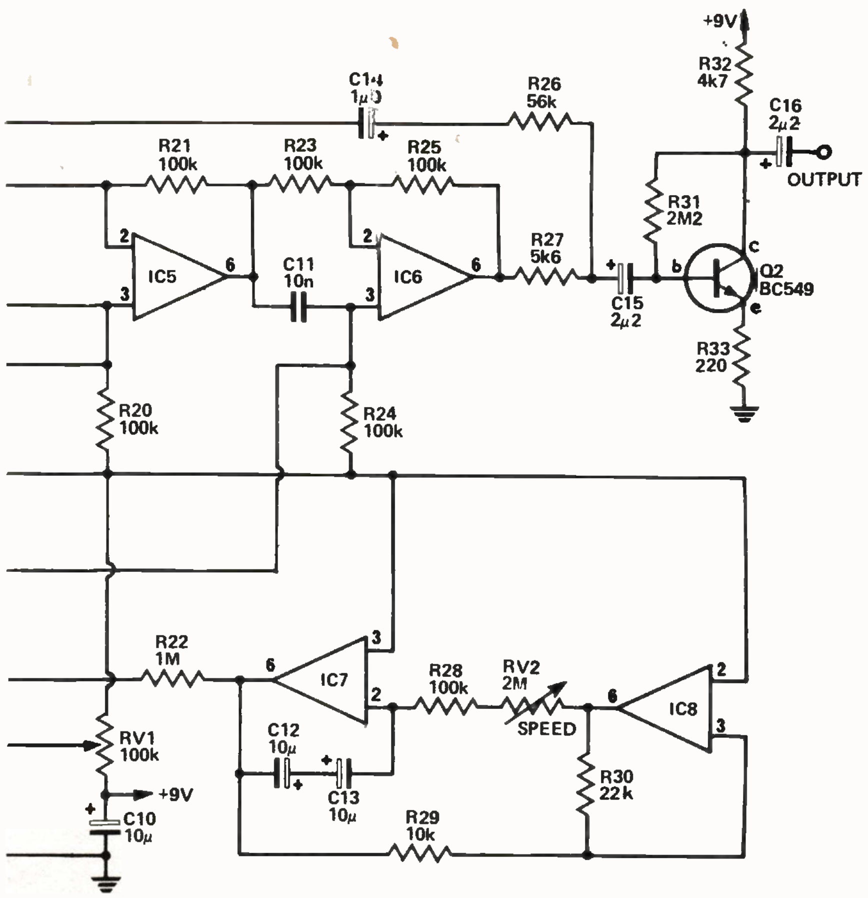
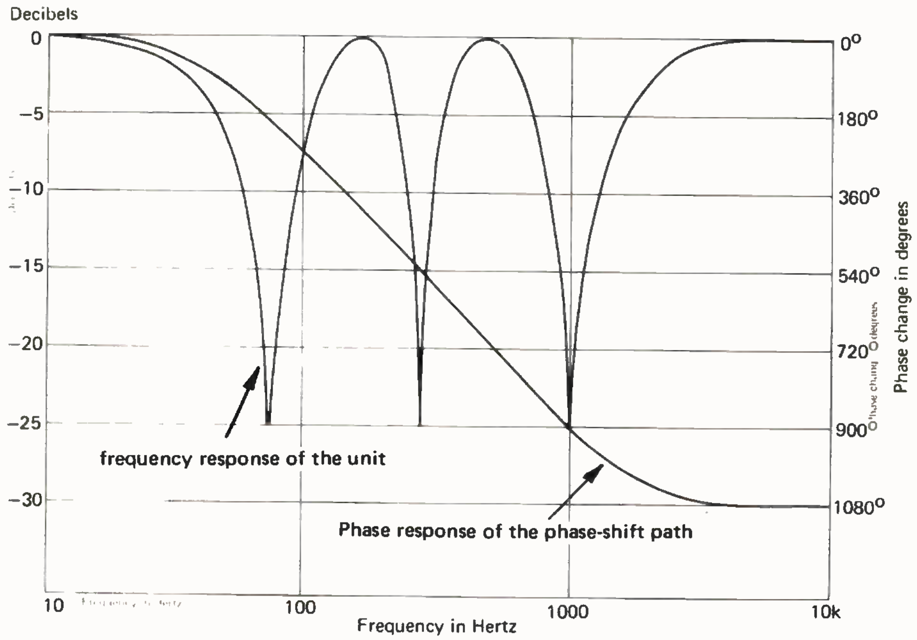



*Fig 3 Frequency response of the unit when the phase shift networks have 56k effective resistance. As this value varies the response curbe is moved up and down the frequency axis.*




The unit we have designed is a six-stage phaser (there are six phase-shift networks in the phase-change path) which gives three minima in its response curve. It is built into a die-cast box so it can be used on stage by a guitarist. The only external control adjusts the speed, except for the foot-operated switch which puts the phaser in or out of circuit. The power is switched on by plugging the jack plugs into their sockets.

## Construction

Apart from the pcb the box contains one pot, two jack sockets and a foot-operated switch, so construction is unlikely to be any problem. Use our design for the pcb pattern and insert the components according to the overlay drawing. IC sockets do not have to be used but a socket would spare the CMOS IC from the dangers of direct soldering.

First solder the low-profile components to the board, then the other components. When the case-mounted parts have been installed, wire up the board to these using sufficiently long leads to enable easy fault-finding, should this be necessary.

For stage use, the phaser needs properly protecting against physical shocks so we strongly recommend you use a die-cast box and wrap the pcb in foam sheeting rather than screwing it to the case. If the phaser is to be built into a mixer or an effects unit then housing is obviously less important.

## Setting up

The best way to set up the phaser is to use a white noise source and then adjust the bias preset to give a continuous whooshing sound. If the bias is incorrectly set the sound will be interupted, it will not whoosh continuously.

If you do not have a white noise source use a signal high in harmonic content: electric guitar, crowd noise, FM hiss, etc.

We cannot teach you how to use the phaser, it is a special effect offered as an aid to creative musicians. It can produce weird effects with almost any audio source (it can, for example, simulate long-distance phonecalls or radio stations) and it is necessary to play certain styles of electric guitar and electric piano.

The phaser can be plugged into the echo send and echo return sockets of the ETI Master Mixer for use on any channel as desired. Kits will be commercially available for this project (see the Jaycar advt. elsewhere in this issue).

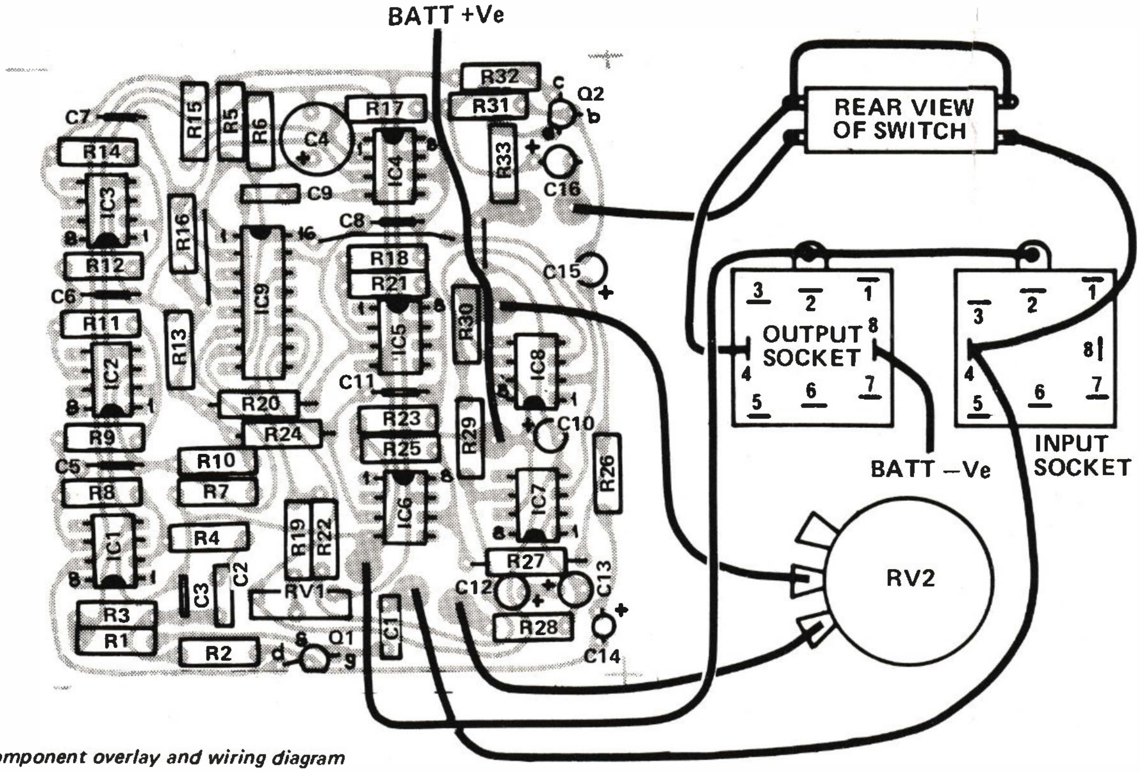



*Fig 4 Component overlay and wiring diagram*



## Parts List ETI 447

| Resistors | all ½ W 5% |
|---|---|
| R1 | 470 k |
| R2 | 10 k |
| R3 | 1 k |
| R4 | 100 k |
| R5 | 10 k |
| R6 | 15 k |
| R7-R18 | 100 k |
| R19 | 330 k |
| R20,21 | 100 k |
| R22 | 1 M |
| R23-R25 | 100 k |
| R26 | 56 k |
| R27 | 5 k6 |
| R28 | 100 k |
| R29 | 10 k |
| R30 | 22 k |
| R31 | 2 M2 |
| R32 | 4 k7 |
| R33 | 220 |

| Potentiometers | |
|---|---|
| RV1 | 100 k trim type |
| RV2 | 2 M log rotary |

| Capacitors | |
|---|---|
| C1,2 | 100 n polyester |
| C3 | 10 n " |
| C4 | 100 µF 6 V electro |
| C5-C8 | 10 n polyester |
| C9 | 100 n " |
| C10 | 10 µF 25 V electro |
| C11 | 10 n polyester |
| C12,13 | 10 µF 25 V electro |
| C14 | 1 µF 25 V electro |
| C15,16 | 2 µ2 25 V electro |

| Semiconductors | |
|---|---|
| Q1 | 2N5485 or similar |
| Q2 | BC549 or similar |
| IC1-IC8 | µA741 op-amp |
| IC9 | 4049 CMOS |

**Miscellaneous**

PC Board ETI 447
Two stereo phone sockets
Switch — push on push off foot operated push button
Case to suit
9 V battery
Knob

## ETI 447 — How it works

The input impedance of the phaser has to be high to prevent damping of the strings when used with an electric guitar. Loading caused by a low input impedance would stop the notes from sustaining properly. In the ETI phaser this is acheived by the high impedance buffer, Q1.

After the input buffer the signal is split along two paths, and the two parts do not meet again until they are mixed back together again at the junction of R26 and R27. One part of the signal undergoes phase-shift, via ICs 1 to 6, and the other part follows a direct path. Q2 amplifies the output to give an overall gain of unity.

The phase-shift is achieved in six identical RC networks; the overall shift being the sum of the shifts at each stage. IC9 varies the value of resistance in each stage, but we will first look at the operation with a fixed value, say 56k.

In this case each stage puts a 10n capacitor and 56k resistor across the signal. The waveform at the junction of these two components has to be of such phasing as to reconcile the perpendicular phasing of the waveforms across each component.

The signal fed into the op-amp undergoes a phase-shift, but the phase-shift is not the same for all frequencies. In the one stage the signal undergoes a change of 180 degrees at high frequencies and a negligible change at low frequencies. The curve of Figure 3 shows that there is little shift at 10 Hz and 1080° at 4 kHz (that is 180° at each stage: a total° of 1080° from all six stages).

When all six stages are taken into account, frequencies from 10 Hz to 4 kHz have a continuous range of phase-shifts from 0 to 1080°.

Figure 3 also shows what happens when equal amplitudes of the two signals (from the direct and phase-shift paths) are mixed.

Because frequencies outside the range 10 Hz to 4 kHz are in phase the response is flat. In-phase mixing also occurs within this range at two places. These are at phase differences of 360° and 720°, in this case at 160 Hz and at 460 Hz.

The holes in the response are caused by out-of-phase mixing, as occurs when the phase differences are 180°, 540°, and 900°. With 10n and 56k in the phase-shift networks these minima occur at 70 Hz, 270 Hz, and 1 kHz.

The number of minima in the response is directly related to the number of phase-shift stages. Four stages would give a maximum phase shift of 720° and minima would then only occur at 180° and 540°. If you use eight stages another minimum will occur at 1260°, giving four in all.

The rest of the circuitry in the phaser is used to vary the the resist ance in the phase-shift networks to move the response curve of the phaser up and down the frequency axis. IC9 is effectively six sets of complementary FETs and the resistance of each can be controlled by applying a voltage onto its gate. Varying the gate voltage of IC9 causes the effective resistance of R7 to be shunted from 100k down to a few kilohms.

IC7 is an integrator and IC8 is a Schmitt trigger; together they make a triangle-wave oscillator. This triangle waveform gives a rising and falling voltage to the gates in IC9. The waveform has to be correctly biased to give the desired resistance change in each phase-shift stage. The bias voltage is set by RV1.

RV2 controls the speed of the triangle-wave oscillator to give periods ranging from a few seconds down to a tenth of a second or so.

The zero reference voltage for the op-amps is taken from the junction of R5 and R6, which is at half the supply voltage. This does away with the need for a split supply — a single 9 V battery is sufficient. The power is switched on and off by the jack socket. The foot-switch switches the phaser in and out of circuit.

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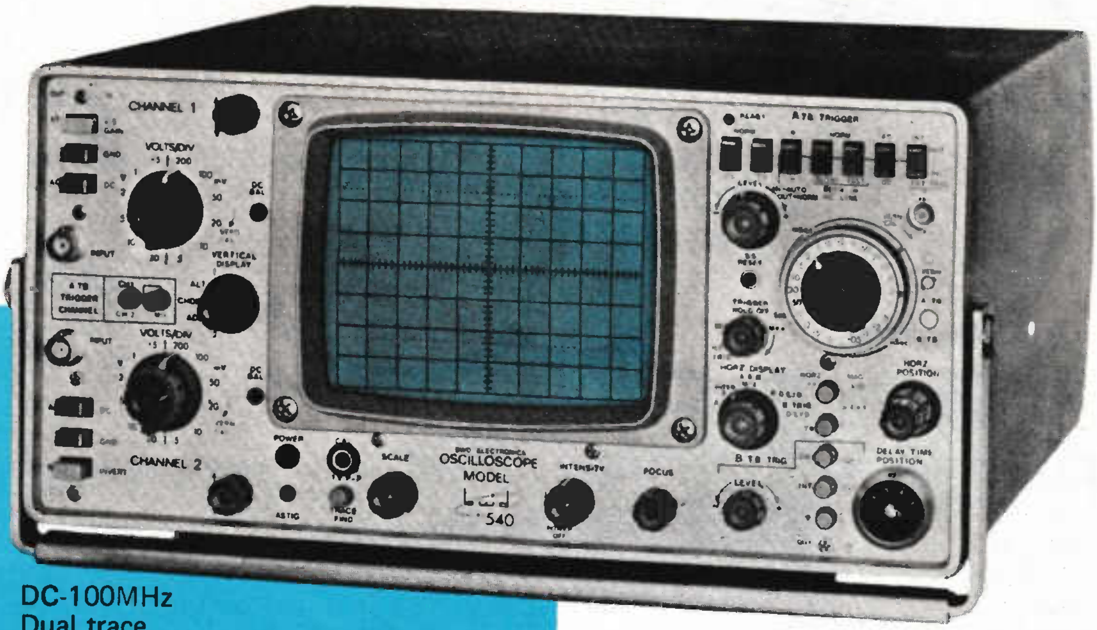


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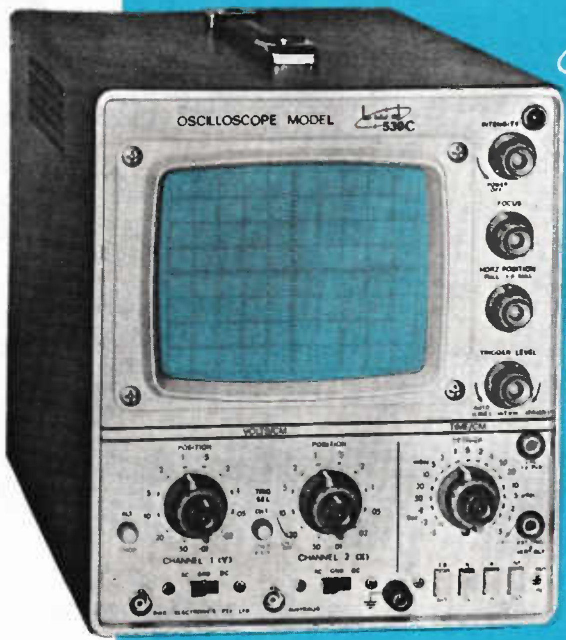


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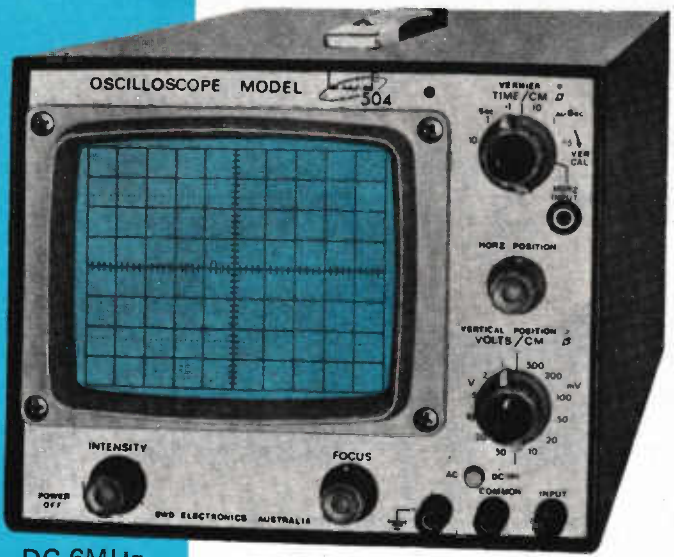


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# REMOTE CONTROL RECEIVER

A full description is given of construction of the receiver and decoder sections of the remote switch system. Next month—relay circuitry and power supply.

IN THE JULY 1976 ISSUE OF ETI WE gave details of the transmitter for ourte-remote-control switch system. The system is capable of controlling up to 8 remote devices, such as garage doors, curtains or tv poser. Last month we gave brief details of the operating principles of the receiver and decoder and we now describe construction of these sections of the system. This only leaves the receiver power supply and relay-circuitry sections to be described next month.

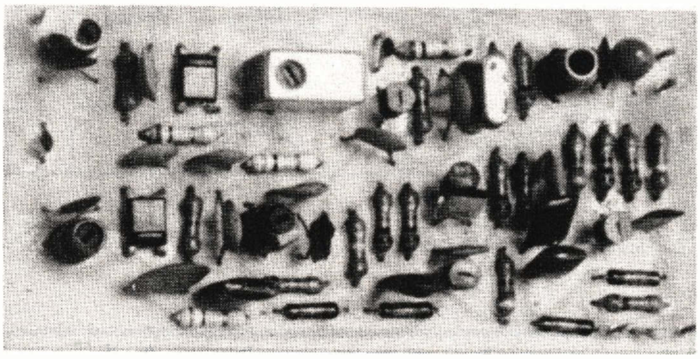
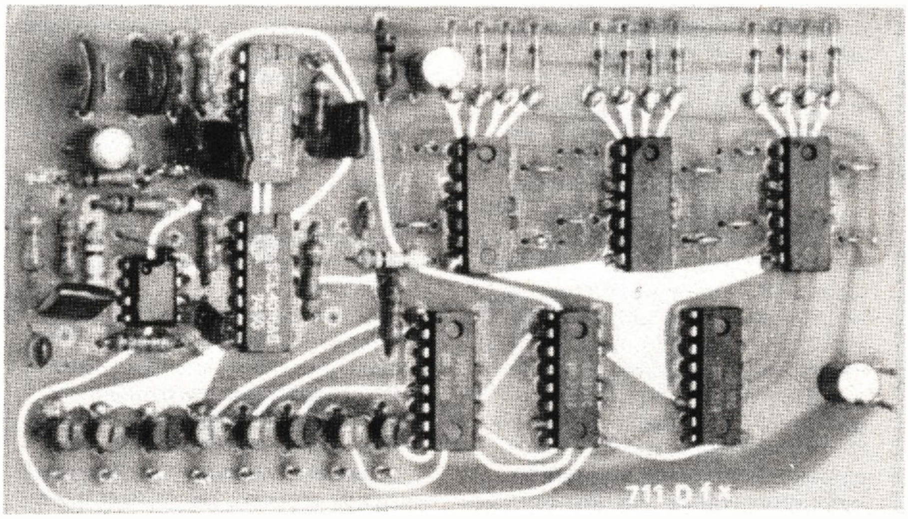


*Fig. 1. The receiver board completed.*

## Construction

The receiver and the decoder are built on separate printed-circuit boards. As layout can be critical with the RF circuitry of the receiver and as the decoder section is fairly complex, we strongly recommend that the published pcb designs be used. Whilst we make no claim that these layouts are the *only* ones that may be used, or indeed that they are the best that can be devised, at least you can be sure that if you use them correctly the system will work.

*Fig. 2. The completed decoder board.*



**The Receiver.** Commence assembly of the receiver by glueing the coil formers onto the ETI 711R board (on the underside) using quick-drying epoxy cement. To wind the coils solder one end of the wire into one of the holes provided and then wind ten and a half turns (close wound) onto the coil. Now return the other end of the wire through the second hole and solder into position. Wind all coils in an identical fashion and fit all of them except L4 with slugs.

Now fit the remaining components to the board taking care to correctly orient diodes, transistors and electrolytic capacitors. The capacitors used should be of the disc-ceramic variety as these perform better than other varieties at the high frequencies used. Note particularly that BC548 and 559 transistors from different manufacturers have different pin connections; connections for the Philips variety are shown on the overlay.

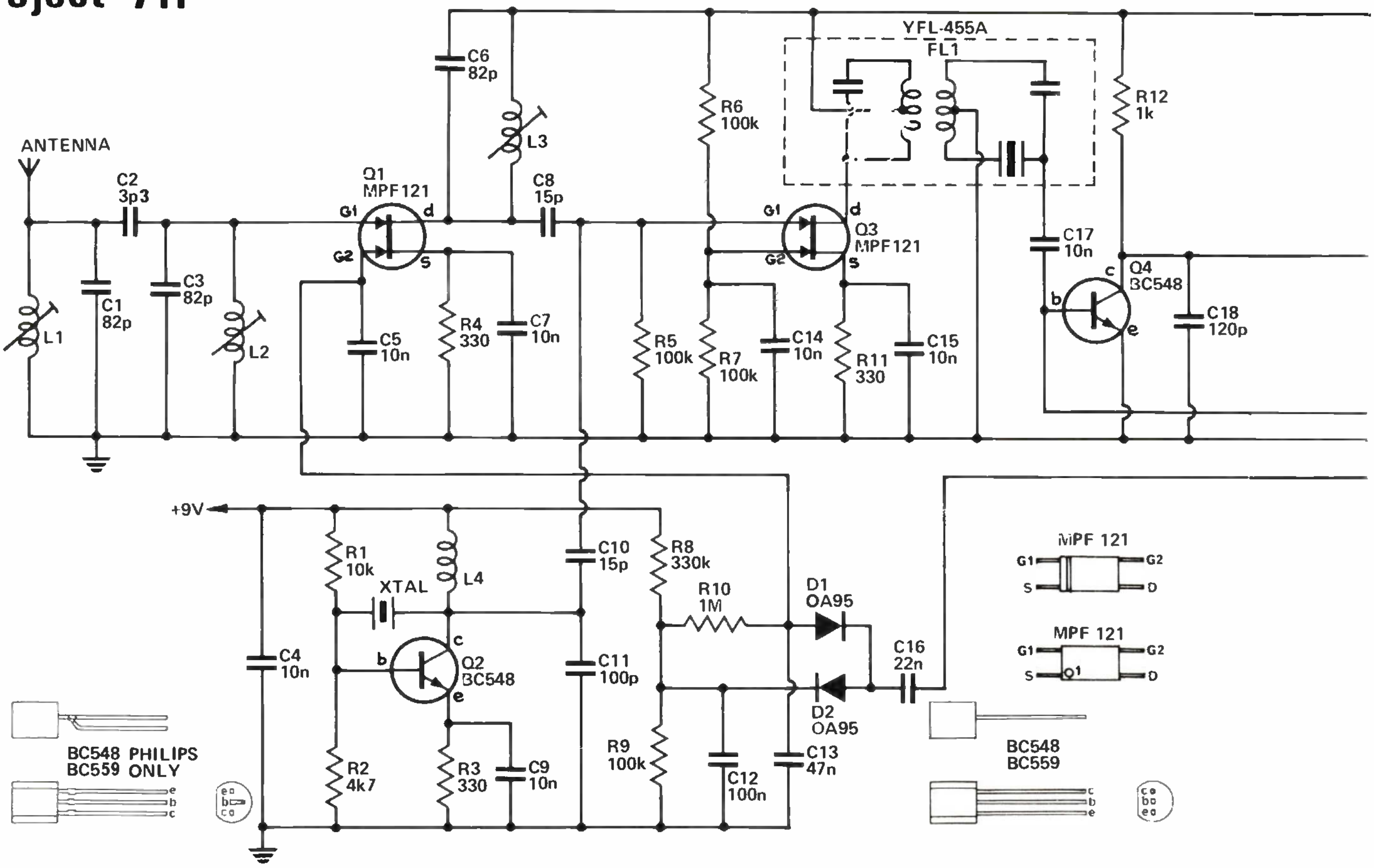



*Fig. 3. Circuit diagram of the receiver.*

## How it works — ETI 711R

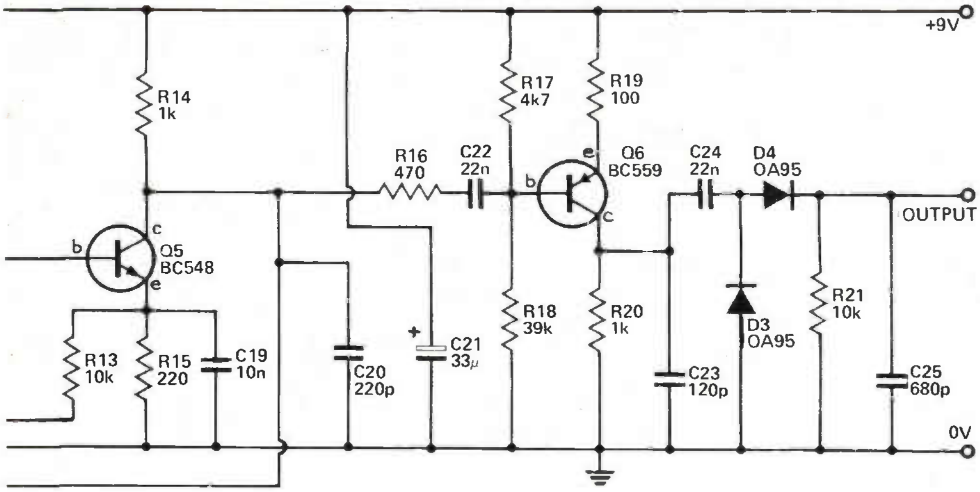
The remote switch receiver is a fairly conventional superhet design, which operates as follows:

The signals picked up by the antenna are put across the filter formed by L1, C1 and L2, C3 which rejects all signals outside the 27 MHz band. Signals within the band are now amplified by the dual-gate FET Q1 which has automatic gain control applied to the second gate. The drain load of Q1 is the tuned circuit L3, C6 which is also tuned to the 27 MHz signal. The output from the RF amplifier stage, Q1, is now coupled into gate 1 of transistor Q3 which together with associated components forms the mixer stage. The second gate of this transistor is biased to half-supply voltage and does not have gain control applied to it.

A crystal-controlled oscillator is formed by the transistor Q2, the crystal and other associated components. The frequency of oscillation is determined by the crystal and should be 455 kHz above the transmitted frequency. The output signal from the oscillator is applied to the mixer stage, Q3. Here it is mixed with the input signal. The output from Q3 is a mixture of signals; the main ones are the oscillator frequency, the signal from the transmitter, the sum of these two frequencies (54 MHz) and the difference of these two frequencies (455 kHz).

The drain load for Q3 is a 455 kHz filter which will pass only that frequency to the IF amplifiers Q4 and Q5. The IF stage has deliberately been kept simple as very long-range operation is not required and the consequent alignment problems are greatly reduced. The output from Q5 is rectified by D1 and D2 in order to produce a dc voltage which is proportional to signal strength. This voltage forms the AGC voltage which is applied to the second gate of Q2. With no signal the voltage at the gate of Q1 is about two volts and as the input signal rises (and consequently the ouptut from Q5 rises) the voltage on Q1's gate reduces and may eventually go negative. Thus the gain of Q1 is reduced with increasing input signal level, thereby stabilising the output level for changes in input signal level.

One further stage of amplification is provided by Q6 before the IF is detected by D3 and D4. The transistor Q6 normally operates in the limiting mode, that is, it is hard on or hard off except when the signal is very low. The signal is full-wave detected by D3 and D4 and the time constant of R21 and C25 is long enough to reject the 455 kHz but short enough to develop a voltage across C25 proportional to the modulation on the signal. Further filtering to remove 455 kHz is performed on the decoder board.



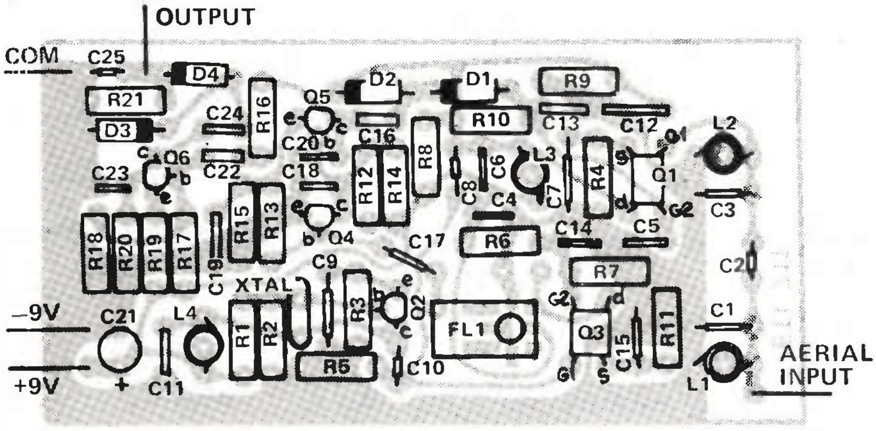




*Fig. 4. Component overlay for the receiver.*

## TABLE 1
### Coil winding details

| | |
|---|---|
| Coil Former | Neosid 722/1B |
| Slug | Neosid 4 x .05 x 6/f29 plus PTFE locking strips |
| Winding | 10½ turns close-wound of 24 B&S enamelled copper wire |

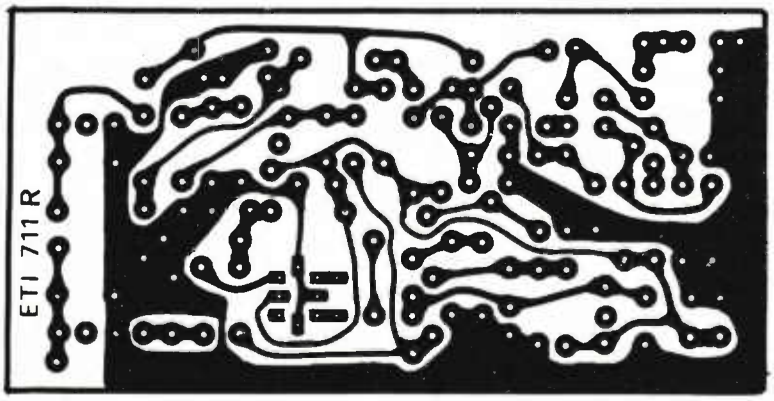



*Fig. 5. Printed-circuit layout for the receiver. Full size 100 x 51 mm.*

## Parts List – ETI 711R

| | |
|---|---|
| **Resistors** | all ¼ W 5% |
| R1 | 10 k |
| R2 | 4 k7 |
| R3,4 | 330 |
| R5-R7 | 100 k |
| R8 | 330 k |
| R9 | 100 k |
| R10 | 1 M |
| R11 | 330 |
| R12 | 1 k |
| R13 | 10 k |
| R14 | 1 k |
| R15 | 220 |
| R16 | 470 |
| R17 | 4 k7 |
| R18 | 39 k |
| R19 | 100 |
| R20 | 1 k |
| R21 | 10 k |
| **Capacitors** | |
| C1 | 82 p ceramic |
| C2 | 3 p3 " |
| C3 | 82 p " |
| C4,5 | 10 n " |
| C6 | 82 p " |
| C7 | 10 n " |
| C8 | 15 p " |
| C9 | 10 n " |
| C10 | 15 p " |
| C11 | 100 p " |
| C12 | 100 n " |
| C13 | 47 n " |
| C14,15 | 10 n " |
| C16 | 22 n " |
| C17 | 10 n " |
| C18 | 120 p " |
| C19 | 10 n " |
| C20 | 220 p " |
| C21 | 33 μF 16 V electro |
| C22 | 22 n ceramic |
| C23 | 120 p " |
| C24 | 22 n " |
| C25 | 680 p " |
| **Semiconductors** | |
| Q1 | MPF121 |
| Q2 | BC548 |
| Q3 | MPF121 |
| Q4,5 | BC548 |
| Q6 | BC559 |
| D1-D4 | OA95 or similar |
| **Inductors** | |
| L1-L4 | see table 1 |

**Miscellaneous**
FL1 Filter YFL-455A
pc board ETI 711R
Xtal 27 MHz band 455 kHz above transmitter frequency

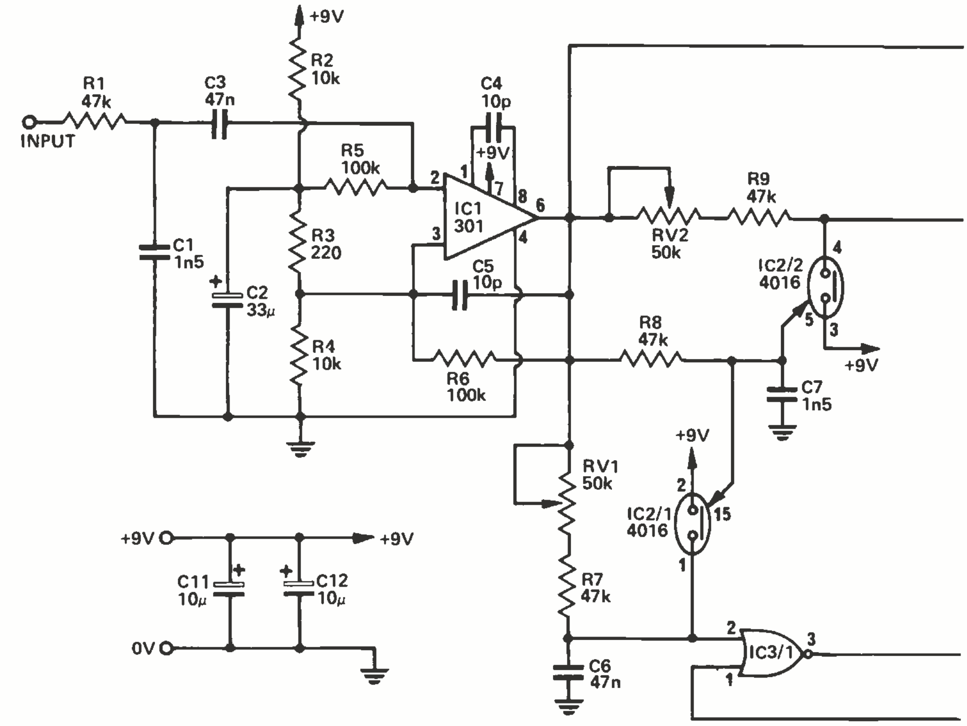
**The Decoder.** The decoder is built on the ETI 711D board. This board is double-sided (that is there is a copper pattern on both sides) but the holes are not plated-through. It is therefore important to solder the component to *both* sides of the board wherever necessary. Note that all the ICs, with the exception of the LM301, are CMOS devices and therefore should be handled as little as possible. The devices will be supplied mounted in conductive foam and should not be removed from this until you are ready to insert them into the board. Use a small soldering iron and solder quickly and cleanly. Check to make sure that the pins have been soldered to the tracks on both sides of the board and that there are no solder bridges between tracks.

The links to ICs 4, 5 and 6 must now be connected so that the decoder has the same key code as the transmitter. Link to the track closer to the IC for a '1' and to the track further from the IC for a '0'.

## Receiver alignment

Once the receiver has been completed it should be aligned using the following procedure:

1. Disconnect capacitor C16.
2. Connect a short aerial to the receiver (300 mm of hook-up wire.
3. Connect an audio amplifier to the output terminals of the receiver via a series 10k resistor.
4. Also connect a dc voltmeter to the output terminals, again via a series 10 k resistor.
5. Connect the power supply and switch on.
6. On the transmitter connect pins 1 and 16 of IC4 to obtain continuous transmission of the code sequence (use a larger battery or separate power supply as detailed in the article on the transmitter).
7. The antenna on the transmitter should be kept short, not fully extended.
8. If all is as it should be the pulse train output from the receiver should be heard on the amplifier and a deflection should be obtained on the dc voltmeter.
9. Adjust L3 for peak output. However it will be necessary to move the transmitter further and further away so that the output does not exceed one volt dc (to avoid saturation). Continue this process until no further improvement is obtainable with tuning L3.
10. Again peak the output by adjustment of L1 and L2 and when no further improvement is obtainable make a final adjustment to the IF filter. Now readjust L3 for a final peak.
11. Switch off the receiver and the transmitter, reconnect capacitor C16 and then disconnect the amplifier and the meter.




## Decoder adjustment

Before making any adjustments to the decoder make absolutely sure that the codes wired into the transmitter and the decoder are identical. Set the potentiometers to their mid positions (Normally no readjustments will be necessary).

Correct operation of the decoder may be observed by connecting a LED to each output transistor as follows: For each transistor connect one end of a 100 ohm resistor to plus nine volts and the other end to the anode of an LED. Connect the cathode of the LED to the transistor output. When a button on the transmitter is pressed one of the LEDs will flash. If the transmitter is running continuously then one of the LEDs will glow continuously. If this doesn't happen then check out the operation of the decoder with an oscilloscope as follows:

## Checking with an oscilloscope

1. Check the output from the receiver to ensure that a pulse train is present of at least 100 mV amplitude peak-to-peak.
2. Check the output from IC1 (pin 6). It should be a squared-up version of the output from the receiver (see waveforms 1a and 1b).
3. With a sharp knife or razor blade cut the track between R14 and the cathodes of the diodes. A narrow cut is required because it must be rejoined later by soldering.

### Parts List — ETI 711D

**Resistors** all ¼ W 5%

| | |
|---|---|
| R1 | 47 k |
| R2 | 10 k |
| R3 | 220 |
| R4 | 10 k |
| R5,6 | 100 k |
| R7-R9 | 47 k |
| R10 | 10 k |
| R11 | 100 k |
| R12 | 4 M7 |
| R13 | 2 k2 |
| R14 | 10 k |

**Variable Potentiometer**

| | |
|---|---|
| RV1,2 | 50 k trim |

**Capacitors**

| | |
|---|---|
| C1 | 1 n5 polyester |
| C2 | 33 μ |
| C3 | 47 n polyester |
| C4,5 | 10 p ceramic |
| C6 | 47 n polyester |
| C7 | 1 n5 " |
| C8 | 10 n " |
| C9 | 1 n5 " |
| C10 | 47 n " |
| C11,12 | 10 μ 16 V electro |

**Semiconductors**

| | |
|---|---|
| IC1 | LM301 |
| IC2 | 4016 (CMOS) |
| IC3 | 4001 (CMOS)* |
| IC4,5,6 | 4030 (CMOS) |
| IC7,8 | 4015 (CMOS) |
| IC9 | 4051 (CMOS) |
| Q1-Q8 | BC548 or similar |
| D1-D12 | 1N914 or similar |

pc board ETI 711D

**This IC must be one made by Solid State Scientific SCL 4001A or Signetics HEF4001P*

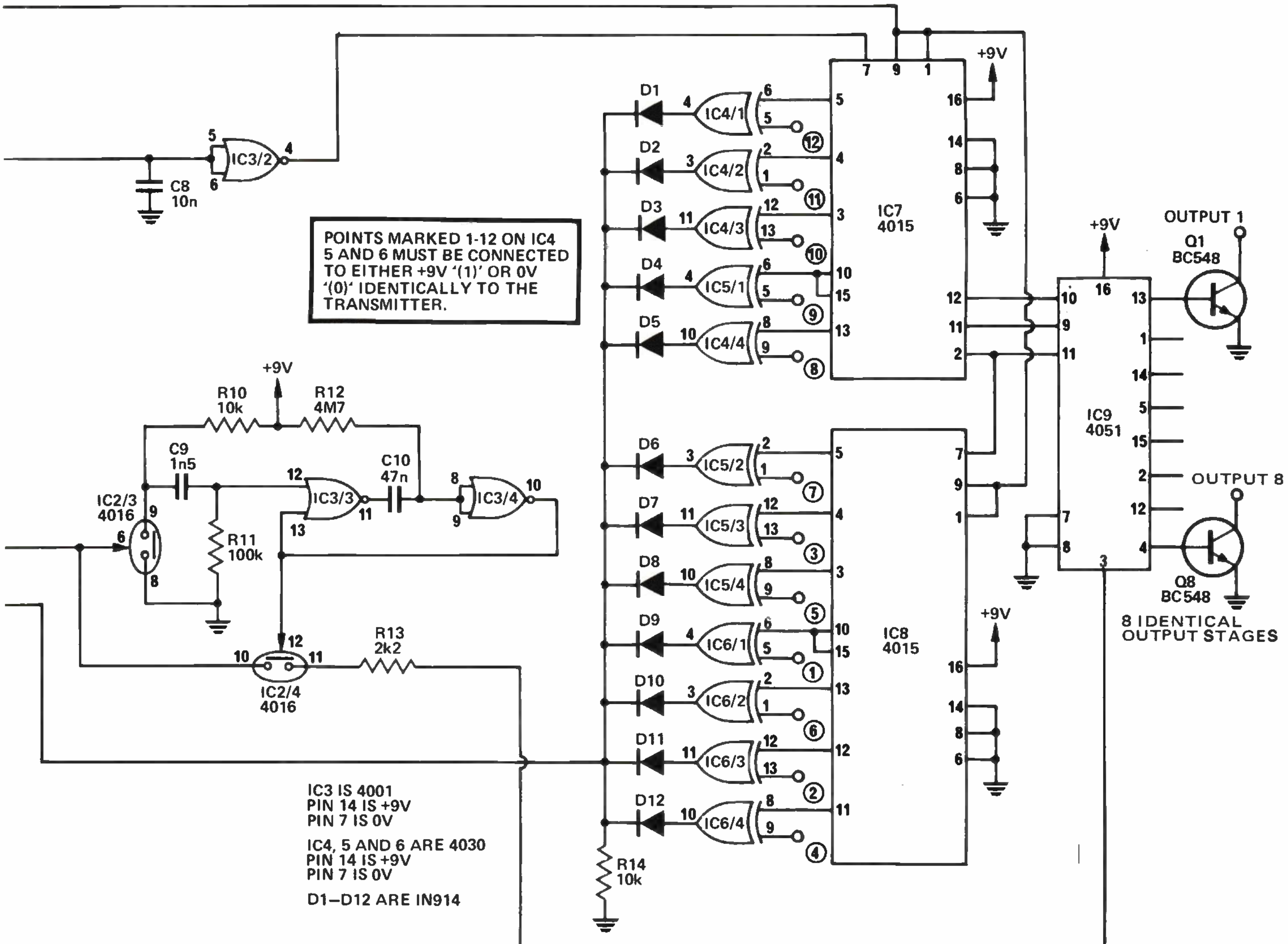



*Fig. 6. Circuit diagram of the decoder.*

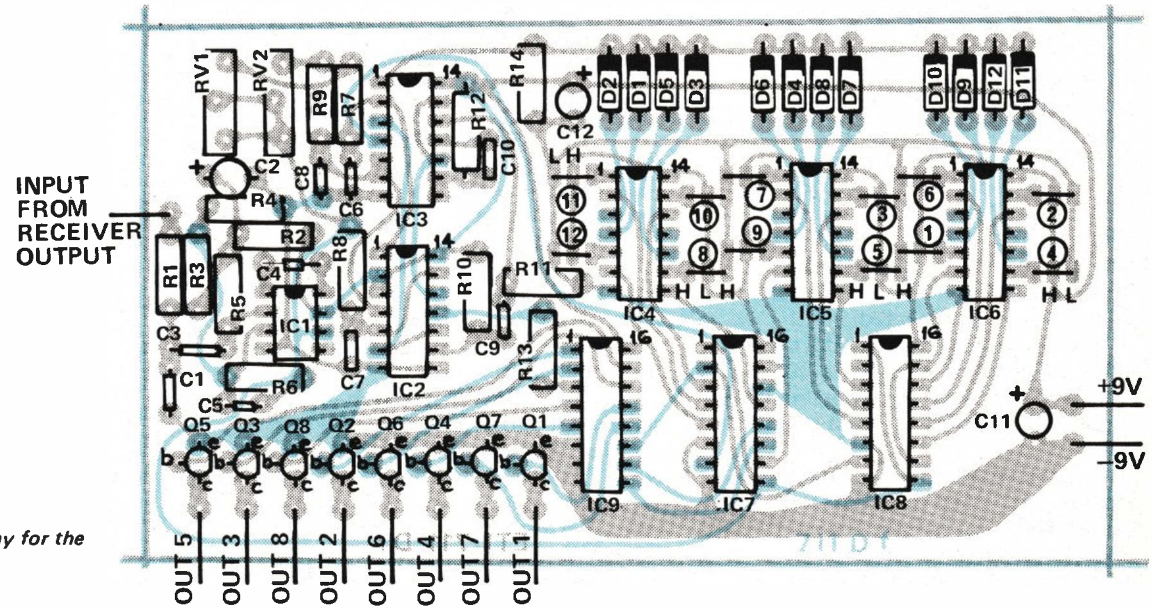



*Fig. 7. Component overlay for the decoder.*

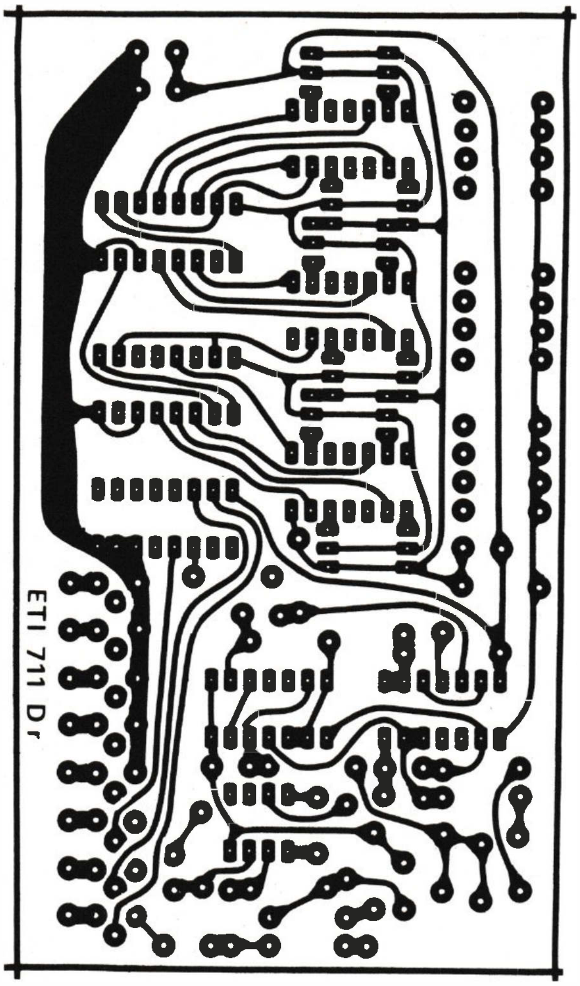



Fig. 8a. Non-component side of the decoder board. Full size 127 x 69 mm.

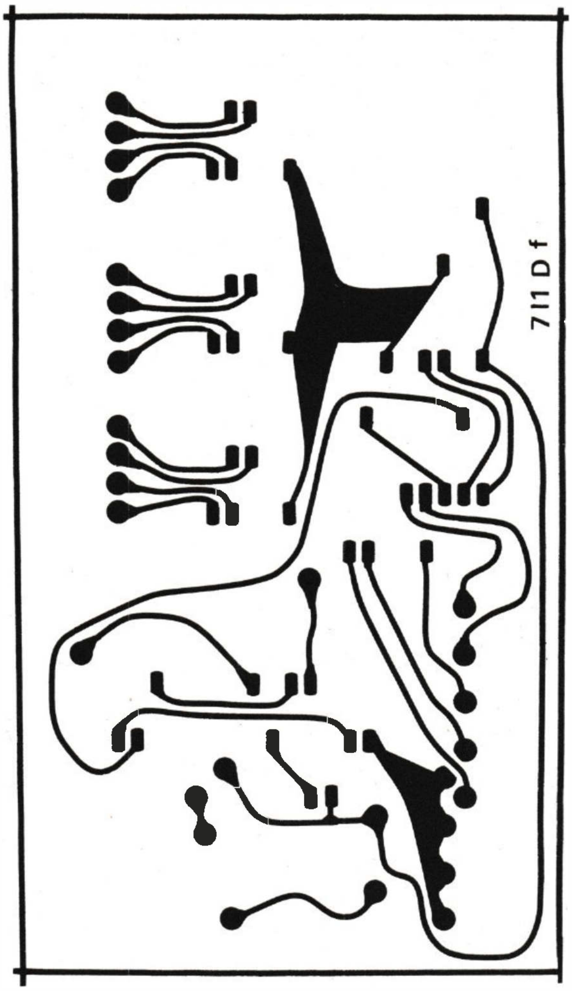



Fig. 8b. Component side.

4. Look at pin 3 of IC3/1 with the oscilloscope. A positive-going pulse should be observed which is about 1 ms wide and re-occurring about every 30 ms or so (depending on word length). This is the synchronising pulse. RV1 should be adjusted for correct detection of this pulse. At one extreme of RV1 all the pulses will be detected together with the sync pulse. And at the other extreme no pulses will be detected at all. Adjust RV1 so that only the sync pulse is correctly detected.

5. Use this pulse to sync the oscilloscope and adjust the timebase of the oscilloscope so that one complete frame of the code word can be seen in a single sweep.

6. Look at the output of IC1 (pin 6) and the complete pulse train should be visible. This can easily be checked against that expected. The sequence of the pulses within the train is detailed in the errata printed on this page.

7. Look at the output of IC3/2 (pin 4). This should be low when the input pulse is short and high when the input pulse is long. RV2 can be used to adjust this stage for correct operation.

8. If the system is still not working trigger the oscilloscope from the positive edge of the sync pulse and expand the trace to about half a millisecond per division.

9. Look at the output from each stage of the shift register. During the sync pulse these outputs should be steady — 'high' or 'low' as set by the wired link code.

10. Rejoin the track which was previously cut and if the unit is still not working check the voltage at pin 10 of IC3/4. This should be mostly at +9 volts. There should be a series of 100 ms pulses but the IC is retriggered rapidly on each sync pulse. If it is not check for faults around IC3/3 and IC3/4.

**ERRATA**

**Sveral errors have occured in the Remote Transmitter project described in the July 1976 issue of Electronics Today. These are listed below.**

**a) The copper track between C3 and C12, nearest the edge of the board, should be broken to remove the short which otherwise exists across C3.**

**b) The resistor R11 is connected to 0V rather than to point 'A' as it should be. This causes the off-state current to be higher than it should be (60 microamps). To correct this disconnect R11 from the zero volt line and connect it by a link to Pin 3 of IC4 (point 'A'). This reduces the off-state supply current to less than one microamp.**

**c) On the circuit diagram pins 9 and 11 on IC3 are shown reversed to that used on the printed-circuit board. The only difference that this makes is to the order of transmission of the code. Using the numbers on the circuit diagram and the overlay the code sequence is— Sync, 4,2,6,1,5,3,7,B,A C,8,9,10,11,12. The letters A,B and C represent the information code.**

**d) On the circuit diagram the line joining R21,22 and 23 should be shown connected to +9V.**

## How it works — ETI 711D

The function of the decoder board is to take the detected signal from the receiver, check the pulse train for correct key code and, if a match is found, turn on one of eight transistors as determined by the command word. The respective transistor is then used to control an external relay or other device as required.

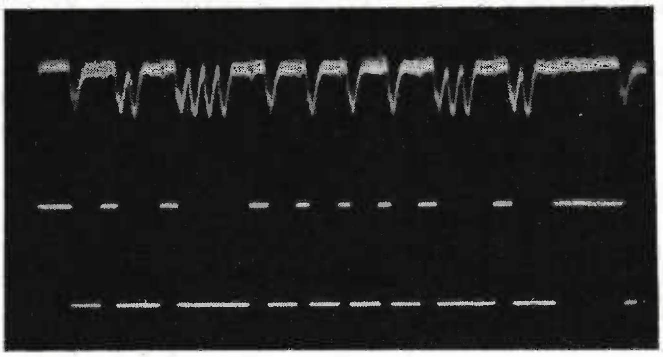
The input signal from the receiver is filtered by R1 and C1 to remove any remaining 455 kHz and is then applied to IC1 which is connected as a Schmitt trigger. The output of IC1 is therefore a squared-up version of the pulse train from the transmitter. The output of IC1 is normally low and goes high for the 200 microsecond off-time of the transmitter.

As there are three different widths of pulse in the transmission these must be separated at this stage. This is performed by IC3/1 and IC3/2. When the output of IC1 is high IC2/1 and IC2/2 are turned on thus charging C6 and C8 to plus nine volts. When IC1 goes low, IC2/1,2 turn off and C6 and C8 discharge via R7, RV1 and R9, RV2. After about one millisecond the output of IC3/2 goes high (as the input voltage is below the threshold) and after three milliseconds IC3/1 goes high. Both of these pulse lengths are conditional on the output of IC1 not going high during the period.

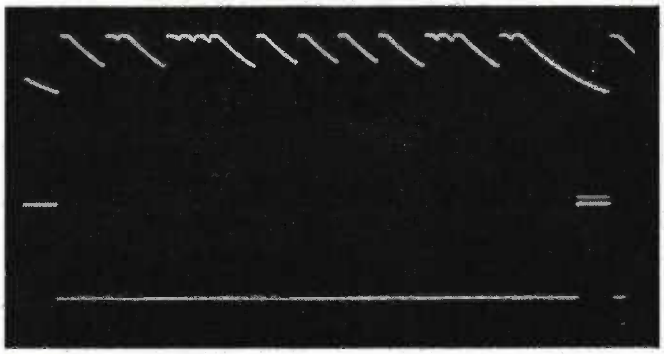
When the output of IC1 goes high it clocks the 16 bit shift register formed by IC7 and IC8 and whatever is at the output of IC3/2 is clocked into the shift register. If the pulse is less than one millisecond a '0' will be clocked in, if the pulse is greater than one millisecond a '1' will be clocked in. With a shift register the data is moved through each stage in turn and is eventually lost out the end. Therefore the series of ones and zeros set up by the input code are clocked continuously into the shift register.

The outputs of the shift register are connected to the exclusive-OR gates of IC4, 5 and 6. The outputs of the exclusive-OR gates are connected, as per the associated transmitter key code, to either +9 or 0 V. The output of an exclusive-OR gate will be low when both inputs are the same, (ie, 1, 1 or 0, 0) and high if the inputs are different (ie 1, 0 or 0, 1). The outputs of the exclusive-OR gates are ORed by diodes D1 to D12 such that the voltage on R14 will be high unless all twelve of the outputs from the shift register agree with the wired-in code. If the code is symmetrical in any way this may occur at numerous points throughout the transmission. This output is therefore passed back to IC3/1 enabling it only if the code and sync pulse sequence is correct. This means that although a sync pulse may be present, the output of IC3/1 will not register it unless a correct code has also been detected.

When a correct code has been detected and a sync pulse is received, the output of IC3/1 will go high for about one millisecond during which time IC2/3 will be turned on. After IC2/3 turns off capacitor C9 couples the edge to R11 and the monostable formed by IC3/3, 4 is triggered. The output on pin 10 therefore goes high for about 150 milliseconds. The first pulse out of IC3/1 is coupled through IC2/4 and R13 to pin 3 of IC9 which is a one-of-eight analogue switch, thus turning on one output of this IC and its associated output transistor for about one millisecond. The three information outputs from the shift register (pins 2, 11 and 12) determine which of the eight transistors are turned on. These three outputs are driven by the code set up when pressing a particular button in the transmitter.

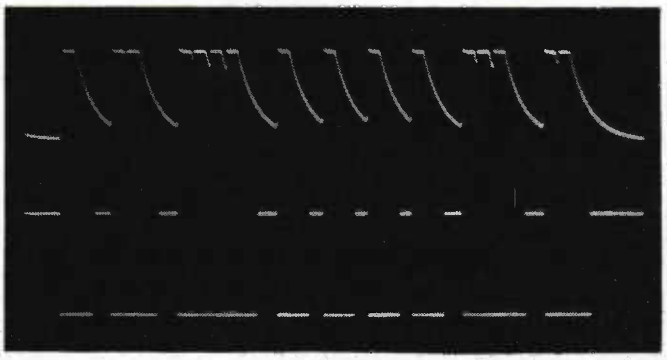


*1a input to decoder.*
*b output of IC1*

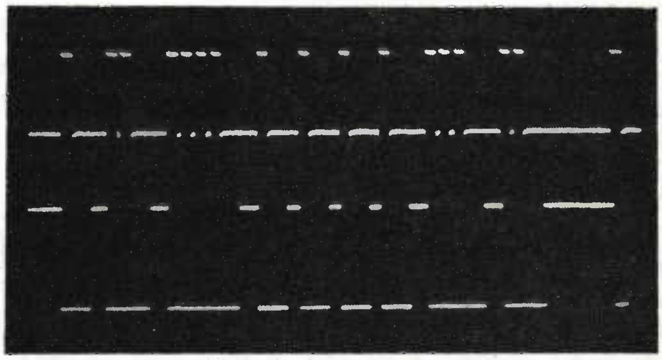


*3a voltage across C6*
*b output of IC3/1*

*2a voltage across C8.*
*b output of IC3/2*



*4a output of IC1*
*b output of IC3/2*



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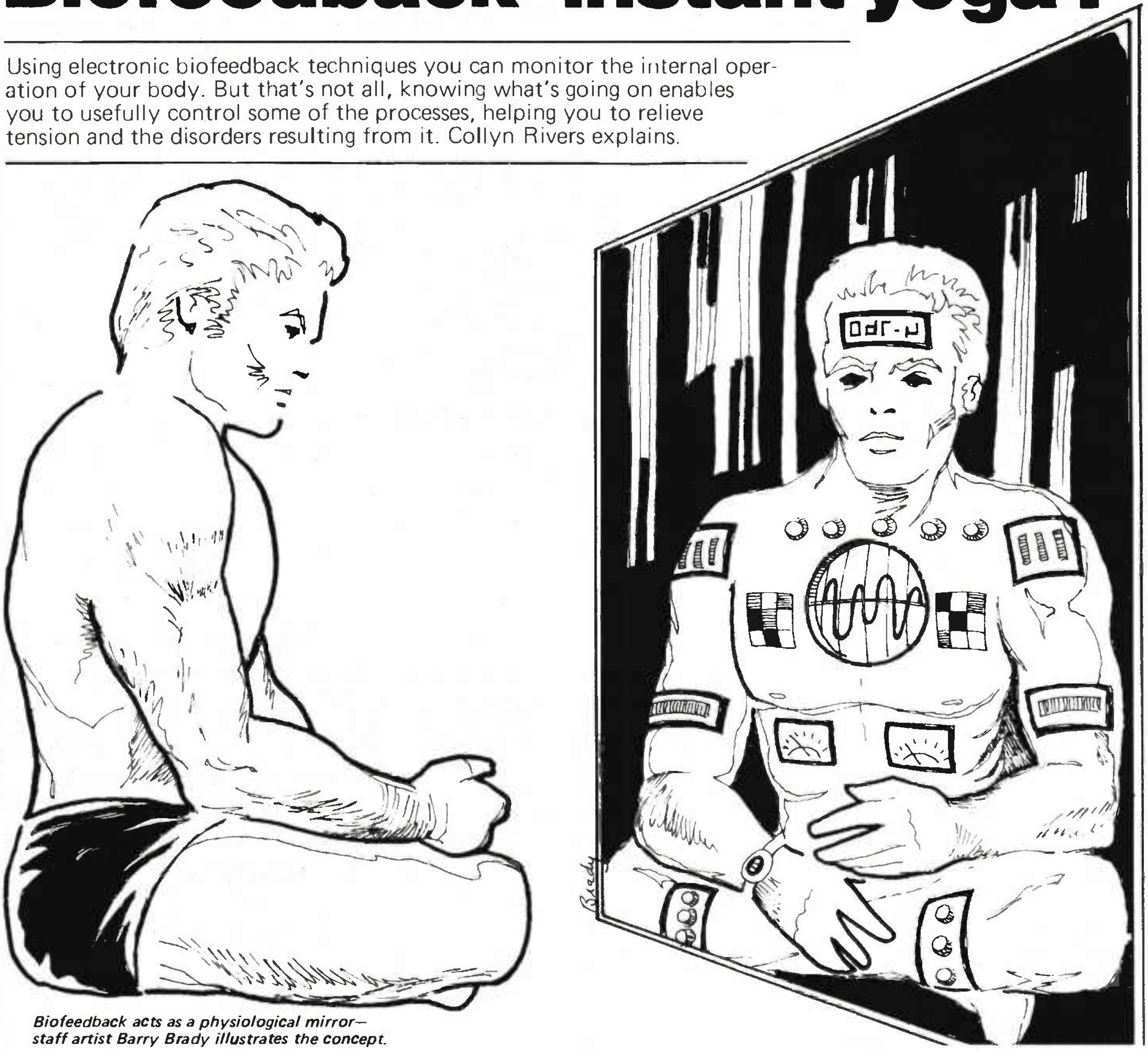
# Biofeedback- instant yoga?

Using electronic biofeedback techniques you can monitor the internal operation of your body. But that's not all, knowing what's going on enables you to usefully control some of the processes, helping you to relieve tension and the disorders resulting from it. Collyn Rivers explains.




*Biofeedback acts as a physiological mirror—staff artist Barry Brady illustrates the concept.*

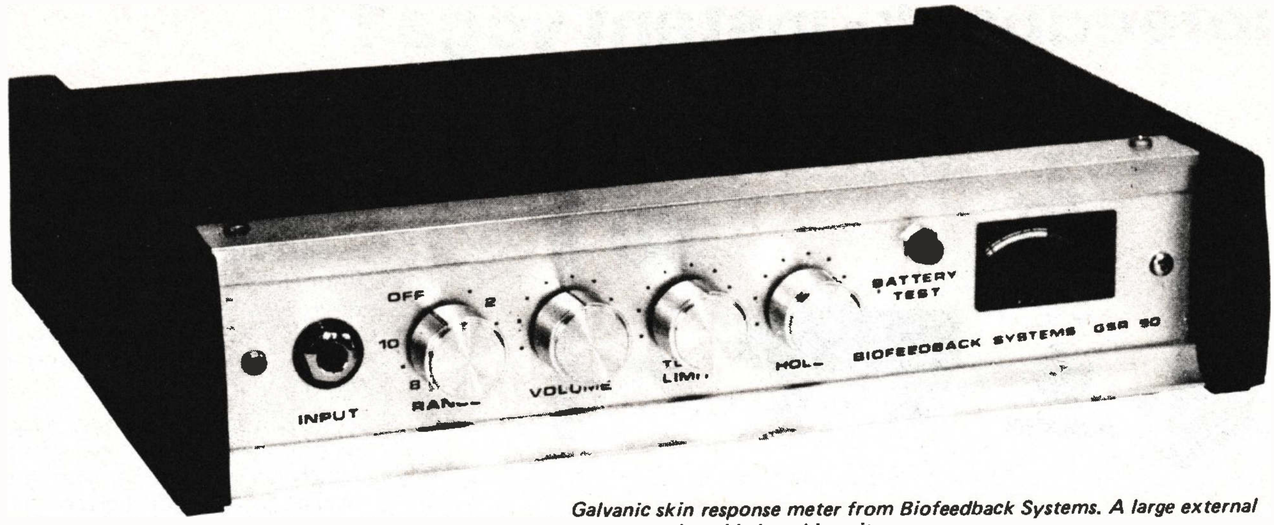
AN ESSENTIAL PART OF MOST control processes is some form of feedback information which enables the system to maintain a controlled equilibrium.

A room thermostat, for example, senses room temperature and regulates heat output accordingly — an indication of the heater's operation is 'fed back' to enable temperature to be automatically controlled.

When you learn the piano you see or sense where the keys are, and how hard you are striking them. The piano makes corresponding sounds which are fed back to your ear. Your brain now compares what you've got with what you hoped you had. This process of feeding back information about what you are achieving so you can compare it with what you are *trying* to achieve enables you to make appropriate corrections. In this example the acoustic feedback is vital.

A similar process is involved when you learn to ride a bicycle — the feedback process is so effective that balancing eventually becomes automatic.

Feedback is used when you first drive a strange car. The first time you brake you know only within wide limits the relationship between pedal pressure and deceleration. It may be as low as 5 kg or as high as 25 kg for (say) 0.4 G. But the very first time you press




*Galvanic skin response meter from Biofeedback Systems. A large external meter may be added to this unit.*

that pedal several feedback loops come into operation. Your stomach is sensitive to rate of change of velocity and it sends signals to your brain — your eyes sense the rate of change also — this data too is sent to your brain. If the tyres are squealing then there's an acoustic loop as well.

These and innumerable other physiological mechanisms collectively tell you whether you're pressing that pedal too hard or not hard enough, and you make a series of appropriate corrections — virtually instantaneously. Once you've done this a few times the response becomes automatic. You've used feedback to learn, and subsequently reinforce, a new skill.

## The autonomic nervous system

So far we've described what are primarily external feedback loops. But the body has a vast number of internal automatic mechanisms — what medics call the autonomic nervous system. These are internal feedback loops and whilst they're working correctly all one normally perceives is the end result. If the body is too hot it perspires — if you run for a bus your respiratory rate increases, if you walk from a light area to a dark area your pupils expand accordingly. And all these mechanisms work in very much the same way as their technological equivalents.

Until recently it has been taken totally for granted that man had no control over the autonomic nervous system. We could learn to control at least some of our external bits — but not our internal systems. We knew we could learn to use our hands — or even wiggle our ears — but to control body temperature or heart rate was something else again.

And until very recently Western science believed this implicitly — despite ever-increasing evidence to the contrary. Yogis have long maintained that *they* have some measure of control over their autonomic systems, but the evidence was always anecdotal rather than scientific. (It is only in the last decade that their performances have been monitored and scientifically authenticated.)

Then ten or so years ago the scene suddenly changed. It was caused by a now classical experiment involving the study of part of the brain's electrical activity. Researchers were studying a subject's alpha rhythms (a low amplitude 10 Hz generated when the subject is relaxed). It was found that if the subject could *perceive* a signal corresponding to his alpha activity he could learn to generate more or less of it at will. Even more excitingly, it was found that almost all subjects could do the same.

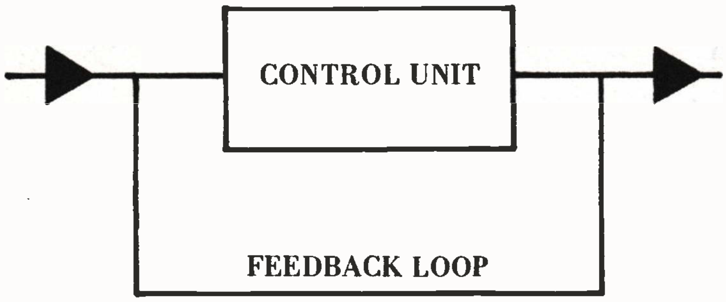
## Controlling your insides

For the first time it was proved scientifically that humans could control some internal processes once a visual or aural feedback loop was established. Yet the tremendous significance of this discovery was not at first appreciated by the medical profession, but rather by engineers and physicists who were of course more familiar with the use of feedback in control systems.

Subsequent experiments have shown that a very large number of internal functions can be controlled in the same fashion — and even more importantly that many partially mal-functioning mechanisms can be 're-programmed' so that newly-learnt patterns can become automatic.

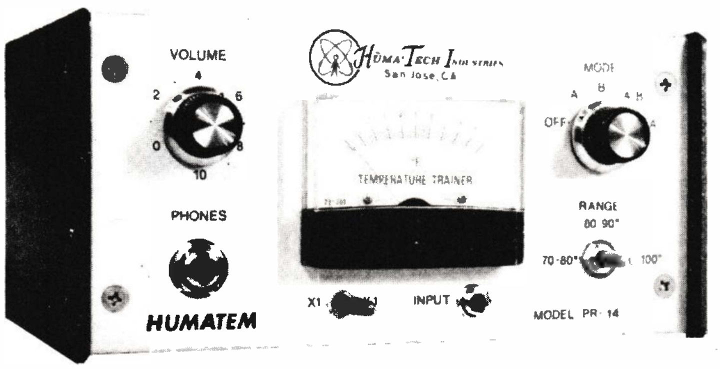
One of the most important of these is conscious control of tension and anxiety, for this implies that it is possible to control tension-related conditions such as migraine, colitis, asthma etc.

Other work has shown that it is possible to control hypertension (high blood pressure), heart rate, muscular tension, body temperature — and of course to generate, or at least partially control, alpha, beta and theta brainwaves. It is in fact now commonly believed that it may eventually be possible to bring under some degree of voluntary control *any* physiological process that can be continuously monitored, amplified and displayed




*The basic feedback loop.*

# Biofeedback - instant yoga?




*Temperature trainer from Huma-Tech Industries has three ranges each switchable to provide 0-10° or 0-1° fsd.*

## Galvanic skin response

The skin is an extraordinarily sensitive and rapid indicator of stress. Some people know this only too well — they literally develop nervous rashes.

When you become tense a number of readily measurable changes take place. A major change is the massive shift in electrical resistance of the dermis (the layer beneath the skin's outside surface). This shift is not only large but also very swift and the reaction happens regardless of where the centre of stress happens to be. A minor change in tension of a stomach muscle will cause just as large a change as clenching your fingers.

Galvanic skin response monitors (or GSR machines as they're generally called) monitor the resistance between two adjacent fingers of one hand. They translate and present this data as a meter indication or as a tone of related pitch (i.e. as tension decreases, pitch falls, and vice versa).

GSR machines are quite easy to build: they can be simply expanded-scale ohmeters covering the range 5000—100 000 ohms. A sensitivity control is essential, as is a readily adjustable method of switching resistance ranges.

Readout may be a simple analogue meter (digital tends to be harder to read in this application) or preferably a corresponding audio tone in which the pitch decreases as tension falls. Surprisingly perhaps GSR resistance *increases* as tension falls.

Electrodes may be made from any flexible conductive material — like steel wool, soft metal mesh etc — held firmly against the fleshy part of your finger tips by a velcro strap or something similar.

GSR machines are very easy to use. In fact one of the best ways is simply to switch on and try to cause the meter reading to fall — or the tone to drop in pitch. Usually you will find out how to do this within a few minutes.

GSR machines make you *aware* of tension — and then enable you to *control* that tension. Eventually — after ten or so half-hour sessions the conscious control that you have learned becomes an automatic response. From then on the GSR machine is no longer required. In fact it becomes a handicap to further progress just like retaining 'training wheels' on a kid's bicycle.

Biofeedback thus operates in the opposite way to drugs. You can use sedatives to control tension if you wish. But if you do you've then got *two* problems. You still have the underlying tension — which will become only too apparent when you run out of sedatives. And you've become a drug addict as well.

To fully appreciate the efficacy of GSR machines in tension reduction it

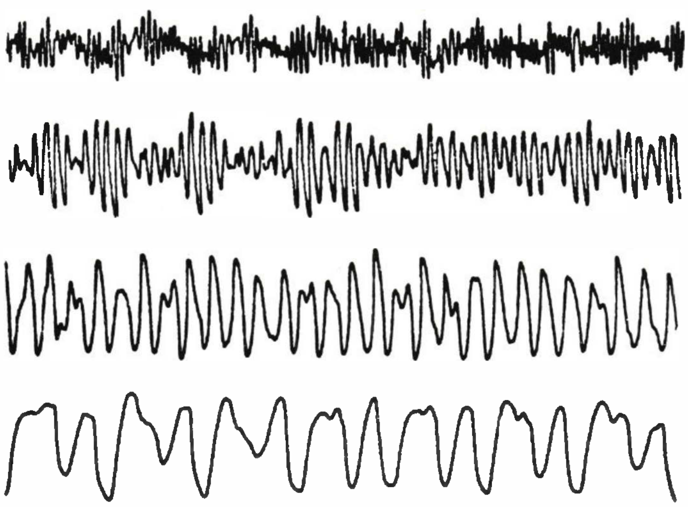
The brain is constantly producing alternating electrical currents termed brain waves. Four major brain wave rhythms each falling within a typical frequency, have been identified, and each of these is generally associated with a particular set of mental and physical states as outlined below:

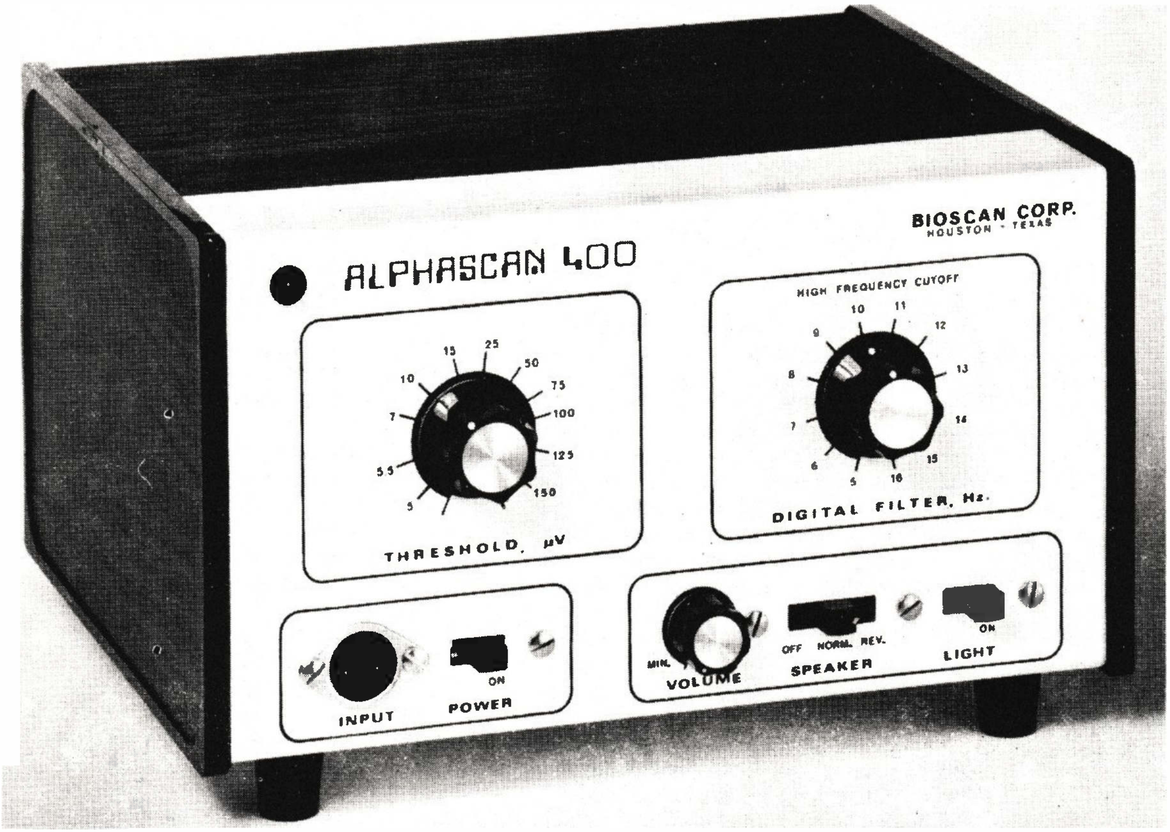
**Beta** — 13+ cycles per second. Focussed attention, anxiety, concentration

**Alpha** — 8 - 12 cycles per second. Rest, relaxation, freedom from anxiety and attention

**Theta** — 4 - 8 cycles per second. Deep relaxation, visual imagery, creativity

**Delta** — 0.5 - 4 cycles per second. Deep dreamless sleep






*Advanced alpha/theta instrument from Bioscan uses digital filtering and threshold adjustment to eliminate interference from spurious phenomena.*

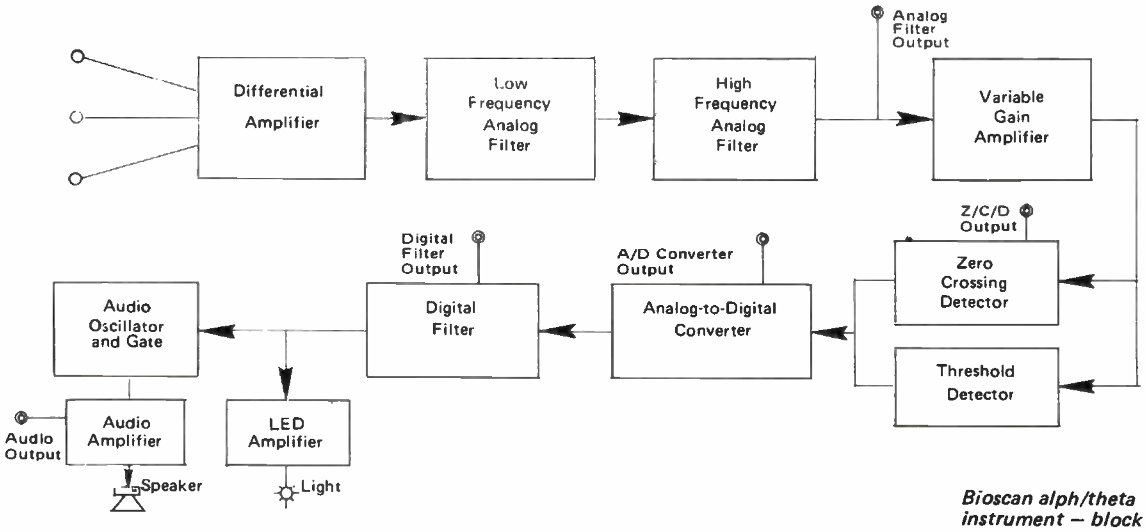
should be understood that there is an almost one-for-one relationship between mind and body. If you reduce muscular tension you will automatically reduce mental tension which in turn will reduce muscular tension yet further — and so on.

## Temperature monitoring

Tension is also reflected in skin temperature — particularly in the hands. A considerable amount of work in this field has been performed by Green and Green of the USA's Menninger Foundation research dept, who use this technique extensively in the control of migraine.

As with GSR, the technique and equipment is remarkably simple. Subjects are simply taught to raise their hand temperature — meanwhile monitoring the effect on an expanded-scale temperature meter. A small thermistor is taped to a finger tip to monitor changes and the output from this is backed off against a second thermistor within the instrument to compensate for ambient temperature changes.

At a recent demonstration (attended by the writer) some fifty subjects with no previous experience of temperature training all succeeded in varying their




*Bioscan alph/theta instrument — block schematic* hand temperature (in some cases by as much as 5°C within a single twenty minute session).

If you're contemplating building your own temperature monitor choose thermistors with a two to three second response time. Build the thermometer so that ambient temperature can be backed off, thus enabling the meter to give a centre zero indication at the beginning of the experiment. The instrument should have two switchable ranges — ± 2.5°F and ± 7.5°F.

As with GSR machines the readout may be either a tone of varying pitch and/or a meter reading.

People teach themselves to use these devices very quickly — usually within ten to fifteen minutes. However, whilst almost everyone can effect a change of temperature, about 50% will find the change to be in the opposite direction to that intended! Nevertheless the correct technique is quickly acquired after a few more minutes.

## Electromyographs

Feedback electromyographs (EMGs) provide information about muscular tension by visually and aurally displaying neuron firings caused by muscular activity. They are commonly used in both clinical and research applications for the observation and reduction of stress and anxiety, tension and migraine headaches, tension backaches, muscle spasms and tics, essential hypertension etc.

Unlike the far simpler GSR and temperature indicators, myographs necessarily need sophisticated electronic circuitry in order to monitor the very low level activity of neuron firings.

The actual signals are picked off by silver, silver-chloride or gold electrodes placed on the surface of the skin directly across the muscle concerned. In some cases the signal may be obtained via implanted electrodes.

Signal level is very low — often as small as 0.1 microvolts, so noise rejection must be high. A typical unit will have common mode rejection of better than 100 dB. A bandpass filter is usually incorporated. This typically rolls off at 18 dB/octave beyond 100—500 Hz. The output signal is generally averaged over an adjustable 0.5 to 5 second period.

This type of instrument is not really suitable for home designing or building.

## Heart rate

The heart is simply a four-chambered pump. It receives circulating blood, causes the blood to be pushed into the lungs where it picks up oxygen, then causes this blood to be returned to the heart and finally and very powerfully this re-oxygenated blood is forced through the body.

The rate at which the heart beats appears to be directly related to the metabolic requirements of the body, but the way in which this is done is not currently understood. However virtually every part of the brain yet examined appears to play some part in the determining and controlling heart rate.

Short of simply feeling one's pulse and timing it with a stopwatch, the next simplest method is to monitor fluctuations in blood density as the pulse occurs. This may be done opto-electronically using a simple light source and photocell attached across an ear-lobe or finger tip.

There is growing evidence that the ability to control heart rate via a bio-feedback process would be of value in protecting it from undue stress. As with most biofeedback activities it is very easy to do this given the correct apparatus. Yogis have, of course, gained such control *without* apparatus. Nevertheless it should be emphasised that less appears to be known about heartrate control than galvanic skin response or myography.

## Brainwave monitors

The brain produces four major electrical rhythms, classified by frequency. These rhythms may be monitored by an electroencephalograph (EEG) which detects, amplifies and displays them electrically.

The major rhythms are —
Beta: 13-30 Hz — associated with attention, anxiety.
Alpha: 8-12 Hz — associated with relaxation, well being.
Theta: 4-8 Hz — associated with imagery, meditation.
Delta: 0.5-4 Hz — associated with dreamless sleep.

Generally the rhythms are produced in short bursts — often of 10—25 cycles — and generally non-overlapping.

The signals may all be monitored via one set of electrodes placed at the front and rear of the skull — a third electrode is also used to provide a 'reference'.

All four rhythms have very low amplitude — about a microvolt or two — so that good noise performance is essential if the equipment is to function correctly.

Very good filtering is also required to eliminate interference from stray 50 Hs signals and also to prevent interference from artifacts (spuria generated by muscular activity). Analogue filters having the required characteristics can be produced but digital filters should preferably be used. If an analogue filter is used, a good one is a three-pole Butterworth with 18 dB/octave rolloff.

It is almost essential to use a differential input amplifier using low noise devices. Input cables must be shielded. Common mode rejection should be about 120 dB at 10 Hz and if possible at least 150 dB at 50 Hz. Input impedance should be no less than one megohm. The output indication should be aural. Most people prefer to have their eyes closed when trying to generate alpha rhythms.

Alpha training has become somewhat of a cult — particularly in the USA where a large industry exists simply to supply alpha monitors (of varying efficacy!)

Most people can learn to generate alpha rhythms at will and there is a great deal of evidence that a state of well-being and deep relaxation is associated with alpha production.

Alpha training is also used by clinical psychologists and psychiatrists particularly in attitude change and re-inforcement.

Theta waves are also controllable. This type of waveform appears to be in some way associated with creativity. It may well be that creativity can be enhanced by learning to control a theta state: we understand that some researchers are investigating this at present.

Biofeedback is still very much an infant and largely orphan science and at present it is difficult to forecast just what impact it will have on mankind.

There is ample evidence that by using biofeedback the average subject can in minutes learn to vary his state of tension, body temperature, heart rate, brainwave generation etc — techniques which have taken gurus a lifetime to master.

Many autonomic nervous functions clearly *can* be willfully controlled and there is growing evidence that many tension-related illnesses (and about 90% of illnesses are currently believed to be so related) can be alleviated or cured by biofeedback techniques.

Clearly the current worldwide interest and excitement in biofeedback is well founded. ●

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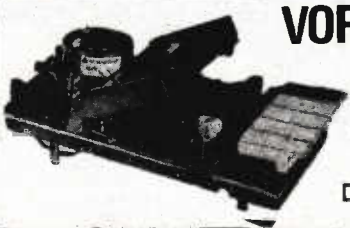

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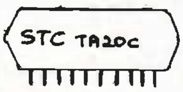


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# HEART-RATE MONITOR

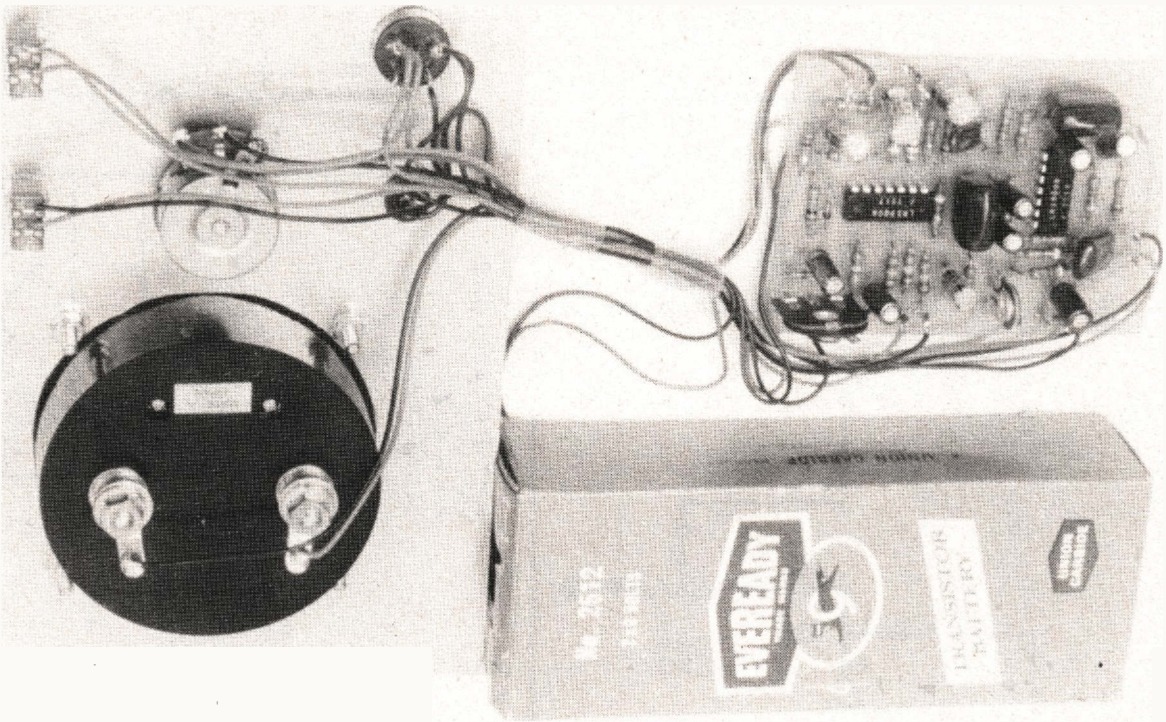
An invaluable tool for the bio-feedback experimenter or for the assessment of athletes.

THE GREEK PHILOSOPHER GALEN exploded the myth and mystery surrounding the functioning of the heart by being the first to describe it as a simple pump.

In the ensuing 1800 years it has become increasingly evident that whilst the heart *is* a pump it's by no means a simple one. This is particularly true of the control mechanisms which determine the rate at which the heart pumps — the heart rate.

In recent years researchers have investigated the way emotions affect heart rate as it is now known that stress gives rise to hypertension (high blood pressure) and heart disease. Heart rate is very sensitive to emotional state and the slightest emotional change can cause the heart rate to vary. Heart rates are higher in a state of anxiety or stress and when the heart rate is higher than normal problem-solving abilities decrease. Continual stress and resultant high heart rate ultimately causes hypertension which if unchecked may cause heart disease and death.

Two other common causes of hypertension are renal (kidney) disorders and arterio schlerosis (hardening of the arteries). Hypertension caused by stress (or other unknown causes) is called 'essential hypertension' and the traditional method of treatment for this or hypertension from any other cause is by means of drugs which in effect reduce the rate but increase the pumping effi-




ciency of the heart. This lowers blood pressure and prevents the hypertensive condition from giving rise to heart conditions.

Most recently considerable experimentation has been taking place in the reduction of heart rate by self control and biofeedback methods. In one experiment the Yogic 'Shavasan' exercise (deep breathing exercises in the prone position) were found to be effective in lowering heart rate and hence controlling hypertension without the use of drugs. Biofeedback type experiments have proven that heart rate may be controlled by a conscious effort of the will. Both these avenues of research offer hope that hypertension may eventually be curable without the assistance of drugs. In such research a heart-rate monitor is an invaluable tool.

Apart from hypertension, heart rate is also affected by muscle activity and by infection. With exertion the heart rate goes up quite rapidly and may rise for example from a rest rate of 50 beats per minute to 150 or more during strenuous and prolonged exercise. When the exercise is completed the rapidity with which the heart rate returns to normal is a measure of fitness and hence heart rate meters are often used in association with exercise bicycles to assess the fitness of athletes.

## DESIGN FEATURES

There are many methods of measuring heart rate ranging from feeling the pulse, to chart recordings via an electrocardiograph. Other methods include monitoring the electrical potential which triggers each heart beat; resistance changes due to changes in blood flow; and change in the volume of blood in blood vessels with each beat.

The detection of electrical signals associated with heart action is the best and most reliable method especially if the subject is exercising. However good connection must be made to the body by special electrodes and conductive paste to ensure very low contact resistance. The method is messy and requires skill in attaching the electrodes.

Similar electrodes are required to measure changes in body impedance and in addition the measurement is usually made by passing an electrical current through the body. This poses a considerable safety hazard as any fault in the insulation of mains-operated equipment can cause lethal currents to pass through the body. For this reason we did not use the method and we strongly recommend that experimenters do not either! With very well attached electrodes even small voltages can produce lethal currents.

This leaves us with the light-beam method, two variations of which are in common use. One is to pass light through flesh to a bone where it is reflected to a photo sensitive device adjacent to the lamp. This has the advantage that the sensor may be taped to any convenient part of the body, e.g., the forehead, but the signal generated is very low. A second method still uses a light source and photo-sensor but the light is passed to the sensor through some thin section of flesh — the fleshy part of a finger or the ear lobe work very well. As there are no electrical contacts with the body this type of sensor is very safe to use and was therefore chosen for use in the ETI meter.

**Specific Circuitry:** While the detection and amplification of the signal due to heart action can be done with normal linear amplifiers the frequencies involved are very low. Measures must be taken to reject frequencies other than those of interest and to overcome dc offset problems due to differences in the path lengths depending on where the probe is attached.

Thought must also be given to the type of readout to be used. Were a digital readout to be used, counting of the rate would have to be performed for a full minute in order to obtain a

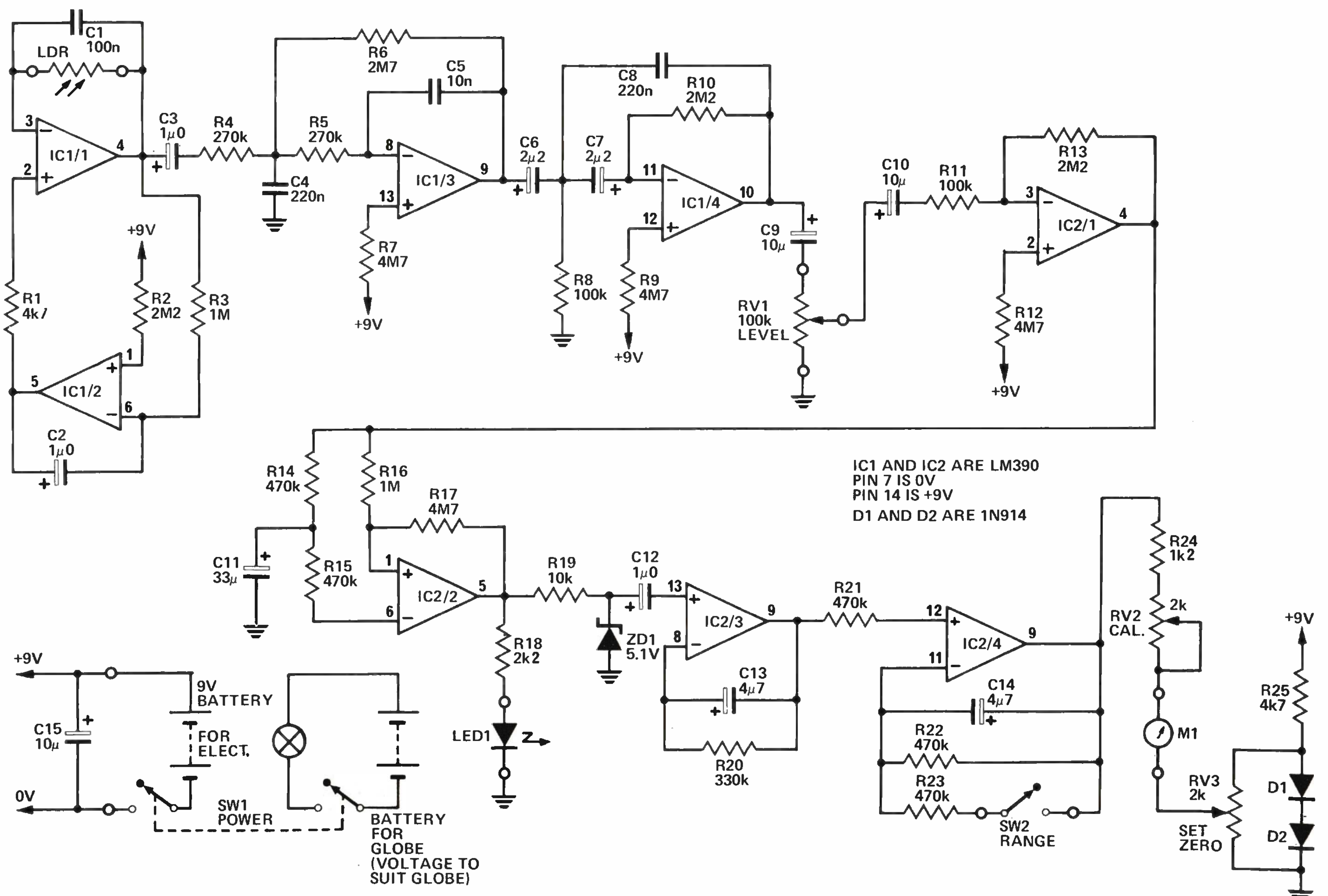



*Fig. 1 Circuit diagram for heart-rate monitor.*

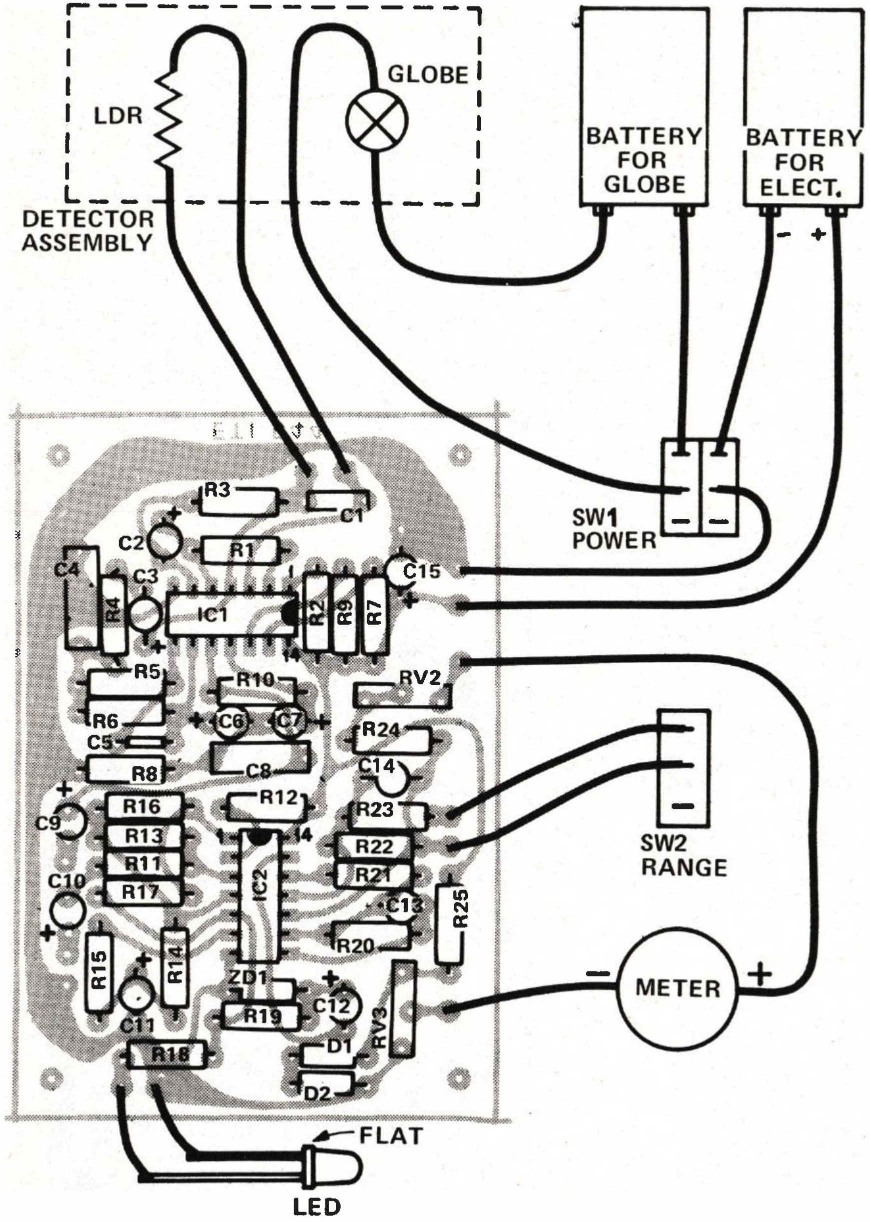



*Fig. 2 Component overlay and wiring diagram.*

## WARNING

The ETI 544 heart rate meter described in this project is not intended to be used as a diagnostic instrument.

It is usable by those experimenting in the control of heart rate by biofeedback and is of course of value to sportsmen or sporting organizations to monitor heart rate whilst exercising.

We must advise readers that this instrument must never be used for any other purpose except under supervision of suitably qualified people.

### Parts List ETI 544

Resistors all ½w 5%

| | |
|---|---|
| R1 | 4 k7 |
| R2 | 2 M2 |
| R3 | 1 M |
| R4,5 | 270 k |
| R6 | 2 M7 |
| R7 | 4 M7 |
| R8 | 100 k |
| R9 | 4 M7 |
| R10 | 2 M2 |
| R11 | 100 k |
| R12 | 4 M7 |
| R13 | 2 M2 |
| R14,15 | 470 k |
| R16 | 1 M |
| R17 | 4 M7 |
| R18 | 2 k2 |
| R19 | 10 k |
| R20 | 330 k |
| R21-R23 | 470 k |
| R24 | 1 k2 |
| R25 | 4 k7 |

**Potentiometers**

RV1 100 k log rotary
RV2 2 k Trim.
RV3 2 k Trim.

**Capacitors**

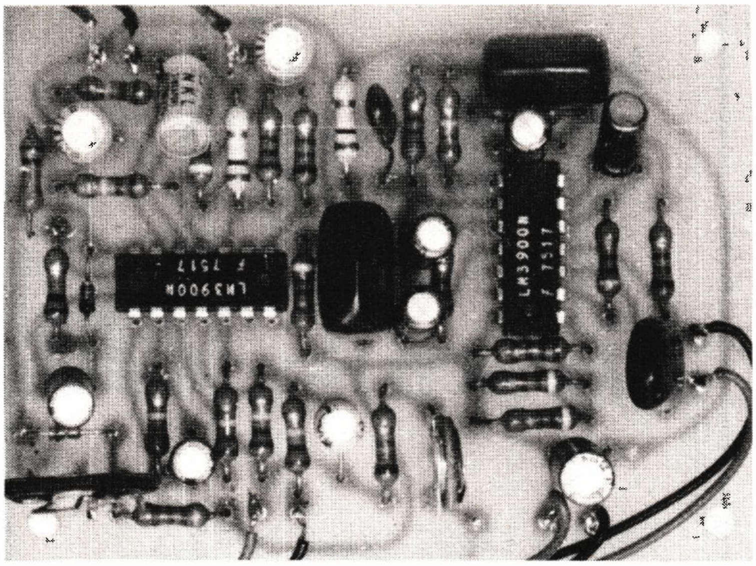
| | |
|---|---|
| C1 | 1 µF 35V electro |
| C2 | 100 n polyester |
| C3 | 1 µF 35V electro |
| C4 | 220 n polyester |
| C5 | 10 n " |
| C6,7 | 2 µ2 25V electro |
| C8 | 220 n polyester |
| C9,10 | 10 µ 35V electro |
| C13,14 | 4 µ7 25V electro |
| C15 | 10 µ 16V electro |

**Semiconductors**

| | |
|---|---|
| IC1,2 | LM3900 |
| D1,2 | 1N914 |
| ZD1 | 5.1V Zener 400mW |
| LED1 | |

**Miscellaneous**

| | |
|---|---|
| Meter | 1mA FSD |
| PC board ETI 544 | |
| Box to suit | |
| 9V battery | |
| 2 x 9V batteries | |
| One single pole switch | |
| One double pole switch | |
| LDR ORP12 or similar | |
| 12V 30mA globe | |



one beat resolution and a new reading could only be taken at one minute intervals if normal frequency measurements are used. However this problem may be overcome by measuring the period between the pulses and converting this to a frequency which can then be measured using digital logic to obtain a reading on every beat. This is quite valuable in a machine used for diagnostic work where information on the variations in regularity of the interval between adjacent beats can be quite meaningful. However the method is complex, and expensive and requires some other type of sensor than the light beam type to obtain the accuracy required. As our meter is not intended for diagnosis the digital technique was rejected in favour of a simple analogue meter display.

Even with an analogue readout we still have a choice of operating methods. We can measure the period between beats as previously discussed or we can use it as an integrating frequency meter. The latter method requires about 25 seconds for the reading to stabilise initially but thereafter it will follow variations in heart rate quite faithfully. The measurement of period between each beat is more rapid in its response but requires more complex circuitry and is very responsive to noise 'glitches' or to phenomena other than heart beat. Furthermore the scale for such an instrument is non-linear and wrong reading. That is high readings are at the left of the scale and vice versa. For these reasons the integrating frequency meter was chosen as the cheapest and most effective method for our particular application.

Our original prototype was built with 741 type operational amplifiers but in the final version we used the LM3900 which contains four Norton type operational amplifiers in the one package. This is a very economical solution as although the circuit is quite complex in concept, the whole device only uses two inexpensive ICs (approx. $1.25 each).

In the development of the circuit for this instrument a laboratory power supply was used. However when the completed board was mounted into its case and run from batteries it worked alright until the batteries had been used for a while and then problems were encountered. The unit would just not count correctly. After much experimentation it was discovered that when the Schmitt trigger operated the power rail changed by about 10 millivolts or so and this modulated the globe thus generating a spurious pulse.

Having located the problem it was a simple matter to cure it – just run the globe from a separate battery and no further problems.

## CONSTRUCTION

The prototype of the heart-rate monitor was built on a printed-circuit board as we find this method of construction neatest and simplest. However the layout is not critical and any other method may be used if desired. An overlay is provided which shows the orientation of components.

There is no need to use the box that we used either – any suitable one will do. Just use the wiring diagram supplied to connect up the unit.

The sensor was made from a spring clip type of clothes peg, by mounting the globe on one leg of the peg and the LDR on the other. Holes must be provided in the peg so that the light can pass through to the LDR. Fix the globe and LDR into position with a little epoxy cement. The area around the rear of the LDR should be painted black or covered with tape to prevent all light other than that from the globe reaching it.

## USING THE MONITOR

To use the monitor simply clip the sensor to the ear lobe or to the fleshy part of the finger or thumb. Now adjust the sensitivity upward until the LED justs starts to flash regularly – indicating that heart beat is being detected reliably. The reading on the meter will start to rise and will become stable after about 25 seconds. Hereafter the reading will faithfully follow variations in heart rate.

Note that the finger or thumb should not be moved whilst taking a reading as this will cause a change in the flesh– which can be interpreted as a spurious heart beat thus giving an erroneous change in the indicated rate.

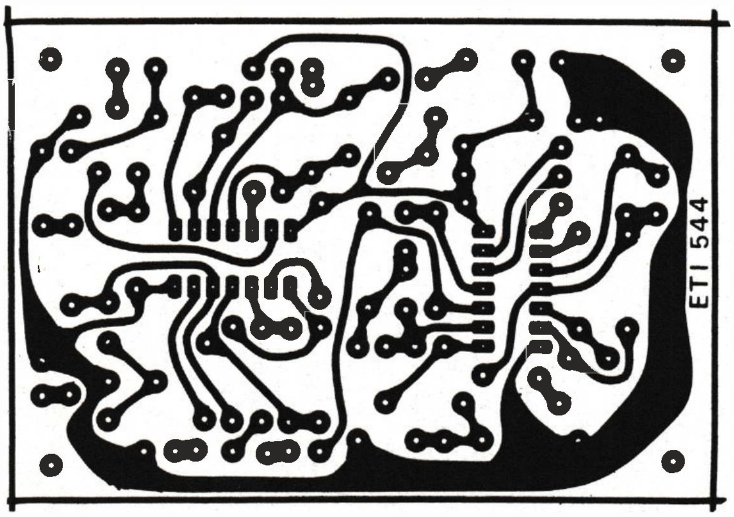



*Fig. 3 Printed circuit layout. Full size 91 x 64mm.*

## How it works ETI544.

The sensor consists of a light globe and a light-dependant resistor mounted in a clothes peg in such a way that they may be positioned on opposite sides of a small section of flesh such as the ear lobe or a finger. As the heart beats it pumps blood through all the blood vessels of the body which swell. The density of the body therefore changes giving rise to a change in light transmission through the section of flesh to which the sensor is clipped. The LDR which is subject to this change of illumination therefore changes its resistance, and it is this change in resistance which eventually drives the meter. As the actual amount of light transmitted varies greatly from person to person and according to the thickness of flesh between the sensors, some method of stabilising the working base line is required.

The stabilising function is performed by IC1/1 and IC1/2. Due to the operating mode of IC1/1 the current through the LDR is always equal to the current through R1. The current in R1 is automatically adjusted by IC1/2 such that the output of IC1/1 sits at about four volts (as the current in R2 must equal the current in R3). Capacitor C2 prevents the current in R1 from changing quickly and hence, relatively fast changes due to heart-beat (which cause changes in LDR resistance) are detected.

As the output of IC1/1 is at a very low level this signal must be amplified by IC1/3 and IC1/4 by about 40 dB. A low-pass filter which limits the rate, which can be detected to about 250 beats per minute, is also formed by IC3/3; and a low-pass filter which cuts off all frequencies below 30 beats per minute is formed by IC1/4. These filters eliminate 50 Hz pickup and any other signals generated by slow movement of the body which could also interfere with the measurement. As the actual signal can vary over a range of 20 dB with different people a level control is incorporated, after IC1/4, and the output from this control is amplified by 26 dB in IC2/1.

The output of IC2/1 has now to be squared up before it can be used. This is performed by a Schmitt trigger formed by IC2/2 where the necessary positive feedback is supplied by R17. Both inputs are biased from the output of IC2/1 but the ac signal is prevented from reaching the negative input by capacitor C11. An LED driven by the output of IC2/1 is incorporated to give a visual indication that heart beat is actually being detected.

It is now necessary to convert the square wave from the output of IC2/2 into a voltage proportional to heart rate and this is the purpose of IC2/3. Each time the output of IC2/2 goes high, capacitor C12 is charged up via R19 and the positive input from IC2/3. By the nature of the IC this current has to be balanced by a corresponding current in the negative input. This current can only be supplied by the output going high and supplying current via C13. This charges C13 up a little. On the negative edge of the output from IC2/2 the capacitor is discharged via the protection diodes on the input of IC2/3. If R20 was not present C13 would continue to charge up on each input pulse, however R20 bleeds a little current from C13 and the charging stops when it reaches a voltage where the amounts of charge and discharge become equal. The voltage reached will of course now be proportional to the heart rate. The amount of ripple on this voltage is determined by the time constant of R20 and C13 and this is selected as a compromise between response time and ripple. The zener diode is used to stabilise the output of IC2/2 against any changes in supply voltage.

The last section of IC2 is used as a buffer amplifier which provides the two ranges required along with an extra stage of filtering. The output of IC2/4 is metered to give a direct readout of heart rate. A resistor and trimpot in series with the meter allow the instrument to be calibrated and the potentiometer RV3 provides a zero correction (as the output of IC2/4 is not at zero volts but at about 0.8 volts). Diodes D1 and D2 stabilise this against supply variations.

# TV CHALLENGER® SERIES 3000

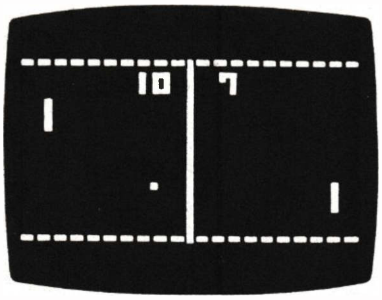
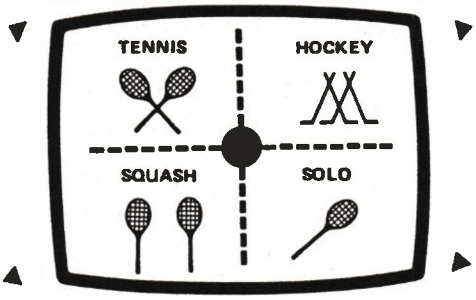



FIGURE 1



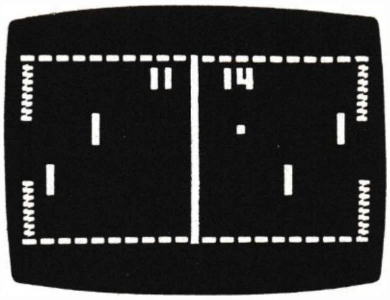




FIGURE 2

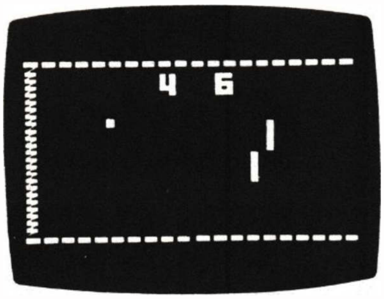



FIGURE 3

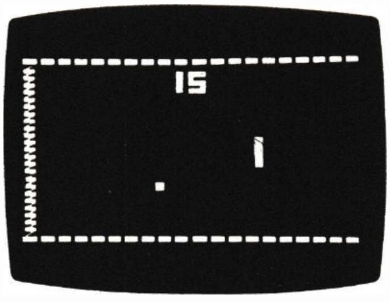



FIGURE 4

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## GAME DESCRIPTION

### TENNIS

The game will appear on your screen as shown on figure 1. It is played by the players who use the left and right paddle controllers to vertically raise or lower their paddles. Play starts upon depressing the reset switch which causes the score to reset to 0 - 0 and when the manual serve switch is in the automatic position will serve the ball from either the left or the right court. The player who is served must hit the ball back to his opponent, who must then return it. When either player misses his shot, a point is scored for his opponent and the next ball is served to him from the opponents court. Scoring is automatically displayed. The game ends with the first player to reach 15 points.

### HOCKEY

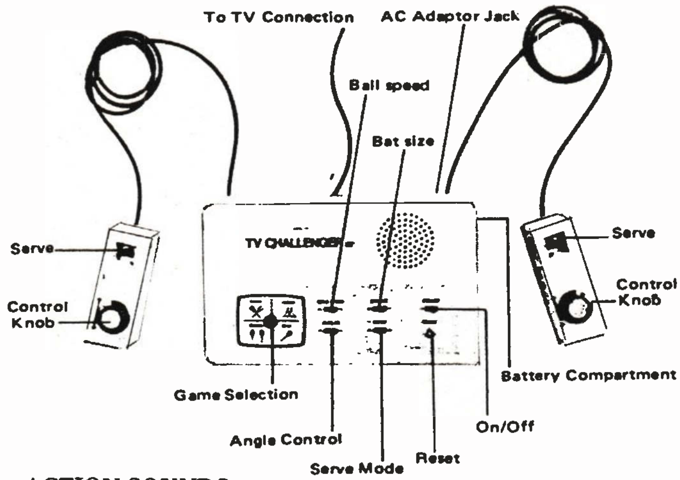
This game will appear on your screen as shown on figure 2. Hockey, while similar to tennis, is a much faster and more exciting game. Each player controls his GOALIE who moves in a vertical motion, and one forward MAN who also moves vertically. These MEN move up and down as a group. As in tennis, the opening serve comes cross-court to either player on a random basis. Further serves are to player who has just lost a point. Since each player has two MEN who can return the puck, the play is very fast. Scoring is the same as in tennis - first player to reach 15 points is the winner.

### SQUASH

Squash consists of a court as depicted in figure 3. It plays identical to tennis except only one player operates at a time and both are on the same side of the court, playing against the opposite wall. After the ball is served the left player must hit the ball first and then alternates between the two players. This action continues until a point is scored. The object of the game is to keep the ball in play by continuously hitting it to the back court wall. The ball can be reflected off 3 sides - the top, botton, and left wall. Again the first player to score 15 points is the winner

### PRACTICE

This game is almost identical to squash exept that it is played by a single player with a single paddle as shown on figure 4. And only one side will score points.




### ACTION SOUNDS

In all games three types of sound are heard
a) Sound when the ball reflects of boundaries.
b) When the ball hits a paddle.
c) When a score is made.

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| NS LINEAR APPS. HANDBOOK VOL.1 | $4.55 |
| NS LINEAR APPS. HANDBOOK VOL.2 | $4.55 |

## MOTOROLA DATA BOOKS

| | |
|---|---|
| FUNDAMENTALS OF INTEGRATED CIRCUITS | $12.65 |
| LINEAR INTEGRATED CIRCUITS DATA BOOK | $4.60 |
| McMOS DATA BOOK | $4.00 |
| McMOS HANDBOOK | $4.60 |
| MECL INTEGRATED CIRCUITS DATA BOOK | $4.60 |
| MECL SYSTEM DESIGN HANDBOOK | $4.00 |
| MOS MEMORIES DATA BOOK | $4.00 |
| POWER CIRCUITS HANDBOOK | $4.00 |
| SILICON RECTIFIER HANDBOOK | $4.00 |
| SWITCHING TRANSISTOR HANDBOOK | $4.60 |
| ZENER DIODE HANDBOOK | $4.00 |

## TECHNICAL BOOKS

| | |
|---|---|
| TTL COOKBOOK | $10.30 |
| RTL COOKBOOK | $6.30 |
| MODERN APPLICATIONS OF LINEAR IC'S | $12.95 |
| SOLID STATE CIRCUIT DESIGN AND OPERATION | $9.95 |
| PASSIVE EQUALIZER DESIGN DATA | $19.95 |
| ELECTRONIC DESIGNER'S HANDBOOK | $9.95 |
| ELECTRONICS REFERENCE DATABOOK | $4.95 |
| FET APPLICATIONS HANDBOOK | $14.95 |
| ELECTRONICS DATA HANDBOOK | $4.95 |
| HANDBOOK OF SEMICONDUCTOR CIRCUITS | $5.95 |
| CIRCUIT CONSULTANT'S CASEBOOK | $9.95 |
| DIGITAL ELECTRONICS: PRINCIPLES & PRACTICE | $5.95 |
| MODERN RADAR: Theory, Operation & Maintenance | $7.95 |
| WHK 112 PAGE TECHNICAL CATALOGUE | $2.50 |

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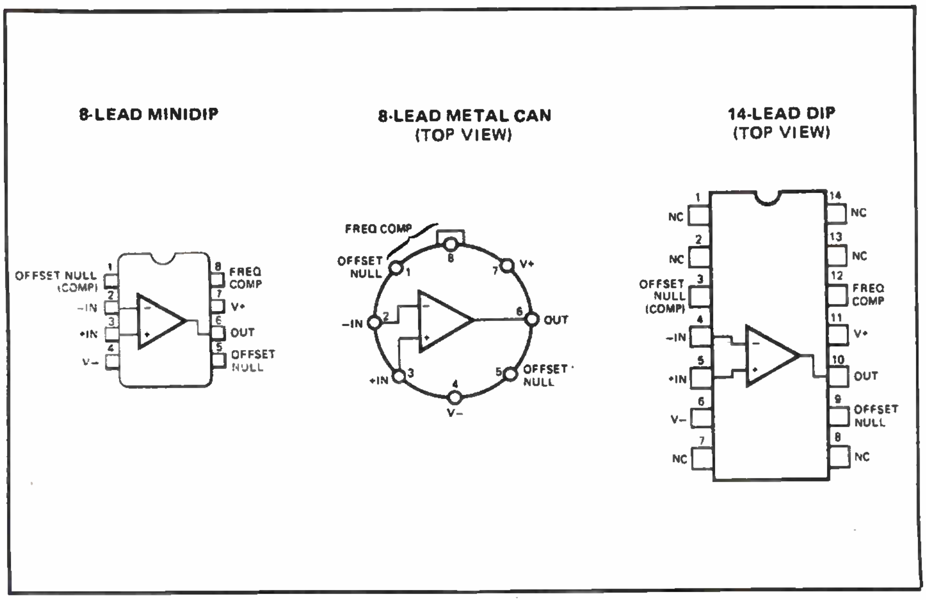
# ETI data sheet

## μA301 general purpose op-amp.

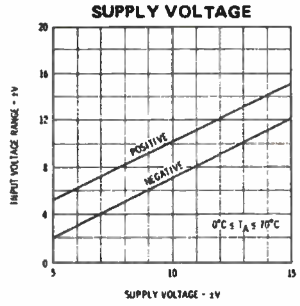
### QUICK REFERENCE GUIDE

| | |
|---|---|
| **Maximum ratings** | |
| Supply voltage | max. 18 V |
| Internal power dissipation | |
| Metal can | max. 500 mW |
| DIP | max. 670 mW |
| Mini DIP | max. 310 mW |
| Differential input voltage | max. ±30 V |
| Input voltage | max. ±15 V |
| Output short-circuit duration | indefinite |
| **Characteristics** | |
| ($V_S$ = 5 to 15 V; C1 = 3p) | |
| Input offset voltage ($R_S \leqslant$ 10 k) | typ. 2 mV |
| Input offset current | typ. 3 nA |
| Input bias current | typ. 70 nA |
| Input resistance | typ. 2 M |
| Supply current ($V_S$ = 15 V) | typ. 1.8 mA |
| Large signal voltage gain ($V_S$ = ±15 V; $V_{OUT}$ = ±10 V; $R_L \geqslant$ 2 k) | typ. 160 V/mV |
| Output voltage swing | |
| $V_S$ = ±15 V; $R_L$ = 10 k | typ. ±14 V |
| $V_S$ = 15 V; $R_L$ = 2 k | typ. ±13 V |
| Input voltage range ($V_S$ = ±15 V) | typ. ±12 V |
| Common mode rejection ratio ($R_S \leqslant$ 10 k) | typ. 90 dB |
| Supply voltage rejection ratio ($R_S \leqslant$ 10 k) | typ. 90 dB |

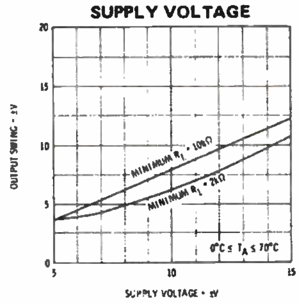



These op-amps (LM301, μA301, etc) are intended for applications requiring low input offset voltage or low input offset current. The low drift and bias currents are advantageous in such applications as long interval integrators, timers and sample and hold circuits. The frequency response can be set with one external capacitor. There is no latch-up and protection against short circuits. Recent projects using 301s include the ETI 446 audio limiter and the ETI 602 mini organ. ETI ads price this device at around 65c.

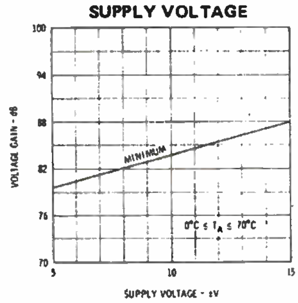
**INPUT VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE**



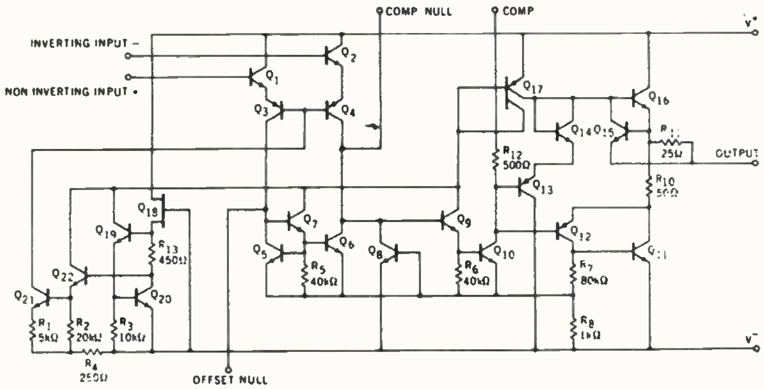

**OUTPUT SWING AS A FUNCTION OF SUPPLY VOLTAGE**



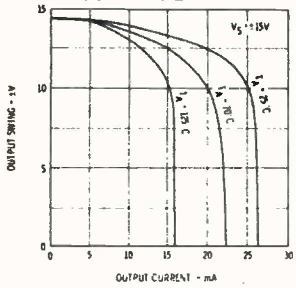

**VOLTAGE GAIN AS A FUNCTION OF SUPPLY VOLTAGE**



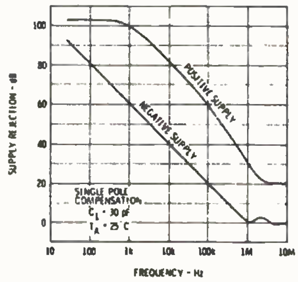
## EQUIVALENT CIRCUIT




## CURRENT LIMITING

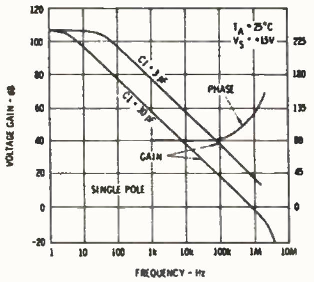



## POWER SUPPLY REJECTION AS A FUNCTION OF FREQUENCY

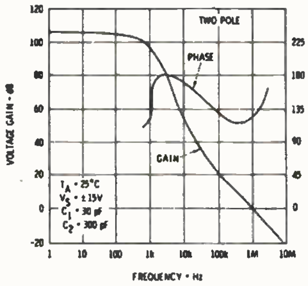



## TYPICAL PERFORMANCE CURVES

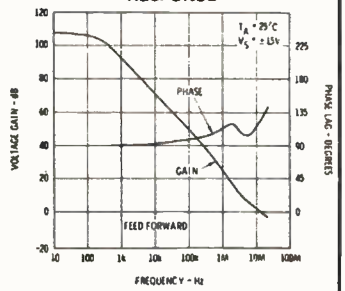
### OPEN LOOP FREQUENCY RESPONSE



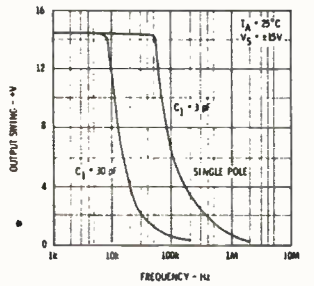

### OPEN LOOP FREQUENCY RESPONSE



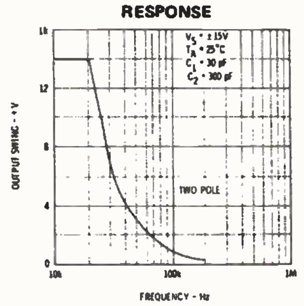

### OPEN LOOP FREQUENCY RESPONSE



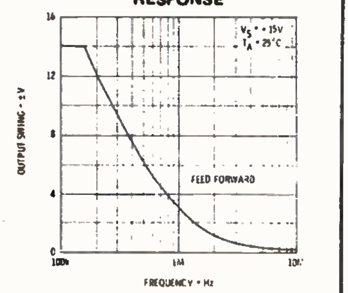

### LARGE SIGNAL FREQUENCY RESPONSE



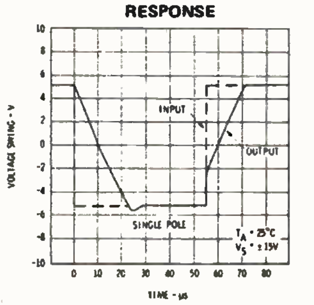

### LARGE SIGNAL FREQUENCY RESPONSE



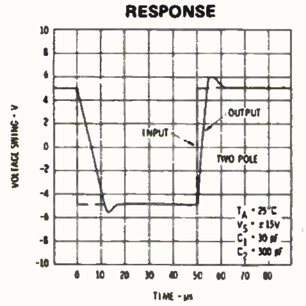

### LARGE SIGNAL FREQUENCY RESPONSE



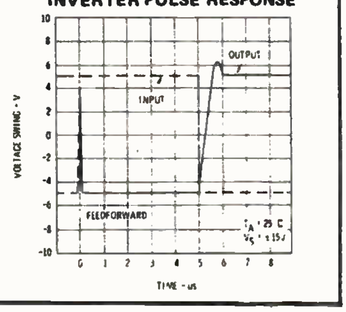

### VOLTAGE FOLLOWER PULSE RESPONSE



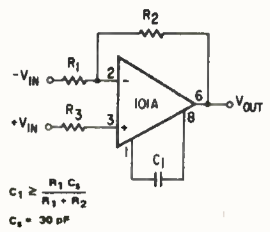

### VOLTAGE FOLLOWER PULSE RESPONSE



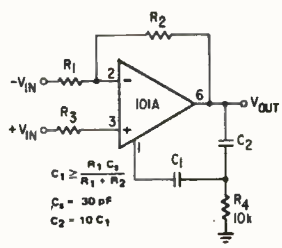

### INVERTER PULSE RESPONSE



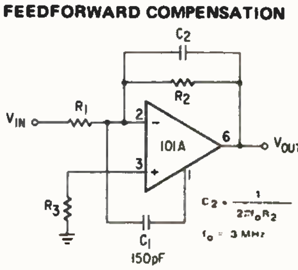

## SINGLE POLE COMPENSATION




## TWO POLE COMPENSATION




## FEEDFORWARD COMPENSATION

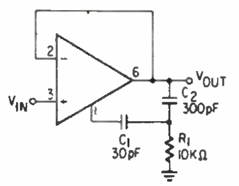


# ETI data sheet

## TYPICAL APPLICATIONS

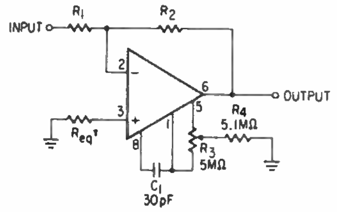
(All pin numbers shown refer to 8-lead TO-5 package)

### FAST VOLTAGE FOLLOWER



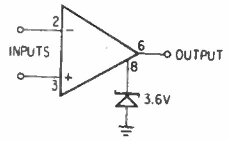

Power Bandwidth: 15 kHz
Slew Rate: 1 V/µs

### INVERTING AMPLIFIER WITH BALACING CIRCUIT

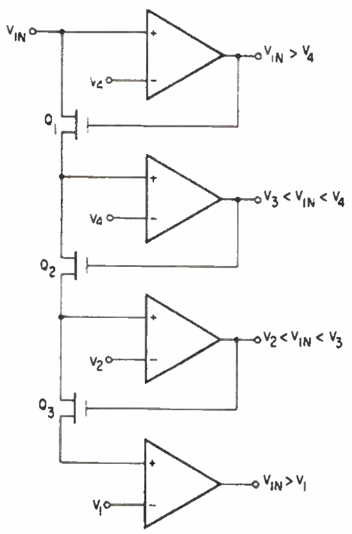



† May be zero or equal to parallel combination of R1 and R2 for minimum offset.

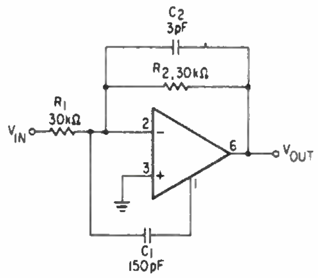
### VOLTAGE COMPARATOR FOR DRIVING DTL OR TTL INTEGRATED CIRCUITS



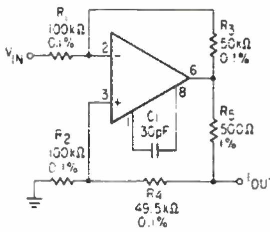

### MULTIPLE APERTURE WINDOW DISCRIMINATOR



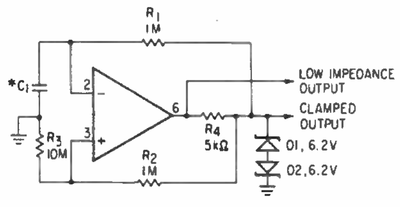

### FAST SUMMING AMPLIFIER




### BILATERAL CURRENT SOURCE

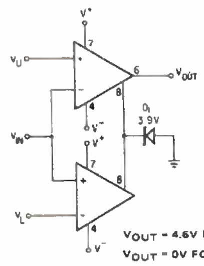



### LOW FREQUENCY SQUARE WAVE GENERATOR




* Adjust C1 for frequency

### DOUBLE ENDED LIMIT DETECTOR



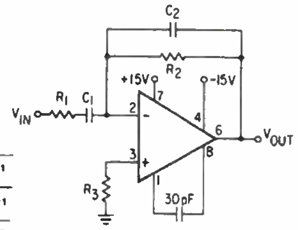

$V_{OUT}$ = 4.6V FOR $V_L \leq V_{IN} \leq V_U$
$V_{OUT}$ = 0V FOR $V_{IN} < V_L$ OR $V_{IN} < V_U$

### PRACTICAL DIFFERENTIATOR

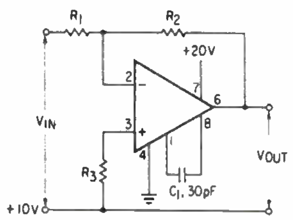
$f_c = \frac{1}{2\pi R_2 C_1}$

$f_h = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi R_2 C_2}$

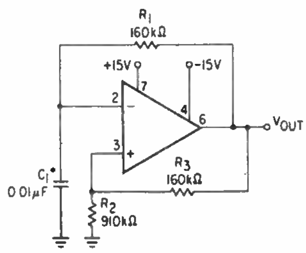
$f_c < f_h < f_{unity\ gain}$




### CIRCUIT FOR OPERATING WITHOUT A NEGATIVE SUPPLY

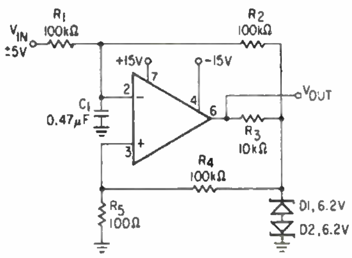



### FREE-RUNNING MULTIVIBRATOR




*Chosen for oscillation at 100 Hz

### PULSE WIDTH MODULATOR



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LER 149

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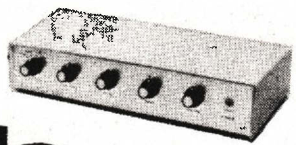
## ETI 444 5 Watt Stereo Amp.



**(See June '76 ETI) Some kits still available.**

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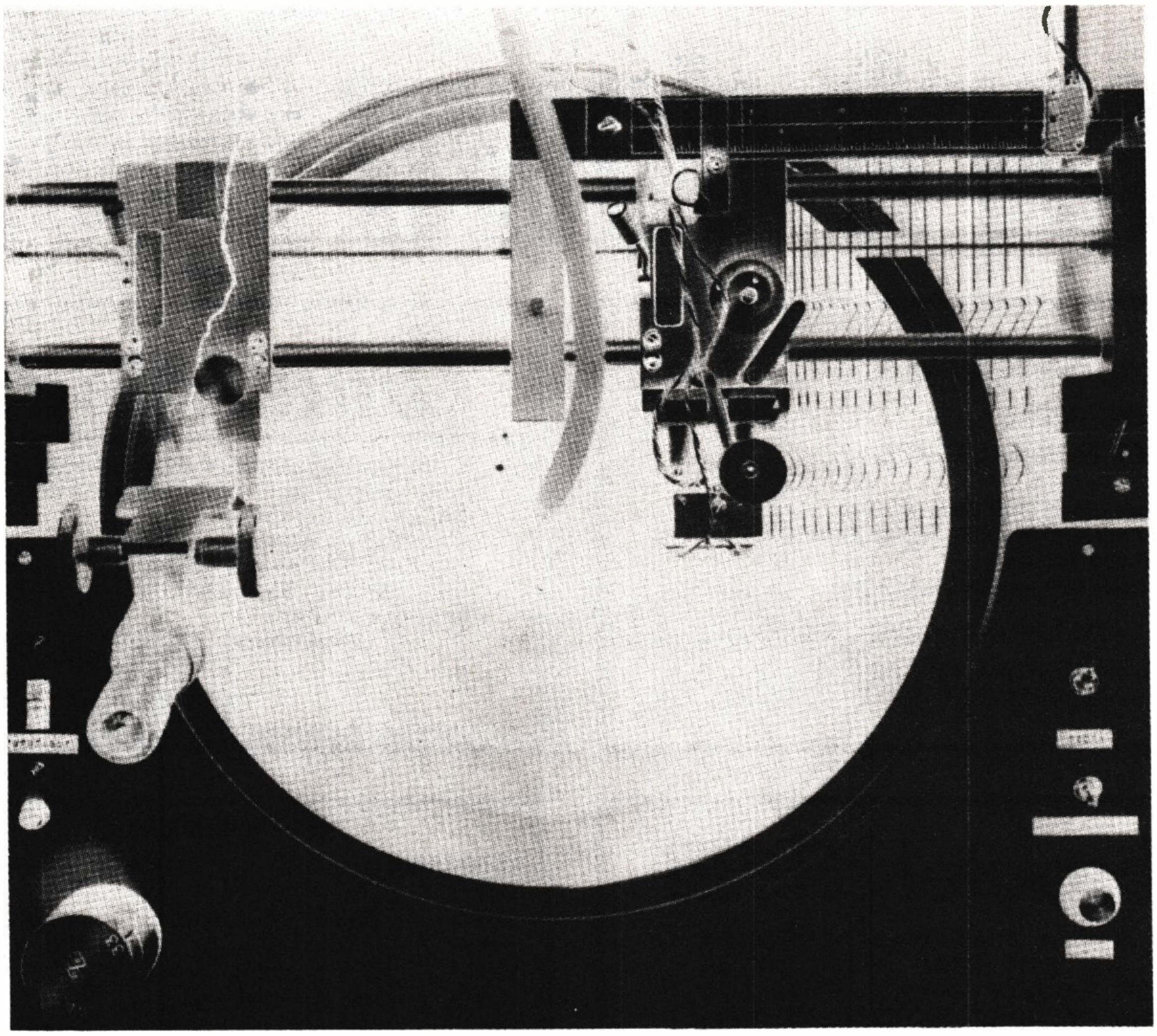
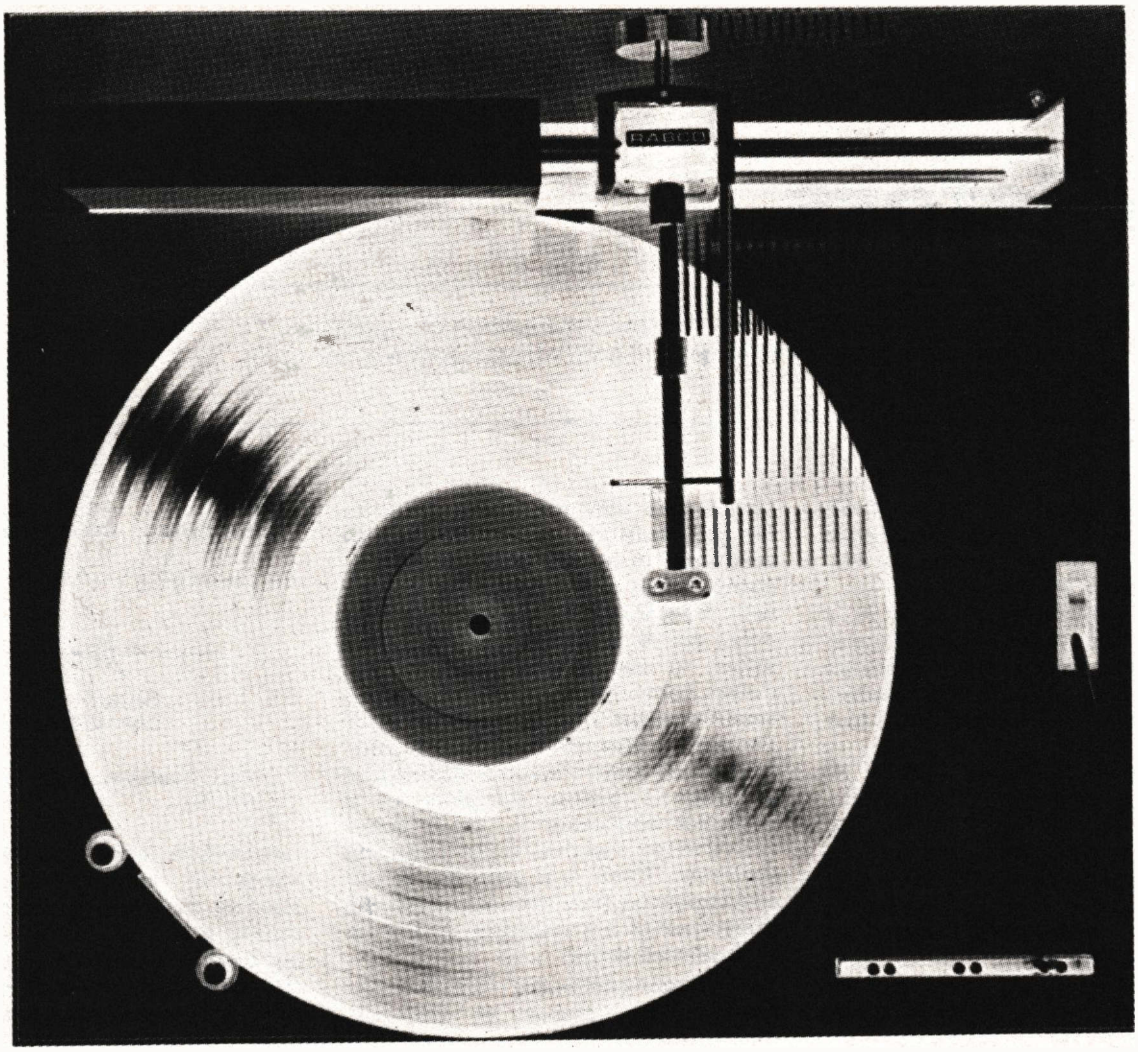


# This is how discs are made.

A master disc is cut on a special lathe. The cutting head moves across the master in a straight line from the edge to the center. The special stylus inscribes a groove in the surface of the disc.

Ideally, a turntable system should enable the stylus in your cartridge to meticulously follow the "path" inscribed during the cutting process. That is, it should play your record precisely as the master disc was originally cut.

A "straight line tracking" turntable system, properly designed, engineered and manufactured, could eliminate problems such as skating force, tracking error, and the resulting excessive record wear, all of which are *inherent* in pivoted arm systems in all their forms and modifications.




# This is how the ST-7 plays them.

The Rabco ST-7 is a *straight line tracking turntable*. Your stylus precisely follows the original path cut into the master record. The result is the total elimination of *both* tracking error and skating force.

The ST-7 begins with straight line tracking. In every other respect—motor. suspension, bearings, drive, controls—it is exemplary of a professional instrument designed for home use.

The ST-7 offers a cascade of zeroes. Zero tracking error. Zero skating force. Zero stylus overhang. Zero horizontal friction. Zero vertical friction.

The ST-7 plays music in the home in a way that makes conventional pivoted arm systems obsolete.

**For complete information write to Harman Kardon, P.O. Box 6, Brookvale. 2100.**

**harman/kardon**

# Resistors

Last month we looked at the most common resistors, the carbon composition types. This article now looks at resistors in general and introduces the other types we will be considering.

RESISTORS MUST BE THE MOST commonly used of electronic components – to the point where they tend to be taken for granted.

Resistors are, however, made in a variety of ways either for general use or because their particular characteristics suit certain areas of application. Modern resistors can be classified into four broad groups:

(a) composition resistors
(b) film resistors
(c) wirewound resistors
(d) semiconductor resistors

There is a variety of construction styles in each group, each style having particular characteristics, advantages and disadvantages.

**General Characteristics** – Resistors are not quite the passive "she'll be right" components they are usually taken to be. All resistors vary in value with variations in temperature. They also change value with applied voltage and with frequency. All resistors generate noise, and thus certain types are better suited to applications requiring low noise components, such as audio amplifier input circuits. Knowing what the various characteristics of a resistor mean in different situations enables you to make a proper selection for a particular application – or to make substitutes without introducing problems. There is a generally agreed convention on how the various resistor characteristics are expressed and these are explained below.

**Temperature coefficient** – With many resistors, the change in value of resistance is fairly linear across a large range of temperature. With such resistors the temperature coefficient is usually expressed in 'parts per million per degrees centrigrade' or ppm/°C. It is also sometimes expressed in percent of value per degrees centigrade, or %/°C.

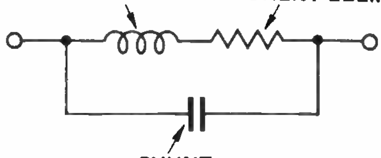
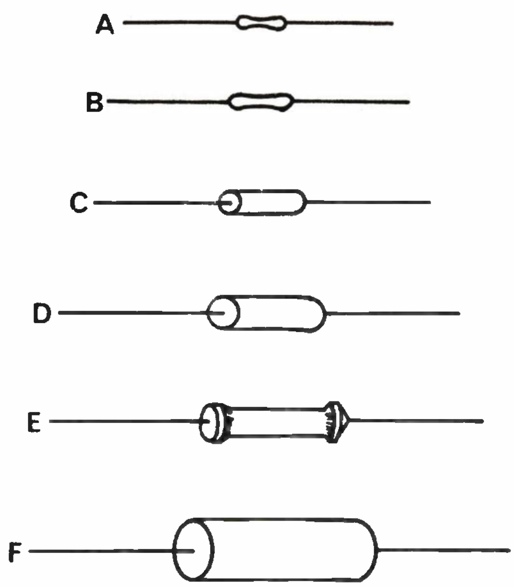



*Fig.1. Equivalent circuit of practical resistor.*




| SIZE | TYPE | WATTAGE RATING @40°C | @70°C | LENGTH | DIA |
|---|---|---|---|---|---|
| A | Carbon Film | | .05 | 4 mm | 1.5 mm |
| B | Composition | | .25 | 6.5 mm | 2.3 mm |
| | Carbon Film | | .25 | 7 mm | 2.3 mm |
| | Metal Film | | .25 | 7 mm | 2.5 mm |
| | Metal Oxide | | .125/.25 | 7.2 mm | 2.5 mm |
| C | Composition | | 0.5 | 10 mm | 3.5 mm |
| | Carbon Film | 0.5 | 0.33 | 9 mm | 3 mm |
| | Composition | 0.35 | 0.2 | 10.3 mm | 4.3 mm |
| D | Composition | 0.5 | 0.25 | 11.5 mm | 4.1 mm |
| | Composition | 0.35 | 0.2 | 12.7 mm | 5.3 mm |
| | Carbon Film | 0.5 | 0.25 | 11 mm | 4 mm |
| | Metal Film | | 1.0 | 12 mm | 5.5 mm |
| | Metal Oxide | | 0.25/0.5 | 11.2 mm | 4.2 mm |
| E | Composition | 0.75 | 0.35 | 17.8 mm | 4.1 mm |
| | Carbon Film | | 1.0 | 14 mm | 4.8 mm |
| F | Composition | 2.0 | 1.0 | 30 mm | 7.8 mm |
| | Carbon Film | | 4.0 | 24 mm | 8 mm |

*Fig.2. Representative sizes and ratings of modern composition and film resistors.*

Some resistors have a nonlinear temperature coefficient and this characteristic is usually referred to as the 'resistance-temperature' characteristic. Some types of resistor, particularly those in the semiconductor group, are manufactured to have a large, controlled resistance-temperature characteristic. They are usually used for temperature sensing, compensation, or in measurement applications.

**Voltage Coefficient** — The nominal value of a resistance is not independent of the applied voltage, usually decreasing with increase in applied voltage. The voltage coefficient is usually expressed as a percentage of the change in resistance against variation in applied voltage from 10% of maximum working voltage to maximum working voltage. This is a characteristic that is only of importance with carbon composition resistors and some types of semiconductor resistors (i.e. voltage dependant resistors).

**Frequency Effects** — All resistors have an inherent small amount of inductance and capacitance and this affects the way they behave at high frequencies and above. The length of the actual resistance path in the resistor and the length of the leads contributes inductance in series with the apparent dc resistance. Capacitance, which may be distributed along the resistor body or through the resistance path, contributes capacitance which is effectively in parallel with the apparent dc resistance. This changes what should look like an ordinary resistor into a circuit like that in Fig. 1. The actual amount of series inductance and shunt capacitance depends largely on the type of resistor and its construction. Some styles of resistor are constructed to minimise these effects.

Carbon composition and wirewound resistors are the most affected of any group. Generally, for values above 100 ohms or so, the apparent resistance will decrease as the frequency is increased. Thus low value resistors exhibit the least variation with increasing frequency while the apparent resistance of high value resistors (i.e. about 100 k and above), rapidly decreases as the frequency increases.

**Noise** — All resistors generate 'noise' in the form of tiny voltage fluctuations which originate in the resistive element. Further noise is generated in the lead connections. The total noise voltage is contributed from a number of different sources. One form of noise that is present in *all* resistors is called 'Johnson Noise' and the magnitude of this depends on the temperature and the value of the resistor. Some resistors (particularly carbon composition types) produce extra noise caused by the current flowing through the component. Faults in the component also cause noise, i.e. for solid body types, minute cracks may add to the noise. Some styles of construction can contribute to noise, for example, those constructed with end caps connecting to the resistive element may become noisy (more noisy) when the end caps are subjected to tension and become slightly loose. For adjustable resistors, added noise may be caused by imperfect contact between the moving contact and the resistive element. The noise is worsened during the time the contact is moving.

To obtain the lowest noise from a resistor it should be operated well below its wattage rating.

The noise figure for resistors is usually quoted in microvolts per volt (μV/V) or in dB related to a reference figure (usually 1(μV/V).

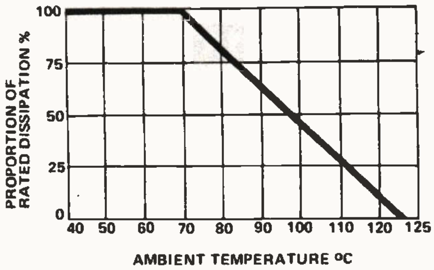



*Fig.3. Typical power derating curve for composition and film resistors.*

## RESISTOR RATINGS

Resistors are rated to remain within specified resistance limits under specified conditions of power dissipation, temperature and applied voltage. These ratings depend on the style and construction of the resistor as well as the way in which it may be used in practice, i.e. if it is subjected to high temperatures or operated at a high voltage.

The primary rating of a resistor is its wattage or power rating, that is, how much power it will dissipate. This is more or less analogues to the voltage rating of a capacitor — how high a voltage it will withstand.

**Power or Wattage Rating** — The maximum power rating of a resistor, as quoted by the manufacturer, is determined by the power it can dissipate continuously for an unlimited time without exceeding a specified maximum temperature and without drifting from its nominal value more than a specified amount.

The power rating of a resistor depends largely on its construction. Low power resistors are quite small in size — the size increasing with power rating as illustrated in Fig. 2. These are representative of most composition and film types. Wirewound resistors are inevitably larger as they are generally manufactured to dissipate considerable amounts of power.

Film resistors are made in a range of power ratings from 1/20th (0.05) watt up to five watts, composition types range from 1/10th (0.01) watt to two watts. Some special film types, made for RF power applications and high voltage, high power applications, are manufactured in wattage ratings from one watt to 100 watts or more.

Wirewound resistors are manufactured in wattage ratings that range from half watt right up to 200 watts. Very low value resistors (i.e. less than a few ohms) are usually wirewound. They may only need to dissipate small amounts of power and are consequently generally quite small.

When a resistor is dissipating power, its temperature will rise above that of its surroundings (or the 'ambient' temperature as it is called). The maximum temperature of the resistor due to both the internal heating and the ambient temperature is called the 'hot spot' temperature. The maximum allowable hot spot temperature for a resistor depends on its construction and the material of the resistance element. The maximum hot spot temperature of a resistor may not be exceeded under normal operating conditions. Thus, resistors are rated to dissipate a given amount of power up to a specified ambient temperature, usually 40°C or 70°C, so that the combination of internal heating and the ambient temperature do not exceed the maximum allowable hot spot temperature. This is usually between 100°C and 170°C depending on the component style and construction, for composition and film types. Wirewound types may have a maximum hot spot temperature in excess of 250°C, which is sufficient to melt solder and fry fingers to a crisp golden brown.

Excessive power dissipation with a resistor causes large, often sudden, changes in resistance, in some types the resistance may decrease — definitely the wrong direction as it will then try to dissipate yet more power — until it reaches its thermal limit and breaks down.

The first signs of overload in carbon composition and carbon film resistors are a pungent burning odour accompanied by a steady stream of smoke. Finally, it breaks down altogether in one of several possible ways:—

(a) The resistor gives a final puff of smoke, becomes open circuit and

# Resistors

joins its ancestors in that great big pc board beyond the sky.

(b) The resistor becomes short circuit, everything else begins to smoke and *they* join their ancestors you-know-where.

(c) The resistor turns into a miniature Vesuvius, splutters hot carbon particles all over the place and eventually bursts into flames, not unlike a Roman candle.

To summarise with the obvious, it is good practice to select resistors which go open circuit under extreme overload and which are non-flammable. Many modern resistors, particularly power resistors, are manufactured this way.

High value resistors are more likely to break down under the stress of high applied voltage rather than excessive dissipation.

**Power Derating** — A resistor may be operated above the maximum specified *ambient* temperature provided it dissipates less power than its nominal rating. In other words it has to be 'derated', With few exceptions, the derating is usually linear from the maximum ambient temperature to the maximum hot spot temperature, where it can dissipate no power at all. This is illustrated in Fig. 3. Here the graph shows that the resistor can dissipate full power according to its rating up to 70°C but this is decreased linearly until it can dissipate no power at 125°C, which is the hot spot temperature. If the resistor was a 1 watt type, then, from the graph, it could only dissipate less than ½ W at 100°C.

The ambient temperature of a resistor is obviously affected by nearby devices that produce heat. One should ensure that resistors mounted near power transistors, wirewound resistors, or other heat producing sources are adequately rated. The same goes for equipment that may be mounted in a high temperature environment, such as in a car engine compartment or under the dash — temperatures here can reach 80-100°C under a hot summer sun. Resistors stacked together must be operated below maximum rating as they do not experience the same cooling as resistors mounted with free space around them. For other than wirewound resistors it is good practice to allow at least the same distance as the component width or diameter around it in order to obtain adequate cooling. Resistors may be mounted right down on a printed circuit board however, without appreciably degrading the cooling. But, if the component is a two watt type or more, and dissipating some power, it is best to mount it above the board by at least its own diameter or thickness to avoid scorching the board.

Although a resistor rated to dissipate ½ W at 40°C will obviously dissipate considerably more at more normal room temperatures of 20-25°C it is not good practice to use it in such a manner. It will, most likely change value permanently, most probably by an amount exceeding the specified tolerance. That is why power derating graphs only indicate a permissable 100% dissipation below the maximum allowable ambient temperature.

Chemical changes within the resistive element destroys a resistor that is operated at excessively high temperatures.

**Voltage Rating** — The value of a resistor is not independent of the applied voltage. It changes with increasing voltage, usually decreasing. This characteristic is worst for composition resistors. A *voltage coefficient* may be specified for a resistor. This is expressed as a percentage of the change in resistance versus the nominal (low voltage) value of the component multiplied by the inverse of 0.9 times the rated maximum working voltage.

The *maximum working voltage* and the *voltage coefficient* of a resistor depend on the materials and composition of the resistance element, the allowable deviation from the nominal (low voltage) value and the physical configuration of the component. For a given type of construction and resistive element, the voltage coefficient decreases with decreasing resistance value and thus the maximum working voltage may be increased.

High value resistors used in high voltage applications, e.g. in EHT voltage dividers for CRO tubes, may suffer from voltage breakdown across the spiral-grooved turns of the resistance element. 'Voids' also occur in the resistance element, causing an increase in value, and sparking occurs across these with consequent detrimental effects. Catastrophic failure of a resistor usually occurs by these voids spreading through the element.

**Pulse Rating** — The reaction of resistors to voltage stresses is almost instantaneous. Where a resistor is subject to voltage pulses it will still be subjected to the sort of limitations placed on it for the voltage rating. Power dissipation is not a limiting factor, it is rather the voltage stress that the component is able to withstand. The spreading of voids through the resistance element increases with increasing pulse frequency. Carbon film resistors are able to withstand about twice their rated dc working voltage under pulse conditions. Usually the pulse voltage rating of the component will be exceeded before the power dissipation becomes significant.

*(series continuing)*

# ELECTRONICS —it's easy! PART 34

Oscilloscopes — the refinements

MANY MEASUREMENTS IN electronics can be handled by the relatively unsophisticated oscilloscopes described in the last part of this series. More capability can be provided at greater cost and this can be valuable if the user understands how to make the most of it. This part describes refinements that will be encountered in more advanced oscilloscopes.

## IMAGE STORAGE

**Screen persistence:** Repetitive signals, such as a sinewave signal, can be made to repeat on the screen overlapping the previous trace produced. If the timebase frequency is sufficiently high — from thirty or forty hertz upward — the screen provides an apparently stationary signal of constant and adequate intensity. This is primarily because the eye cannot detect individual scans (as in motion pictures and television) and secondly because the phosphor, at frequencies above a few hundred hertz, re-energized before its light emission due to the previous scan, has decayed away.

Phosphors with large time-constants are available (such as P2, which takes one second to reduce to 10% of original brightness and P7 which takes three seconds) and oscilloscopes have been manufactured which use these to enable signals of less than one hertz to be studied. This feature, however, largely restricts the use of the instrument to low frequency work because medium and high-frequency signals that are not well synchronised will produce separate traces which remain and add up with time to produce an unclear picture. This method of studying slow-transient phenomena has not been developed to any great degree because of this and other factors (such as poor resistance to burning). In addition the retained-image times are still inadequate for many applications.

## CAMERAS

Storage requirements fall into two classes — those where the transient is unique and therefore needs to be recorded only long enough to allow the trace to be studied and those where a permanent record is needed.

The oscilloscope fulfils both these needs. Until the advent of the Polaroid-Land process this involved a time-consuming development process before the operator was certain of having even recorded the trace. Most oscilloscope makers now offer specially built trace-recording cameras that fasten onto the large bezel surrounding the screen.

Such cameras use a Polaroid-Land film pack of some kind and often incorporate a 35 mm roll film facility also. A Dumont unit is shown in Fig.1. The user sets the CRO controls until satisfied that the trace will be as needed. This is done using the viewing aperture which reflects the screen image to the observer via a mirror. It is essential that the camera has the correct focal distance set for the CRO concerned, so in general cameras relate to specific units. Some models incorporate adjustable object-image ratios; a few are fixed ratio. With experience it is even possible to capture multiple trace events (by multiple exposure) for comparison purposes.

A considerable amount of film and patience can be consumed trying to record once-only events. Cameras can be quite expensive — several hundred dollars — but they do provide a permanent record for reports which no other storage system can provide, and the price of a camera is not as great as the extra cost of the variable — persistence storage units to be discussed later.

## STORAGE OSCILLOSCOPE

Most of the objections of the above storage methods, with the exception of permanent photographic reproduction, are overcome by using an advanced form of the basic CRO tube. It is called a variable persistence storage tube and is a development of early 1950's more basic storage tubes in which the waveform could only be held at a constant intensity (without the feature of gradual fade out). In fact variable persistence is a feature of tube operating circuitry not the tube itself.

The construction of a typical storage tube is given in Fig.2. The phosphor viewing screen (having 0.1 s persistence time from P31 material) and the writing electron gun shown are similar to those used in the simple cathode ray tube. Additional components are the flooding electron gun system, a storage mesh which is coated

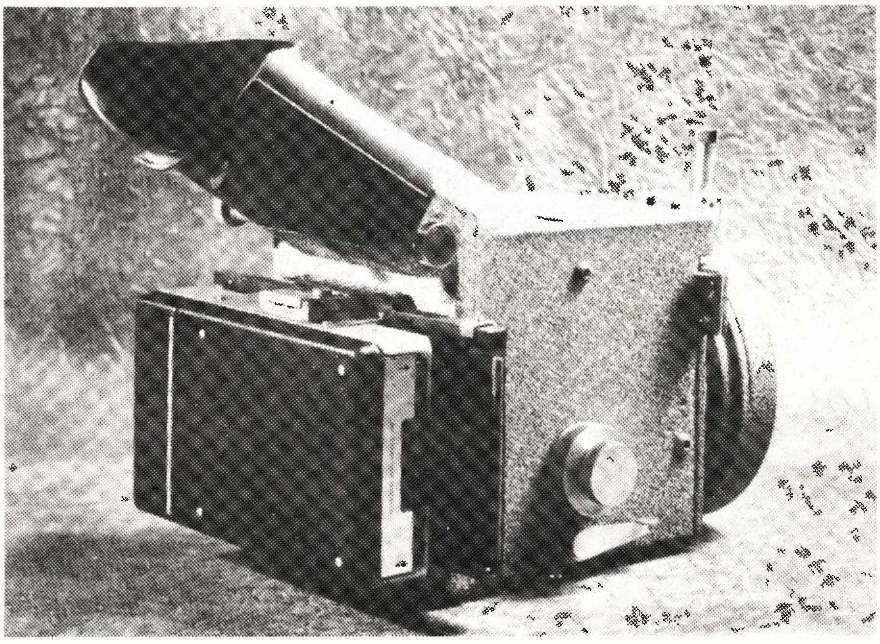


*Fig. 1. Recording camera using Polaroid film pack.*

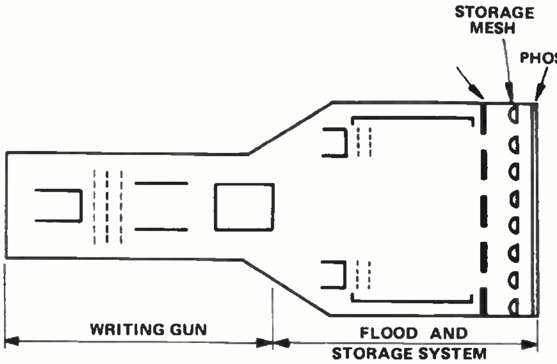



*Fig. 2. Schematic construction of storage cathode ray tube.*

with a non-conducting, highly-resistive material such as magnesium fluoride, and a collector mesh which is held at a positive potential.

To store a trace the writing gun is scanned over the storage surface. Where the beam strikes the storage mesh electrons are knocked loose leaving a positive-charge pattern. The high-resistivity of the surface prevents the charges moving toward a neutral state: the scan is thus stored — and can be held for at least an hour (one maker offers four hours) in a reduced intensity mode.

To make the trace visible, low velocity electrons are sprayed by the flood guns onto the entire mesh surface. These electrons are allowed to pass through to the phosphor in proportion to the amount of positive charge at each aperture of the storage mesh. The positive field pulls many electrons through causing them to pass on to hit the phosphor.

The collector mesh is provided to help accelerate the flood electrons; to repel the positive ions generated by the flood guns; (which would otherwise write the whole screen bright) and to absorb the emitted secondary-emission electrons produced whilst writing is in operation. It is not possible to store the trace in the view mode for as long as in the store mode: one to ten minutes of viewing time are typical for various makers' designs.

Erasure is done by applying a large positive voltage to the storage mesh which charges capacitively to the same value. The mesh voltage is then brought back to a small positive value whereupon the flood guns reduce the voltage to zero. A small sudden negative excursion is finally applied to the mesh making it ready to write. (This procedure is automatically initiated at the single action of a switch.)

Variable persistence is incorporated by changing the time taken to erase the picture. In the Hewlett-Packard unit, shown in Fig.3, this is achieved by using a variable-width pulse generator that applies erase voltage pulses to the storage mesh. The positive-ions created by the flood-guns limit this mode to a maximum of 10 minutes persistence.

Storage oscilloscopes can be used as conventional units by applying about 30 volts to the storage and collector meshes. Long persistence has many virtues — it enables successive traces resulting from adjustments to a system response to be overlaid together for comparison purposes. It also allows us to see very low-frequency scans, and to plot scans of spectrum analysers. Long persistence also finds use in time-domain reflectometry where the time between send and receive pulse needs measuring.

By stacking sweeps on top of each other a long persistence time can be used to integrate or average a set of traces. Variable-persistence storage oscilloscopes are extremely versatile but the high price restricts their use to large laboratory groups.

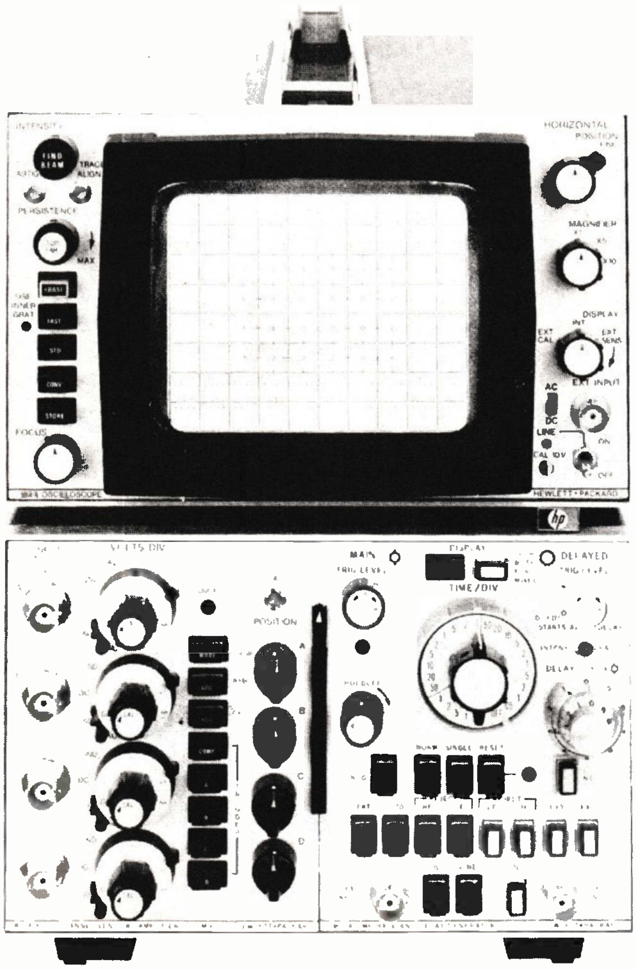


*Fig. 3. Hewlett Packard Model 184A variable persistence and storage oscilloscope. Controls for storage are on the left-hand side of the screen.*

## STORAGE USING DIGITAL MEMORY

Figure 4 shows a unit marketed around 1972. The transient recorder unit accepts the analogue signal, converts it to a digital equivalent with respect to time and stores the values in digital registers. Readout can be obtained by using digital-to-analogue conversion of the stored increments which are scanned sequentially, the resultant analogue voltage being fed to an oscilloscope or chart recorder. Digital print-out is taken direct from the scanned store locations.

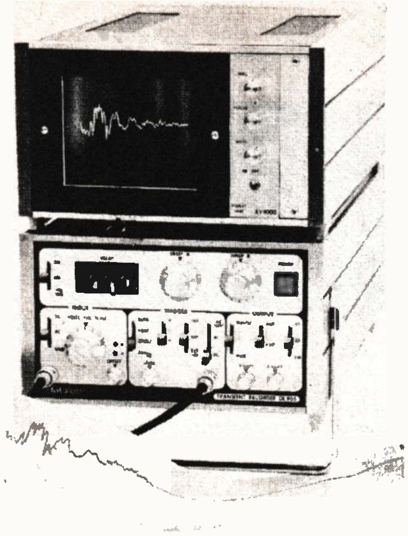


*Fig. 4. Storage can also be obtained using a digital memory to capture the event which can be displayed at will on an oscilloscope or recorder (Datalab DL 905).*

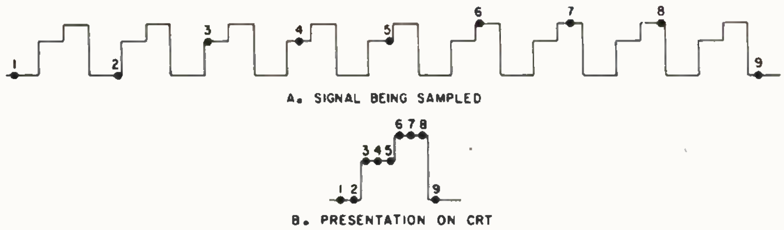



*Fig. 5. The sampling oscilloscope builds up the waveform on the screen from sampled values taken from the original.*

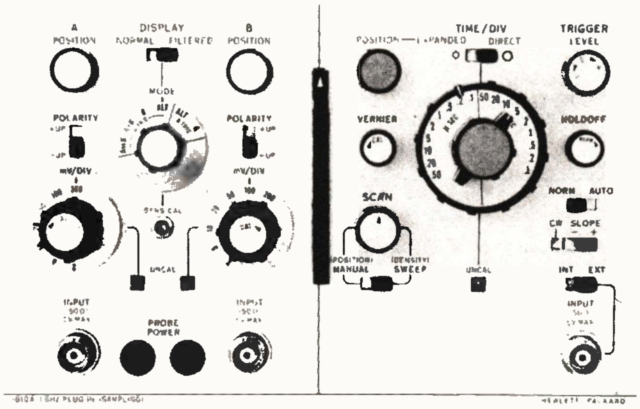



*Fig. 6. 1 GHz dual-channel sampling plug-in. (Hewlett Packard Model 1810A). The controls are designed to provide operation as for those on normal real-time oscilloscopes. With such a unit it is possible to view nanosecond rise time signals of repetitive nature.*

This method is less common than the storage oscilloscope alternative but the ever-reducing cost of digital methods may put this technique into a competitive price region.

Another method of capturing difficult to see, once-only transient signals, and very slowly changing waveforms is to record the level of the signal, increment by increment, as the signal occurs, using a digital memory. The concept is simple and the method offers certain advantages. These include ability to speed up or slow down the timescale of the original event, ease of providing a permanent numberical printout and the facility to process the signal before display.

## SAMPLING OSCILLOSCOPES

How to capture a very fast repetitive event, say near to the GHz region where scan times of 0.1 ns/division are needed, is a problem because the electron beam cannot transfer enough energy into the phosphor to obtain a useable trace brilliance. Further it becomes increasingly difficult to deflect the beam at such speeds. The sampling oscilloscope offers a solution to these problems.

The sampling oscilloscope makes use of the stroboscope concept to look at a waveform, which must therefore be repetitive (as shown in Fig.5). The beam is set to illuminate the screen at point 1 in the diagram, waiting there until the next cycle where it moves to point 2 — and so on. The trace therefore gradually works its way through the complete cyclic waveform and because the scan speed is slower than with a conventional sweep system the cathode-ray tube system can operate with a lower bandwidth than the signal. The waveform produced is an average of many so the display is not only sharper but more uniform. (This may be a disadvantage in some applications for the sampling unit is effectively smoothing the unknown true original signal). Sample and hold methods were discussed in the previous part discussing D-A and A-D conversion.

In practice a sampling oscilloscope is a normal high quality scope which can accept a sampling plug-in. Figure 7 is the panel of a dual sampling unit.

## DELAY FACILITIES

Often one needs to study a certain part of a repetitive waveform — the very beginning, for instance. An example is the ringing of a non-ideal square wave shown in Fig.7a. The trace is triggered, to begin the sweep, by a fast-going edge. Due to circuit response-times, the trace does not

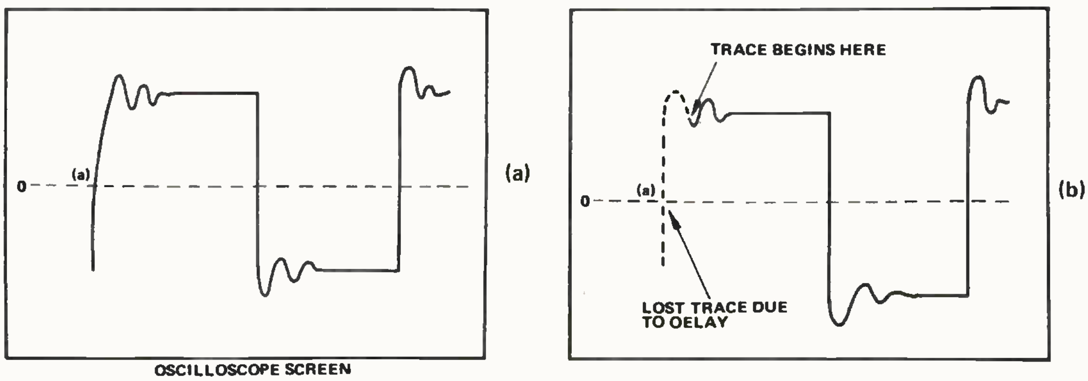



*Fig. 7. Inherent trigger delay, if not compensated for, will lose the leading edge of a waveform.*

# ELECTRONICS–it's easy!

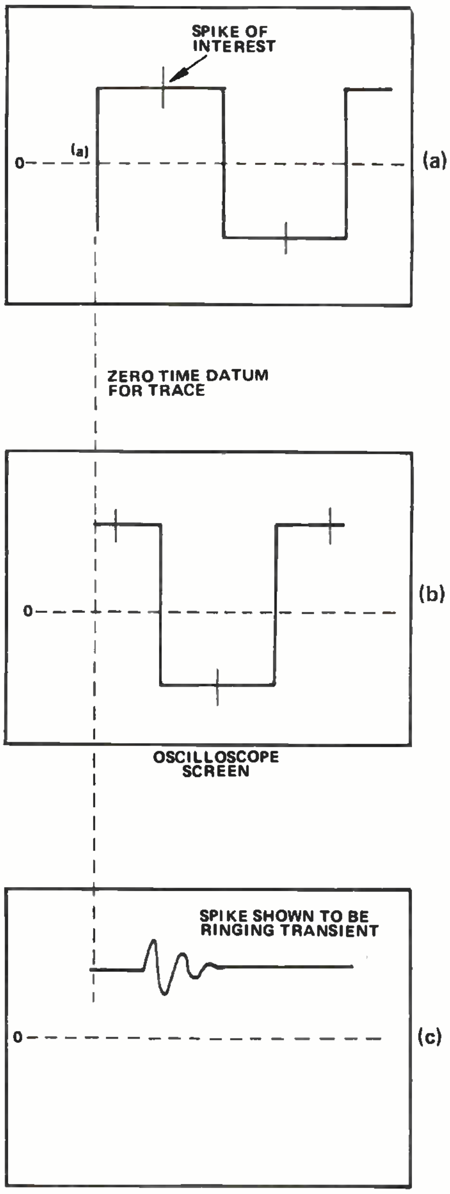



*Fig. 8. Use of introduced delay in triggering to enable an event away from trigger transient to be investigated.*
*(a) Original spike on pedestal of square wave.*
*(b) Delay introduced to bring spike back to time origin.*
*(c) Scale expanded to reveal true nature of spike.*

begin to sweep at exactly that time but begins a little later. The result is loss of the leading edge region of the wave as shown in Fig.7b. The following waveform may provide the information sought but attempts to widen the waveform in the horizontal direction lead to the second front disappearing. The simplest solution to this problem is to incorporate an appropriate fixed delay into the triggering circuits and this is often provided within the circuits. A slightly better method is to provide an adjustable delay control on the trigger panel.

A more difficult problem is capturing a point on the signal train that is remote from the triggering transient. Consider the signal shown in Fig.8(a), where the problem is to investigate the spike transient on the pedestals of the square wave. Triggering is best achieved by using the edge (a). But this means that scale expansion puts the spike off scale when the horizontal expansion scale is great enough to provide information about the spike structure.

Variable delayed sweep is the answer. The trigger circuit is set by the (a) edge but trace scan does not begin until after a period, as in 8(b). Thus the trace captures the spike at the left-hand side of the screen and scale expansion will now be possible as in 8(c).

To make this workable in practice the operator must know just where triggering occurs for there may be several somewhat similar events along the trace. It is vital to know which one is being viewed. A refinement provided in variable delay circuits is to brighten the original display from the point where triggering will begin. Taking the idea one step further leads to a second delay that effectively decides where the trace stops Figure 9 shows the waveform brightened to show the portion that will be expanded and the second trace of the dual-beam unit is used to show the expanded part. Another useful feature

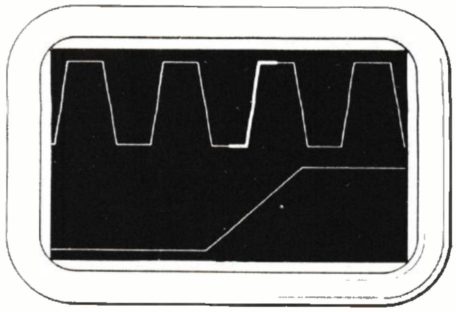
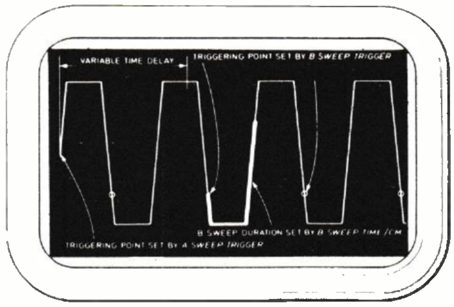
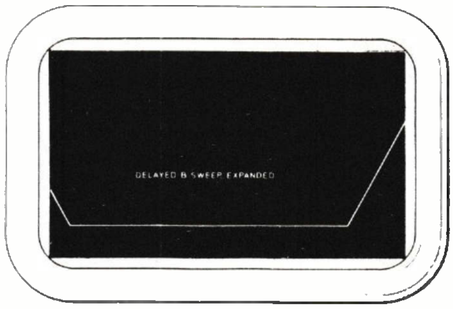


*Fig. 9. Trace brightening is used to show which part of the waveform is to be expanded. In this display the expanded portion is also displayed on the second trace of the CRO.*



*(a)*



*(b)*

*Fig. 10. Use of dual delayed triggering point. (a) original (b) expanded.*

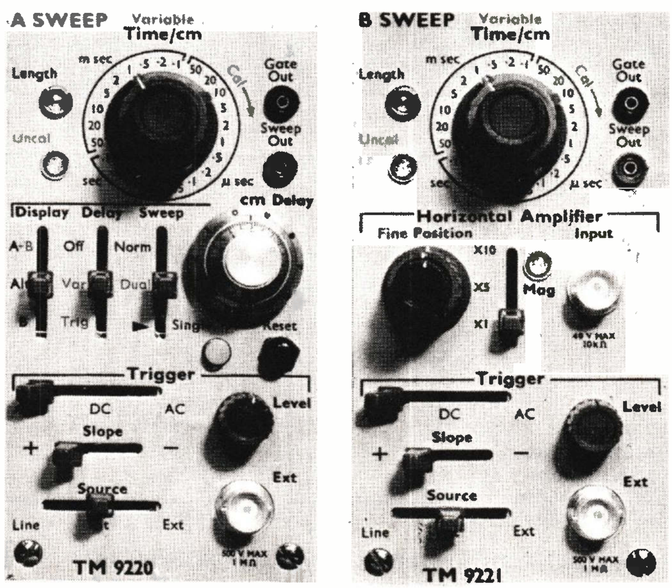



*Fig. 11. Marconi TM 9220, TM 9221 sweep units.*

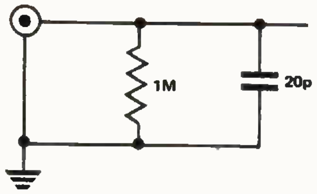



*Fig. 12. Most oscilloscopes have this input equivalent circuit. Although the values seem insignificant, at high frequencies they become dominant requiring the use of special probes.*

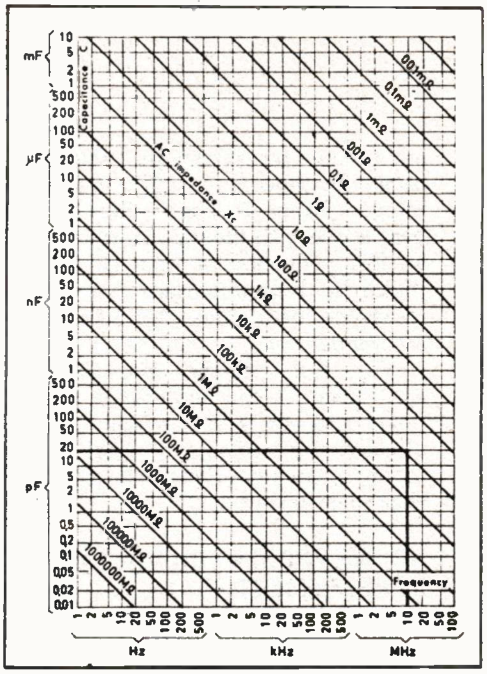



*Fig. 13. Chart for obtaining reactance of capacitors at various frequencies of operation.*

is to be able to use a trigger point not on the origin of the first trace set up — as in Fig.10. Here a marker dot is provided to help the operator. Figure 11 shows the panels of Marconi plug-ins which provide these and other variable delay features.

## PROBES

**Passive probes** for voltage measurement: In part 32 the importance of providing the right matching conditions between two electronic systems was stressed. This is also important when connecting an oscilloscope to a circuit, for each output and input has certain resistive and reactive conditions which must be properly combined to get realistic signal transfer.

The oscilloscope can be represented as an ideal termination shunted by a large R and an adequately small C value — or at least they appear this way at first sight. Figure 12 is the most common approximate equivalent circuit. (Others used include 50 ohms with negligible reactance in certain applications). Referring to the chart in Fig. 13, it can be seen that with 20 pF at 10 mHz the circuit being measured must have an equivalent output resistance of no more than 8 ohms!

For high frequencies, those above 100 kHz say, we therefore need a better connection method. To further compound the problem the oscilloscope input leads can easily increase the equivalent C value to 100 pF — leads for 1:1 connection must therefore be carefully designed to ensure known loading conditions which can be allowed for in signal measurement corrections. It is very bad practice to use any piece of coaxial cable and connector for frequencies beyond 100 kHz.

The first improvement is to use a probe which has 10:1 attenuation built in, for these are designed to have a lower effective cable capacitance — see Fig.14(a). Still better is a special correction arrangement that balances the shunt against series capacitance to provide a wider bandwidth — see Fig.14(b). By the use of inductive tuning a further improvement in bandwidth can be obtained — Fig.14(c).

There is no easy answer to the selection of which attenuator probe to use. These guides are the start. For Probes with division ratio of 100:1 also are manufactured — these can provide equivalent termination conditions of 5 k/0.7 pF, 10 M/1.8 pF, 1 M/1 pF. The reason for different pair combinations arises from the need to alter the trade-offs between rise time and signal loss in high-frequency and very fast transient measurements.

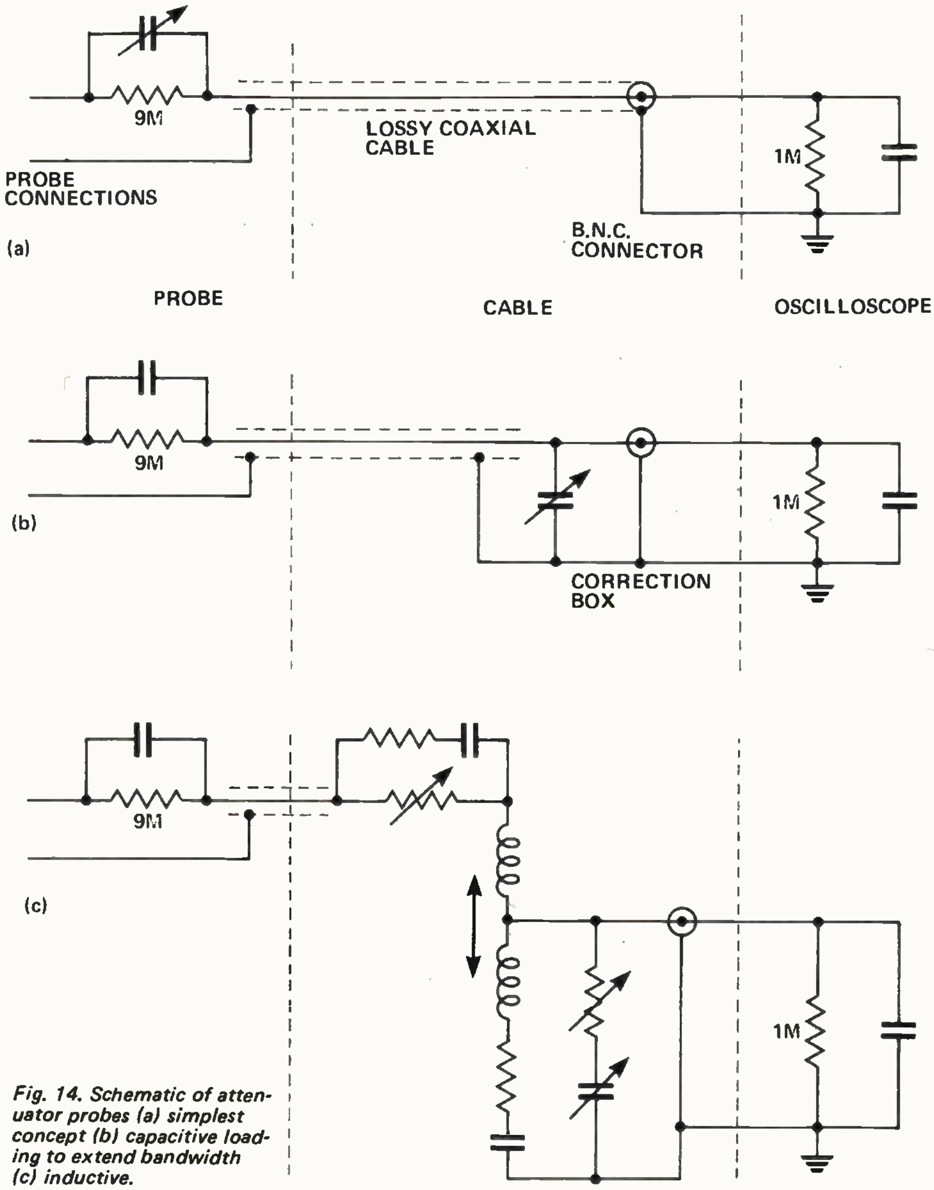



*Fig. 14. Schematic of attenuator probes (a) simplest concept (b) capacitive loading to extend bandwidth (c) inductive.*

amplitude measurements select a minimum-impedance source point to measure from. The best probe to use here is one with the highest impedance at the frequency of interest. Capacitance is less important here than resistance for it alters edge shapes, not amplitude.

For fast risetime measurements again select a low impedance source point and use a probe with lowest effective capacitance — signal attenuation is less important than transient edge shape changes.

## ACTIVE PROBES FOR VOLTAGE MEASUREMENT

The above probes make use of passive matching arrangements. But for the extremes of frequency and/or risetime measurements the values of components required in passive probes become impractical. However active amplifiers interposed between the circuit and the oscilloscope can be used to improve performance by increasing input resistance and lowering capacitance (short loads). FET probes are marketed to meet this. Figure 15 is a Phillips PM 9354 FET probe which can be used for dc to 1 GHz measurements. These need an additional power supply to operate, and problems of dc drift (0.5mV/°C) and added amplifier noise (60 μV — 1.5 mV) may be disadvantaged in certain applications. As well as being the choice for very high-frequency work, FET probes also find useful application in low-frequency situations where measurements across high source impedances are needed.

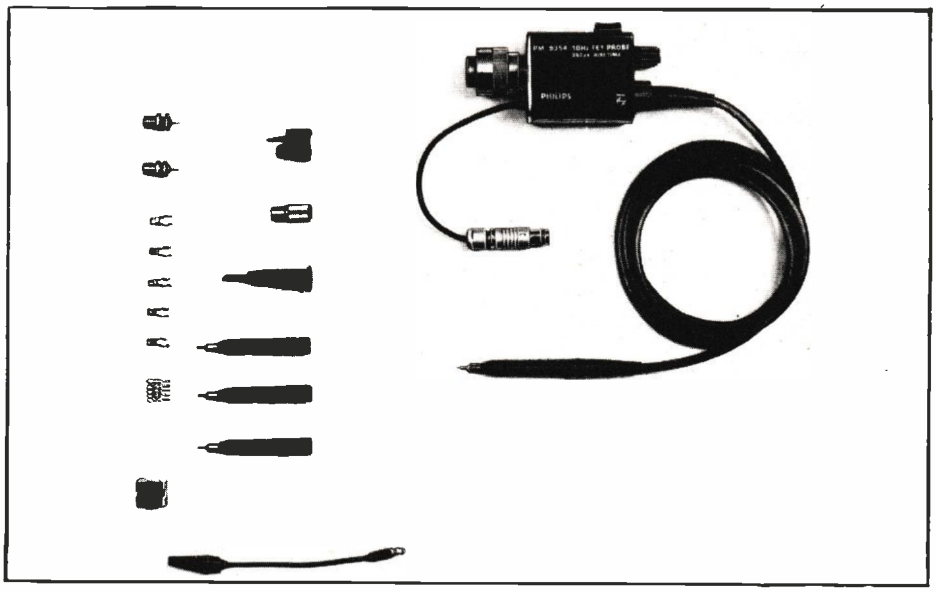



*Fig. 15. This FET probe uses active coupling to overcome oscilloscope connection problems.*

## OTHER PROBES

Voltage measurements are by far the most frequent measurements made but in some instances it may not be possible to determine voltages, and current measurement is used instead. An example is the current flowing in a direct-coupled Darlington pair configuration where no significant resistance exists over which a voltage can be developed. DC current probes (see Fig.16) clip over the wire in question coupling the dc magnetic field created by the current flowing in the wire into a Hall effect transducer which generates a voltage equivalent to the current flowing. These will also measure ac currents. The maker specifies the conversion constant — typically 1 mV/mA. AC only, current probes are also made using a current-transformer principle.

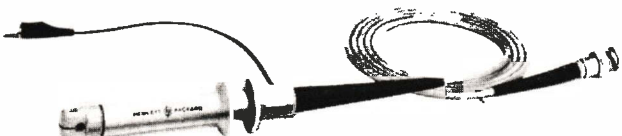


*Fig. 16. D.C. current probe.*

Probes for use in digital circuits are also available. These may incorporate a logic gate that combines the outputs from up to 6 circuit points as shown in Fig.17. Power for the gate is obtained from the circuit under test.

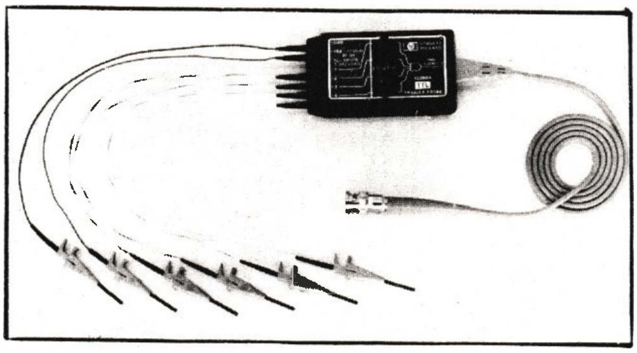


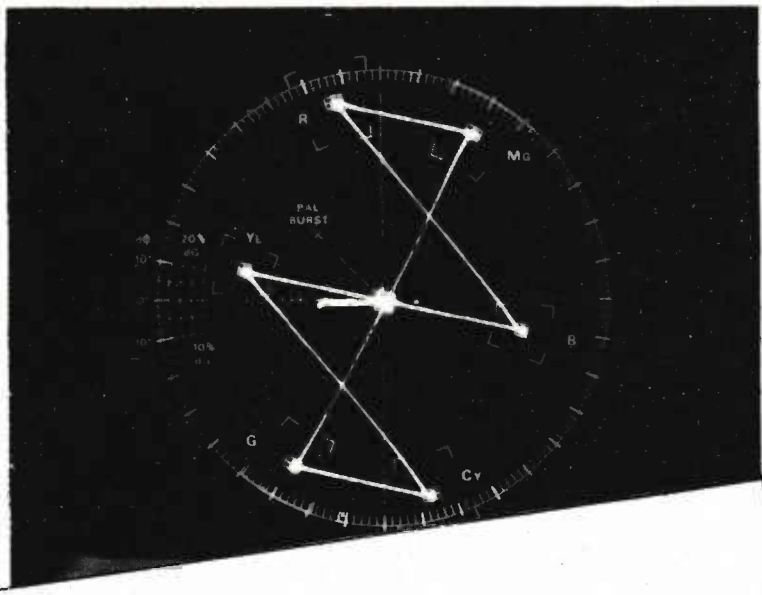
*Fig. 17. Digital circuit logic probe.*

## SPECIAL PLUG-INS

The oscilloscope, due to its extensive flexibility, can form a major part of many test systems, thereby reducing the overall price of advanced measurement systems where a suitable CRO already is available. Special plug-ins are offered (to suit certain mainframes) that will convert an oscilloscope into a spectrum analyser or into a semiconductor characteristic-curve tracer. Another plug-in is offered that converts the CRO into a four-trace unit.

A basic need in manual measurement is the provision of output form that best suits the operator. In many tasks a visual output in the form of a picture or graph is better than having

*Fig. 18. Display monitors can now provide an exhaustive arrangement of visual output forms. The next step is to provide this capability for routine use in oscilloscopes by making plug-ins available to go into suitable main frames.*


R
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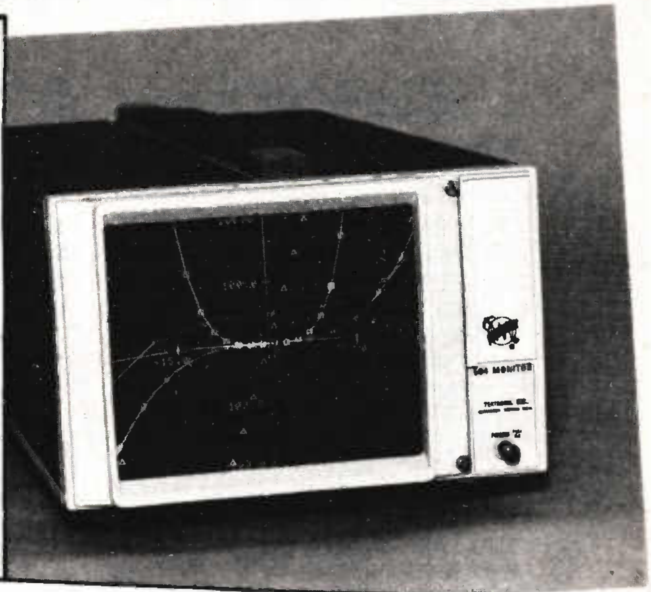
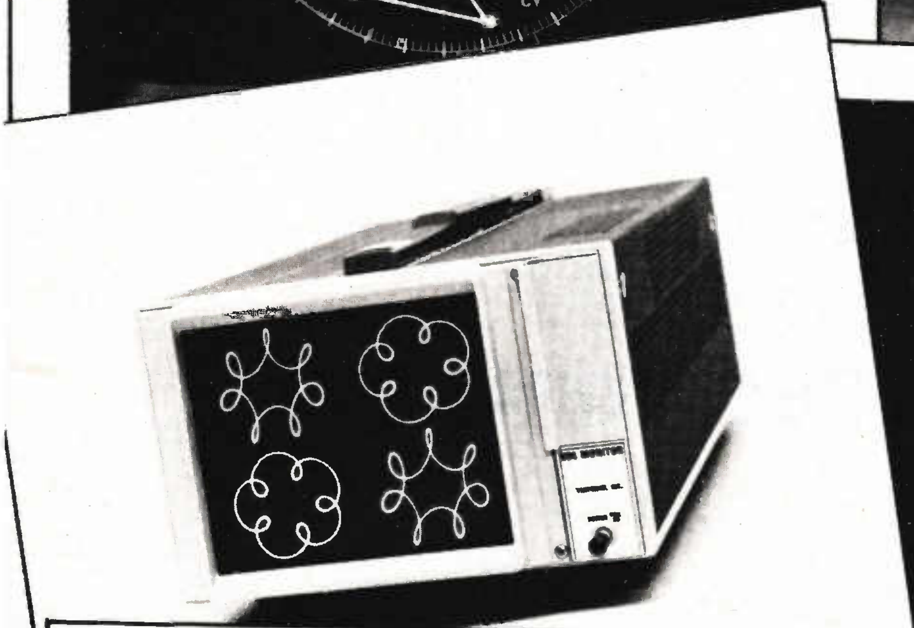
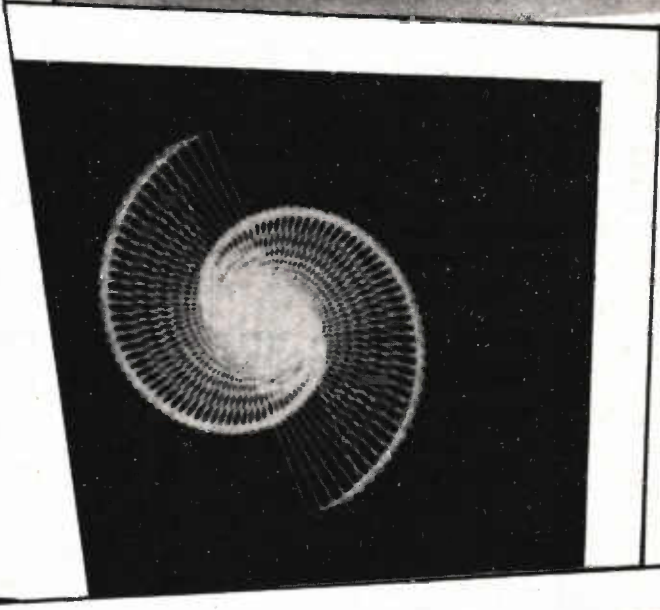
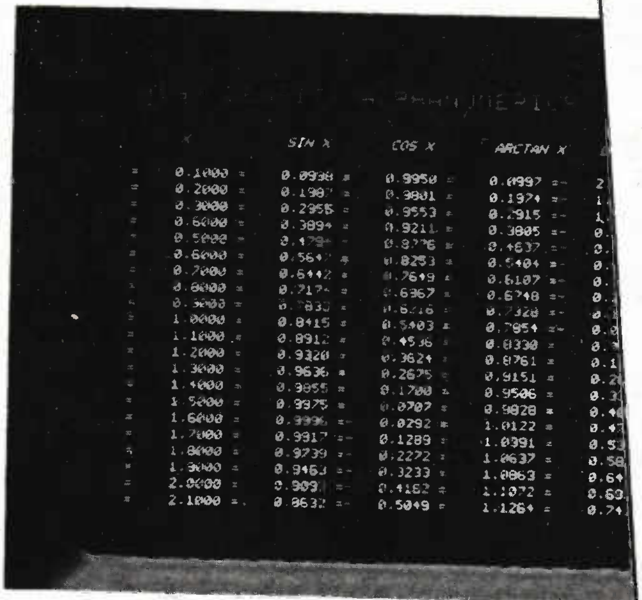
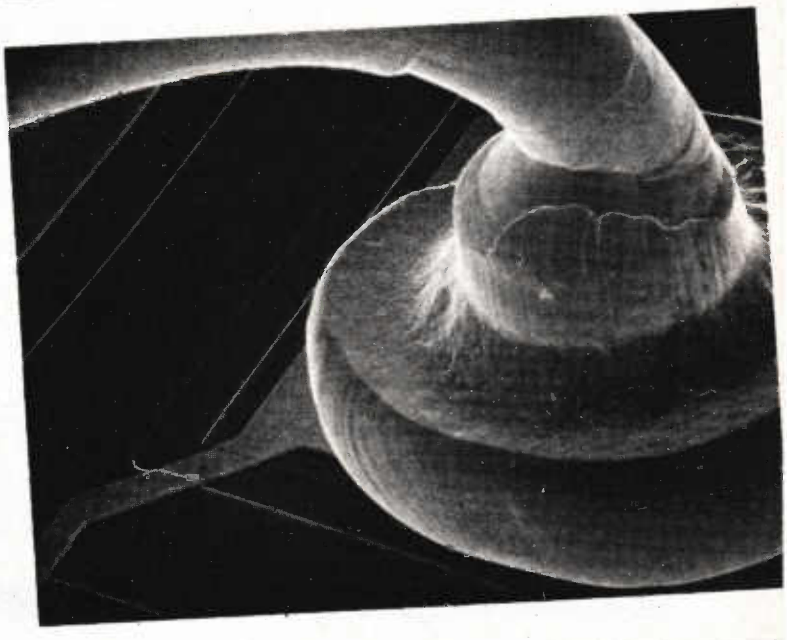







SIN X
COS X
ARCTAN X
0.1000 = 0.0998 = 0.9950 = 0.0997
0.3000 = 0.2955 = 0.9553 = 0.2915
1.0000 = 0.8415 = 0.5403 = 0.7854
1.2000 = 0.9320 = 0.3624 = 0.8761
1.3000 = 0.9636 = 0.2675 = 0.9151
1.4000 = 0.9855 = 0.1700 = 0.9506
1.5000 = 0.9975 = 0.0707 = 0.9828
1.6000 = 0.9996 =- 0.0292 = 1.0122
1.7000 = 0.9917 =- 0.1289 = 1.0391
1.8000 = 0.9739 =- 0.2272 = 1.0637
2.1000 = 0.8632 =- 0.5049 = 1.1264



to view many traces of a time sequence taken over the whole system. Already we have logic analysers which display space-plane information on the CRO screen, multi-meter CRO units that write digital values on the screen and units that provide axes information on screen graphs. With the reducing cost of advanced processing it will not be long before the microprocessor and memory (already in use in very sophisticated units) are introduced into quite moderately priced oscilloscopes for converting the information taken from the circuit into better forms of display. Display monitors are already available with many display forms – see Fig.18. The next stage must be the marrying of the basic CRO unit to such capability via a wider range of sophisticated plug-ins. The colour oscilloscope will also soon be with us extending the information rate at which the operator can be informed about a system via a CRO.

The only weak link in present systems (as far as robustness, life and cost is concerned) is the CRT itself for it is just about the last remnant of thermionic device technology remaining in general use. This too will soon be replaced by a solid-state equivalent. Perhaps this will take the form of a matrix of three-colour, LEDs in a flat display – making maximum use of the low-cost production advantages of LSI techniques.

## FURTHER READING

Due to the versatility of the oscilloscope most books on electronic instrumentation include basic descriptions of how oscilloscopes work and how to perform basic measurements with them. Many books are devoted entirely to the oscilloscope.

General considerations are discussed in "Test and measuring instruments – 1974 Catalogue", (Philips). Tektronix, Hewlett-Packard, Dumont and Marconi outlets also provide basic articles on the selection and use of oscilloscopes.

The principles of storage tubes are explained in the Philips catalogue and in "Variable persistence increases oscilloscope's versatility", R.H. Kolar, Electronics, November 29, 1965, 66-70.

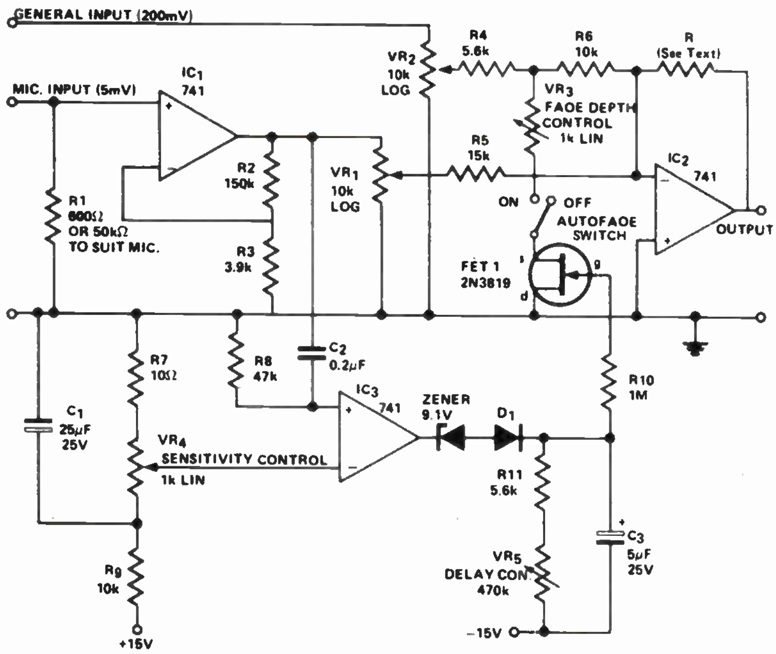
The subject of correct probe choice is quite extensive. The Philips Oscilloscope series referred to above has two articles by PFW Zwart on probes (Nos. 3 and 4 of series). V. Bunze in "Matching oscilloscope and probe for better measurements" Electronics, March 1, 1973, p 88-93 discussed voltage measurements. ●

Electronics It's Easy is published in book form. Volumes 1 and 2 may be obtained directly from ETI at the address below for $3 per volume (incl. post and packing). Volume 3 will be published in Nov/Dec this year.
Electronics Today, 15 Boundary St., Rushcutters Bay NSW. 2011.

# Ideas for experimenters

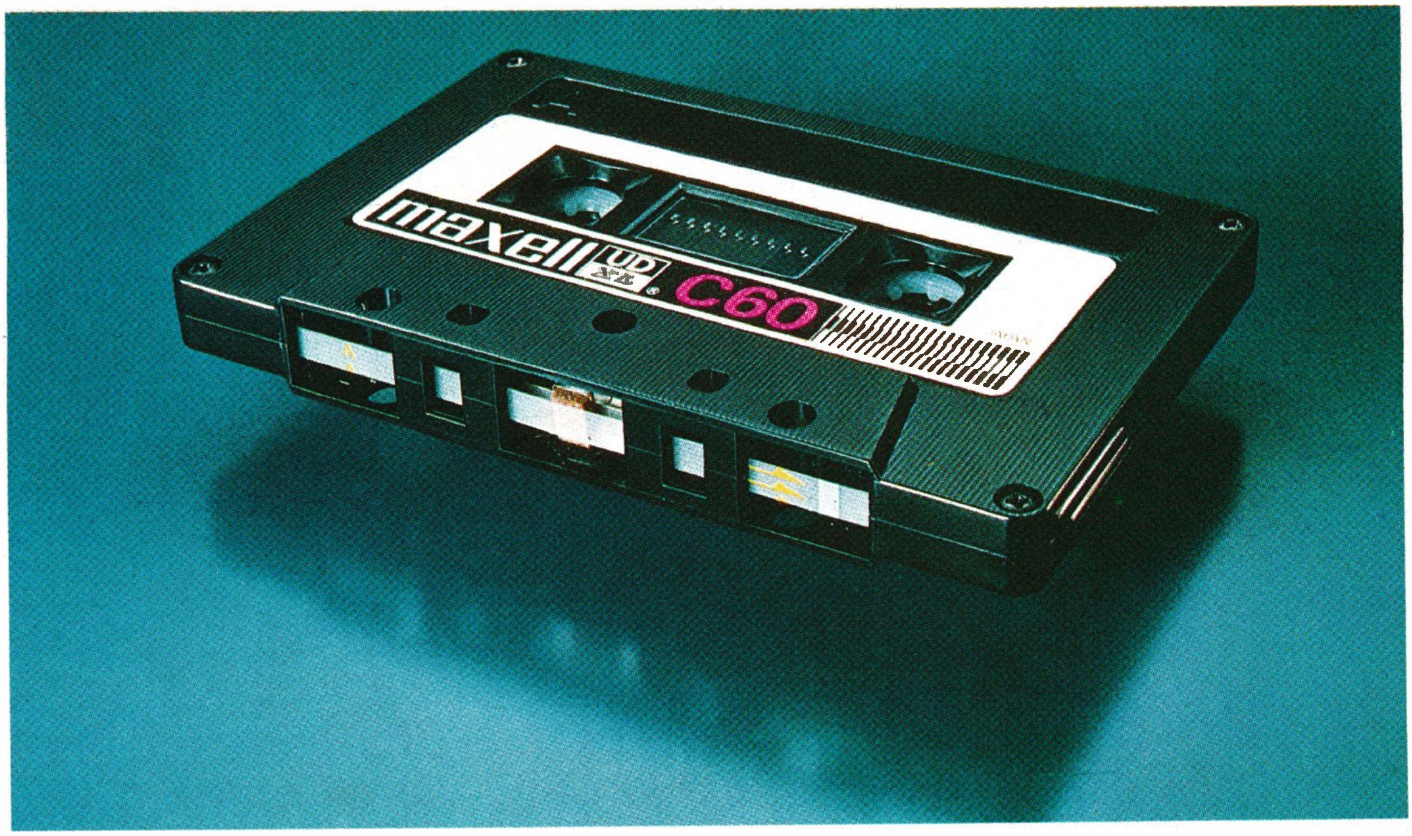
These pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory. Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we produce constructional details.
Electronics Today is always seeking material for these pages. All published material is paid for – generally at a rate of $5 to $7 per item.

## Disco autofade




This is an autofade circuit for use in discotheques and the like. This unit has advantages over voltage-controlled gain ICs which introduce distortion and noise by using a FET to switch the signal gain characteristic. The principle may be easily adapted into existing mixers.

The microphone is amplified by IC1 and fed to the input mixer (IC2 the gain of which is set by R) and to the comparator IC3. If the input is large enough (larger than the voltage on the wiper of VR4) the output swings positive and charges C3 (in about 4ms). When the voltage across C3 is sufficient the FET is turned fully on and the fade depth control is grounded hence attenuating the signal. The FET turn off time is determined by R11, VR5 and C3 and may hence be varied between 25ms and 2.5s.




# Introducing the revolutionary UD-XL EPITAXIAL cassette

Developed by MAXELL this completely new EPITAXIAL magnetic material combines the advantages of the two materials (gamma-hematite and cobalt-ferrite): the high sensitivity and reliable output of the gamma-hematite in the low and mid-frequency ranges and the excellent performance of the cobalt-ferrite in the high-frequency range. The result is excellent high-frequency response plus wide dynamic range over the entire audio frequency spectrum.

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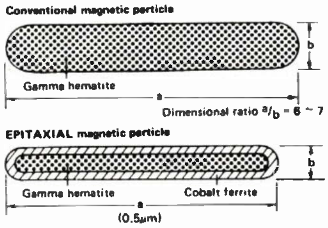
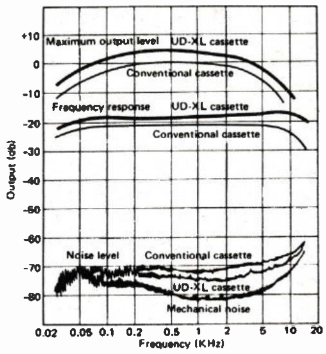
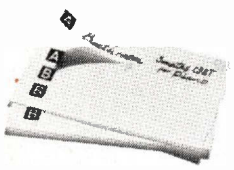



Fidelity is also ensured by a precision-manufactured cassette shell with a special anti-jamming rib that provides smooth tape travel and helps eliminate wow and flutter.



Another good idea of the UD-XL cassette is a replaceable self-index label. Simply peel off the old label and put on a new one when you change the recording contents. No more mess on the label.

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WT.GD. 76M

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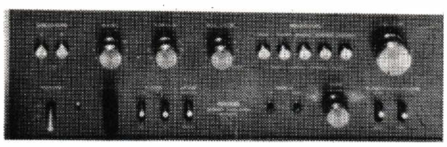

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  Semi Automatic with magnetic cartridge.
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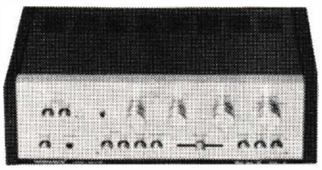

You should hear the magnificent sound from these three famous names:—

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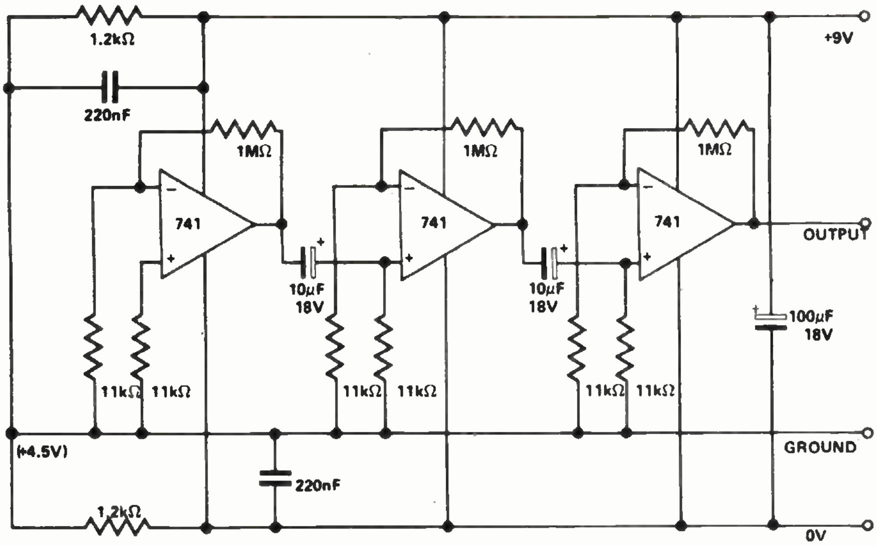
# Ideas for experimenters




## Pink noise generator

A useful method of frequency response testing of audio equipment is to excite the system with a random noise electrical signal and then analyse the output into its various frequency components using narrow band filters. The ideal noise signal is one having unit power per unit bandwidth (this is termed "white" noise). The system will be effectively driven by all frequencies at once. The frequency spectrum of the output will then be the required frequency response of the system.

However, the most common form of frequency analyzer uses filters with a constant percentage bandwidth (often one-third-octave). Thus an analysis of true white noise would give a frequency spectrum rising at 3 dB per octave, because the power in a noise signal is directly proportional to the measuring bandwidth.

Pink noise was developed to give a flat frequency spectrum into such filters. The output of pink noise generator falls at 3 dB per octave. Normally they are made by installing a –3 dB per octave filter after a white noise source. By a fortunate coincidence, the electrical noise from a 741 operational amplifier, when connected as shown, does have a pink noise frequency spectrum.

The circuit is simply three high gain operational amplifier stages cascaded. The first stage generates internal electrical noise which is amplified to approximately one volt rms by the two following stages. The circuit must be laid out as closely as possible to the schematic diagram, and carefully screened, because the input stage is very sensitive to extraneous signals and could pick up hum or oscillate due to capacitive coupling with the output. The prototype is run from a PP9 battery, mounted inside the case, to further reduce any possibility of hum pick-up.

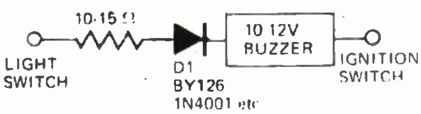
The output does have a slight roll-off from a pink noise characteristic, starting at about 100 Hz. This is caused by the ac coupling between stages in the circuit which is necessary to prevent dc fluctuations from saturating the output. Also there is a roll-off at the high frequency end caused by the internal compensation in the operational amplifiers. There is, nevertheless, useable output up to 25 kHz.

My apologies are due to the manufacturers concerned for using their devices in this unorthodox fashion. It may be useful to point out that the cheaper brands of 741 op-amp are likely to have higher noise levels and thus be more useful for this particular purpose.

## Car lights reminder

This circuit ensures that car lights are switched off when the ignition is turned off.

Any low power silicon rectifier diode will be satisfactory together with a suitable 12 V buzzer or bell. Only two connections are required. The alarm will sound if you leave the lights on after cutting the ignition.



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| BC548 | .26 | .22 |
| BC549 | .26 | .22 |
| BC557 | .26 | .22 |
| BC558 | .26 | .22 |
| BC559 | .26 | .22 |
| BC639 | .55 | .50 |
| BC640 | .55 | .50 |
| BD139 | .85 | .75 |
| BD140 | .85 | .75 |
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| CORAL 8SA1 speaker kit | $37.50 | P&P $3.50 |
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# AUDIO FACTS

No matter how carefully they are handled and stored, gramophone records pick up a surprisingly large amount of dirt. Some of this dirt will be removed by devices such as the Dust Bug but none can cope with ingrained dirt. This must literally be scrubbed out using a great deal of water and wetting agents.

Keith Monks Audio manufacture a very ingenious machine which washes, scrubs and then uses a vacuum pump to remove all remaining debris and washing liquid.

W.C. Wedderspoon, Keith Monks' Australian agents recently lent us one of the machines for a few days. The machine really is effective. We cleaned about fifty records — some very old LP's dating back to the early 1950's — and were genuinely surprised just how free of surface noise they became.

The record to be cleaned is placed on a rotating platter and a brush assembly swung across. A mixture of industrial alcohol and distilled water is then pumped over the record's surface and the brush lowered onto the now revolving record for a few seconds. This action loosens all the dirt trapped in the grooves and this dirt together with the washing liquids is then sucked up by an inbuilt vacuum cleaning device which travels slowly across the disc.

The total operation takes about one and a half minutes per record side.

Wedderspoon's tell us that the machines are so popular — mainly with broadcasting companies — that they are exported to forty seven countries. Apparently quite a few are bought by wealthy hi-fi enthusiasts. So for the man or woman who has everything . . .

Philips Electronic Systems (Vision & Sound), have introduced a motional feedback speaker for broadcast monitoring applications.

The new RH 532B accepts a balanced line-level input of 600 ohm impedance enabling standard distribution signals to be used.

The speaker unit is made up of three special speakers, two power amplifiers and a power supply. Electronic crossover networks are between the bass and treble drive units.

The bass amplifier delivers 40 watts to a 203mm speaker while the treble amplifier delivers 20 watts to a 127mm midrange speaker and 254mm dome tweeter.

## ELCASET LATEST

Last month's Audio Facts reported the development of the ELCASET, a new large format tape cassette intended for high quality music reproduction etc.

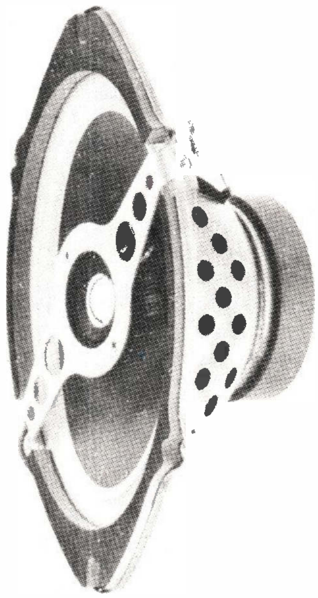
But no matter how good the cassette may be in theory it's useless without ready availability of appropriate hardware. Sony, TEAC, and Matsushita — the new cassette's sponsors — have each announced that they would soon produce the necessary hardware, and both Aiwa and JVC state that they too will support the new venture.

Sony however appear to have stolen a march on them all for Sony unveiled two Elcaset machines at the recent (US) CES show. Superscope, Sony's US distributors plan to distribute the Sony ELCASET decks and cassettes next year.

In the meantime — guess who's got an ELCASET deck for review!

# AUDIO FACTS

## NEW CAR SPEAKERS FROM PIONEER



Pioneer Electronics have released five completely new loud speakers for car stereo systems. They are the TS-35, TS-164, TS-570 and the TS-571.

The TS-35 is a high powered (40 watt) box type speaker designed to fit on the rear parcel shelf. It can also be separated from its box and flush mounted in the door, kick panels or other suitable surfaces. An aluminium voice coil enables the unit to handle high power output without physically increasing the size of the speaker or magnet.

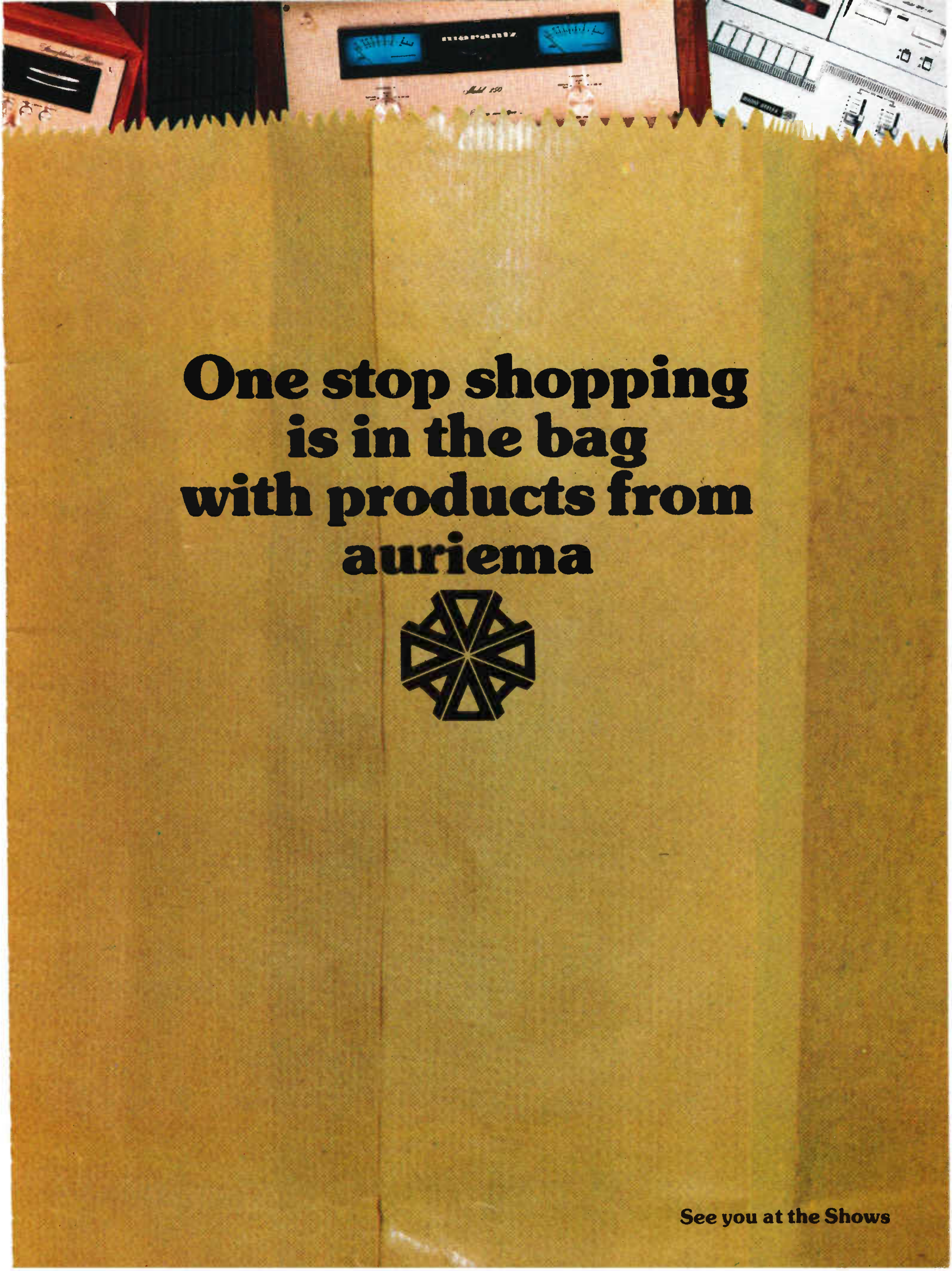
The TS-164 and TS-165 are unique in that they have a tweeter mounted on a mushroom type stalk in the centre. This ensures that sound from the large woofer is not hampered by a co-axial bridge.

Both speakers handle 20 watts maximum power. (The TS-165 has a 20 oz. magnet rather than the 10 oz. used in the TS-164).

The TS-570 is a dual cone 5" x 7" loudspeaker, with a 10 oz. magnet and capable of handling 20 watts maximum power – this unit has been made specifically for the Australian market.

Six mounting holes will ensure the unit will fit all Australian or Japanese cars

The TS-571 is of the same basic design but has a separate tweeter suspended across the woofer.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See you at the Shows

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The finest stereo sounds in the world. The Marantz line isn't just a pretty face: There's a whole lot of highly complicated thinking, years of expertise and skilful technology going on inside.
Marantz has a world-wide reputation for quality, precision, reliability.
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ags

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The AGS component range is finding its way into more and more homes where once the 3-in-1, or 4-in-1 or 1-4-all reigned in total, uncompromising supremacy.
Most record collectors today realize the way to better sound is through *component systems* — systems that are co-ordinated to bring matched electronic units all working in perfect harmony to produce an end result of realism and clarity no totally integrated single units could ever do.
An AGS music system is simplicity itself to operate — and matching extras such as cassette decks and tuners are available.
There's an AGS music system priced for *your* pocket.
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Listen to us

You never heard it so good.
A full range of audio equipment that doesn't cost the earth to run.
Striking magenta illuminated dial of Superscope equipment underscores the brilliance of this complete new line of stereo receivers, components and compact music centres. There are portable tape recorders and speakers too — and all priced for the sound-conscious shopper.
You can see a representative range of Superscope at the Hi-Fi Shows but, for a more comprehensive selection, catch the Sun International Home Show in Melbourne or the Better Living Exhibition at the R.A.S. Spring Fair in the Sydney Showground.

## AND NOW FOR THE AUDIO FILE

A magnificent range of audio goodies designed especially for the audiophile who's well into sound — and knows right where it's at!
From the luxuriant majesty of Klipsch horn-loaded speaker systems!
The dynamic dynamite of dbx!
The exquisitely delicate tracings of ADC cartridges! To the uncoloured, uncluttered sounds of Epicure loudspeakers.
These are just a few of the little luxuries coming your way every day from . . . Auriema

# Please Explain

## Stereo and speaker phase

**In Please Explain in August ETI you outlined a procedure for checking the phase of the loudspeakers in a stereo system. Surely this method will set up the speakers out of phase: the facing speaker cones will move back and forth a fixed volume of air, resulting in a quieter signal at the ear.**

**If, however, the speakers are correctly sired the in-phase pressure waves will oppose each other, but in doing so they will force air out of the gap between the cabinets and suck back air into the gap — a loud signal will be transmitted to the ear.**

**Also the reference to constructive addition is wrong; in-phase bass signals are normal so phasing cannot over-emphasise the bass.**

**B.W., Sydney.**

All we can do is apologise for letting that one slip through; I wonder how many of you spotted it?

Here then is the corrected method: Place the speakers 30mm apart with the fronts facing each other. Listen to a mono signal with the speakers wired first one way and then the other. When the speakers are correctly wired the signal will be louder.

## VU meters

**Please explain VU.**

**D.V., Canberra.**

The volume unit (VU) is used to specify a change in volume for a complex audio waveform, as indicated on a V.U meter. It is the same change in volume as that of a sine-wave changing by 1 dB. Complex waveform changes are difficult to measure because there is no specific relationship between volume and power: for a speech waveform the VU meter reads somewhere between the average and peak values.

The operation of the VU meter is controlled by the ballistic characteristics of the movement and the rectifier circuit and they are designed to have a dynamic characteristic approximating to that of the ear. Many cheap meters marked with VU scales have normal sensitive movements and do not read true VU.

The reference level for calibrating VU meters is 1 mW in a 600 ohm line (ie, 773 mV), the same as the reference level for dBm. However, a VU meter connected across a 600 ohm line will indicate zero dBm (1 mW) at minus four on the scale, and zero VU will be indicated by +4 dBm or 1.228 V. The scale covers −20 to +3 VU, and these numbers can be read as dBm levels as long as the meter attenuator is set to +4 dBm.

## Why MPU?

**In your microprocessor articles you use MPU as an abbreviation for microprocessor. What does MPU stand for?**

**K.F., Melbourne.**

The central processing unit of a full-scale computer is called (for obvious reasons) the CPU. When Motorola launched their microcomputing system they called their microprocessor the MPU, short for micro-processing unit. Other manufacturers have used $\mu$P as an abbreviation ($\mu$ for micro and P for processor). These two are the only abbreviations we are likely to use in ETI.

## Relays and diodes

**Please explain why sometimes you put diodes across relays and sometimes you do not(for instance, in your Automatic Car Theft Alarm project RLA has a parallel diode and RLB does not).**

**What determines when a diode should be used?**

**What is the basis used to choose between, say, EM401, 1N914, OA47, and OA90?**

**Does it make any difference if a reed relay is used?**

**R.A.V., Oakleigh.**

As a simple rule you should always put a diode across a relay when it is in series with a transistor. More specifically, the diode should be used when a transistor is used to turn the relay off.

This is what happens when one side of the relay coil is disconnected: As the coil is an inductor, it cannot immediately stop passing current so a voltage builds up across it. When a transistor is used to switch the relay off this voltage appears across the transistor. Even with a miniature relay and a low supply voltage this can reach 100 or 200 volts! And a voltage like that on the collector of the transistor is more than enough to break it down.

Putting a diode across the coil provides a circuit for this current so the voltage on the collector does not build up (it simply increases until it has overcome the forward voltage of the diode and stays at that level until the current has died down).

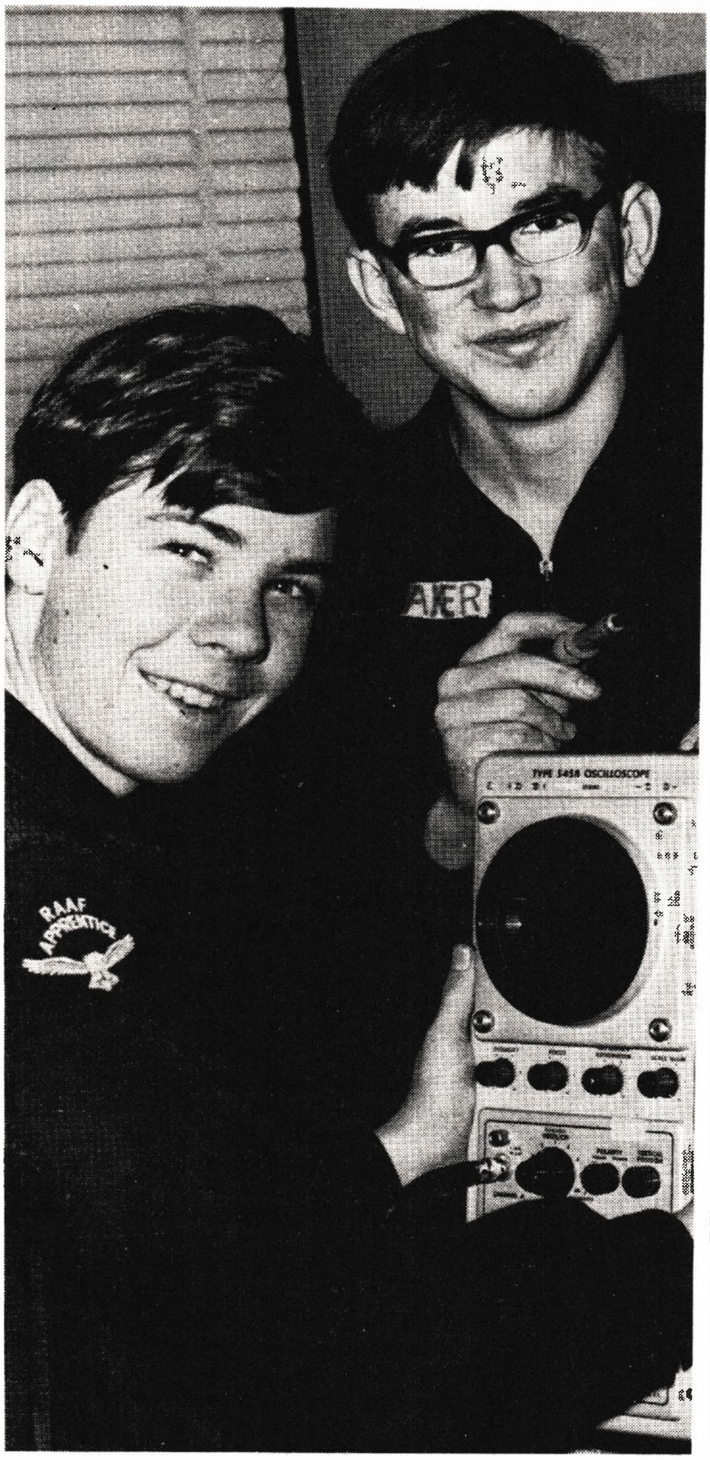
Almost any diode will do; it has to be able to handle the current normally taken by the coil, but this is usually small so any common diode will do. The 1N914 is faster than the EM401.

Because the diode enables the current to flow back through the relay, it slows down the response of the coil.

If speed is important then the sooner the energy can be got rid of the better. This means quicker response can be obtained by allowing the collector voltage to rise to a contolled extent, within the maximum safe limit for the transistor being used. This can be done by using a zener diode or a resistor rather than a simple diode.

To find the required value of resistance use Ohm's law on the maximum safe voltage and the normal coil current.

Protection, using one of the methods outlined above, should always be used when a transistor is used to switch off a relay coil. In the car alarm project RLB is switched on by a transistor but is switched off by a mechanical switch (the transistor remains on for a while). In this case the high voltage builds up across the switch and causes no problems.



# Mini-Mart

Here's a chance to let other ETI readers know about items you have to sell — or wish to buy.

We'll print your 24 words (maximum) totally free of charge. Copy must be with us by the 18th of the month preceding the month of issue. Please, **please** write or preferably type your adverts clearly, using BLOCK LETTERS.

This section is available to private readers only — it is not available to commercial organisations.

If, like many of our readers, you'd prefer not to cut up your copy of ETI, just make a copy of the relevant part of this page. Please make it the same size as the original — and write your copy using BLOCK LETTERS.

## PLEASE USE BLOCK LETTERS

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*Name and address plus phone number (if required) must be included within the 24 words allowed.*

*Reasonable abbreviations, such as 25 Wrms, count as one word.*

*Private adverts only will be accepted. Please let us know if you find a commercial enterprise using this service.*

*Every effort will be made to publish all adverts received — however, no responsibility for so doing is accepted or implied.*

## THE FIRST ADS

Ads had just started coming in when this issue went to press. Here are the first few.

**SALE OR EXCHANGE** ¼W resistors, electro caps, diodes,pots, greencaps, trimpots, transistors: BC108, BC109, 3055, 2N3702, BC213L, new condition electronic books. B Oliver,5 Wiangarie Street, Casino,NSW.

**WANTED** circuit diagram for octave divider suitable for use with electric guitar. Write Karl May, 10d Endeavour Gardens, Launceston Street, Lyons 2606.

**PHILIPS SPEAKER ENCLOSURES** 7A kit, ˀimilar 14 12100/W8 woofers, AD5060 midranges, ADO 160T tweeters,crossovers, pineboard , h 30in w19½ d12½. $200. M O'Brian, 93 O'Brian Parade, Liverpool 602-6045.

**ETI440** 25Wrms amplifier. Requires 8 ohm speakers,Fully built and tested,$80. Not a kit. Salvatore Sidoti,3 Paling Street, Leichardt. Phone 660-5120, anytime after 6pm.

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**Acoustical Consultants** — Louis A. Challis & Associates.

Electronics Today International is published by Modern Magazines (Holdings) Ltd, 15 Boundary St, Rushcutters Bay, NSW 2011. It is printed (In 1976) by Wilke & Co Browns Road, Clayton, Vic and distributed by Australian Consolidated Press.
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# At 160 watts per channel, you're in charge in the sound department.


SX-1250

Pioneer's new SX-1250 AM/FM Stereo receiver. Continuous power output is 160 watts per channel minimum RMS at 8 ohms from 20Hz to 20,000Hz with no more than 0.1% total harmonic distortion. With high performance power like this, total sound management is right at your fingertips.

Just as an example, today's advanced recording techniques capture the entire sound spectrum of a musical program. Owning the SX-1250 assures that you will receive the full acoustical value of this achievement. Enormous power is maintained by the use of a large Toroidal-core transformer and four 22,000μF electrolytic capacitors. To insure that this incredible power is delivered with the absolute minimum distortion, RIAA equalization is precise within ±0.2dB and the phono overload level is extended to 500mV (1kHz, THD 0.1%) with input sensitivity held at 2.5mV. The step-type attenuator volume control is calibrated for direct readout of the decibel amount. And an infinite variety of tonal adjustments can be achieved with Pioneer's unique Twin Tone Control System.

Perfectly complementing the amplifier section is the outstanding performance of the FM tuner. A 5-gang variable capacitor and three dual-gate MOS FETs are combined to provide high performance spurious rejection, an effective sensitivity of 1.5μV and the S/N ratio is 74dB (stereo). Annoying drift is avoided via the sophisticated PLL (phase-locked loop) circuitry in the MPX section. Thus, switching signals are always in phase with pilot signals and effective stereo separation is guaranteed at all times. Flexibility was a determining factor in the final design of the SX-1250. Low and high filters, a Tape Duplicate switch, anti-birdie filter, FM muting, loudness contour switch, multipath switch. Terminals for two turntables, two tape decks, three sets of speakers, a Dolby* noise reduction unit and independent inputs for left and right channel microphones.

Pioneer's new SX-1250 stereo receiver. Power to manage your sound. Power to control it. Power to recreate the true excitement of the original performance. Power to capture the brilliance of every note that's played. The SX-1250 ..... power to play it any way you want.

| | Power Output (20-20kHz, 8 ohms, T.H.D. 0.1%) | Sensitivity (IHF) | Alternate Channel Selectivity | Input | | | | Output | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Phono | Tape Monitor/ Adaptor | Mic | Aux. | Speaker Pairs | Tape Rec./ Adaptor | 4-ch. MPX |
| SX-1250 | 160W x 2 | 1.5μV | 83dB | 2 | 3 | 2 | 1 | 3 | 3 | 1 |
| SX-1050 | 120W x 2 | 1.8μV | 80dB | 2 | 3 | 2 | 1 | 3 | 3 | 1 |
| SX-950 | 85W x 2 | 1.8μV | 80dB | 2 | 3 | 1 | 1 | 3 | 3 | 1 |

*Dolby is a trademark of Dolby Laboratories, Inc.

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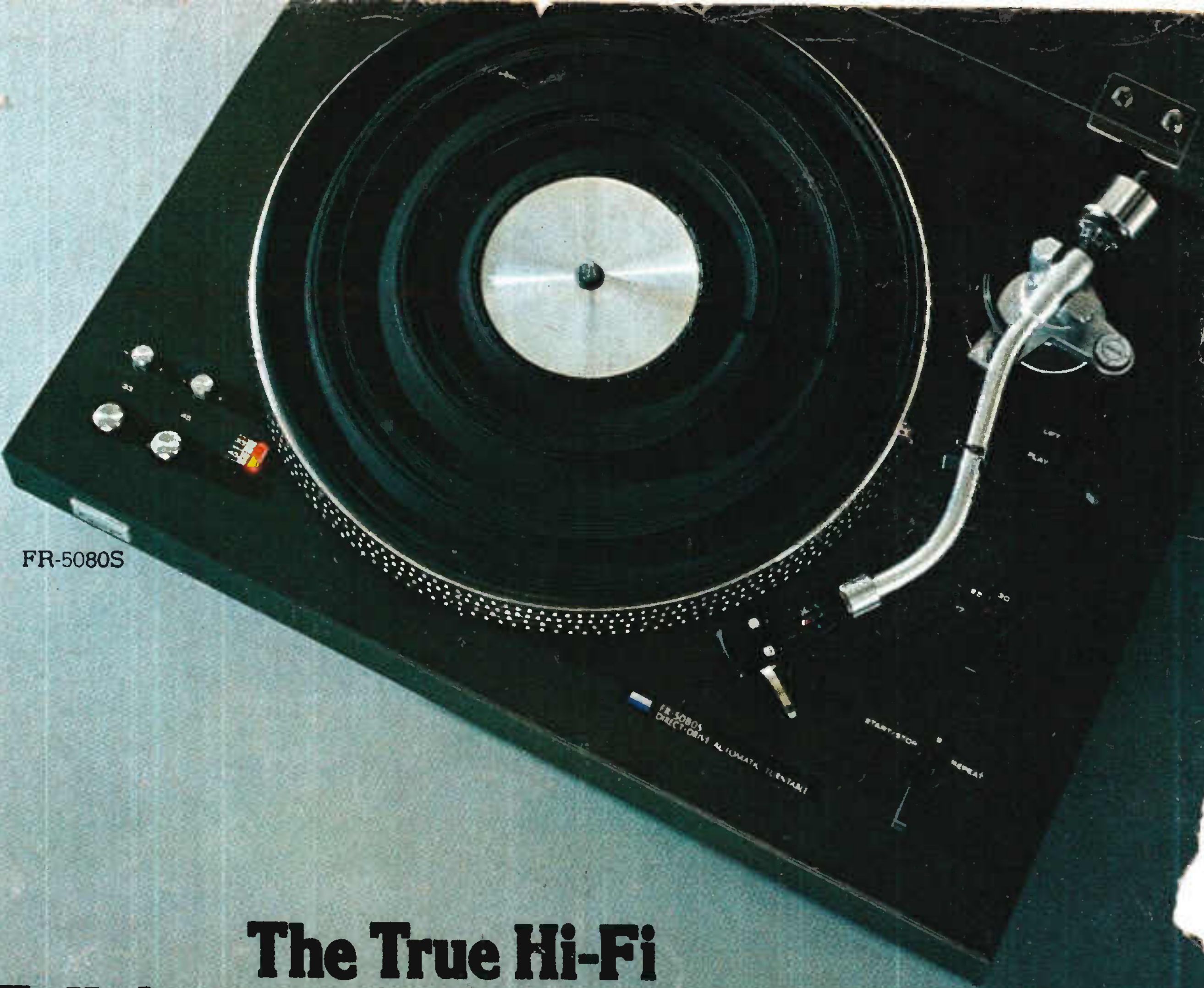

FR-5080S

# The True Hi-Fi Full-Automatic Direct-Drive Turntable. Test drive it.

The FR-5080S is the one from Sansui that combines automatic convenience with direct-drive precision. Quite a combination.

It's the one with brushless DC servomotor to eliminate speed drift, keep wow/flutter to an amazing 0.03% WRMS or less and signal-to-noise ratio better than 62dB.

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And the one with independent automatic mechanism, with 16-pole, 3-rpm gear motor that is completely disengaged during actual play from the tonearm linkage.

Almost everything is automatic, by the way. Lead-in, cut, return, repeat and shut-off. That's convenience.

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You already know that a bargain turntable is better than nothing.

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## Sansui True Hi-Fi

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