OCTOBER 1976 $1.00*
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electronics TODAY INTERNATIONAL

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Use your scope to fix your car

Win this BWD Scope

MICROPROCESSORS

-More introductory articles

'Project Electronics'

-a new course for beginners

Win a MARANTZ hi-fi! FM tuner dbx unit

electronics TODAY INTERNATIONAL

A MODERN MAGAZINES PUBLICATION

OCTOBER 1976, Vol. 6 No. 10

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.

HI-FI CONTEST

1st prize — Stereo System
2nd prize — FM tuner
3rd prize — dbx unit

— see page 10

Win a BWD scope

— see page 19

Where to get kits for our projects —

— see page 108

COVER: Most of you have a car and most of you have access to an oscilloscope, but have you ever thought of connecting the two together? Turn to page 14 and read how to do it, and how to interpret the waveforms you see.

* Recommended retail price only

PROJECTS

PROJECT ELECTRONICS —
A series of simple projects to educate the beginner:

FEATURES

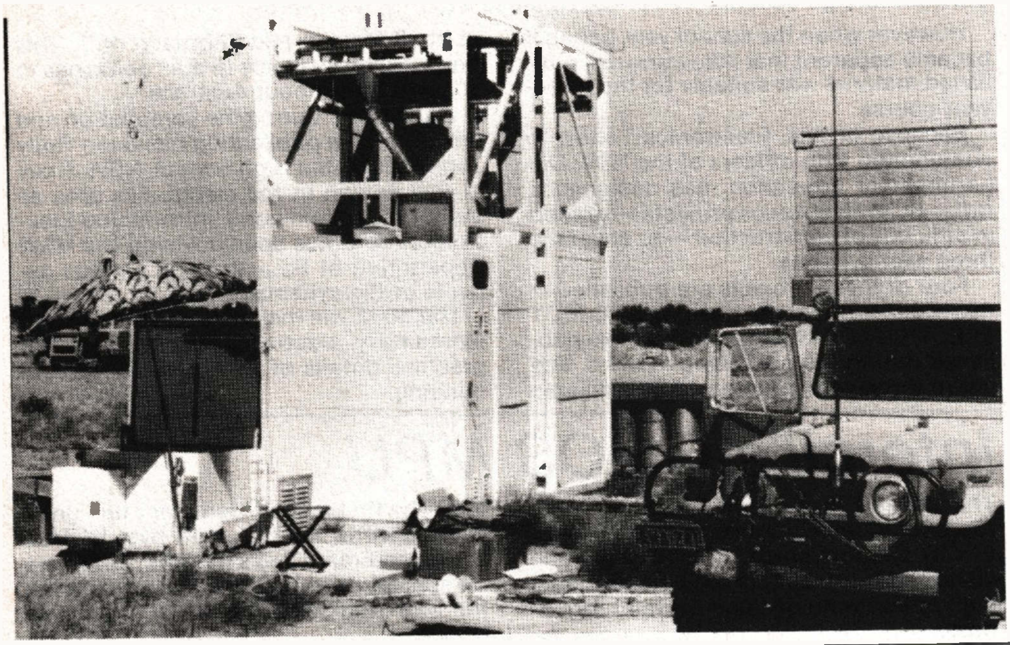
MICROPROCESSORS

NEWS & INFORMATION

Printed by Wilke and Company Limited
37-49 Browns Road, Clayton, Victoria.

SC-2002

NEWS DIGEST



A fleet of 92 radio-controlled vehicles, including two light aircraft and a helicopter, will patrol and maintain the natural gas pipeline from central Australia to the east coast when it comes into operation.

The equipment for the vehicle communications system has been designed and installed by Amalgamated Wireless (Australasia).

PLLs in, Xtals out

Crystal manufacturers have been doing quite well out of the CB boom in America but they now fear that the equipment manufacturers will turn to phase-locked loop circuits when they produce new gear for the 40-channel band which comes in next year. At present an estimated 40 percent of manufacture uses PLL circuitry (which only needs one crystal, not fourteen).

CB designers have also come up with a novel way of changing the operating frequency of the PLL without redesigning the circuit. They use a PROM to control the programmable counter in the circuit.

Melbourne's IREE International Convention

Organised by the Melbourne Division of the Institution of Radio and Electronics Engineers Australia, IREECON International convention and equipment exhibition will be held in the Exhibition Building, Melbourne, from August 8 to 12, 1977.

It will be the IREE's sixteenth convention at which overseas and local scientists and engineers will deliver papers on a wide range of subjects and manufacturers and distributors will show the latest technological advances in electronic equipment.

Chairman of IREECON Convention Board, Mr S.J. Rubenstein, said that although the convention was almost a year away it had already aroused considerable interest both locally and overseas.

Manufacturers and distributors were enquiring regarding space reservations in the equipment exhibition which will occupy the Eastern Annexe with a total gross area of more than 30,000 sq ft. At last year's International Electronics Exhibition '75 in Sydney, he said, the value of equipment on display was about $15 million. This indicated the considerable interest shown by both international and local organisations in a technical 'show window' such as that organised by the IREE.

Companies and government instrumentalities wishing to reserve space should contact the IREE at Clunies Ross House, 191 Royal Parade, Parkville, 3052, or 157 Gloucester Street, Sydney, 2000. These Information Centres would also supply information regarding the call for and submission of technical papers for inclusion in the lecture programme delegate registration.

Japan's first 8-bit microcomputer chip from Toshiba

The T3444 is a 42-pin ceramic IC containing the ALU, the RAM, the ROM, and the I/O parts for a simple microcomputer. The ROM can hold 256 24-bit words but it is mask-programmed for the specific application. The RAM is only 16 8-bit words and the I/O drivers are not on the chip. But it is fast; clock cycles of 1.25 microseconds are possible. The instruction set of the ALU is 14, compared to fifty-plus for common microprocessors.

Toshiba expects the T3444 to be used in heating control, microwave ovens, video games, and data processing applications. The price will be around $22 in quantity.

Would you like to sell CB?

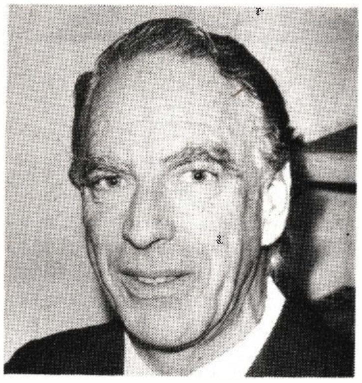
Dick Smith Electronics Pty Ltd of Sydney, Australian Agents for 'Midland' communication equipment, advise that they still have a number of openings in their Australia wide dealer network.

Dick Smith's have only been marketing Midland Equipment since last February. During that time, the growth rate of sales has been staggering, they claim. The bulk of sales so far have been in the Marine CB area. The great potential, however, is in the 23 channel gear that is so popular these days in the USA. In this connection, Staff of Dick Smith Electronics are confident that the PMG will eventually allow CB for everyone to use.

Anyone interested in becoming a dealer should contact:

Gary Johnston. D.S. Distributors,
P.O. Box 747,
Crows Nest, NSW 2065

ETI Staff



We are delighted to report that Geoff Petschler has recently joined ETI as NSW Advertising Sales Manager.

Geoff is very well known in the Australian electronics industry. For many years Geoff was NSW sales manager of A & R Soanar.

Microcomputer Hobby News

What was claimed to be the first America-wide microcomputer hobby show was held in Atlantic City at the end of August. I wonder how long it will be before one is held here in Australia?

Those readers who wrote in response to the piece in the August issue about forming an Australian Amateur Computer Club should be hearing from us soon. A newsletter is being prepared and a meeting is being planned.

Electronics projects for schools

There is no better entry to enjoying and understanding electronics than building electronics projects. We were therefore delighted to learn that project construction was to be part of the high schools' Technical Syllabus from 1976 onwards.

However when the school year began it became apparent that little currently published material was suitable for the three-year course.

Because of this, Electronics Today, in conjunction with officers of the NSW Department of Education, has designed a range of 28 electronics projects — graded in difficulty of construction — to cover the three year syllabus.

Four of these projects are published in this issue — under the heading PROJECT ELECTRONICS. Several more will be published during the next three months. The entire three-year course will be available in book form in mid-February 1977. This book will be available in bulk deliveries to schools throughout Australia.

Our advisor during the compilation and design of this publication has been Rolly Jones of Galston High School, NSW. Rolly is well known in the electronics area as author of the text book 'Introducing Electronics', and has been advising the NSW Department of Education on various aspects of the syllabus.

The book will include a short course in elementary electronics as well as full practical details of all aspects of project building.

Intercil's CMOS MPU

The IM6100 is a 12-bit CMOS microprocessor IC which comes with a range of CMOS support chips. CMOS offers the advantages of simple power supplies, high noise immunity, and overall ruggedness.

This means that the Intercil computer can be run off solar cells and batteries to control, for example, weather stations in the middle of the desert or the ocean.

Another big advantage of the 12-bit word length of the IM6100 is that minicomputer software can be used — the IM6100 is compatible with PDP-8E software.

In the US Intercil are advertising two interesting packages to promote the system. The first is their 'sampler'; this gives you the MPU, the PIE, a 1K byte ROM, a UART, and three 256 x 4 RAMs. These are on special offer until the end of October for less than half the usual price, for US$55.

The other interesting package is a one-card computer called the Intercept Jr Tutorial System. This battery-operated computer has its own keyboard, and display (eight LEDs). It comes complete with Tutorial manual for US$281. Optional extras include RAM (an extra 1K bytes for $145), ROM (for up to 2K words of program, $74.65), and I/O (for TTY and paper tape, $81.70).

Limericks

The Unitrex calculator for the winner of the contest in the August issue goes to W. G. Mottram of Bowral. The entries for this contest were limericks on the theme of life in the next century. The winning limerick is shown below:

In 2001 on sabbatical,
By matter transmitter it's practical,
At a million parsecs,
To transduce by Videx,
'Electronics Today Intergalactical'.

Voltages on the ETI443 Expander- Compressor

The tables show voltages measured on the prototype of this project. They are given as a guide only. The setting of RV1 affects the relationship between the input voltage and the other readings in table one.

TABLE I

Input Signal*	Output 1C1/1	Output 1C1/1	Output 1C3	Output 1C2/2	Output 1C4
1 mV	3.4 mV	−1.6 mV	+4.88 V	−4.84 V	−0.5V
10 mV	30 mV	+28.6 mV	+4.86 V	−4.83 V	−0.5 V
100 mV	350 mV	+338 mV	+1.95 V	−1.96 V	−0.55 V
1 V	3.7 V	+3.59 V	−2.34 V	+2.32 V	−0.63 V

* Input signal is a 1 kHz tone fed to both inputs. The output from 1C1/1 is ac, all other readings are dc.

TABLE II

RV2 Wiper	Output 1C5	Output 1C6	Output 1C7/2	Pins 5/3 TP3
−4 V	−0.84 V	+93 V	−9.79V	−0.67
−3 V	−0.73 V	+5.31 V	−6.0 V	−0.63 V
−2 V	−0.67 V	+3.1 V	−3.78 V	−0.61 V
−1 V	−0.62 V	+1.78 V	−2.44 V	−0.59 V
0 V	−0.59	+1.03 V	−1.68 V	−0.58 V
+1 V	−0.57 V	+0.61 V	−1.24 V	−0.56 V
+2 V	−0.55 V	+0.35 V	−0.98 V	−0.55 V
+3 V	−0.54 V	+0.20 V	−0.82 V	−0.54 V
+4 V	−0.52 V	+0.12 V	−0.72 V	−0.53 V

The voltage on the wiper of RV2 can be set by adjusting RV2 and the input signal.

New microprocessor makes the others look out-of-date

The third generation of microrprocessors has arrived. The Z-80 microcomputer chip set is as big an advance over the Intel 8080 as the 8080 was over the 8008. The chart shows a comparison to the 8080A. Note the double-size instruction set which includes all the 8080 instructions, this software compatability means that the Z-80 will be easily incorporated into present systems and 8080 designers will find it easy to use in new systems.

Features:	8080A	Z80-CPU	Features:	8080A	Z80-CPU
Power Supplies	+5,−5,+12	+5	Instructions	78	158*
Clock	2Φ, +12 Volt	1Φ 5 Volt	OP Codes	244	696
Standard Clock Speed	500 ns	400 ns	Addressing Modes	7	11
Interface	Requires 8222, 8228 & 8224	Requires no other logic and includes dynamic RAM Refresh	Working Registers	8	17
			Throughput	Up to 5 times greater than the 8080A	
Interrupt	1 mode	3 modes; up to 6X faster	Program Memory Space	Generally 50% less than the 8080A	
Non-maskable Interrupt	No	Yes	*Including all of the 8080A's instructions		

For less than half of the program mèmory used by its predecessors the Z-80 can handle two to five times the throughput.

The microcomputer chipset is now out in the United States and we don't yet know when or how it will be available in Australia. Zilog Microcomputers are the American manufacturers; their address is 170 State Street, Los Altos, California, 94022, phone 415-941 5055.

Transducers in measurement and control

A series of articles dealing with all aspects of transducers was published in Electronics Today during 1972 and 1973, The series were written by ETI's special contributor, Dr Peter Sydenham M.E., Ph.D., F.I.I.C.A., M. Inst. M.C.

Continued requests from tertiary institution teachers, both in Australia and in Britain have resulted in the series being reprinted as an inexpensive reference and teaching text. Research workers, hardware system designers, students in engineering and the sciences, scientific instrument manufacturers and their agents, and managerial level technical executives should find this extensive cover of value.

Profusely illustrated with several hundred diagrams and photographs, it explains how the commonly encountered measurement variables are converted into electrical signals in order to make records or achieve control. Each chapter contains a reading list: an index has been added.

Transducers in measurement and control is still available at $4.50 post paid (in Australia) from Electronics Today International, 15-19 Boundary St, Rushcutters Bay, NSW.

Dick Smith, of Dick Smith Electronics will be flying his Piper Twin engined Commanche Aircraft — REG VH-DIC, in the Australian Air Race from Perth to Adelaide, Melbourne and Sydney from October 20th to the 24th. He will be operating continuously on all 2 Metre Amateur Channels using an FDK Multi 7 feeding a ¼ wave whip. (call sign VK2ZIP).

Dick will be on the look out for all contacts and will QSL with an attractive 'Air Race' QSL Card. He will make an award for the contact with the longest communication distance (we hear one Amateur is setting up on Ayers Rock).

Co-Pilot for the race will be famous Australian Aviatrix, Nancy Bird-Walton. Route segments are as follows — if you are planning to travel to a remote mountain top write to Dick first and he will listen especially for you.

AIR RACE ITINERARY
VH-DIC.
DICK SMITH ELECTRONICS

October 20th
Start Perth — Norseman — Forest.

October 21st
Forest — Ceduna — Port Augusta — Adelaide

October 22nd
Adelaide — Camerai — Warnambool — Melbourne

October 24th
Melbourne — Narrandera — Parkes — Bathurst — Sydney

Sanken Components

Autotronics has just appointed J.E.S. Electronic Components of 6 Shofer Rd, Blackburn, Vic. as their official Victorian distributor and stockist.

Low-cost calibrated oscilloscope

A new version of the popular BWD 504 single beam oscilloscope has been produced by BWD Electronics Pty Ltd. In addition to being calibrated and carrying a full 12 months warranty, it is claimed to have a low price tag for a quality instrument.

It has a full sizes 8 x 10 CRT, and features a DC to 6 MHz bandwidth, 10 mV to 50V/cm sensitivity, and a remarkable 5 Hz to 15 MHz automatic trigger for the 0.5u Sec to 0.1 Sec/cm time base. The X-Y operation is within 3 degrees from DC to 50 kHz. With a common line isolated to 400V DC, it is an excellent instrument for use by students and teachers, as well as experimenters, servicing and production work. The new version incorporates a beam rotation facility controlled by a rear panel preset potentiometer. This enables the trace to be accurately aligned to the precision graticule. Full technical details are described on a data sheet which is readily available from BWD Electronics Pty Ltd., Miles Street, Mulgrave Vic. 3170, phone (03) 561-2888 or branch offices throughout Australia.

Design a contest and win a prize

For the Unitrex calculator contest this month we can't think of a suitably interesting puzzle to set, that is we couldn't until someone thought of getting you the reader to help. We will give the calculator offered by Unitrex as a prize to the reader who can think up a good idea for a contest. We don't want you to give us something you've seen in another magazine, we want you to enter something you have made up yourself. And it will have to be better than the ideas we have had in recent calculator contests or you won't stand a chance of winning the prize.

If you want a start we can suggest you try a mathematical puzzle based on an interesting numerical phenomenon. If you must send in quiz-type problems make sure they are interesting . . . nobody is going to enter a contest if you ask them to do some boring problem from a school maths book (and certainly they won't if its a question from a school history book).

So, in summary, our main criterion is that the idea be interesting; at the same time it would be advantageous if it was within the resources of the average reader to attempt an answer, and if you want to be really clever make sure that if we eventually use it in the magazine it will make interesting reading both when posed as a question and when, in a subsequent issue, the answer is published.

Send your entries (to reach us by November 9th) to ETI/Unitrex Contest (October Issue), Modern Magazines, 15 Boundary Street, Rushcutters Bay, NSW 2011.

Permit number TC7578

Microprocessors and ETI

For the last three issues we have published introductory articles on microprocessors and now we announce the establishment of a regular section to be published in future ETIs to cover this new field. We will print news, background information, reviews, and projects. This section will be edited by Kevin Barnes and each month there should be something for the amateur and something for the professional.

Would you like to work on ETI?

We're currently seeking a youngish man or woman to help produce Electronics Today and associated publications.

You must know a fair bit about electronics — and be able to write clear concise English. Previous journalistic experience would be useful but by no means essential.

Interested? Then write to or telephone Collyn Rivers as soon as possible.

Siemens Evaluation Kits

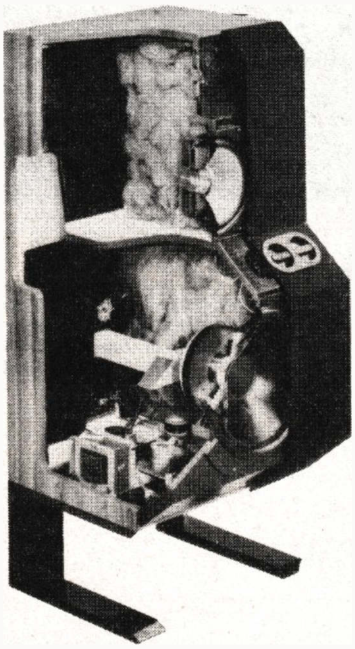
Seimens in West Germany have announced two evaluation kits based on their SAB8080A microprocessor. The Sikit-N/8080 sells for about $170 and contains an electrically programmable and erasable 256-byte ROM. The other kit is the Sikit-DK8080 which sells for about $360 and contains more ROM, RAM and interface facilities.

ERRATA

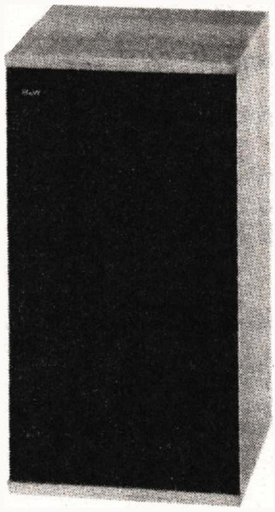
The NF Ltd model E-1011 function oscillator described in News Digest last month was credited with a distortion of 0.5 percent. This should have read 0.05 percent.

Each B & W speaker comes with its own written proof of superb performance:

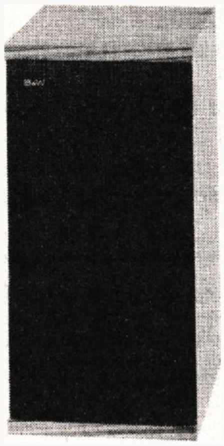
B&W's reputation is based on producing clean natural sound without distortion, even at low volume. Each B&W speaker is tested in an Anechoic Chamber and issued with its own individual pen graph. You know exactly the performance of the speaker you are buying



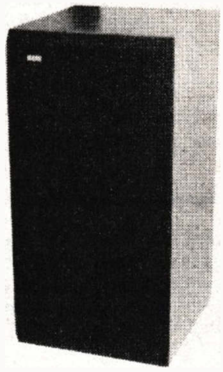
B&W DM6 Monitor
A brand new design. A high powered dynamic loud-speaker with low colouration and very high transient performance.



B&W DM2A Monitor
A more conventional design, utilising B&W research into acoustic line rear loading.. Brilliant clarity and lack of distortion.



B&W DM4 Monitor
A speaker with large B&W Monitor characteristics; its performance surpasses speakers of much greater size.



B&W DM5
A speaker for small living areas. It has above average performance at moderate cost.

Hear B & W Speakers at:

ALLANS MUSIC (AUST) LTD., 276 Collins Street, Melbourne, Vic. 3000. (03) 63-0451; ENCEL ELECTRONICS PTY' LTD. 431 Bridge Road, Richmond, Vic. 3121. (03) 42-3761; INSTROL HI-FI (VIC) PTY. LTD. 375 Lonsdale Street, Melbourne Vic. 3000. (03) 67-5831; SOUTHERN SOUND, 337 La Trobe Street, Melbourne. Vic. 3000. (03) 67-7869; SOUTHERN SOUND 963 Nepean Highway, Moorabbin, Vic. 3189. (03) 97-7245; TIVOLI HI-FI, 91 Cotham Road, Kew, Vic. 3101. (03) 80-4956; E & B WHOLESALE, 172 Moorabool Street, Geelong, Vic. 3220. (052) 9-6616. THE GRAMOPHONE SHOP, Shop 151, Westfield Shopping Town, Parramatta, N.S.W. 2150. (02) 633-2846; INSTROL HI-FI PTY. LTD. 91a York Street, Sydney, N.S.W. 2000. (02) 29-4258; MILVERSON PTY. LTD. Warringah Mall, Brookvale, N.S.W. 2100. (02) 938-2205; MILVERSON PTY. LTD. 793 Pacific Highway, Chatswood, N.S.W. 2067. (02) 412-2122; RIVERINA HI-FI, 549 Pittwater Road, Brookvale, N.S.W. 2100. (02) 938-2663/4; UNITED RADIO DISTRIBUTORS PTY. LTD., 32 Angel Arcade, Sydney, N.S.W. 2000. (02) 232-3718; WESTS (BURWOOD) PTY. LTD. 170 Burwood Road, Burwood, N.S.W. 2134. (02) 747-4444; PITMAN'S RADIO & T.V., 38 Baylis Street, Wagga, N.S.W. 2650. (069) 25-2155; JOHN GIPPS SOUND 12 Douglas Street, Milton, Qld. 4064. (07) 36-0080; PREMIER SOUND, Elphinstone Street, Rockhampton Nth, Qld. 4701. (079) 28-2701. BEL CANTO, 138 Liverpool Street, Hobart. Tas. 7000. (002) 34-2008. AUDIO DISTRIBUTORS, 10 Glyde Street, Mosman Park, W.A. 6012. (092) 31-5455. PACIFIC STEREO, Style Arcade, Manuka, A.C.T. 2603. (062) 95-0695; DURATONE, Altree Court, Phillip, A.C.T. 2606. (062) 82-1388. SOUND SPECTRUM, 33 Regents Arcade, Adelaide, S.A. 5000. DECIBEL, 345 North East Road, Hillcrest, S.A. 5086. (08) 61-1865; ERN SMITH HI-FI, 50 King William Street, Adelaide, S.A. 5000. (08) 51-6351; ALLANS MUSIC (AUST) PTY. LTD., 58 Gawler Place, Adelaide, S.A. 5000. (08) 223-5533.

B&W

Sole Australian Agents
Convoy International Pty. Ltd.
4 Dowling Street, Woolloomooloo, 2011
Sydney, N.S.W. Tel: (02) 357-2444
387 George Street, Sydney, NSW.
Tel: (02) 29-1364

SUPER SYSTEM

Here's a chance to win a superb Marantz-based 75 watt stereo system.

The heart of the system is Marantz' great 3200/140 pre-amp/power amp combination. Driving this is the Marantz 6200 belt drive servo-controlled fully automatic turntable — complete with an ADC Q36 cartridge. Loudspeakers are a pair of Marantz HD 66s.

Total value of this first prize is approximately $1600.

SECOND PRIZE is a Marantz model 112 AM/FM tuner — value approximately $300.

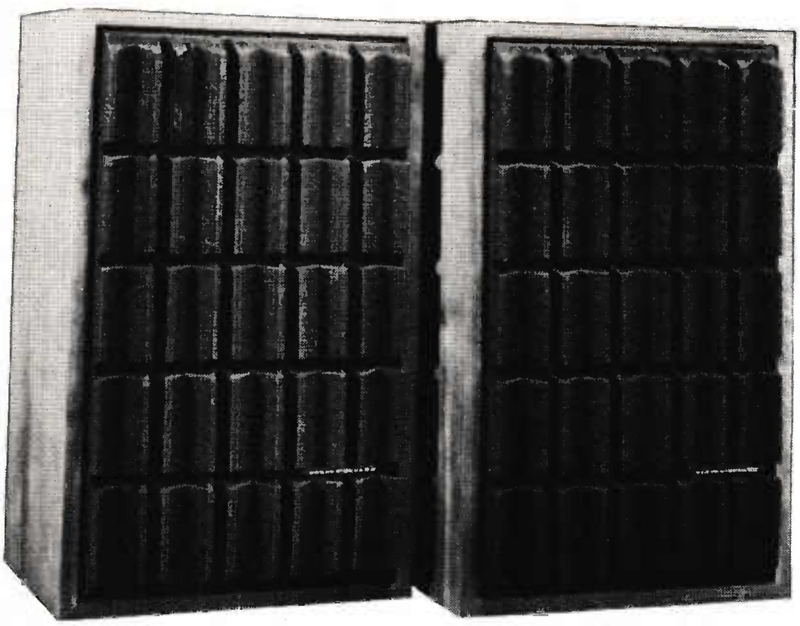
THIRD PRIZE is a dbx 117 noise reduction unit — value approximately $200.

The contest consists of nine questions all carrying equal marks.

In the event of more than one all-correct entry being received, we will thoroughly mix the all-correct entries and draw them one by one from a barrel. The winning entries will then be in the order drawn.

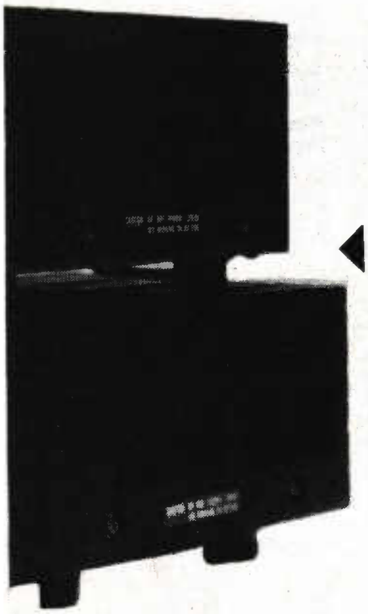
dbx 117 dynamic range enhancer — a two-channel expander/compressor enhances dynamic range of records, tapes and FM broadcasts simultaneously reducing surface and background noise.

Marantz HD 66 bookshelf speakers — handles up to 150 watts programme material. Frequency response 37 Hz to 20 kHz ±3 dB. Driver are 10" woofer, 4½" mid-range and 1" dome tweeter. Recommended retail price $498 pair. A unique feature of the HD66 is the Vari-Q Acoustic Plug; this converts the speaker from an acoustic suspension format to a bass reflex format when the plug is removed. It also increases bass efficiency.



TO WIN!

Model 6200 belt drive single play turntable has servo control. All functions are automatic. Pitch control and strobe light assure constant speed.



Model 3200 preamp. This low noise, low distortion unit has less than 0.05% thd from 20 Hz to 20 kHz. Frequency response is virtually 'ruler flat' over the audio range (20 Hz to 20 kHz ±0.5 dB). Slide controls adjust bass, mid-range and treble output — with selectable frequency turnover points.

QUESTIONS

1. What is a 'boffle'?
   - A mispelled baffle. ☐
   - A rigid plate mounted behind the midrange driver in a bass reflex enclosure. ☐
   - A peak in the response of a bass drive unit. ☐
   - A boffin's habitat. ☐
   - A loudspeaker enclosure designed by Hartley ☐

2. The dbx 117 compressor/expandor alters the dynamic range of signals fed to it. Explain in less than 35 words why this is desirable for realistic music reproduction.

   ....

   ....

   ....

3. The running speed of Marantz' 6200 turntable can be adjusted by a control knob. Give at least two reasons why this is a desirable feature.

4. In 1963 a Chinese soprano lost her ability to sing top notes. Her predicament was likened to a sailor serving 20 years in Long Bay gaol.
   Sum this up — using no more (or less) than four words.

   ________ ________ ________ ________

   (Clue — the answer we have in mind contains a total of 11 letters).

5. Who wrote the following:

   "Lord Finchley tried to mend the electric light
   It struck him dead, and serve him right.
   It is the business of the wealthy man
   To give employment to the artisan."

   - Chesterton ☐
   - Belloc ☐
   - Elliot ☐
   - Shaw ☐
   - Gilbert ☐

6. Experts generally agree that if an amplifier's total harmonic distortion is below a certain level the distortion cannot be heard. What is that level?
   (The Marantz 3200 has 0.05% thd).
   - 0.05% ☐
   - 0.10% ☐
   - 0.30% ☐
   - 1.0% ☐
   - 3.0% ☐

SUPER SYSTEM TO WIN!

7. What is the full address of your nearest Auriema dealer?

. . . .

. . . .

8. 1200 cents equals $12. But what else is it equal to? Keep your temper answering this!

. . . .

9. Under average conditions what is the minimum change in sound level that the average listener can detect?

- 0.01 dB ☐
- 0.1 dB ☐
- 1.0 dB ☐
- 1.5 dB ☐

ENTRY FORM

I have read and agree to abide by the contest rules published on these pages.

Name . . . .

Address . . . .

. . . .

. . . . P/code . . . .

Permit No.

We would appreciate if you would also answer the following questions:

How many gramophone records do you buy each year?

- 1–10 ☐
- 10–25 ☐
- 25–50 ☐
- 50 + ☐

If your system cost more than $500 may we have brief details (Use separate sheet please).

Do you intend to upgrade any of the following items this year?

Amp	YES/NO
Speakers	YES/NO
Cartridge	YES/NO
Turntable	YES/NO
Cassette Deck	YES/NO
Tape Deck	YES/NO

CONTEST RULES

THIS CONTEST is open to all persons normally living in Australia except employees of Modern Magazines and associated companies.

Entries should be sent to ETI/Auriema Contest, Electronics Today International, 15 Boundary St, Rushcutters Bay, NSW 2011 to arrive before Monday, November 29th, 1976.

The contest will be judged by the editor and assistant editor of ETI. Their decisions will be final and no correspondence can be entered into regarding their decisions.

Winners will be advised by telegram on the day the results are known. Their names together with the winning answers will be published in the earliest possible issue of ETI.

Photostats or clearly written copies of the entry form will be accepted, if you don't want to cut up your copy of ETI. Up to four entries per person will be accepted.

Please please make sure you include your name and address on each page of your entry.

AURIEMA AGENTS

NSW & ACT

Allied Music Systems, Crows Nest.
Anno's Hi-Fi, Orange.
Arrow Electronics, Sydney.
Car Radio & Hi Fi, Wagga Wagga.
Ron Chapman Hi-Fi, Newcastle West.
Convoy Technocentre, Woolloomooloo.
Douglas Hi-Fi, Sydney.
Dubbo Hi-Fi, Dubbo.
Electronic Parts, Sydney.
Goodwins Retrovision, Taree.
Gramophone Shop, Parramatta.
Hornsby Hi-Fi, Waitara.
Hunter Valley Electronics, Maitland.
Kibblers, Cowra.
Jock Leate, Hurstville.
Leeton Record Centre, Leeton.
Macarthur Radio, Katoomba.
Milversons, Chatswood.
Miller & Chaney, Parkes.
Miranda Hi-Fi, Miranda Fair.
Miranda Hi-Fi, Liverpool.
Miranda Hi-Fi, Gosford.
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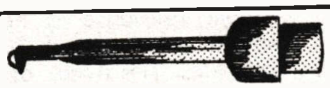

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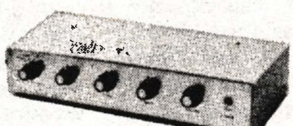

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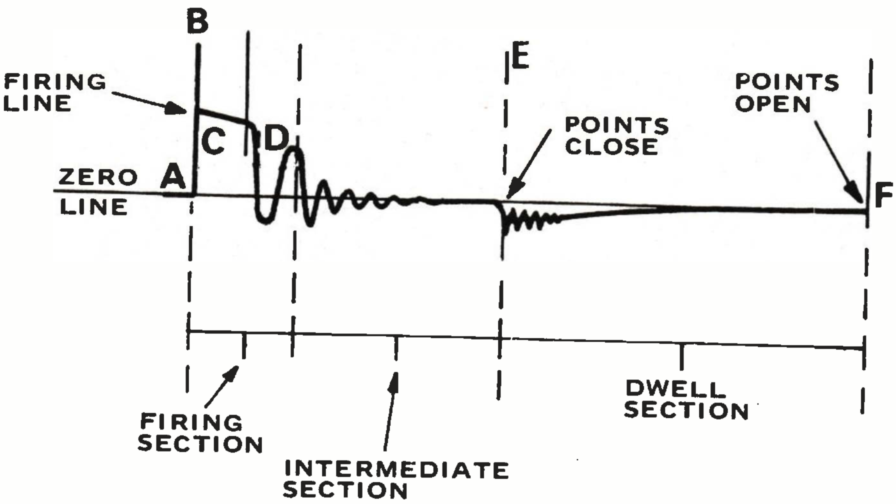
'Scope test your car

How to use your 'scope to check out a car's carburetion and ignition systems.



AUTOMOBILE ENGINE TUNING IS A grossly misused and misunderstood operation. To many it implies some esoteric knowledge or ability — of listening to an engine and somehow deducing that the ignition must be advanced — or the mixture strength richened a bit on the front carburettor.

In reality it consists almost entirely of ensuring that ignition and carburetion is adjusted to the vehicle manufacturer's specifications.

No more — no less.

But to do this it is virtually essential to use at least some basic instrumentation; a dwell meter, a tachometer, a good exhaust gas analyser — and preferably an ignition analyser.

Many car enthusiasts have at least a tacho/dwell meter — but few have access to an ignition analyser for such devices are costly indeed. Nevertheless if a few limitations are accepted virtually *any* standard oscilloscope can be used as an ignition analyser simply by making a couple of very simple capacitive probes — which can be as simple as clothes pegs and a few square inches of aluminium foil.

An ignition analyser displays waveforms from the primary or secondary side of the vehicle's ignition system. Surprisingly perhaps, this waveform provides information not only about the ignition system in general but also about carburetion, and a number of mechanical conditions.

The analyser can do this because the voltage required to fire a petrol/air mixture in an engine is affected by many different variables including air/fuel ratio, cylinder compression, ignition timing, ignition polarity, spark plug gap and condition etc, etc.

THE SECONDARY WAVEFORM

The simple waveform shown at the beginning of this article is a typical secondary waveform that is derived from the secondary (or high voltage) side of the ignition system. This waveform is the one most commonly used since phenomena occuring in the primary side of the system will be reflected through the coil windings and appear in the secondary pattern.

Point A: is the instant at which the contact points open thus causing the magnetic field to collapse through the coil's primary winding. A very high voltage is thus generated in the secondary winding and this continues to rise — until a spark jumps across the distributor rotor gap and the spark plug gap (point B). The voltage at which this occurs is known as the 'ionization' or the 'firing' voltage and may be anywhere between 5 kV and 15 kV depending on the factors outlined above.

Points C—D: after a very short time the voltage drops substantially but the arc is maintained (point C). The subsequent section from point C to point D is known as the spark line and when viewed on a 'scope the amount by which this line slopes away from the horizontal is directly related to resistance in the plug and coil ht leads (ignition suppression). A slope of 30° or so is OK — if it's more than that then it's worth checking lead resistance with an ohmeter. The total resistance between the centre terminal of the coil and the centre electrode of the plug should not exceed about 20 k assuming the rotor gap is shorted out of course! Actual resistance is not critical but anything more than 30 k may cause problems. Resistance over 50 k almost certainly will.

Point D: the section immediately following the end of the spark line (point D) should be a series of diminishing oscillations. These should appear as our illustration. If there are no oscillations — or just or or two — then it's a safe bet that there's a shorted turn in the coil. It may not have broken down completely yet but it's a safe bet it shortly will. (See also below).

Point E: is where the contact breaker points close. It is essential that there is a gap between the last oscillation of the preceding section and point E for otherwise the diminishing coil energy will be fed into the now closed points thus preventing the coil re-building its magnetic field for the next cycle of ignition.

A great deal may be learnt by studying point E carefully, point misalignment, point bounce, burnt points etc may be spotted at this part of the waveform. The correct waveform at point E should be a short downward line followed by six or so diminishing oscillations.

Point F: magnetic energy will now build up in the coil until Point F. This is in effect the same point as our previous point A but in the next firing sequence. The section from points E to F is known as the dwell section and should occupy roughly the proportion of the total waveform as shown in our main drawing. Dwell is adjusted by varying the contact breaker gap and should be set using a dwell meter.

SPECIFIC INDICATIONS

Firing waveforms should be observed with the engine warm and running at about 1000 rpm — that is about 400 rpm higher than normal tickover speed.

Check each section of each firing sequence slowly and carefully. The various figures shown in this article indicate how specific faults will show up.

FIRING LINE

All firing lines should be of roughly equal height. If any plug is 10-15% or more higher than the rest, connect a jumper lead to earth and short out at the plug terminal. If the firing line now decreases the fault lies within that cylinder — either a faulty plug or unusually weak mixture (probably caused by a leaking inlet manifold gasket). If the firing line does *not* decrease there is a partial open circuit in the associated plug lead or that lead is not making firm contact with the connector within the distributor cap.

If the firing lines are unequal on a multi-carburettored engine check to see if the lines which are higher correspond to those cylinders fed by one common carburettor. If so it is probable that the mixture from the carburettors is unbalanced. A further but less common fault that may be spotted this way is an eccentric distributor cap — the gap between rotor and distributor contacts being wider on one side than the other.

At some time during the check 'snap' the throttle wide open momentarily, meanwhile watching the firing lines. They should all rise by about the same amount. If one or more lines rise substantially higher than the others then there is an open circuit plug lead or resistor, a wide plug gap or badly deteriorated plug electrode.

One or more lines staying lower than normal indicates spark plug breakdown or insulation breakdown in the circuit concerned.

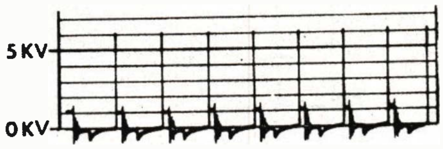
COIL OUTPUT AND INSULATION TEST

While the engine is running disconnect a plug lead and observe the firing pattern for that cylinder. The firing line should rise to about two to three times its previous level (to about 20 kV) and should extend below the base line by about half the upward distance.

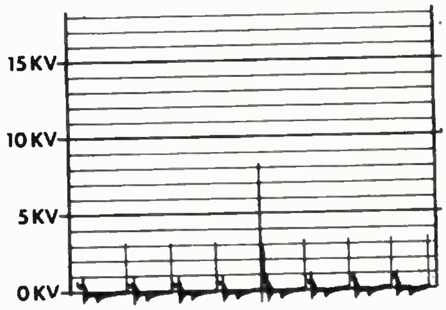
If the firing line is short or inter-

FIRING LINE INDICATIONS

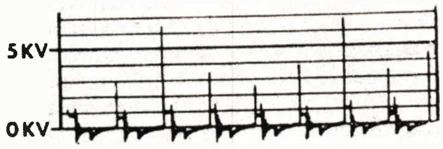
Normal pattern:
Note that the firing line for cyl. 1 appears at the extreme end of the trace. The remaining cylinders then appear in engine firing sequence.



Firing lines even but high:
Excess plug gaps, rotor gap, break in coil ht lead, mixture too lean ignition retarded.

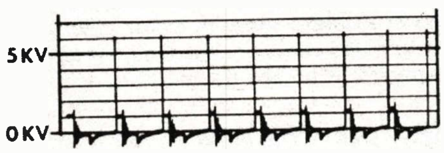


Firing line high on ONE cylinder:
Break in plug lead, broken electrode in spark plug. To test short plug — if line drops, problem is within cylinder.

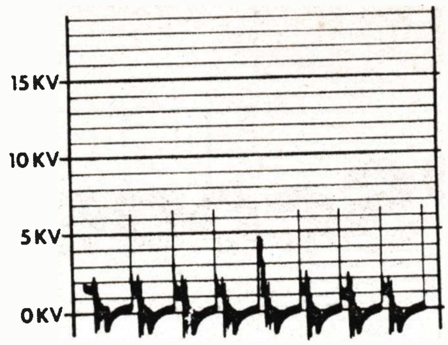


Firing lines uneven:
Break in plug leads, worn plugs, burnt distributor cap contacts, uneven air/fuel mixture.

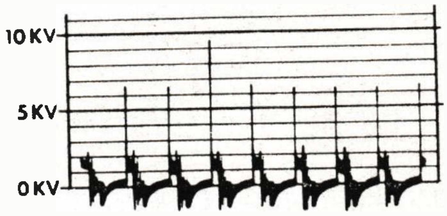
SNAP THROTTLE INDICATIONS



All lines should rise but remain even.



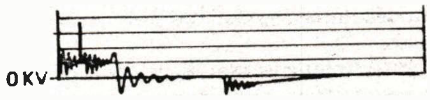
One line breaks up. Insulation break down — probably spark plug fouling. Extreme cases will show similar signal under normal steady running.



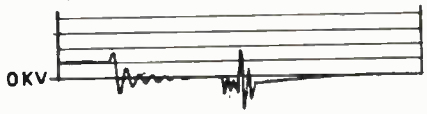
One line rises above rest. Wide plug gap, partial break in suppression resistor, plug lead etc.

CONTACT POINT INDICATIONS

Unusual point opening signal (note hash extreme right of picture) burnt or arcing points.

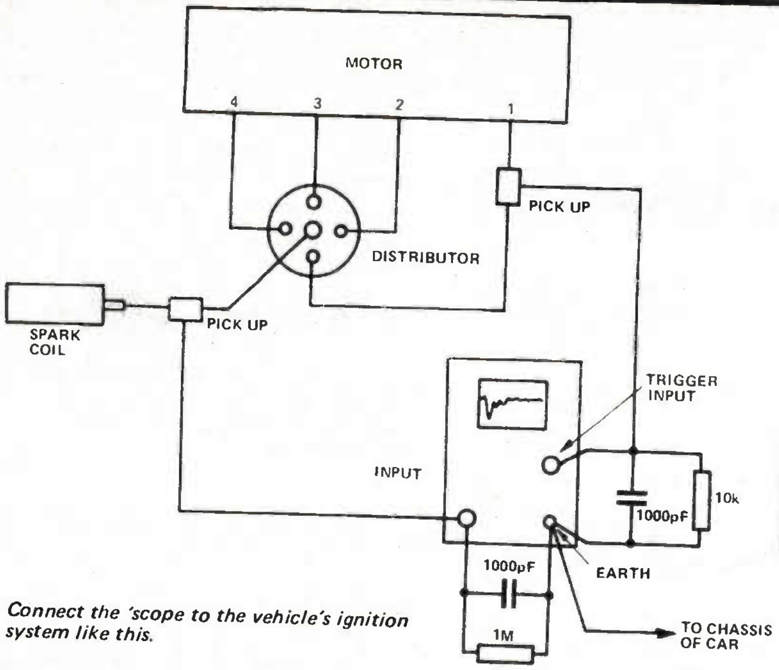


Spike on spark line. Point arcing caused by faulty capacitor.

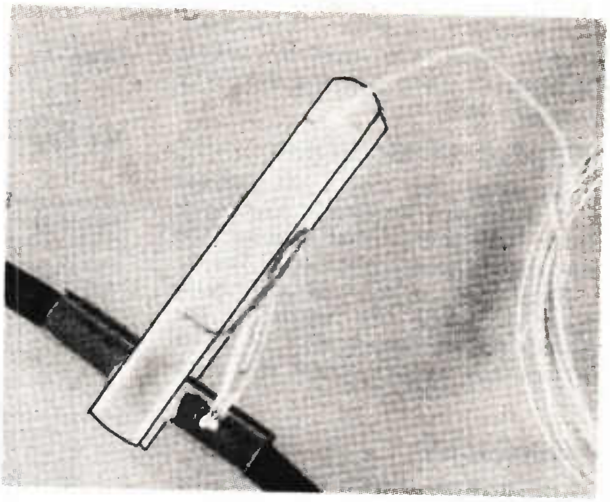


Points bouncing probably caused by weak closing spring.

Points misaligned — or dirty.



Connect the 'scope to the vehicle's ignition system like this.



A simple pick-off can be made by glueing short lengths of split metal tube to a clothes peg.

CONNECTING THE 'SCOPE

A motor vehicle's ignition system produces output voltages varying from 3 kV to 20 kV or more. These high voltages must be reduced to a workable level before coupling into an oscilloscope.

The simplest way of doing this is via a resistive voltage divider — however a capacitive divider will work equally well (we are dealing with ac signals) and is simpler to connect.

We can make one of the capacitors by wrapping a piece of Alfoil — about 50 mm long — around the required lead and connecting this foil to the scope. A more professional approach is to glue a short length of split tube to a clothes-peg — as shown in the accompanying photograph. This will have a capacitance of about 1 pF — not much but ample for the massive signals we are sampling.

A second capacitor of about 1000 pF should be connected as shown. The capacitive divider thus formed divides the input signal by about 1000:1 thus reducing the input signal to a workable 3—20 volts. A 1 M resistor should be connected across the 1000 pF capacitor to provide a dc load.

The technique in use: Place the 1 pF capacitor over the main lead from the coil to the distributor and connect it to the 'Y' input of the scope.

If the scope has a trigger input this may be used to lock in the ignition signal. Just make up a second capacitive pick-up and place this around number 1 plug lead. Once again use a 1000 pF capacitor as a divider but bridge this capacitor with a 10 k resistor — not 1 M as previously.

Start the motor and adjust the 'Y' gain and timebase frequency to give four (or 6 or 8) complete firing sequences across the screen. The first complete pattern will be number 1 cylinder and the rest will follow in the engine firing order.

All waveforms may be superimposed by expanding the trace and triggering via the X input.

If the scope does not have a trigger input, synchronization is slightly harder to achieve. Number 1 cylinder may be identified simply by shorting out that cylinder momentarily.

When the scope is connected as described above, the ignition waveform will appear inverted relative to that seen on a commercially produced ignition analyser — and the waveforms shown in this article. It is surprisingly easy to adapt to an inverted picture, however if this is found to be a problem it can be remedied simply by coupling the signals into the scope via a simple 1:1 transformer. Details will vary from one scope to another but all that is basically needed is two coils of wire taped together. It may be necessary to reduce the 1000 pF capacitor/s to 470 pF. Just connect the secondary to give the correct picture.

If possible arrange to calibrate the scope's vertical axis so that the magnitude of the signals may be measured. This is best done simply by taking average indications from several vehicles and 'calibrating' by transferring data from the graphs in this article. The result may not be accurate but only a rough guide is required.

'Scope test your car

mittent — or if the lower section does not appear — then there is an insulation breakdown in the distributor cap, plug leads, rotor or coil.

COIL AND CAPACITOR

A series of diminishing oscillations should be observed at point D in the waveform. If these do not appear, or are truncated, there is either a shorted or crossed turn in the coil — or the capacitor is breaking down.

BREAKER POINTS

Point E on the main waveform. The drawings accompanying this article show various fault indications. Note however that faulty point action may also show up at the point opening position (A). Check breaker point action with the engine running at all speeds. Weak or incorrect breaker springs will cause the points to bounce — and this is readily seen on the scope pattern.

COIL

With very few exceptions — notably on some Citroens — the high voltage side of a vehicle's ignition system is designed to have positive earth — *regardless of overall vehicle battery polarity.*

The reason for this is that electrons are emitted more readily from a hot surface than a cold one so as a spark plug centre electrode always runs hundreds of degrees hotter than the side electrode the ignition system is devised so that a negative potential is applied to the centre electrode.

If this polarity is reversed, the plug will require an extra 5 kV or more to fire it — and that voltage may not be available from the coil under heavy load — or when running at light throttle at high speed (remember a weak mixture needs a higher voltage to ignite it than a rich one).

If you are checking polarity on a specialist ignition analyser then the polarity is correct if the pattern is as shown in the illustrations in this article. If you are checking it with a standard scope (with no inverting device) then the pattern should be upside down if polarity is correct. (See inset for full explanation).

Polarity is corrected simply by reversing the coil terminals. (Incorrect polarity is usually caused by a mechanic replacing a coil intended for a negative earth vehicle with a coil meant for a positive earth vehicle — or vice-versa. It may also, but less probably, be caused by an incorrectly manufactured coil, or less likely, by the vehicle's polarity being accidentally reversed by the battery being connected the wrong way round).

MIXTURE STRENGTH

This section is intended for the lucky man who has access to an exhaust gas analyser and tachometer as well as a scope.

If cylinder compression pressures are identical, plugs in good order and evenly gapped, and plug leads and distributor in good order — then any significant difference in firing line heights will almost certainly be caused by differing mixture strength from one cylinder to another.

The voltage required to fire a rich mixture is substantially less than for a weak mixture: for instance a 12:1 ratio may need 3 to 4 kV — whilst a 15:1 ratio may need 7 to 9 kV (typically). Thus even quite small differences in mixture strengths will be reflected quite dramatically in firing line height.

The only accurate way to adjust mixture strength is as follows:

Connect a tachometer to the engine and adjust slow running to 1000 rpm. *Without looking at the gas analyser* adjust mixture strengths so as to produce the highest tickover speed whilst maintaining the firing lines at an even height. If necessary reduce the tickover speed to keep it around 1000 rpm. Finally richen the mixture a shade until tickover speed drops by about 50 rpm.

Then *and only then* — look at the gas analyser. You should now have a reading somewhere between 14:1 and 15:1. If you haven't then there's something wrong with the carburetion system — an air leak in the induction manifold: incorrect float chamber level: blocked slow running jet or *something.*

Never ever tune an engine by using a gas analyser alone — or in any other sequence than that spelled out above. If you do it's a certainty that sooner or later you're going to start with one fault and end up with two or more. ●

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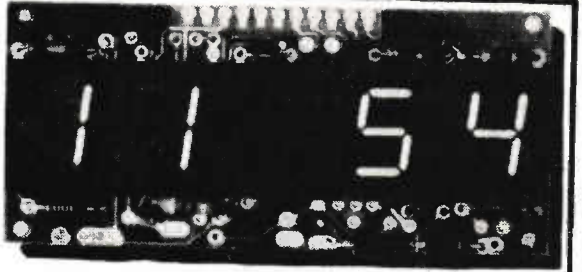

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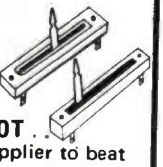

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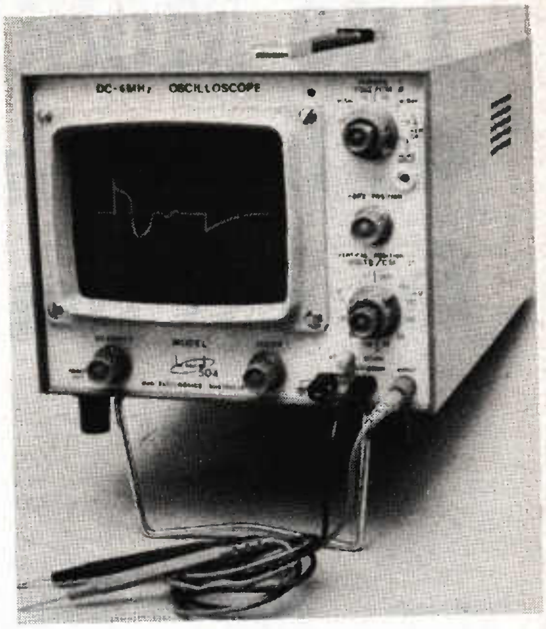

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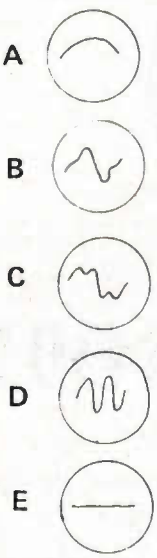
Calibration: <5% with vernier at Cal.
Vernier: 12:1 continuous control between each range.
TRIGGERING: Auto-lock with no manual controls. Sensitivity: >1 cm deflection 10 Hz to >10 MHz typicall to >15 MHz at 2 cm.

LF. trigger extends below 5 Hz with 2 cm deflection. Trigger circuit locks to the mean value of the displayed waveform.
HORIZONTAL AMPLIFIER: Sensitivity: Approx. 500 mV to 50 V/cm continuously variable.

BANDWIDTH: dc to 1 MHz, –3 dB
Input Impedance: 100 KΩ and 20 pF. X–Y Phase Shift: <3° from dc to 50 kHz.

1 Two of these

could give –



TICK ONE BOX ON THE COUPON

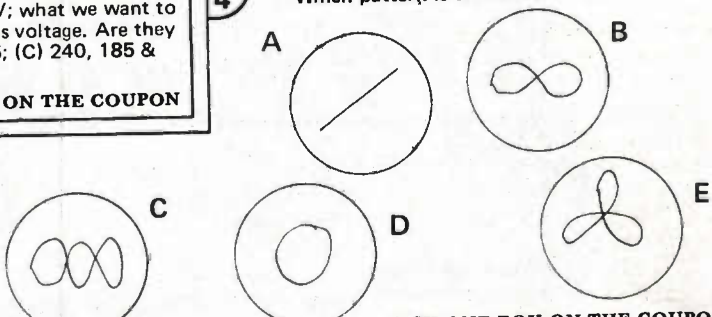
2 AC mains in Australia is nominally 240 V; what we want to know is the peak, the average and the rms voltage. Are they (A) 340, 185 & 120; (B) 240, 216 & 185; (C) 240, 185 & 216; (E) 340, zero & 240?

TICK ONE BOX ON THE COUPON

3 Where was the prize in this contest made?
(A) Palo Alto, CA, USA.
(B) Reading, UK.
(C) Tokyo, Japan.
(D) Hamburg, Germany.
(E) Mulgrave, Victoria, Australia.

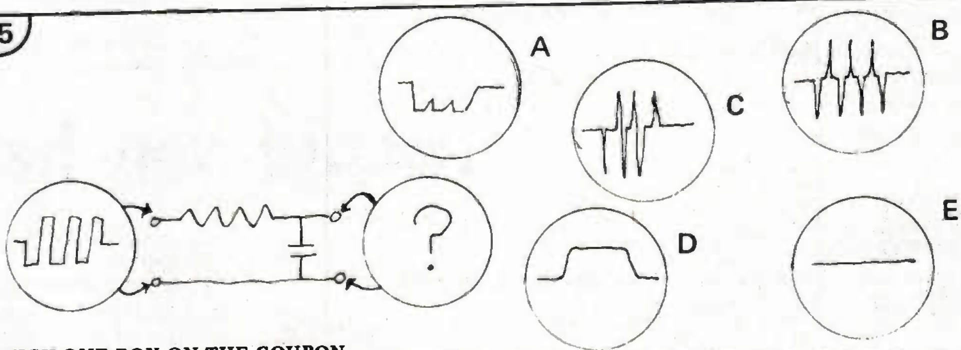
TICK ONE BOX ON THE COUPON

4 Which pattern is the odd one out?



TICK ONE BOX ON THE COUPON

5



TICK ONE BOX ON THE COUPON

CUT OUT THIS COUPON

A					
B					
C					
D					
E					

AND SEND TO ETI/BWD CONTEST, MODERN MAGAZINES, 15 BOUNDARY STREET, RUSHCUTTERS BAY, TO REACH US BY NOVEMBER 1ST 1976

FILL IN THESE SECTIONS

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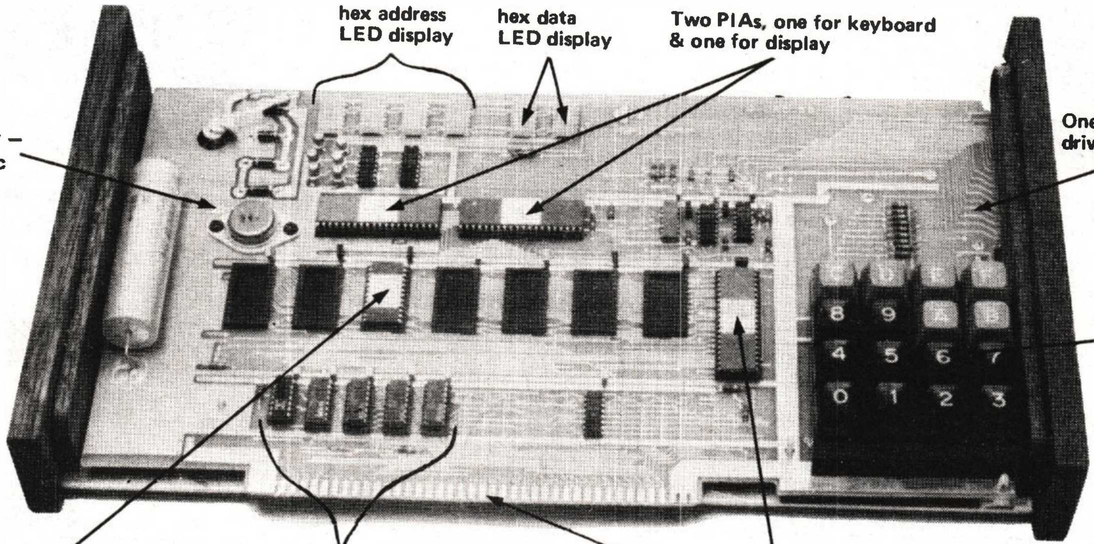
The M6800 Microprocessor with terminal and power supply for less than a thousand bucks?

The Micro 68 computer –



...would you believe $430!

Monitor Program –
Contains routines needed to load, inspect & change data in the RAM so programs can easily be written & edited.

Memory –
Plugging in 6810, 128-byte, RAM ICs expand the memory on-board to 768 words, but the full addressing capability of the M6800 (64K words) can be used utilising external memory cards.

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Telex AA27136. Ph: (02) 747-2731, 74-8063. MELBOURNE: Arlec Instruments Ph: (03) 569-6984.

Three ETI projects connect up to make a

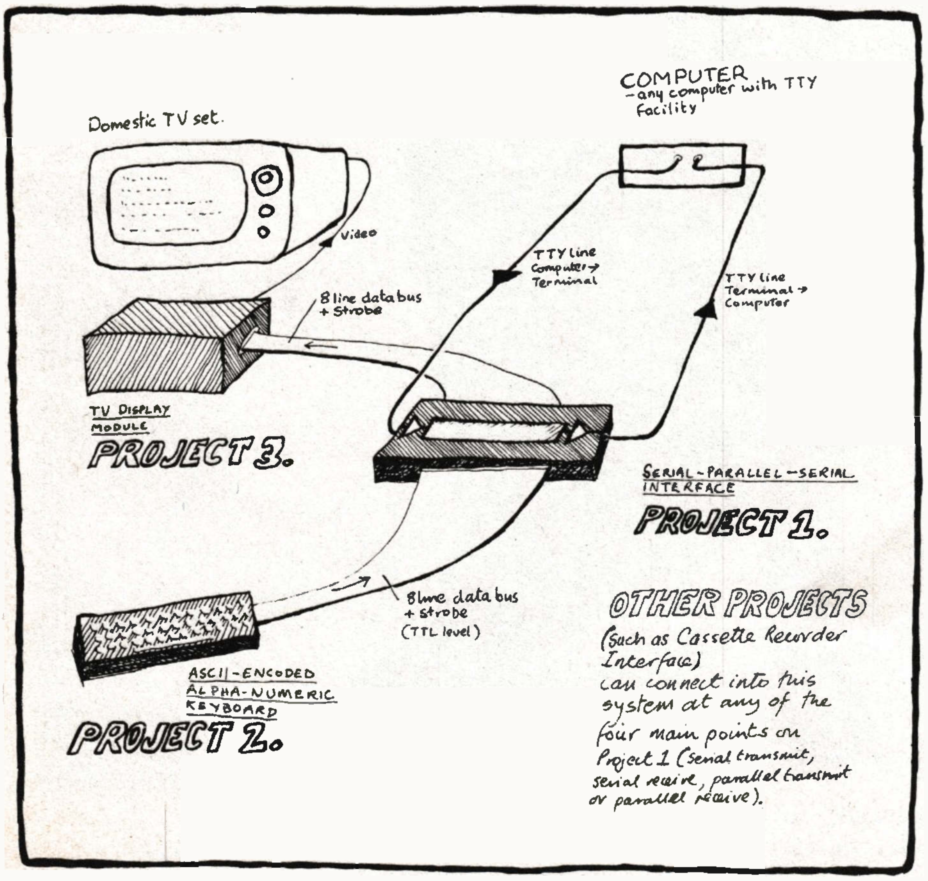
MICROCOMPUTER TERMINAL

Here we release plans for three projects soon to be published in ETI. Together they make a computer terminal which can directly replace a teletype (as far as the computer is concerned).

IN THE LAST FEW WEEKS WE HAVE had quite a few enquiries from readers wanting to know what projects we have lined up in the microcomputing area, so we decided to publish our plans so you will know what to expect.

We feel that the most-wanted project at the moment is a terminal which looks like a teletype as far as the computer is concerned. This can be then used with an evaluation-board computer (using the monitor program to the full), a home-made computer with a teletype interface, or with a ready-built machine.

The approach we chose is illustrated in the sketch — we will use a domestic TV set for the display and an alpha-numeric keyboard as an input device. The sketch also shows that we are planning to make the terminal in three parts. Each part we designed as a project in its own right using standard codes and levels at points of interconnection. This will enable readers to build only the parts they require if they intend to use other equipment in their system. The modular design makes it easy to add other peripherals at a later stage (for example an ASCII printer could parallel or replace the TV display).



Sketch of microcomputer terminal projects.

The method we have adopted, making a teletype substitute, is not the simplest way of using a TV display and an alphanumeric keyboard with any given microcomputer. It would be simpler to connect a display module directly to the data bus of the computer but individual designs would be needed for different microprocessors. Our terminal can be used with any microprocessor — we feel this is important for our first microcomputer project.

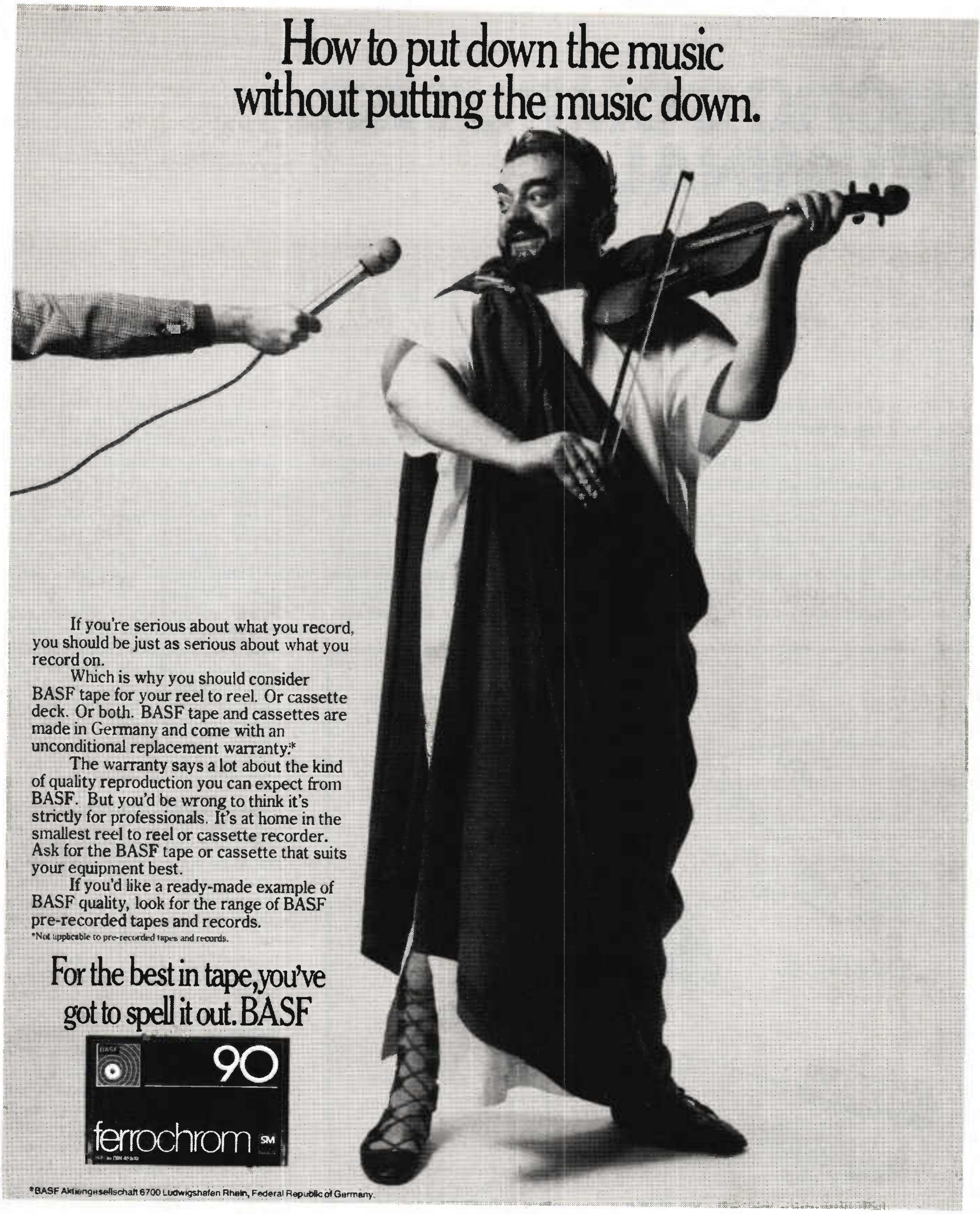
There are three projects we will publish:

1 Serial-Parallel Interface: This device will handle the TTY input and output lines and provide parallel lines for the data to be transmitted or received.

2 Keyboard: This project will enable you to buy a computer keyboard equipped only with switch contacts and furnish it with the electronics required for ASCII operation. The output will be capable of driving several TTL loads or connecting directly into the serial-parallel interface.

3 Display: This project will be designed with low-cost and availability of components as the main criteria. It will store characters as they arrive (coded in ASCII) on its parallel input bus and from its memory it will generate the video signals required to display these characters on the screen. Although intended for use with a microcomputer this project can be incorporated into other systems — for TV caption generating, for instance.

We will start publishing constructional details of our terminal projects as soon as possible. ●


How to put down the music without putting the music down.
If you're serious about what you record, you should be just as serious about what you record on.
Which is why you should consider BASF tape for your reel to reel. Or cassette deck. Or both. BASF tape and cassettes are made in Germany and come with an unconditional replacement warranty.*
The warranty says a lot about the kind of quality reproduction you can expect from BASF. But you'd be wrong to think it's strictly for professionals. It's at home in the smallest reel to reel or cassette recorder. Ask for the BASF tape or cassette that suits your equipment best.
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ferrochrom
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MICROCOMPUTERS FOR THE PROFESSIONAL

In the last couple of issues of ETI we have looked at the microprocessor IC and the evaluation kits that are available from the manufacturers. We have looked at these products from the point of view of the amateur with a limited budget. In this article Ed Schoell of National Semiconductor in Melbourne looks at what microprocessors have to offer the professional user with a specitic application in mind. He goes beyond the 8-bit evaluation card and discusses 16-bit systems, development systems, assemblers, and training schools.

IN THE LAST YEAR OR SO, THE microprocessor, as a design tool for the electronic engineer, has become noticed. This is only the tip of the iceberg — in the next months and years its presence will be felt to a much larger extent. Most digital design engineers and technicians will find that the microprocessor offers them the design flexibility and the power of problem solution equivalent to the change from using individual resistors, capacitors and transistors (or valves!) to make a flip-flop to now using a DM7474 (and having a spare thrown in).

This article discusses some of the development aids available for microprocessor system design, how these are used, and how a typical system is put together.

THE FIRST STEP: Should I use a microprocessor?

As with most things in life, the answer is "it depends"! It depends on a lot of things.

The questions to be answered are:

1. Is my problem mathematical or logical in nature?
2. Do I have a variety of inputs and outputs to be examined and/or controlled?
3. Do I need to be able to vary the control and system parameters easily? Changing a program is often a lot easier than carving up a printed circuit board.
4. Is it going to be more economical to use readily available microprocessor printed circuit cards, than "doing my own thing"? (Taking "off-the-shelf" cards saves having to do a lot of hardware development. Often, only a custom interface card is needed — the rest of the system uses standard module and custom software (program) stored in field-programmed PROMs.)

If a project is being rushed often a microprocessor approach allows the custom interface boards to be designed first, to interface to standard bus configurations, and to be checked out from a control panel and go to final production. The program writing can proceed at a more leisurely pace, and, as the programming of PROMs takes only a few minutes, a last minute change of program (or changes of mind by the customer!) can be accommodated relatively easily.

If a production run is anticipated, the first units can go out to the field using PROMs (reprogrammable if necessary), and minor changes can be made after field and salesman's comments likes/dislikes are evaluated.

Production can then proceed using factory programmed "fast turn around" PROMs (or ROMs) for added economy.

THE SECOND STEP: which one?

Of the range of microprocessors available, the chances are that there's more than one (from different manufacturers) that could do the job. There are two areas which must be analysed:

1. Microprocessor Characteristics:

(a) Word width. Obviously taking a 12, 14 or 16-bit data word from a counter or A/D connector and working on it with an 8-bit microprocessor adds a lot to program complexity. Similarly the complexity of the maths greatly increases as multiple-word arithmetic becomes necessary. The 16-bit PACE microprocessor gives the mathematical capability in single-word operations and so makes handling of 16-bit data easy.

On the other hand if 8-bits or less of data are used, (implying accuracy of the order of 1%) an 8-bit microprocessor is probably appropriate.

(b) Logic power of instruction set. If the microprocessor is to be used to handle inputs and outputs logically (i.e. to simulate relay "trees", etc) the power and flexibility of the logic instructions must be examined. Logic AND, OR, and EXCLUSIVE-OR operations are needed here, preferably directly from input devices. The National Semiconductor SC/MP microprocessor has a particularly powerful set of these instructions, being capable

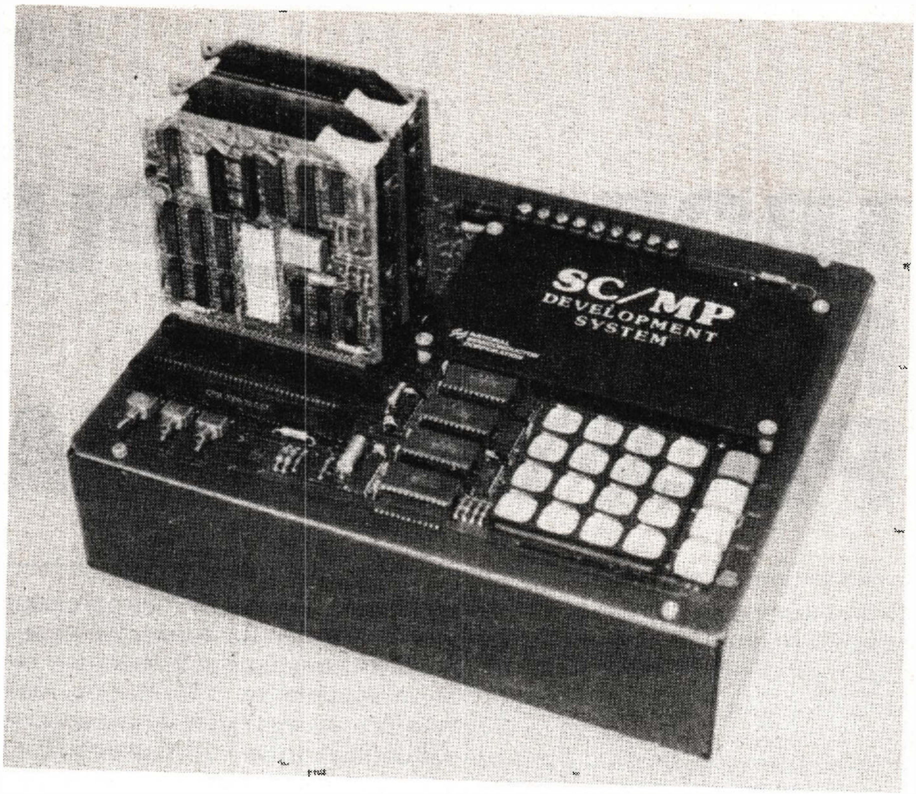

Fig. 1. SC/MP Low Cost Development System (LCDS). Application cards (CPU, RAM, ROM) are plugged into the mother-board.

of doing AND, OR, X-OR, as well as ADD, COMPLEMENT-and-ADD and DECIMAL ADD from any of 65,536 peripheral addresses, memory addresses or from the extension register to the 8-bit accumulator. Data can then be output from this accumulator to control relays, etc, using the "STORE" instruction.

(c) Microprocessor speed. Obviously speed is applications oriented — although often speed comparisons are made blindly, ignoring the factors like efficiency of instruction sets (how much work the machine actually does in an instruction) and interface ease. However it is often possible to make an intelligent decision as to how to interface a particular peripheral:

For example, if we want to talk to a communications line (for remote data transmission) we can have the microprocessor doing this "bit serial", at say 1200 Baud. This means the microprocessor has to look at the line 1200 times a second to take data in, and then form an 8-bit data word and store it again. Alternatively, by adding a $5 device (a UART) to the system the microprocessor only has to look at the data 120 times per second and the UART does the fast work. The microprocessor speed requirement is reduced by a factor of 10.

In a lot of industrial applications, where heaters, pumps etc are being controlled and relays are the interface elements speed is a "red herring" — times are measured in seconds or minutes and a slower microprocessor is quite adequate.

2. Back-up facilities:

The other thing to be considered when choosing a microprocessor is who you are buying it from. Obviously a company with technical backup and support in Australia is a better bet than an "agency" type organization. If the vendors are doing development work of their own in Australia, so much the better — they are then going to have experienced engineers familiar with programming, interfacing and use of prototype systems.

Training schools

National is at the moment setting up a training school in microprocessor applications. Courses will be run in Melbourne and Sydney, starting in October '76 and these will give design engineers a speedy start with "hands on" experience with prototype systems.

Classes will cover program writing, and use of prototyping systems to develop and debug software, and also will give experience in interfacing and talking to a range of peripheral devices via ptototyping cards.

"LCDS" low cost development system

Figure 1 shows a development system intended as a low-cost design tool for system development. Custom interface cards are connected in parallel with the standard application cards shown. A cable connection point is provided to allow ribbon cable to connect into an external equipment rack. Because con-

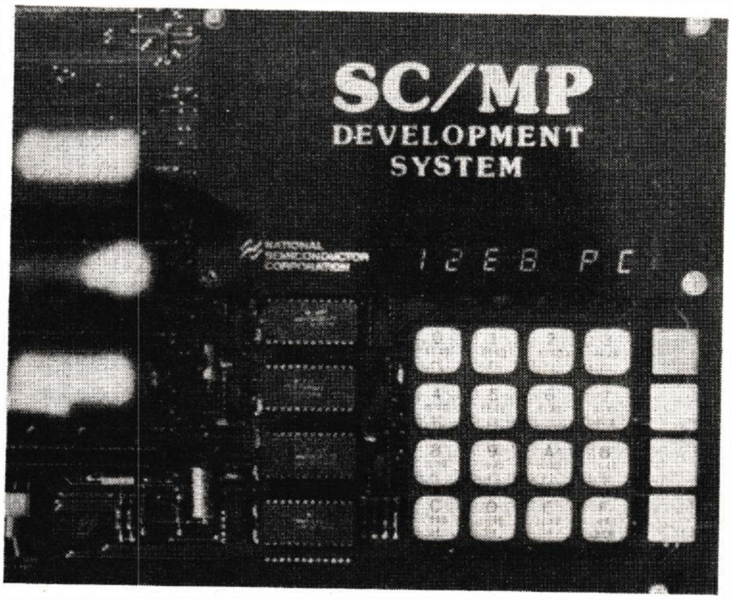

Fig. 2. Control panel of the LCDS system. The display shows the PC (Program Counter) = 12E8 in hexadecimal.

trol panel is provided, no teletype is needed, so this system provides a convenient field servicing tool.

This panel (see Fig. 2) allows examination and alteration of all internal SC/MP registers and memory. As peripherals are addressed as memory, all I/O devices can also be examined or altered from the panel (i.e. relays, motors, etc, can be directly commanded for easy checkout).

As well as the keyboard, the LCDS includes a teletype interface. Program checkout can also be done from the teletype (or CRT) keyboard, and program breakpoints are included.

Paper tape "loading" and "program-save" routines are part of the teletype package. The paper tape output from a cross assembler can be loaded, the program checked out, and then saved on paper tape. This tape can be used to program a MM5204Q PROM.

True program single-stepping, instruction-by-instruction, is available from either panel or teletype. This is a feature really appreciated during program checkout.

NIBL — National Industrial BASIC Language

In the near future a ROM card will be available to plug into an LCDS system containing a sub-set of the popular BASIC language. This will allow the programmes to use commands like LET, INPUT, GOSUB, and the mathematical operations ADD, SUBTRACT, MULTIPLY, and DIVIDE, with brackets. So algebraic statements can be used to describe mathematical program steps.

To allow for applications in a "real-world" environment, a powerful "@" indirect statement can precede numbers or variables which allows the BASIC program to very simply read data from peripherals and write data to peripherals. This will be the first time BASIC has been available in a small system of this type.

Assemblers

Discussion so far has assumed the program has been hand-coded, i.e. an instruction like "ADD" has been converted to "FO", in hexadecimal, and "JUMP IF POSITIVE" (JP) converted to "94" in hexadecimal (as prescribed in the instruction set).

Serious program development really needs program assembly capability; this saves a lot of the programmer's time in code-conversion and address calculation.

The printout shows how a typical assembler does this translation.

This assembly was done on an IMP16 microprocessor system (as shown in Fig. 3) in National's Application Lab.

```
NSC SC/MP ASSEMBLER
MEMORY =0:16

NEXT ASSEMBLY
*.ASM DI0200,D00205

END PASS 1
     1                  .TITLE DSPLAY,     SC/MP 8 DIGIT DISPLAY  PROG
     2                  ;
     3                  ;THE DISPLAY ROUTINE STORES THE NEXT
     4                  ;DECODED DIGIT IN THE APPROPRIATE
     5                  ;SEVEN SEGMENT DISPLAY.
     6                  ;THE DIGITS HAVE BEEN DECODED BY THE
     7                  ;USER'S PROGRAM AND ARE STORED IN MEMORY
     8                  ;LOCATIONS POINTED TO BY P2 AND THE
     9                  ;CORRESPONDING OFFSET "DIGSEL".
    10                  ;THE PROGRAM IS ENTERED AS A SUBROUTINE
    11                  ;USING P1 AS SUBROUTINE POINTER.
    12                  ;
    13       0200               .=0200                    ;PROGRAM STARTS 200
    14                  ;DEFINITIONS
    15       0001       P1        =       1
    16       0002       P2        =       2
    17       0003       P3        =       3
    18                  ;
    19  0200 C408       DSPLAY: LDI       H(FPLOC)        ;LOCATION OF PANEL
    20  0202 37                 XPAH      P3              ;P3 POINTS TO PANEL
    21  0203 C400               LDI       0               ;CLEAR P3 LOW
    22  0205 33                 XPAL      P3
    23  0206 BA00               DLD       DIGSEL(P2)      ;DIGSEL IS OFFSET
    24  0208 9C08               JNZ       NEXT
    25  020A C401               LDI       1               ;SET UP DIGDRV
    26  020C CA01               ST        DIGDRV(P2)
    27  020E C408               LDI       8               ;RESET DIGSEL
    28  0210 CA00               ST        DIGSEL(P2)
    29  0212 01         NEXT:   XAE                       ;DIGSEL TO E
    30  0213 C280               LD        -128(P2)        ;DIGIT INTO AC
    31  0215 01                 XAE                       ;SAVE DIGIT IN E
    32  0216 C201               LD        DIGDRV(P2)      ;DIGDRV TO AC
    33  0218 1E                 RR                        ;ROTATE TO NEXT DIGIT
    34  0219 CA01               ST        DIGDRV(P2)      ;SAVE NEW VALUE
    35  021B 01                 XAE                       ;DIGDRV TO E
    36  021C CB80               ST        -128(P3)        ;AC TO NEXT DIGIT
    37  021E 3D                 XPPC      1               ;RETURN FROM SUBR.
    38                  .END
NO ERROR LINES
END PASS 4
SOURCE CHECKSUM=07CB
 OBJECT CHECKSUM= 00C3
FIRST INPUT SECTOR HEX -  0200
FINAL INPUT SECTOR HEX -  0203

FIRST OBJECT SECTOR HEX - 0205
FINAL OBJECT SECTOR HEX - 0205
```

Sample program assembly: An SC/MP program assembled on the system shown in Fig. 3. The source program is called from disc (DI0200) and the object data (binary) is put onto disc (D00205).

The actual program is the one which takes a decoded digit at a prescribed memory location and displays it on a seven-segment display.

The first column is the line number, the second column is the memory address (starting at location 0200 hex), the third column is the translated code, and the other columns are input codes and labels for lines and comments.

For example, line 19 shows that locations 0200 and 0201 contain C4 and 08. These are the equivalent codes for the instruction LD1 and the immediate data calculated from H (FPLOC).

Cross Assemblers are also available on the GE Timesharing network, and some Australian systems.

PROM Programming

Object tapes from assemblers, tape dumped out of the LCDS system or data on disc can be programmed directly into PROMs of the MM5204Q type. This erasable device is programmed in under 30 seconds for 4096 bits of data.

Figure 3 shows the PROM card installed in a system.

PACE 16-Bit System Prototyping

So far most of our discussion has been on the SC/MP system. A similar-range of applications cards is available for the PACE system. Figure 4 shows a series of these cards in an application system being checked out with the PACE prototyping system.

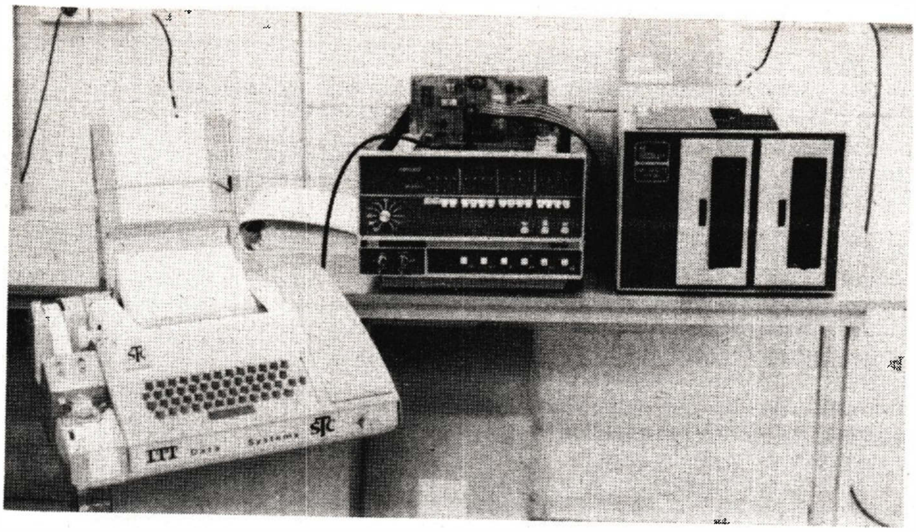

Fig. 3. IMP16 microprocessor development system. The system includes dual floppy disc backing store and PROM programmer.

In this photo, the CPU card is replaced by an umbilical cable so that system check out can be done from the large control panel.

Programs can be loaded, dumped, single stepped from the control panel and system peripherals. Both IMP and PACE systems can be used for program assembly for SC/MP — cross-assemblers are available for both systems. ●

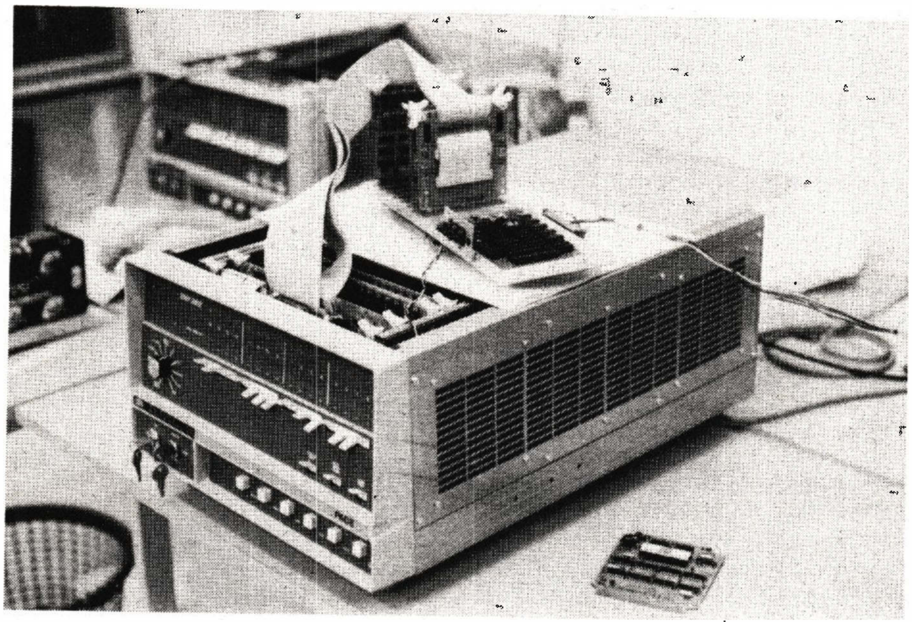

Fig. 4. PACE prototyping system. This shows use of umbilical cable replacing the CPU card.

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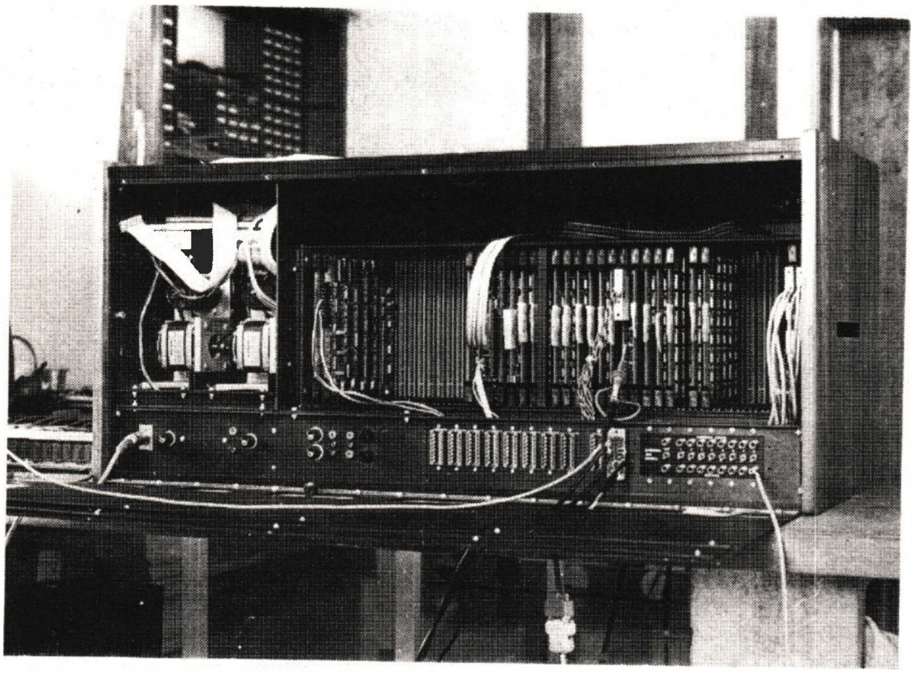
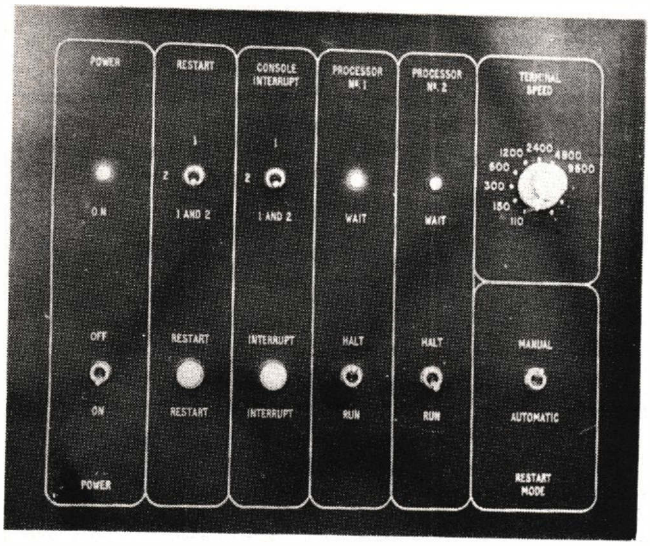
MULTIPROCESSOR

Economies of scale enable microprocessors to be made quite cheaply but there are some jobs that are just too much for them to handle — when used conventionally. Then somebody thought of using two or more microprocessors to handle one problem . . .



This is the back view of the prototype Qasar synthesiser with about two-thirds of the boards in place. The boards for the dual-processor computer are at the left near the two floppy disc drives. The basic computer system used in this synthesiser consists of one dual processor board, one processor control board (with up to 68 K of ROM), three 16 K RAM boards, one video display board, one light-pen board and two floppy disc boards.



Left: The processor control panel consists only of a few switches and indicators

THE LATEST DEVELOPMENTS IN microprocessor systems are in using two or more processors with shared memory. We know of one American microcomputer manufacturer offering a 'shared memory' board but surprisingly we discovered a couple of people working with dual processors here in Australia. Information Electronics in Canberra sell a terminal using two processors (one to handle the screen and keyboard and one to handle the line) and in Sydney we discovered a guy who has developed a general-purpose dual-processor computer soon to be available from Fairlight Instruments Pty. Ltd. This computer was designed by one of Australia's leading microcomputer consultants, Tony Furse, and we went out to visit him to see what his system could do.

The world's best music synthesiser?

The dual-processor computer was originally developed to control an electronic music synthesiser. But surely *one* microprocessor would be enough, especially when current synthesisers don't have any sort of digital control? But wait 'til you hear what the machine can do — there's a polyphonic keyboard, eight 'instruments' can be synthesised at one time, there's a VDU screen which can be used to graphically display all sorts of information to the operator, there's up to eight terminals which can be used to synthesise sounds using programs in the firmware of the machine (for example, key in 80 80 80 80 80 80 . . . and watch the VDU display. You get a sine wave of amplitude 80 (I've no idea what units) followed by its 1st harmonic at the same amplitude, then the 2nd, 3rd, 4th ... at the prescribed amplitudes. As you watch the synthesis of the waveform you hear the sound out of the speakers). Obviously it would take a complete article to describe the system but you can see it is pretty complicated — too complicated for one microprocessor to handle with the response demanded by musicians in a live performance.

So dual processors take over where single processors leave off?

No, even in a simple application (capable of single-processor control) there are advantages offered by the dual-processor.

What advantages of the dual processor?
Put simply there are three advantages:

1. **Speed** due to one processor being optimised for dealing with the outside world.
2. **Programs are simpler** because interrupts (servicing the outside world) which normally divert the processor temporarily can be handled by one processor optimised for this task, enabling the other to be expert at number-crunching. The second processor is more organised because it doesn't have to worry about things coming in from the outside world. Its data is pre-processed by the first processor and arranged in an optimal way for the second processor. The two processors are more than twice as good as one (it is something like four times as fast as a single processor for some jobs).
3. **Debugging and testing.** Testing of a program can be made quite simple because you can make the program go round and round without doing any output. You don't have to worry about output routines because you can use the debugging firmware package in the second processor to read the data tables that the first one uses.

Normally (with a single processor) if you are trying a program and nothing comes out you don't know if it's your output routine or what.

With a dual-processor system you can use the second processor to change the numbers in the program being run by the first processor. Then you can see the effect immediately.

Would the advantages of using two processors be similar to the advantages of using a 16-bit processor rather than an 8-bit type?

No. Two eight-bit processors don't provide a simple substitute for a 16-bit processor if it's 16-bit arithmetic or logic you want, provided of course that your choice of 16-bit processor is such that it does a 16-bit operation in the same time as an 8-bit processor does a similar 8-bit operation. It turns out however that many 16-bit microprocessors are quite a bit slower than the 6800, in fact this difference can be such that one 6800 even though it must execute upwards of twice as many instructions for a given 16-bit function still produces the 16-bit result faster.

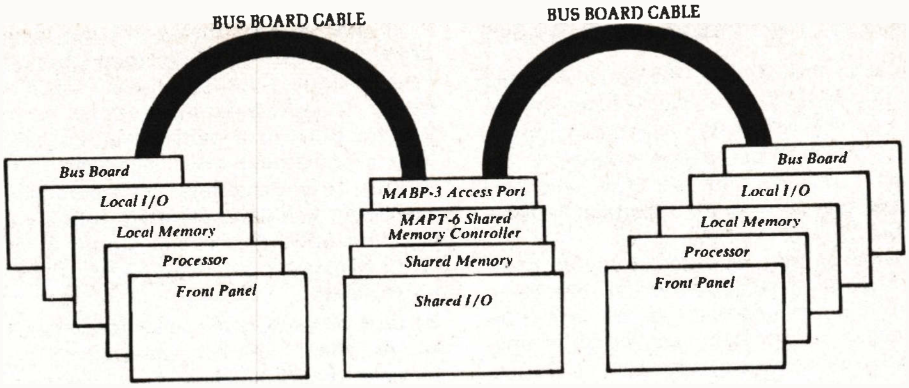
One other problem one encounters regularly is a need for 24-bit arithmetic. To give the one part in a million precision needed in these applications to the 8-bit processor this problem is merely a matter of triple precision arithmetic, but to the 16-bit processor one would usually be tempted to go to 32-bit precision to avoid programming complication. However this may be very wasteful of memory space if arrays of 32-bit data must be maintained. Once again this 8-bit processor tends to win against the current 16-bit opposition, this time on two counts: speed for a given operation and memory efficiency.

One other interesting aspect of the 8-bit versus 16-bit debate is the fact that generally a large part of all information to or from the outside world is in 8-bit bytes. Some 16-bit microprocessors are quite ugly when it comes to processing bytes and text and unfortunately byte processing constitutes something like 60% to 80% of the programme of human engineered interactive systems.

Can the two processors communicate?

On the computer there is an interface which enables the two processors to interrupt each other, but this doesn't happen often: only when there is a whole table of new data.

The processors have a second way of talking to each other — through memory locations. Periodically they can look up certain "mailbox" locations to see if any flags have been left there by the other processor.



MULTIPROCESSORS AND SHARED MEMORY

The IMSAI multiprocessor system uses a different concept to that of the Qasar system described in the text, it is a method of interconnecting two or more of the IMSAI 8080 computers so that they share memory. Not only do you have two processors but have have two of everything else, plus the extra boards in the centre of the diagram. Each 8080 processor has its own memory, which may be anything up to 64K minus the amount of shared memory. The Shared Memory Access Port and Shared Memory Controller boards available can link up to six computers.

Another advantage is that you can run an editor and an assembler simultaneously. Two completely independent programs can be run simultaneously.

Interface

Having the second processor means you can have peripheral interfaces that are a lot less sophisticated.

One could use most of the resources or the second processor in avoiding complicated hardware to interface to various peripheral devices, this technique, often termed "bit banging", uses the processor to control various individual input and output bit patterns normally controlled by external gates, flip flops, one shots etc. For example, a floppy disk normally needs around 60 to 150 TTL ICs for its microcomputer interface using up 50% of the processing resources of the second processor and providing a serial synchronous communications adaptor chip and several other TTL MSI chips. One gains a floppy disk interface which is controlled by software operating the second processor. The cost in hardware terms is possibly as little as 25% of the cost of the alternative, not to mention the extra flexibility gained.

If you take out the second processor chip, you have a port capable of gulping information out of the memory at a million bytes a second. And this has continuous access.

How do you keep the processors from colliding?

They are never operating at the same instant, they run out of phase. The memory is twice as fast as either of them needs: one processor does its cycle and before it gets round to doing the next the other processor has been in. With the 6800 all the activity occurs within half of the cycle so these devices are particularly suited to interleaving.

In a scientific application would you use one processor to do the number-crunching and one to handle look-up tables?

Providing you can organise the program in such a way that you've got something for the first processor to do when the other processor is doing some crunching, then its advantageous. But if you've got to halt everything while the other processor goes off then you might as well just use one. Quite often you can organise a program so you can pass a multiplication or a division over to the second processor and the first can go with something else.

Is the dual processor only for people who know about microprocessors already, or does it offer advantages to the beginner?

The advantage for the guy who doesn't know so much about microprocessors is that he doesn't have to diddle about with input-output routines to try out programs. Once he knows the two processors behave identically he can load his program under the control of one with the other switched off, then he can start it running which immediately takes all the time of that first processor. Then he can use the second processor to get at the program while it is running. He can change numbers and things and see the immediate effects.

Quite often normal single processor debugging techniques make it very difficult to debug programs in which time critical closed loop control of some device or peripheral is a feature; in such programs data is read from the device processed and new control information is then output in order to keep the device under control. Use of program breakpoints or instruction tracing results in interference with the integrity or the control loop and of course under such circumstances the data gained in this manner may at best be misleading.

Use of the second processor in such applications allows inspection and modification of data without any interference to the loop integrity and of course allows far more effective debugging since loop overload recovery and other exotic s may be simply tested.

In practice, if you're handling a lot of peripherals, you use one processor to deal with the outside world (8 terminals, a graphics display, disc storage, etc in the case of the synthesiser). This is then the peripheral controller processor. It queues up work for itself to do and then does it. The other processor is free to get on with the business of crunching numbers and handling its very high-priority tasks.

In the case of the synthesiser both processors are handling interrupts at four levels, and the response is critical — its got to service an interrupt within a few fractions of a millisecond, because there's something you will hear if it doesn't. It is impossible to have a single processor handling all that load and handling other devices like floppy discs and displays and all the other keyboards.

So dual processors are ideal for systems where there are an unusually high number of peripherals and interrupts.

Yes, it helps in getting a large amount of information into a system and it makes the job of writing a real-time executive very simple (because you've got something which is totally optimal to collecting information from the outside world).

What about the typical business system, where say an accountant would have a terminal for interrogating a computer undertaking stock control?

This is where you come into a very simple way of doing things, one processor can be working away doing a little batch job, leaving the second processor available for someone to come in and interrogate files of the memory.

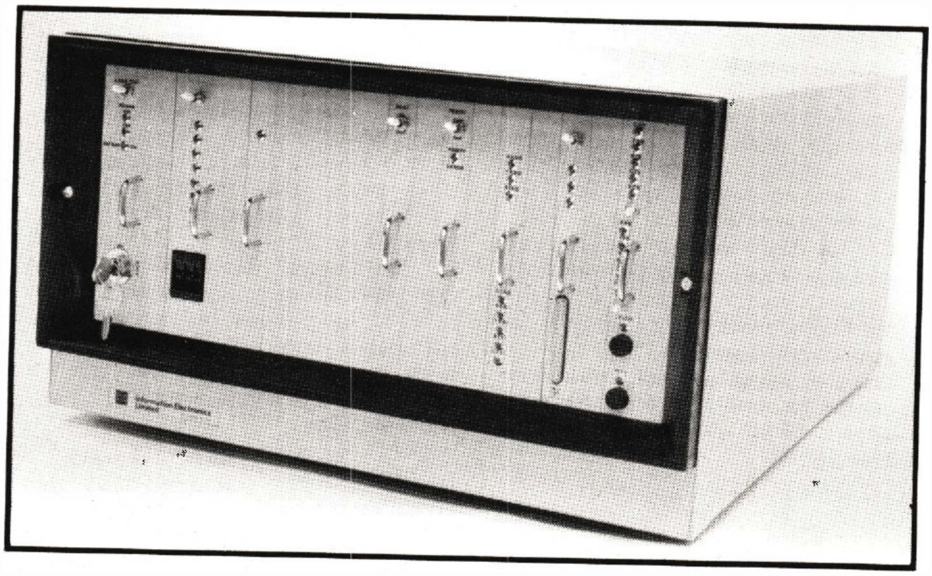
But in that application speed is not important, so one processor could handle it?

It's the question of the sophistication of the software that's important: it is quite complicated to make a one-processor system do two things at once. With the dual system: you just start two different programs off at two different places in in the memory. It's like having two different computers but with the added advantage that they share common storage devices. With two computers it can be quite a job getting them to use common storage.

What other applications can you suggest?

If you've got a lot of file searches the dual system can be an efficient way of handling this: one processor can search and prepare data for the second one to start processing. This is very advantageous, especially when you are dealing with things like floppy discs, where there's quite a bit of time involved in setting up the transfer and finding out where you are going to get the information, looking up the index on the disc and finding where the file is and putting it in a buffer. The dual system gets rid of the need for one of the processors to wait; you can create a smooth loop flow for it if you use a bit of nous in writing the program.

Another obvious application of the dual processor is of course that of providing for the first time at a low cost a tool for the educator or "computer ham" to study the software and programming systems; the trend in the computer industry seems to be toward multiprocessors, however it is a select few who know anything much about such things. I would suggest that there is enough work required in this area to keep several universities in PhD students for the next few years. ●



The IE 180 microprocessor system from Information Electronics is aimed at the data communications and process control markets. It is based on the Intel 8080 processor but can incorporate two other processors, one for fast functions like moving memory blocks and one for doing complex scientific calculations.

The company also uses the multiprocessor concept in a Visual Display Unit, the IE 139. Two Intel 8080s are used as follows: One microprocessor is dedicated to line handling and communication, permitting line data rates up to 9600 baud. The second microprocessor controls the display functions and manipulation of data within the unit. The microprocessors have access to a common central dual port memory and interprocessor buffer thus making their actions time-independent. In addition, each microprocessor can address up to 4K of Read Only Memory for the firmware control program.

2+4!!

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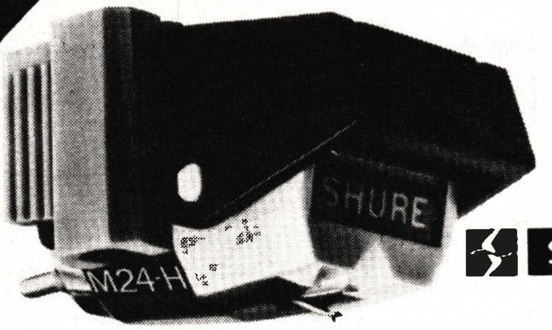

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We call it "2+4": *a totally different concept in a phono cartridge* that combines Shure's traditional pre-eminence in *stereo* and state-of-the-art *quad* technology. It's the first such cartridge that doesn't sacrifice stereo for quad capability!

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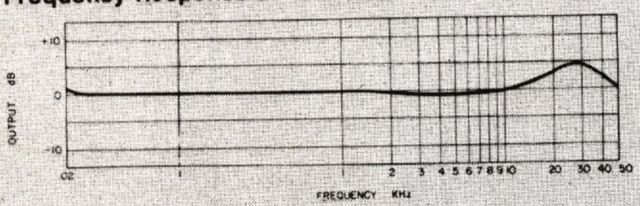


Output Voltage 3.0 mV per channel (at 1,000 Hz, 5 cm/sec peak recorded velocity).

Channel Balance Within 2 dB.

Channel Separation (minimum) 22 dB at 1 kHz.

Optimum Load Stereo and Four Channel Matrix: 20,000 to 100,000 ohms resistance in parallel with 100 to 250 picofarads total capacitance* per channel.
Discrete Four-Channel: 100,000 ohms resistance in parallel with 100 picofarads total capacitance* per channel.

* Total capacitance includes the capacitances of the tone arm wiring, phono cables, and the amplifier input circuit.

Tracking Force Optimum: 1¼ grams.

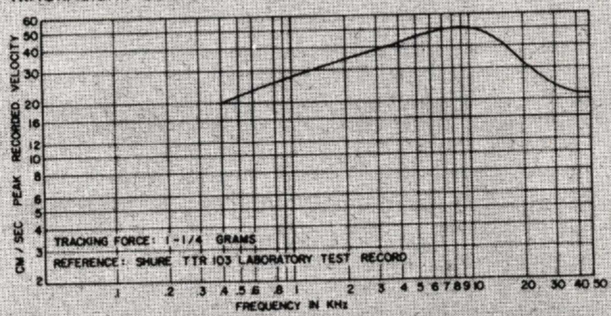
Trackability

400 Hz	20 cm/sec*
1,000 Hz	28 cm/sec*
5,000 Hz	47 cm/sec*
10,000 Hz	50 cm/sec*

* Peak recorded velocity.

(Measurements made using a Shure/SME Tone Arm.)

TRACKABILITY CURVE



Stylus Model N24H: 8 x 18 microns (.0003 x .0007 in.) hyperbolic diamond tip.

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MILTON 4064. Qld.

ATHOL M. HILL P/L
1000 Hay Street
PERTH 6000. W.A.

AE107/FP

Computer on a board

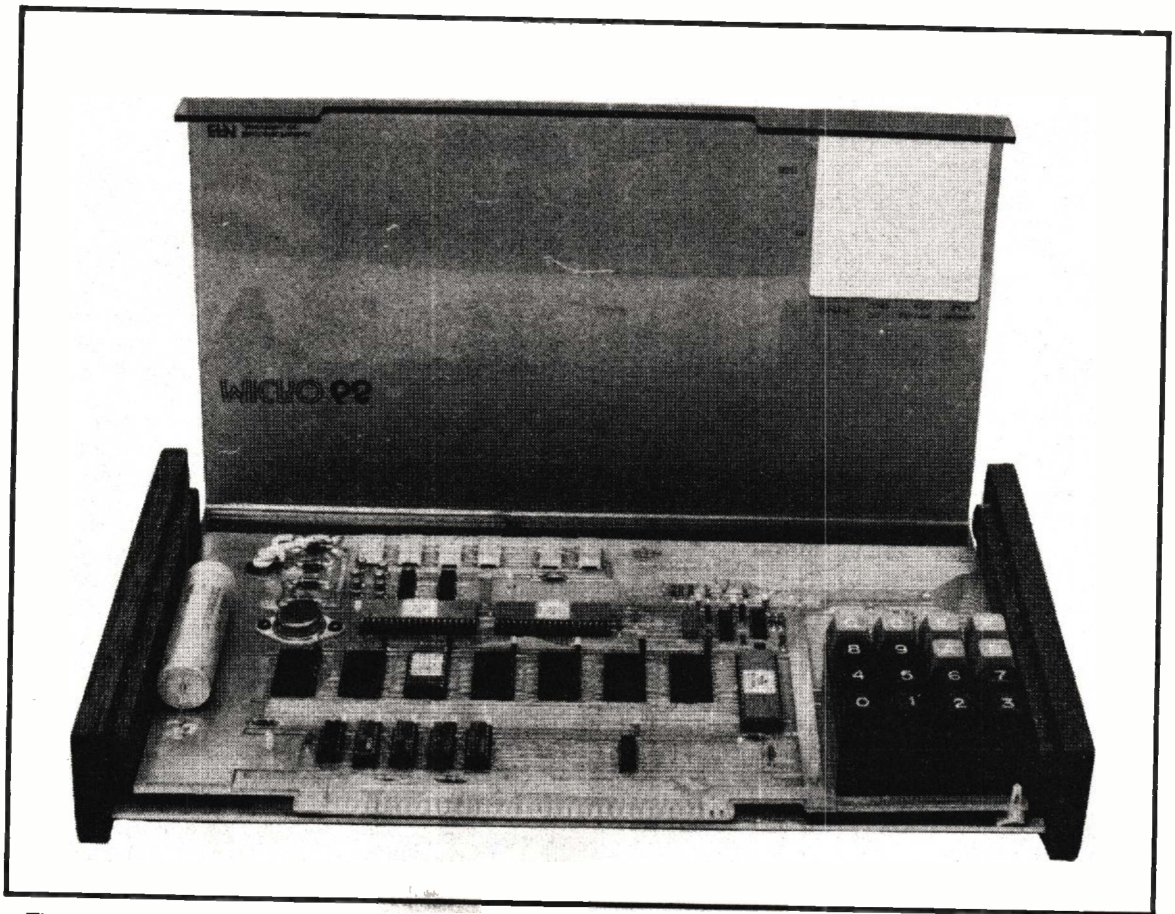
This basic microcomputer with its own hex terminal is readily available in Australia for $430. It comes ready assembled so the beginner with no knowledge of electronics can start directly learning how to program.

IN THE MAY ISSUE OF ETI WE HAD an advertisement for this computer, an advertisement which took us a little by surprise. We were surprised to find that anyone in Australia was importing microcomputers for the educational/hobby market, and especially pleased that the Micro 68 was a complete computer with its terminal build-in for less than $500.

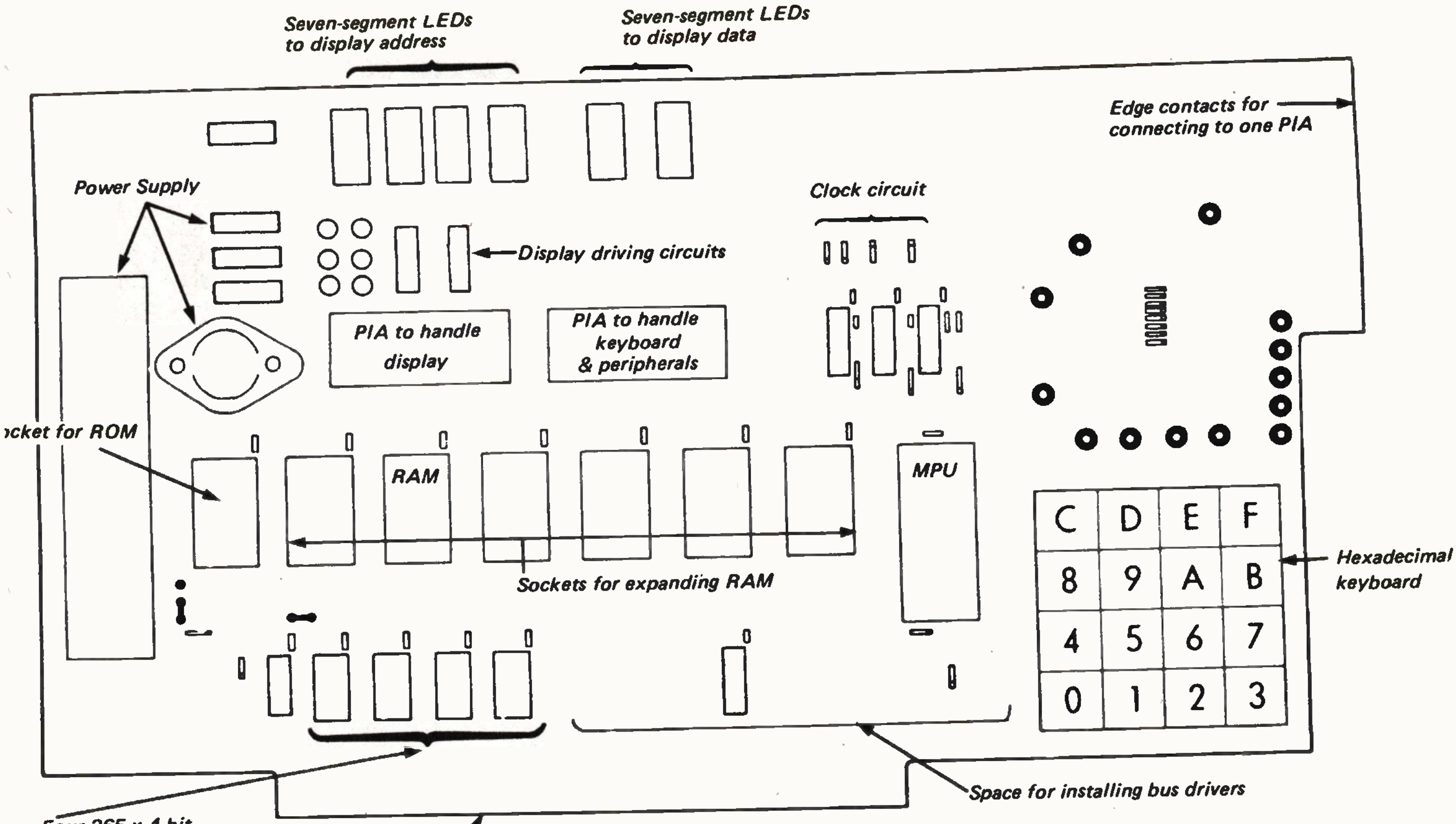
This article results from the importer, Ampec Engineering Co, lending ETI one of these to play with.

The M6800 microprocessor

Last month's ETI looked briefly at the capabilities of the 6800: this processor (with its 6 registers, 72 instructions and seven address modes) is one of the most versatile and is the best-documented of the 8-bit types. The monitor program used in the Micro 68 is not the same as the one used by Motorola in their evaluation kits, but the full capabilities of the M6800 can be used as the data and address buses are available at an



The complete computer comes on one pcb. Other pcbs can be added later when it comes to expanding the system.



What you get on the board and what you can add to it.

edge of the board. This, however, would require additional electronics for some of the facilities because the Micro 68 cannot (unmodified) handle serial inputs or outputs.

RAM

The computer comes with six sockets for the 6810 RAM chips, but comes with only one of these plugged in. This means you initially get 128 words of RAM which, at a cost of $6.40 per 128 words, can be expanded to 768 words on the pcb. Using more boards the full 64K addressing capability can be utilised. There is also space on the board to buffer the memory lines.

ROM

Four 256 x 4-bit PROMs hold the 512 word monitor program, 'John-Bug'. On the pcb there is also a socket for the Motorola evaluation-kit ROM "MIK BUG", available from the suppliers for $33. MIKBUG overcomes the limitations of the simple John-Bug program and allows you to interface to a teletype and a cassette recorder (although you will need a $149 adaptor to do this).

The John-Bug monitor program

This handles interface to the display and keyboard and allows the operator to write, load, inspect, edit and execute his own programs. The top eight keys are used to enable eight commands of the monitor program when the computer is in an 'expect command' mode; at other times they represent hexadecimal numbers. Pressing both 4 and 0 at any time will reset the computer.

These are the command keys and the commands:

E gives the EXAMINE command; pressing E002A will display 002A XX, where XX is the data at location 002A.

F gives the FORWARD command; continuing from the previous example pressing F will display 002B YY, where YY is the data the next address, 002B. Repeated pressing of the F key will step through successive addresses.

B gives the BACK command; this decrements the displayed address by one digit so the data stored there can be examined.

C gives the CHANGE command; this enables the operator to change the data at the address being displayed.

A is the AUTO command; if you enter A followed by an address you can load a large block of data or program into successive memory locations starting from that address, the addresses will increment automatically so only the data has to be keyed in.

D is the DO command; enter D followed by the starting address of a program and that program will be executed.

8 gives you the RTI (return from interrupt) command; this lets you handle interrupts from the keyboard.

9 is the LOAD command; this lets you load the RAM from an external device via the PIA edge connections.

Subroutines & programs

The programmer can call on the subroutines of the monitor program. These enable 8-bit patterns to be displayed as 7-segment configurations, 4-bit patterns to be displayed as hex characters and depressed keys to load data.

The manual contains a listing of the monitor program (although we did find a couple of mistakes in it) which provides a useful model for programs you may wish to write yourself.

Computer on a board

The manual also contains a couple of simple programs to get you started. One program automatically scans consecutive address locations and displays the address and data, automatically incrementing at 1 second intervals. The other program loads data into the first 41 locations of RAM and from those produces a 41-character message which moves across the LEDs in a ticker-tape fashion. The published program gives data for a . . . HELLO CAN I HELP YOU? message. We were soon able to write our own messages for this program (the lit/unlit status of the eight elements of the 7-segment display is translated to 0s and 1s in an 8-bit byte, and this is then converted to two hex characters for entry via the keyboard). It is, however, difficult to get recognisable representations of alpha characters like W, M, K, etc, using 7-segment displays.

The simple 41-character message program takes up all the available programming space of the Micro 68 as supplied. The program (including the message) takes up 81 locations . . . this is all that is left to the programmer out of the 128 byte RAM.

The PIAs

One PIA is used to handle the display and the other is used for the keyboard and peripherals. The LOAD command uses the PIA and the edge connector to load data from a peripheral into consecutive memory locations. The PIA, however, can be configured to act as an input or an output.

The manual

If you want a very simple introduction to microcomputers the manual is OK — for an hour or so. The complete manual is 63 pages and apart from the monitor program listing and the two programs mentioned there is little else: a circuit diagram, brief instructions and a few diagrams. But there would have been little point in the makers' duplicating the stacks of Motorola material on the 6800. This literature is absolutely necessary to any programming on the Micro 68 and any owner must buy it.

Still, the complexity of the Motorola manuals can be a little overpowering and the Micro 68 manual makes it all look fairly simple. In fact the best feature of the Micro 68 system is that it makes microcomputers so simple: you don't need to build up any pcbs, you don't need to connect anything to the computer, the display and keyboard are easy to understand and you can copy a program from the manual and get it running without needing any prior knowledge of computing. And the hands-on experience will teach you more quickly than just reading ETI.

Problems

The first problem is the power supply. The computer comes with an American 8.5 V, 1.5 A, ac mains adaptor which has to be plugged into a 110 V mains supply. If you can't manage that then there is an easy solution, replace the transformer with a 240 V–8.5 V type.

The next problem is getting more RAM; at the time we borrowed the Micro 68 there was a general shortage of 6810s but the suppliers of the Micro 68 say they have lots in stock. I have already mentioned the brevity of the manual, but think I should mention it again under the 'problems' heading.

For the length of time that we had the computer it's limitations didn't develop into problems, but I'm sure they would eventually do so. No hard copy and no easy means of storing programs makes programming tedious when things start to get complicated. But more peripherals are available from Ampec, for those who can afford them. Like an expansion cabinet with power supplies and sockets for RAM cards and floppy-discs. And there's a dot-matrix 40-column, 80-character printer for $520.

Micro 68:
Manufactured by Electronic Product Associates, Inc. San Diego.

Australian Agents:

Ampec Engineering Co., 42 The Strand, Croydon, N.S.W. 2132.
P.O. Box 18, Strathfield, 2135.
Phone: (02) 747-2731, (02) 74-8063.

Price $430.

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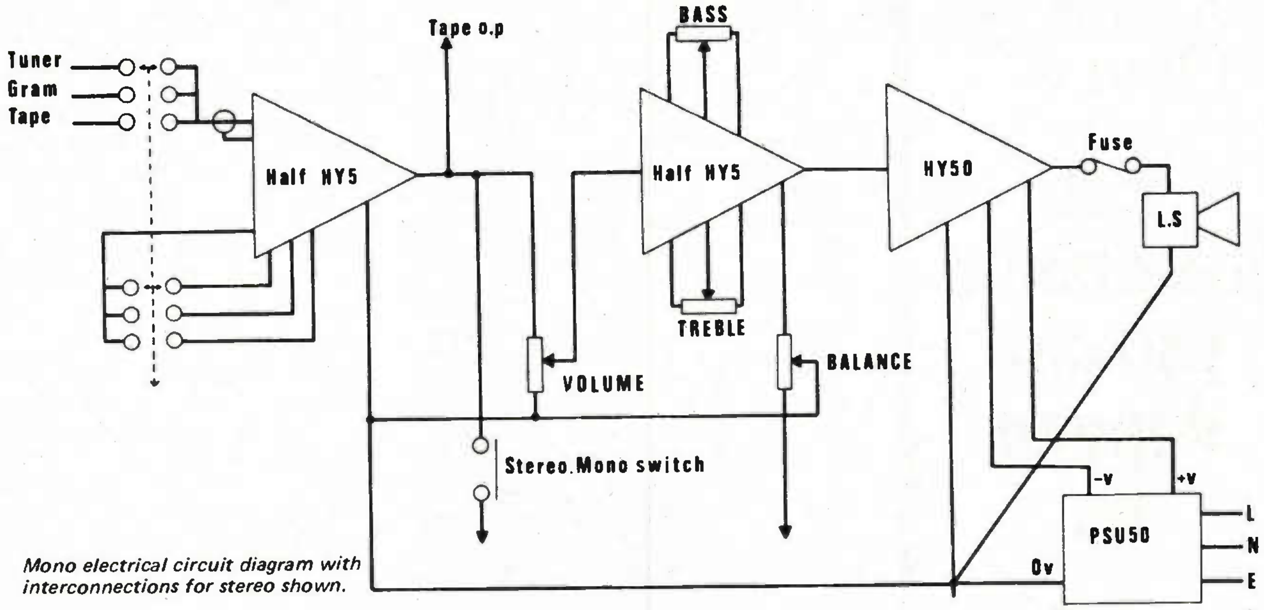
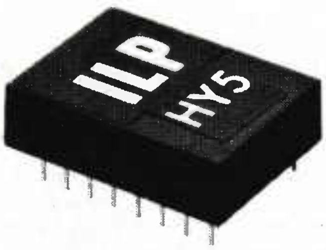
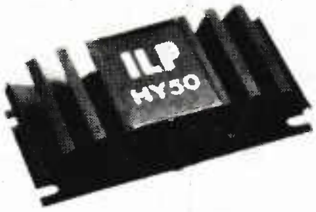
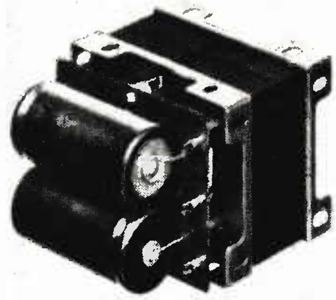
SHEER SIMPLICITY!



Mono electrical circuit diagram with interconnections for stereo shown.







The HY5 is a complete mono hybrid preamplifier, ideally suited for both mono and stereo applications. Internally the device consists of two high quality amplifiers—the first contains frequency equalisation and gain correction, while the second caters for tone control and balance.

TECHNICAL SPECIFICATION

Inputs

Magnetic Pick-up	3mV.RIAA
Ceramic Pick-up	30mV
Microphone	10mV
Tuner	100mV
Auxillary	3-100mV
Input impedance	47kΩ at 1kHz.

Outputs

Tape	100mV
Main output Odb (0.775 volts RMS)	

Active Tone Controls

Treble	±12db at 10kHz
Bass	±12db at 100Hz
Distortion	0.05% at 1kHz
Signal/Noise Ratio	68db
Overload Capability	40db on most sensitive input
Supply Voltage	+16—25 volts.

PRICE $16.06 P&P. $0.30

The HY50 is a complete solid state hybrid Hi-Fi amplifier incorporating its own high conductivity heatsink hermetically sealed in black epoxy resin. Only five connections are provided: Input, output, power lines and earth.

TECHNICAL SPECIFICATION

Output Power 25 watts RMS into 8Ω
Load Impedance 4—16Ω
Input Sensitivity Odb (0.775 volts RMS)
Input Impedance 47kΩ
Distortion Less than 0.1% at 25 watts typically 0.05%
Signal/Noise Ratio Better than 75db
Frequency Response 10Hz—50kHz ± 3db
Supply Voltage ± 25 volts
Size 105 x 50 x 25 mm.

PRICE $20.27 P&P $0.40

The PSU50 incorporated a specially designed transformer and can be used for either mono or stereo systems.

TECHNICAL SPECIFICATIONS

Output voltage	50 volts (25–0–25)
Input voltage	210–240 volts
Size	L.70, D.90, H.60 mm.

PRICE $20.41 P&P $2.00

P&P $2.00 FOR 1 COMPLETE SET OF HY5 + HY50 + PSU50

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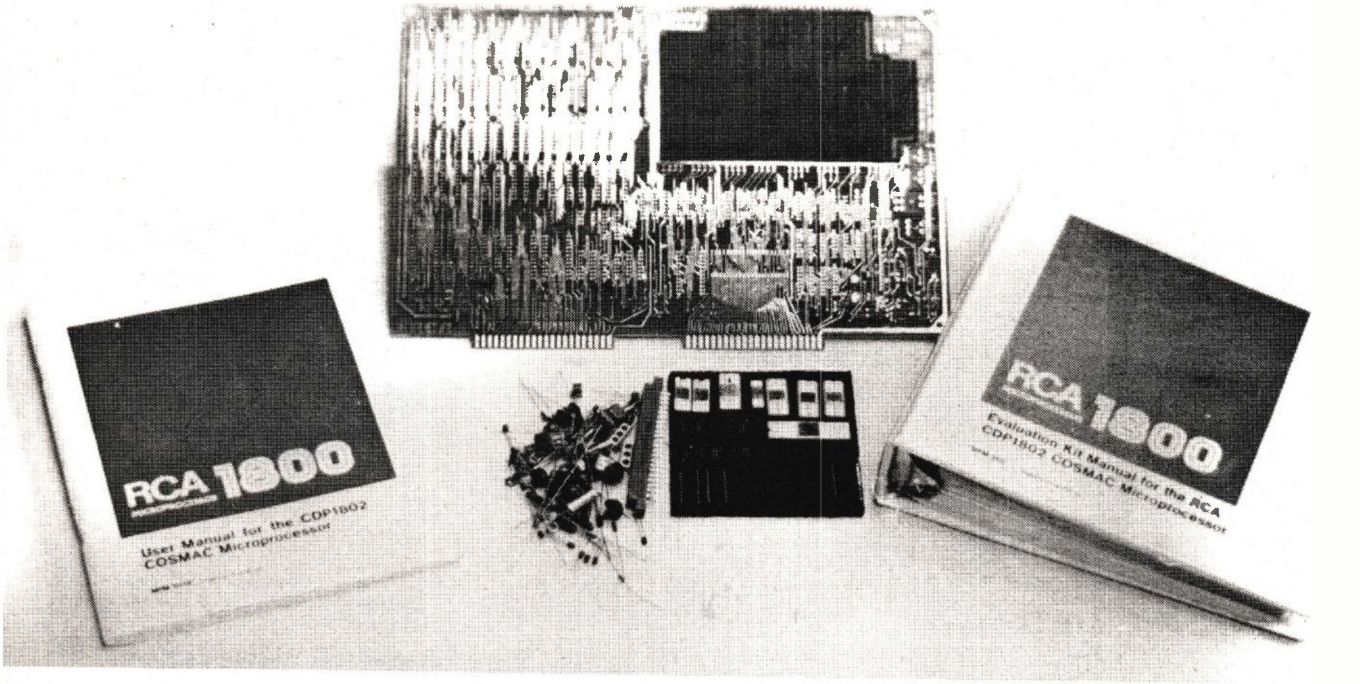
KIT SUMMARY

Last month we looked at four evaluation kits available from the manufacturers of common microprocessors. We complete the survey this month by looking at two more kits and listing other microprocessors that are available.

RCA



The evaluation kits for the RCA 1802 microprocessor chips are only just beginning to arrive in Australia and unfortunately we were unable to obtain one to try out. This was disappointing because the 1802 is made utilising CMOS and has features that make it different from the other processors so far examined.

AWA were able to show us the set of manuals that come with the 1802 COSMAC evaluation kit and from these we have been able to list the kit's main features.

RCA CDP 185020 EVALUATION KIT

Microprocessor	RCA CDP 1802 CD
Word Size	8-bits
Technology	CMOS
Max. Memory	65,536 bytes (a 16 bit address bus multiplexed over 8 lines)
RAM	Kit comes with 256 bytes with room on the pc board to expand it to 4096 bytes.
ROM	Comes with a 512 byte ROM containing the monitor program. This ROM is mask-programmed and cannot be reprogrammed. There is space on the board for another 512-byte ROM and provision to configure 1K of RAM to behave like a ROM.
Monitor Program	Called UT4, 512 bytes in length and it expects to communicate to a terminal in ASCII code via a teletype RS232 interface.

No. of Instructions	91
I/O	One 8-bit output port and one 8-bit input port. The output port is a static output, that is, once data has been sent there by the microprocessor it remains latched until a new 8-bit word arrives. Unique to the 1802 kit is an 8-line output strobe. Under control of the microprocessor this strobe can be used to select output devices or operate switches.

DOCUMENTATION

Comes in the form of two soft cover manuals and a large 3 ring binder.

The User's Manual: (115 pages) appears to give a quite detailed description of the microprocessor. Forty-six pages are used in the explanation of the instruction set, 20 pages on programming techniques and 18 pages on interfacing other ICs to the 1802 and on timing diagrams. My overall view of this manual was that it contained a lot of essential information and has to be read by any 1802 user.

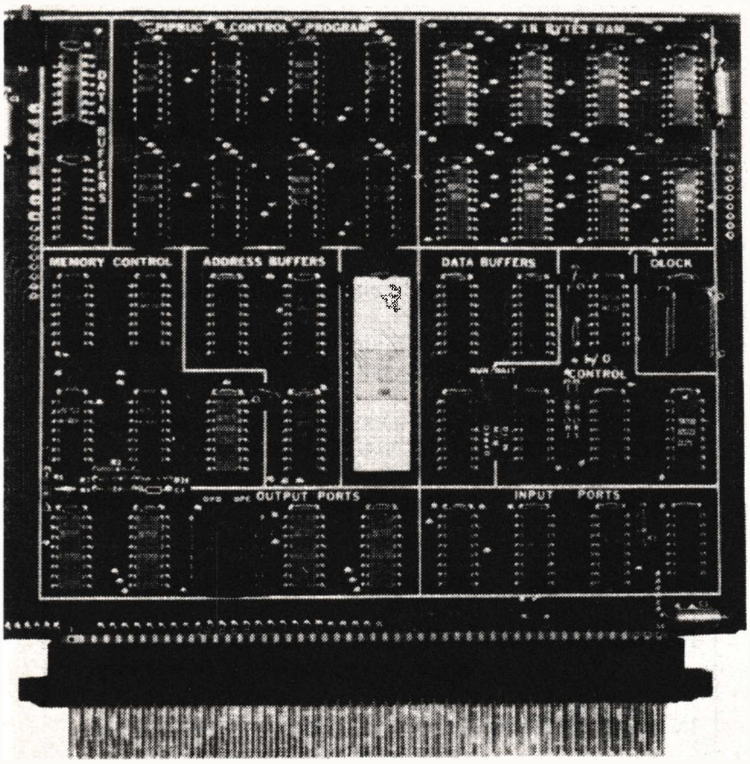
The Evaluation Kit Manual: Comes in the 3 ring binder and is grouped into five sections:
Section 1. — 29 pages on how to assemble the kit. Included is a checkout list and a troubleshooting guide if by some chance something does go wrong. The assembly instructions are very detailed and much use is made of overlays to show component placement.
Section 2. — a 30 page description of how the evaluation kit's circuits work.
Section 3. — 23 pages on how to use the monitor program, complete with examples.
Section 4. — complete set of data sheets on all ICs used in the kit.
Section 5. — application notes on clock generator, I/O ports, memory and software.

Cosmac Resident Software Manual: Is a 73-page run-down on the 1802 symbolic assembly language, and the rules for using it. This is essential reading for commercial users who can afford the extra memory and terminal and have another computer capable of running a cross assembler program.

Power Supply	Nominally 5V at 800 mA. Note, however, that being a CMOS device the 1802 microprocessor (or certain versions) will run on voltages between 3 to 12 volts.

COMMENTS: Of interest particularly to those who won't be using a terminal, the 1802 evaluation board has LEDs to display the state of the data and address bus. It also has single step circuitry. This allows the operator to execute one instruction at a time and it means that half the work of building an operator's front panel has already been done.

SIGNETICS



SIGNETICS PC1001 PROTOTYPING CARD

Microprocessor chip —	2650 8 bit
Technology —	NMOS
Clock —	Board supplied with a crystal oscillator
Maximum memory —	32,768 bytes.
RAM —	The PC1001 board comes complete with 1024 bytes of read-write memory. Expansion of memory must be off-board and to help the control and data bus signals are available at an edge connector.
ROM —	Has a total capacity of 1024 bytes and is made up with eight 256 x 4 bipolar programmable ROMs. These ROMs have been preprogrammed with the monitor program by blowing fusable links and can't be reprogrammed with new data. The ROMs are mounted in IC sockets and can be easily replaced with new ones containing other programs.
Monitor Program —	Called Pipbug and is 1024 bytes long. It has been written to be driven from a terminal via a teletyper or RS232 interface, and it expects ASCII code.
Command Types —	(1) Display the contents of a memory location and change it if need be. (2) Punch a paper tape copy of memory on the terminal. (3) Load memory from a paper tape copy. (4) 'Go to' command to transfer control from the Pipbug program to the users program in ROM. (5) To set break points in the user's program to force control back to

Pipbug. The user has the option of setting one or two breakpoints in his program.
(6) To clear or automatically remove breakpoints from the program.

Number of Instructions — 39 instructions, but counting the different addressing modes this gives 75 instructions (note: with the other evaluation kits we only gave the basic number — for example, the 72 instructions of the 6800 became 232 when different modes are considered).

Number of Addressing Modes — Up to 8 (depends how you define them).

D.M.A. — Yes, the 2650 can disconnect itself from the data and address bus for direct memory access for you to connect an operator's front panel.

I/O PC1001 has 16 latched output ports, organised into two groups of eight. One other output is available if you don't use the TTY. For input there are also 16 ports organised as two groups of eight. One other input is also available if you are not using the TTY. All these ports are designed for TTL signals. As well, available at the edge connector is the address bus, and an inverted data bus. These signals have been buffered by an IC on the PC board and are capable of driving more than the one TTL load that the other evaluation boards are limited to.

Power Supply — +5.0 volts at 2.0 amps
+15.0 volts)
−15.0 ") at 50 milliamps

Available as a kit — No, but Philips do a kit based on the 2650 — see comments.

DOCUMENTATION:

With the sample PC1001 we received a 2680 introductory manual, a Pipbug Application Note and a 15 page 2650 Evaluation PC board level system (PC1001) manual. This documentation proved enough to get the thing going and to write a simple program but was rather less than the other manufacturers had supplied. A quick phone call to Philips revealed that much more was available in the form of a BM1000 users Manual for $32 and a 2650 manual for $5 and that these had not been supplied to us because they thought we already had copies.

If you want more information about the different systems offered, get hold of the 2650 Introductory Brochure and Short Form Catalogue as this has quite detailed information on each of the systems offered by Philips. These catalogues should be available at most Philips distributors.

COMMENTS: The PC1001 is supplied in an assembled form so all it took to get it going was to hook up the power supply and teletype leads. This ended up taking more time than expected because we didn't have a suitable edge connector. A polite letter that arrived with the evaluation board revealed that Philips were also having trouble obtaining edge connectors, but we found a way around the problem and the PM1001 soon had the teletype humming.

Operating Pipbug proved very easy. In fact the Pipbug program must rate as just about the easiest to use of all the monitor programs so far tested.

At around the $400 mark, the PC1001 is expensive compared to the other kits tested, so what can it offer to entice you to buy it? To the home constructor I think these things are worth noticing:

It comes with 1024 bytes of ROM, compared with most others' 256 words, all signal and control lines are buffered and are available at an edge connector, the ROMs can be easily replaced with PROMs that can be programmed at home with a simple fuse blower and it is already assembled so there is no chance of an expensive mistake because of an assembly error.

For those who will not be using a teletype terminal and want a cheaper system there is the KT9000 prototype kit for around $156. It comes with the 2650, 512 words of RAM, 512 words of unprogrammed ROM, two 8-bit bidirectional I/O ports, and some bus drivers for buffering and a user's manual. Note that no pc board is included and the actual constructional method is left to you.

If you want a pc board then there's the KTG500 kit at $190 or assembled as the KT1500 at around $245. Briefly you get the 2650 microprocessor chip, 512 bytes of RAM, 1024 bytes of ROM programmed with the monitor program Pipbug, two 8-bit I/O ports and buffers on the data, address and control lines. The pc board also has some unused area drilled out with plated-through holes to take unconnected IC sockets. ●

OTHER MICROPROCESSORS

Here are some more microprocessors which didn't get mentioned in the Kit Summary. Note, too, that there are other kits available for the microprocessors that were mentioned.

MOSTEK 5065 a PMOS eight-bit microprocessor.

NATIONAL IMP 8 a PMOS eight-bit processor which can address 64 K of memory.

TEXAS INSTRUMENTS TMS8080 this is a locally-available second-source of the NMOS Untel 8080.

AMI S6800 a second-source of the Motorola 6800.

MOS TECHNOLOGY 6502 an eight-bit NMOS microprocessor.

ROCKWELL PPS8 an eight-bit PMOS microprocessor which can address 12 K of memory.

INTERSIL IM6100 a CMOS microprocessor with 12-bit word length and capability of addressing 32 K of memory.

Next month we will be giving names and addresses of companies handling these and other microcomputer products.

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* Simply connects to speaker terminals.
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Cat. K-3140 .. .. $49.50

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YOU GET ONLY WHAT YOU WANT – THE PRINTED CIRCUIT BOARD, ALL COMPONENTS INCLUDING TRANSFORMERS & CONTROL POTENTIOMETERS.

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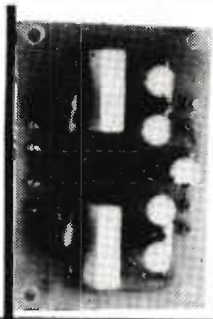
ON THE COMPLETE KIT

Ideal for all those who wish to mount this new unit into existing equipment – or were discouraged by the high cost of the full kit. Add your own hardware,wire etc.

Cat. K-3141.. .. ..$29.50



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Single PCB – Only ONE IC. Supplied with PCB pins. Runs on 10V to 40V DC. Complete with all parts for —
1 – Magnetic Preamp (RIAA)
2 – Tape Preamp (NAB)
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Cat. K-3427.. .. .. $7.50

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RE-4 Reverb Spring	Used in Reverberation Kit	Cat. X-1035	$9.75
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76/VG5 Printed Circuit Board	Used in TV Game Kit	Cat. H-8308	$5.50
76/M5 Printed Circuit Board	Used in TV Game Kit	Cat. H-8310	$1.50
74C00 CMOS Integrated Circuit	Used in TV Game Kit	Cat. Z-5410	$0.50
74C02 CMOS Integrated Circuit	Used in TV Game Kit	Cat. Z-5412	$0.50
76/R4 Printed Circuit Board	Used in Reverberation Unit	Cat. H-8314	$2.00
76/SA4 Printed Circuit Board	Used in Twin 25 Amplifier Kit	Cat. H-8302	$3.95
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Special LED Displays. 10 Green, 1 Yellow, 1 Red.	Used in LED VU Meter	Cat. SEM5	$3.60
76/LM5 Printed Circuit Board	Used in LED VU Meter	Cat. H-8315	$2.00
76/S7 Printed Circuit Board	Used in 650 MHz Prescaler	Cat. H-8316	$2.50
76/E04 Printed Circuit Board	Used in 760 Organ Keyer Module	Cat. H-8305	$3.20
4016 CMOS Integrated Circuit	Used in 760 Organ Keyer Module	Cat. Z-5616	$1.05
11C90 Integrated Circuit	Used in 650 MHz Prescaler	Cat. Z-5364	$19.75
MTI Box	Used in 650 MHz Prescaler	Cat. H-2495	$4.25
ETI 602 Silver Plated F/Glass Board	Used in Mini Organ Kit	Cat. H-8603	$4.90
Musicolour III Printed Circuit Board	Used in Musicolour III	Cat. H-8318	$3.95
Musicolour III Metalwork	Used in Musicolour III	Cat. H-3160	$10.90
Musicolour III Front Panel	Used in Musicolour III	Cat. H-3162	$3.50
76EX 10 Printed Circuit Board (F/glass)	Used in Novice Transmitter	Cat. H-8894	$6.00
ETI 602 P.C.B. (Fibreglass + Overlay)	Used in Mini Organ Kit	Cat. H-8604	$4.90
ETI 445 G.P. Stereo Preamp	Used in General Purpose Preamp Kit	Cat. H-8603	$1.60

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Cat. T1910 . . . . $ 3.90

Cigarette lighter plug to suit 50c
Spare tip to suit only 50c

JUST RELEASED

SEE E.T.I. AUG. 76.

ETI 602 MINI ORGAN KIT

COMPLETE WITH TREMOLO SILVER PLATED FIBREGLASS KEYBOARD – TWO VOICES.
Cat. K-3430 (*Case NOT included*) ONLY $24.75

MAGAZINE BINDER

Keep your Electronic Magazines in good shape. Binder holds 12 issues.
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SIGNAL INJECTOR $4.75

This Signal Injector (TE-101) uses a circuit designed to make blocking modulation for high frequency at low frequency of 1 KHz. Transistorised. Complete with battery.

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Two excellent 7" reel tapes with that extra special sound quality !

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In sum, the new D-450 is high cost performance, the kind of deck you'll love living with you.
Cat. A-3653 .. .. $219.

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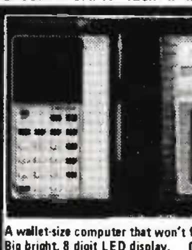

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Cat. L-5055 .. .. $47.90

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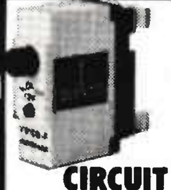

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Yamaha B-1 Vertical FET Power Amplifier

THERE IS A UNIVERSAL NEED, said Nietzsche, to exercise some kind of power, or to create for one's self the appearance of some power . . .

Some followed Nietzsche rather more closely than they might, but amongst his less militant disciples are a growing number of hi-fi amplifier manufacturers. Crown, Phase Linear, Marantz, Dynaco, Ampzilla and many others have each produced amplifiers with outputs such that a chassis dynamometer might fittingly replace our dummy resistive loads.

All are good offering tremendous value in terms of dollars per watt and all are capable of generating truly magnificent sound levels with very low levels of distortion.

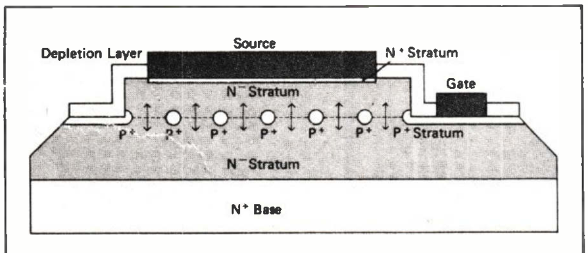
We suspect the motive to be Nietzschian — or at least a strong desire for each manufacturer to upstage his competitor by producing the ultimate amplifier — but whatever the motivation the results are remarkably good!

Conventional power output transistors produce a fairly high level of distortion as a result the non-linearity of their transfer characteristics. In fact transistor manufacturers have been searching for many years for a solid state device which would have characteristics more nearly equivalent to the hitherto ubiquitous valve.

Professor J. Nishizawa's development of the field effect transistor provided the break-through that had long been sought. The characteristics of these FET s, when compared with the conventional bipolar transistor, are firstly the elimination of carrier storage effects, reducing switching or notch distortion when used in Class AB or B power stages, and extremely rapid rise and decay times. High order harmonic distortion is dramatically reduced because of the squareness of the transfer characteristics and the power drive requirements are extremely low.

Unlike bipolar transistors, when the temperature rises the quiescent current decreases and so the big bugbear of bipolar transistors, thermal runaway, is very conveniently avoided. When placed in a power output stage of a power amplifier this provides the opportunity to develop extremely low open loop

YAMAHA VERTICAL FET CONSTRUCTION

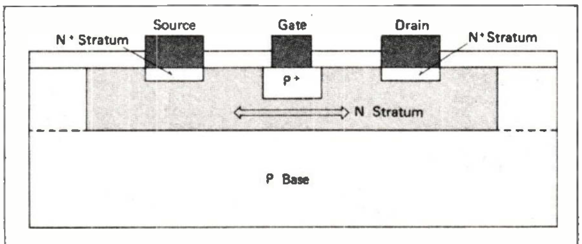


Arrows show current flow direction

As the vertical FET illustration below shows, the source, gate and drain are aligned vertically, permitting much higher power capacity. Each element of the mesh is, in effect, equivalent to an independent FET; a single Yamaha vertical FET contains tens of thousands of such elements.

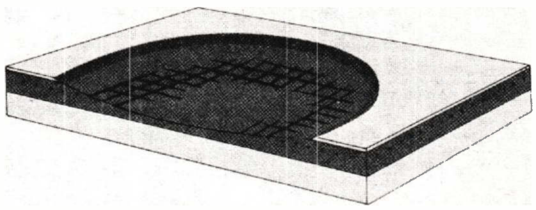
The mesh itself measures 5-10μ across. To assure highest possible drain-source and drain-gate breakdown voltage, impurity concentration is reduced to a level far below any previous semiconductors, through a special epitaxial layer formation method.

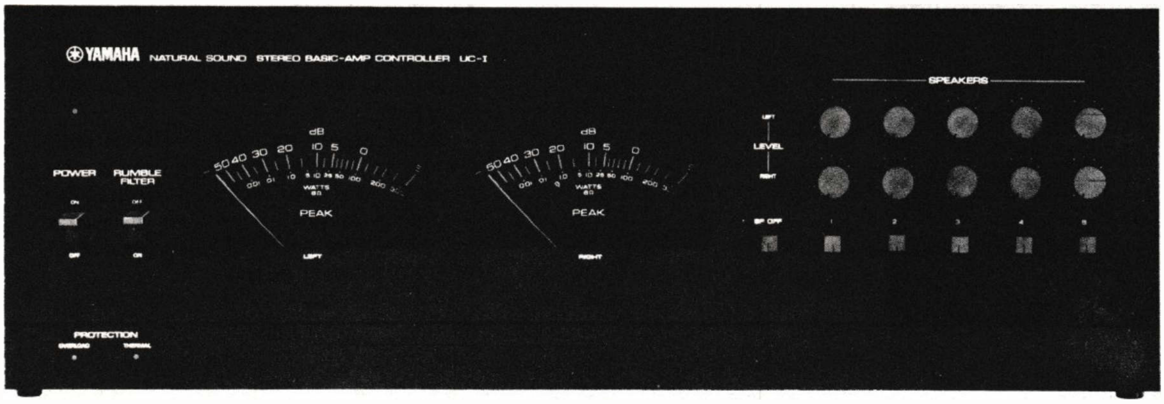
Conventional FET Construction



Arrow shows current flow direction

Yamaha Vertical FET Mesh Configuration





Yamaha B-1 amplifier with UC-1 control unit.

distortion and, in theory, almost the ultimate in power amplification characteristics.

The B-1 Power Amplifier is a braggart's delight! It's bigger, heavier, more powerful (within limits) and has better performance than any other power amplifier in its class that we have ever tested. It also has many most valuable features that are not commonly encountered.

The B-1 unit is a big ventilated black box on which are mounted a power ON/OFF switch, two speaker level controls and three LED s indicating the operation of the overload protection, the state of the thermal overlaod protection and power ON/OFF.

These controls are set in an anodised aluminium panel which is readily removeable to enable it to be interchanged with a Basic Amp Controller UC-1 which includes two large peak level meters with the unusually wide dynamic range of –50 dB to +5 dB.

These are also calibrated in terms of watts into an 8 ohm load; i.e., a range of up to 0.01 W to 300 W. This unit allows the connection of any one or more of up to five pairs of stereo speakers each with its own pair of individual pre-set level controls, the load terminals for which already exist on the rear panel of the main amplifier.

Main amplifier features include completely separate power supplies for left and right channels and a third power supply for the relay control functions.

These are activated via a relay from the front panel power switch such that when the power is switched on the speaker protection muting circuit operates to disconnect the speaker loads until the amplifier voltage conditions have stabilised.

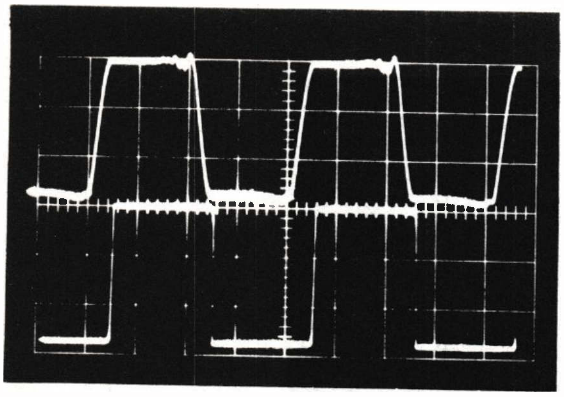
There are two separate protection circuits whose operation is indicated on the front panel. These are, firstly, thermal protection – designed to cut off the power supply if there is any danger in any circuit elements rising to a temperature exceeding 100°C: simultaneously, the speaker protection circuit will be activated cutting off the sound.

MEASURED PERFORMANCE OF YAMAHA B-1 POWER AMPLIFIER – SERIAL NO. 2869

Frequency Response:	–0.4 dB at 10 Hz and 122 kHz			
	–3.0 dB at 2.3 Hz and 122 kHz*			
Power at Clipping Point: (Both channels driven)	210 watts (8 Ω 1 kHz)			
	222 watts (4 Ω 1 kHz)			
Power Bandwidth:	5 Hz: 144 W	8 Ω	0.13% THD	
	50 kHz: 105 W	8 Ω	0.3% THD	
Total Harmonic Distortion: (Both channels driven)	100 W	8 Ω	100 Hz	0.03%
			1 kHz	<<0.01%
			6.3 kHz	0.07%
	1 W	8 Ω	100 Hz	<0.03%
			1 kHz	<0.03%
			6.3 kHz	0.04%
Noise:	–99 dB re max. power i.e. 0.46 mV (= .026 μW 8Ω)			
	–106 dB (A) " "			
Hum	–126 dB " "			
Sensitivity:	60 mV input gives 1 watt (8Ω)			
Input Impedance:	92 kΩ at 1 kHz			
Output Impedance:	0.08 Ω at 1 kHz			

*Max measurable frequency with test gear used.

Yamaha B-1 Vertical FET Power Amplifier



This circuit is self re-setting when the internal temperature returns to a safe level. A second protection circuit operates on overloads resulting from three distinct conditions. Firstly, the speakers are disconnected if a dc level exceeding ±2 volts is detected at the out output terminals. Secondly, the muting circuit already mentioned is activated immediately following power turn-on to eliminate loudspeaker thumps and thirdly, the power supply is disconnected whenever an abnormal voltage or current is detected in the output circuitry. This provides amongst other things protection against short circuits on the output or loads of less than 4 ohm impedance. This feature may preclude the amplifier being used with some 4 ohm speakers – the impedance of which falls to well below 4 ohms at some frequencies.

A rumble filter with a 12 dB per octave filter (below 10 Hz) protects the loudspeakers from low frequency transients. The control switch for this filter is at the back of the unit.

MEASURED PERFORMANCE

Our past experience with Yamaha products has been that the manufacturer's specification is generally bettered. The Yamaha B-1 was no exception. It has a frequency response which was +0 –0.4 dB from 10 Hz to 122 kHz, a straight line on a level recording. The manufacturer's power ratings were easily exceeded, both with 8 ohm and 4 ohm loads, being 210 watts into an 8 ohm and 220 watts into 4 ohm with both channels driven. The power bandwidth was 5 Hz to 50 kHz – precisely as stated by the manufacturer.

Distortion is very low indeed – over most of the frequency and power output range the unit introduced no increase in distortion beyond the inherent distortion of our measuring system.

Yamaha conservatively state that at one watt output, the distortion at 1 kHz is 0.02% – and 0.03% at 20 kHz. Our findings indicated that under those conditions the distortion was respectively less than 0.03% and less than 0.04% respectively. At 100 W output the distortion was very much less than 0.01% (being typically less than 0.005%) and at 6.3 kHz it was a precise 0.07%.

Until recently it was generally believed that ultra-low distortion levels were irrelevant. It is certainly true that few people can hear the slightest difference between an amplifier producing say 0.01% total harmonic distortion and another producing distortion even ten times as great.

Nevertheless there is increasing evidence that basic design improvements such as those incorporated in the Yamaha B-1 amplifier result in audible improvements – even though these improvements are not necessarily measurable by standard steady-state test methods.

Noise was found to be –99 dB with respect to maximum output or, if you prefer it, less than half a millivolt at the output terminals. Hum was an extraordinarily low –126 dB with respect to maximum power output.

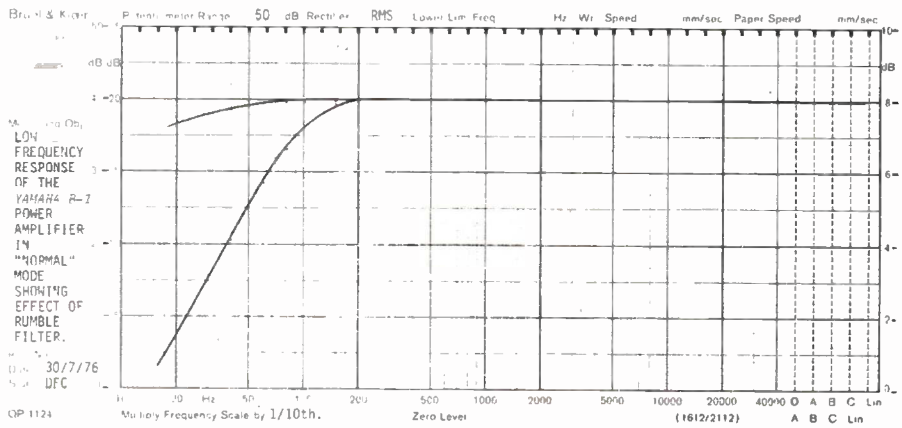
SUMMARY

As hard as we tried we could in no way fault the performance of this unit, except lamely to say that when we picked it up we found it too heavy (it weighs 37 kg) and rather expensive – close to $2,000 with the UC-1.

Currently research shows that amplifiers offering higher linearity with lower levels of inverse feedback offer very good transient performance.

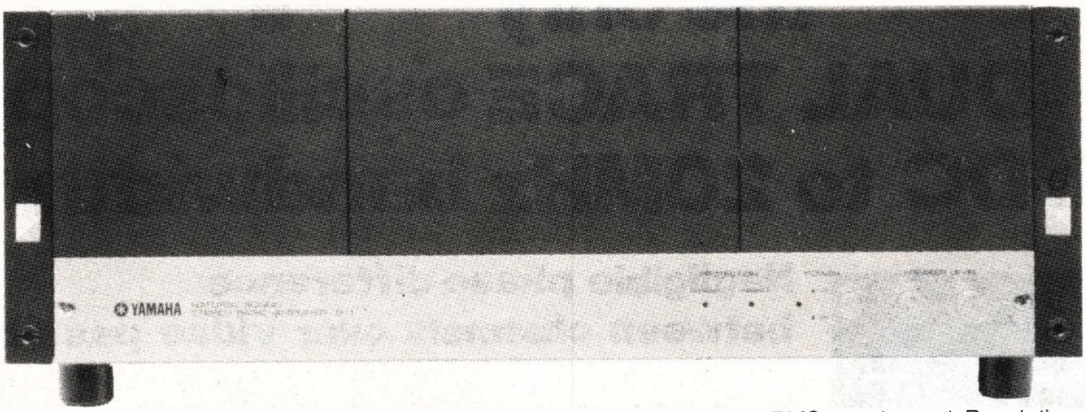
We think, but cannot prove, that the subjective performance of this unit is better than other amplifiers using conventional bipolar transistors but must honestly say that we have not positively proven it so, on the basis of instrumental measurements.

Let it suffice to say that our subjective evaluation leads us to believe that the performance that this amplifier produced was the cleanest that we believe we have ever heard up to this time.



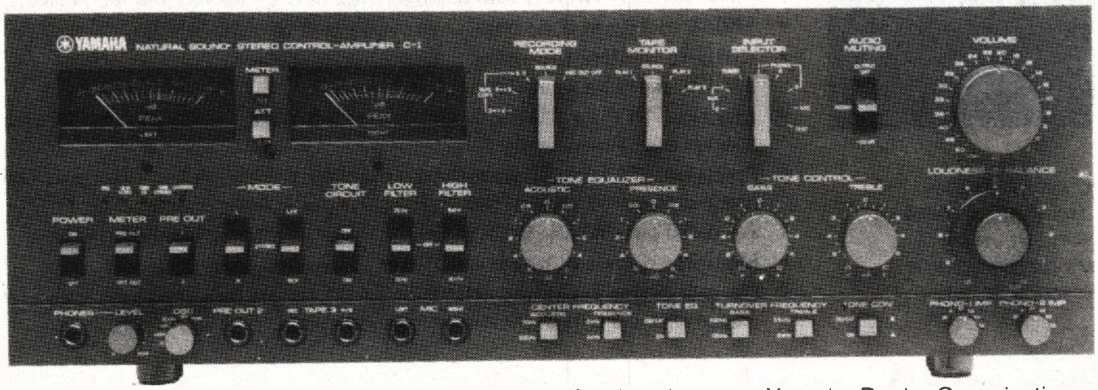
$4,300!

Why this spectacular Yamaha amplification system is worth every cent of its audacious price.



You don't pay this much money for any amplifier without very good reasons. Here are some of them:

Power amplifier: Laboratory-standard unit with spectacular specifications. Absolutely the most advanced electronic technology. 150 watts RMS per channel. Revolutionary vertical FET circuitry. Excitingly superior to bipolar transistors — with all the benefits of triode vacuum tubes.



Pre-amplifier: One of 3 models, all utilising laboratory-standard circuitry. This model, with state-of-the-art specifications is equipped with professional facilities.

Yamaha Dealer Organization,
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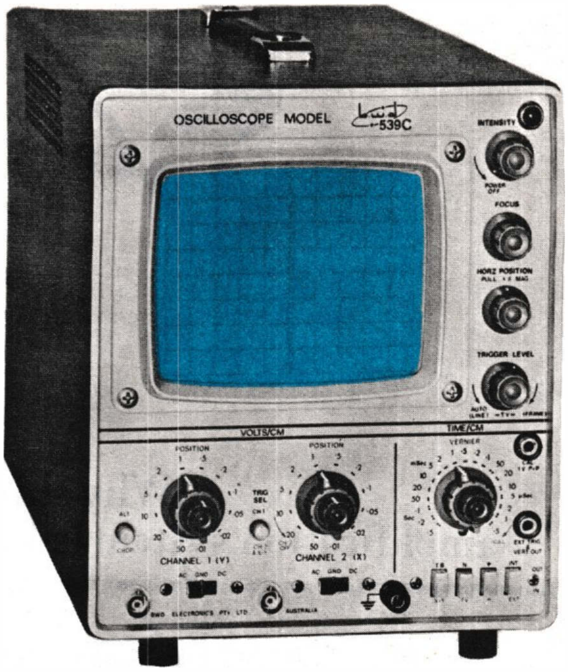

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- **100nS to 1S/cm time base** — 19 steps + 5—1 vernier.
- **<5Hz to 30MHz triggering** — bright AUTO base line.
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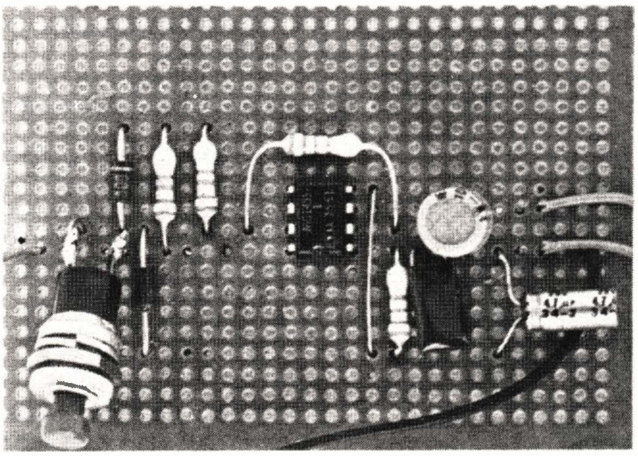
TWO TONE DOORBELL

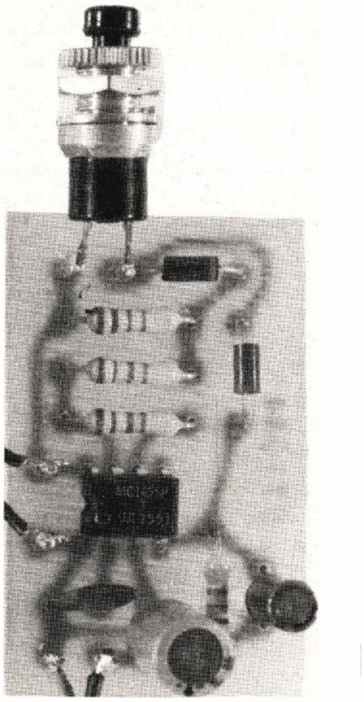
project electronics

A simple circuit based on the 555 integrated circuit used in both timing and oscillator modes of operation.

THIS ELECTRONIC DOORBELL IS based on the 555 integrated circuit. The device is widely used in many types of timers and as a simple oscillator. In this project both operations are used. When the button is pressed the 555 oscillates at one frequency (tone), when the button is released the tone changes and the IC continues to produce this second tone for a predetermined period. Thus by pressing the control button once a two-tone doorbell sound is produced by the speaker driven directly from the integrated circuit.



How the completed unit looks when constructed on Veroboard.



Construction

The circuit is very simple and contains only a few parts. It may be very quickly assembled on a piece of Veroboard. However any other method may be used if desired as the layout is not critical.

Veroboard has copper tracks on one side and these must be cut in ten places as shown in Fig. 2. The tracks are cut by using a small drill bit, rotated by hand, to clear the copper from around the hole. Note also that two holes are cleared between the integrated circuit pins, as pins 2 and 6 must be linked on the track side of the board. Clearing these holes eliminates any possibility of the link shorting to the track through the centre of the pins.

Assemble the components as shown in the component overlay diagram. Note that in this diagram the copper tracks are shown dotted as they are on the opposite side of the board from the components and therefore cannot be seen.

The integrated circuit, diodes, and the electrolytic capacitors must be mounted the correct way around. The overlay shows the distinguishing marks on each component, and the component must be placed so that the marks on the component are the same way as on the overlay diagram.

Whilst the push button on our unit is shown mounted onto the board it would normally be mounted remote from the board and a pair of leads would need to be run from the board to the remote button. We used a small nine-volt battery to power our unit but as the current drain is about five milliamps at all times a battery eliminator or separate power supply would need to be used in permanent installations.

HOW IT WORKS – ETI 044

The two-tone doorbell project is based around the 555 timer IC which is made to operate as an oscillator at two different frequencies. The second frequency is held for a fixed time before the unit switches off.

The 555 IC has a number of functional circuit blocks within it. The first of these are two level detectors. The first level detector is set to operate when the voltage at pin 2 rises above 6 volts (two-thirds of the supply voltage) and the second level detector is set to operate at 3 volts (one third of the supply voltage). If both pins 2 and 6 are higher than their respective threshold voltages the output from the IC at pin 3 will be 'low' at about 0.5 volts. If both pins 2 and 6 are lower than their respective thresholds the output of the IC will be 'high' at about 8.5 volts. The case where pin 2 is higher than its threshold and pin 6 is lower than its threshold is not defined and the output could be in either a high or low state. The only remaining possibility is where both pins are somewhere between 3 and 6 volts. In this case the output will not change from its previously set state.

When the output of the IC is caused to go low, an internal transistor connected between pin 7 and ground is turned on thus effectively shorting pin 7 to ground (pin 1). There is also a reset input (pin 4) available but we will leave the explanation of this for the moment.

Operation of the doorbell may be described as follows: The capacitor C2 initially charges towards plus nine volts via resistors R2, 3 and 4. However the top of the capacitor is connected to both pin 2 and pin 6 of the 555 timer IC. Hence when the voltage on the capacitor reaches 6 volts both comparators will be above threshold and the output of the 555 at pin 3 will go low and the internal transistor will switch on, shorting pin 7 to ground. However pin 7 is connected to the junction of R3 and R4 and C2 will therefore now be discharged via R4. When the voltage on C2 falls below 3 volts the output will go high again, the transistor will turn off, and C2 will commence charging again via R2, 3 and 4. This sequence continues thus producing a triangular waveform across C2 and a pulse train at pin 3. The pulse train output from pin 3 is coupled to the loudspeaker via C3 which prevents the dc component of the voltage from reaching the speaker.

The triangular waveform is produced by C2 charging from 3 to 6 volts and then discharging from 6V to 3V.

The time for C2 to charge from 3V to 6V is:–

$$Tc = 0.69\,(R2+R3+R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 1.5 \text{ milliseconds}$$

and the discharge time from 6V to 3V is:–

$$Td = 0.69\,(R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 0.5 \text{ milliseconds}$$

The total time for a complete cycle is therefore about 2 milliseconds and since frequency is the reciprocal of period

$$f = \frac{1}{P} = \frac{1}{2 \times 10^{-3}}$$
$$= 500 \text{ Hz}$$

When the button is pressed resistor R2 is shorted out by the push button and this reduces the charging time to

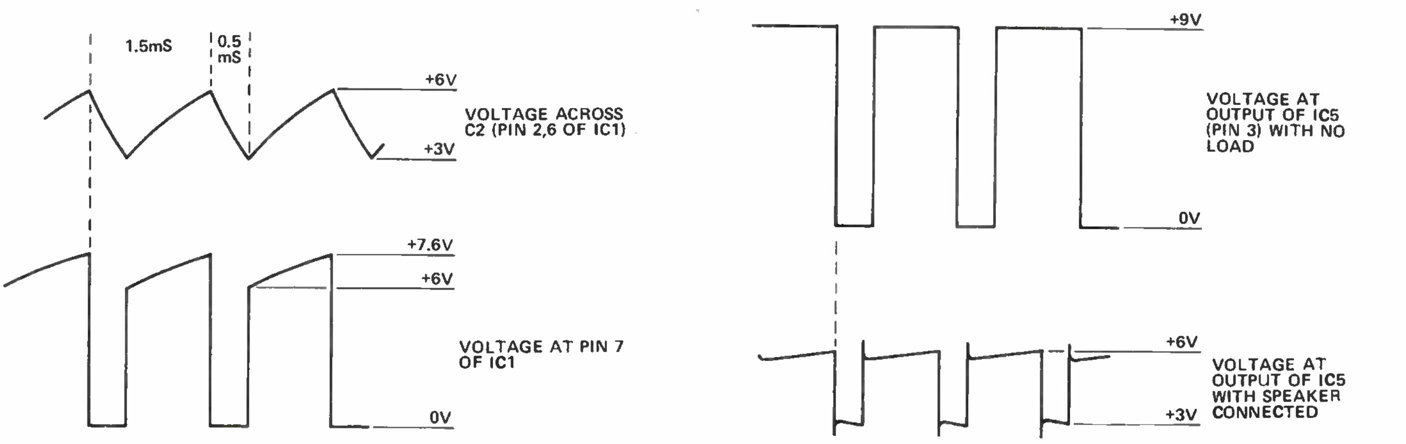
$$0.69\,(R3 + R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 1 \text{ millisecond}$$

The total period whilst the button is pressed is about 1.5 milliseconds equivalent to a frequency of 667 Hz. That is the pitch is higher whilst the button is pressed.

Lastly we must consider the effect of the circuitry connected to the reset terminal. If the voltage on this terminal is less than about 0.8 volts the output of the IC will go high and the oscillation will stop. When the button is pressed capacitor C1 is charged up to about 8.5 volts via diode D2 allowing the oscillator to start. Whilst ever the button is pressed it shorts out resistor R2 via diode D1 and the output of the oscillator will be 667 Hz. When the button is released the lower frequency is produced immediately and C1 begins to discharge via R1. After about ¾ of a second the voltage across C1 will have dropped below 0.8 volts and the oscillator will stop. The output will therefore be the higher tone whilst the button is pressed followed by ¾ second of the low tone after the button is released.

The two diodes are needed to isolate the two control functions which are performed by the one push button. If a two-pole push button were to be used the functions could be isolated and the diodes would not be required. However two-pole push buttons are not generally obtainable and the diode approach was therefore used.

If a different pitch tone is required R2,3,4 or C2 may be altered in value. The new frequencies may be calculated using the formulae given above. If a longer period is required for the second tone this may be obtained by increasing the value of C1. (Decrease the value for a shorter second tone).



These are the main waveforms generated within the two-tone doorbell circuit.

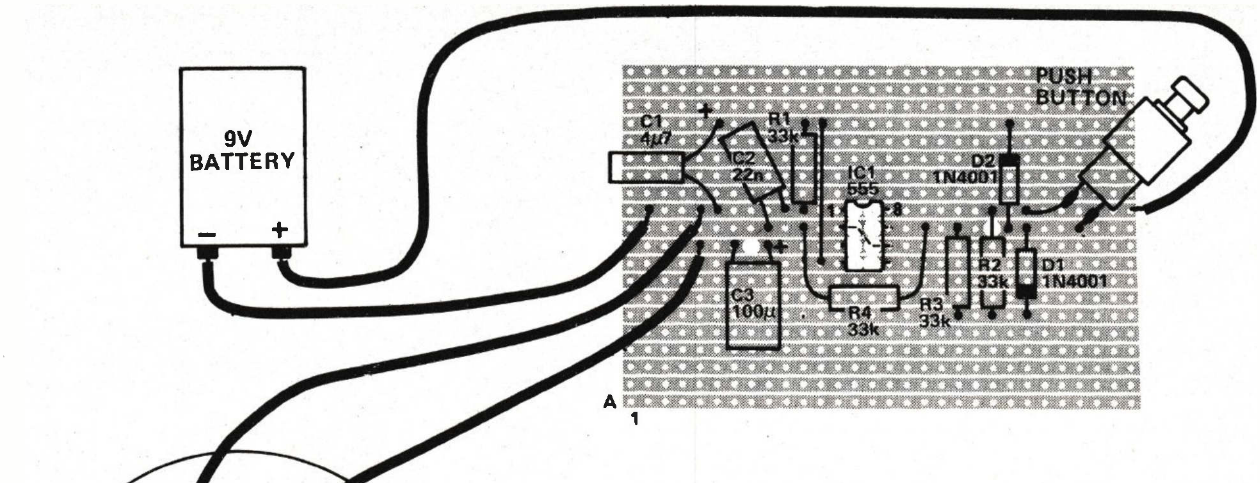
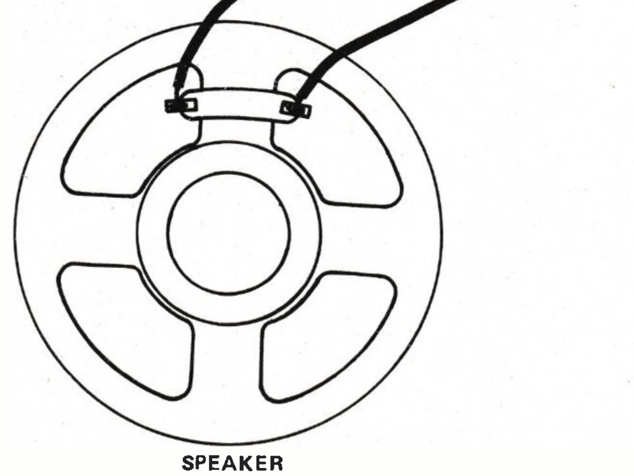



Fig. 1. Use this diagram to fit the components or wire the unit. Note the wire link between R1 and IC1 and the link between pins 2 and 6 of IC1 which is on the track side of the board.

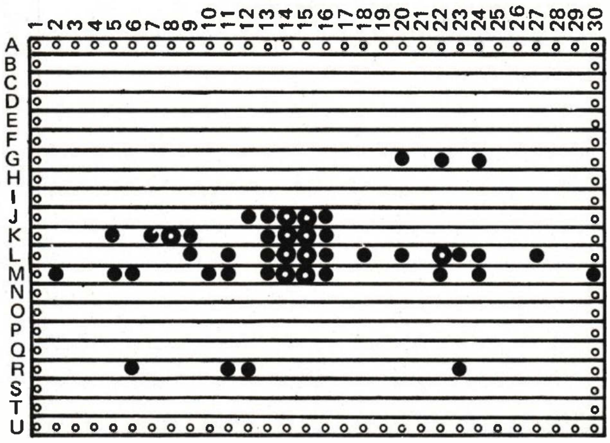


Fig. 2. The pads with holes through them indicate where the Veroboard track must be cut with a small drill as detailed in the text. The solid dots indicate where components are soldered to the tracks.

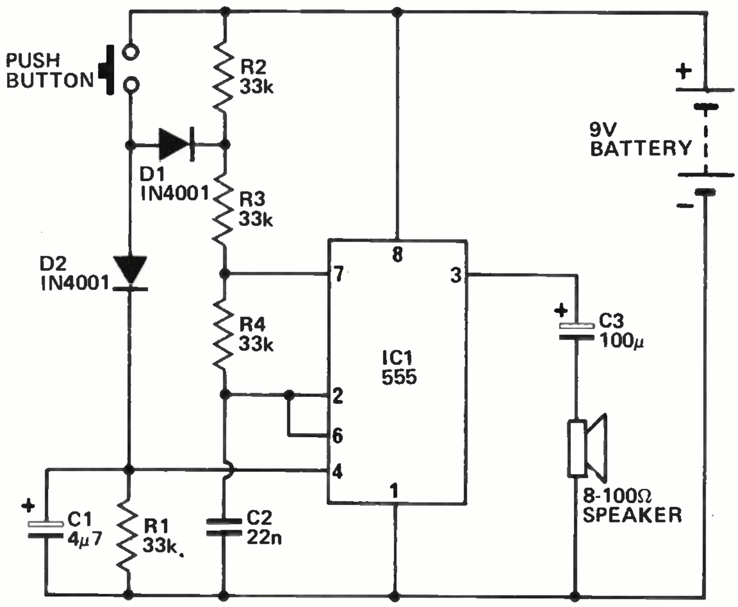


Fig. 3. Circuit diagram of the two-tone doorbell.

PARTS LIST ETI 044

R1-R4	Resistors	33 k ½ W 5%
C1,3	Capacitor	4.7 µF 25V electro
C2	"	22 nF polyester
C3	"	100µF 16 V electro
D1,2	Diodes	1N4001
IC2	Timer	555

Speaker 8—100 ohm
Push button—press to make
9 V battery
Battery clip
3" x 2" veroboard 0.1" or PCB ETI 044

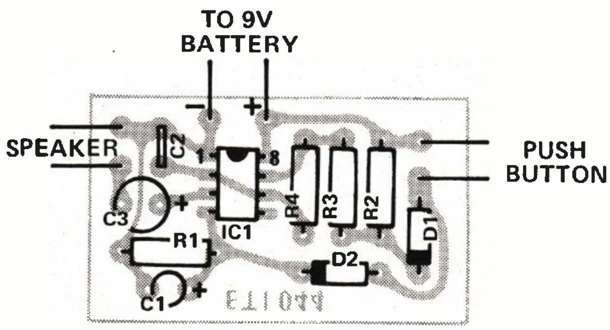


Fig. 4. This overlay shows how to fit components to the printed-circuit board.

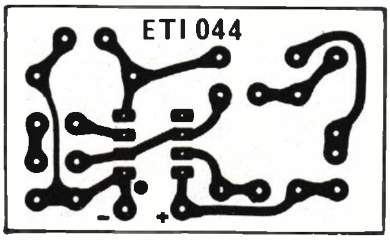


Fig. 5. Printed-circuit board layout (copper side). Full size of this board is 50mm x 30mm.

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HEADS OR TAILS

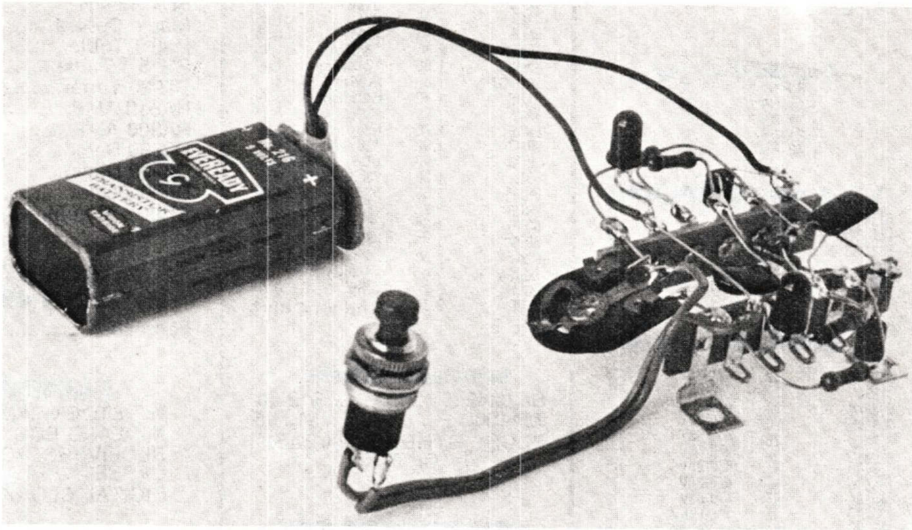
Play electronic two-up with this simple project and learn the basics of multivibrator circuits.

THE MULTIVIBRATOR IS ONE OF the most commonly-used circuit blocks in electronics — especially in digital circuitry. And the multivibrator forms the basis of this 'heads or tails' project.

The multivibrator is a basic form of square-wave oscillator which in our design runs at about 700 Hz whenever the push-button is pressed. When the button is released the oscillator will stop and the circuit will assume one of the two possible stable states. Either Q1 will be conducting and Q2 will be cut off, or Q2 will be conducting and Q1 will be cut off. Whichever transistor is conducting draws enough current down through the resistor and the light-emitting diode (in series with its collector) to cause the LED to light. The abbreviation 'LED' is commonly used instead of 'light-emitting diode'.

Notice that the circuit is symmetrical and that the two transistors are cross-coupled between their collectors and bases (via R3,C1 and R4,C2). If corresponding components on each side are matched there is equal probability of either transistor being on when the button is released. In practice, however, electronic components do not have exactly the values they are supposed to have, so it is necessary to include potentiometer RV1 to adjust for equal probability. Alternatively it may be useful to maladjust RV1 so that the effect of bias on the results can be assessed.

When either Q1 or Q2 is on, as said before, the associated LED will be on and this gives us our 'heads' or 'tails' indication. When the button is pressed, however, the LEDs are switched on and off alternately at a rate of 700 Hz. The switching cannot, of course, be seen due to the limited flicker-frequency response of the eye. Both LEDs will therefore appear to be illuminated.



LED ORIENTATION

It is important that you identify the anodes and cathodes of the LEDs.

See the text at the bottom of page 57.

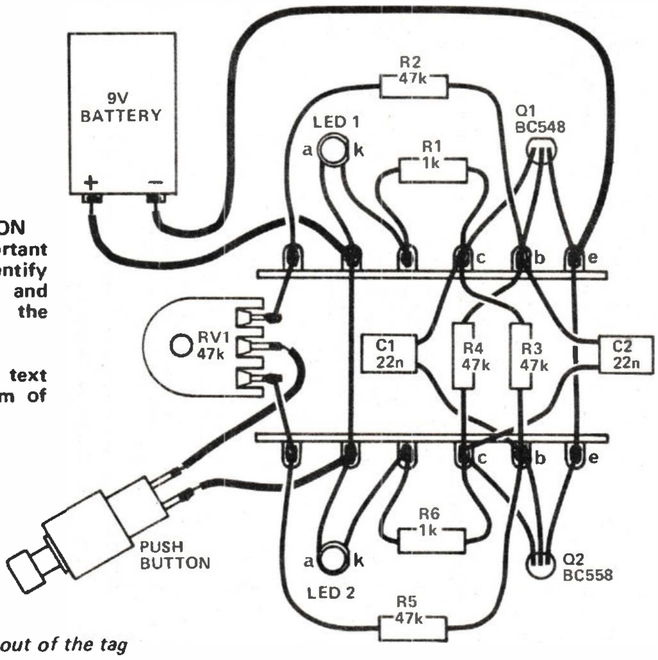


Fig. 1. Layout of the tag strip version.

HOW IT WORKS – ETI 043

This circuit may be considered as a multivibrator, when the button is pressed, and as a flip flop, when the button is released. If initially we consider the circuit with R2,R5,C1 and C2 deleted we have a standard flip flop. If Q1 is on it robs current from the base of Q2, thus turning it off. Transistor Q1 will be held on by the current through R6 and R4. However, if Q2 is on, the reverse is the case. Thus only one of the transistors can be on at any time – never both.

The addition of R2,R5 and C1,C2 will not alter the above, providing the push button is not pressed. However if the button is pressed the current through R2 and R5 will try to turn on both transistors.

Take the case where initially Q1 is on and Q2 is off. The voltage on the collector of Q1 will be about 0.5 volts and the voltage on Q2 collector about seven volts. We therefore have about 6.4 volts across C2 (as the base of Q1 is at about 0.6 volts). When the button is pressed Q2 will turn on and its collector will drop to 0.5 volts.

However a capacitor cannot instantly change its voltage and the base of Q1 will therefore be forced to -5.9 volts which turns off the transistor. Capacitor C2 then discharges via R2 and R4 until the base voltage is again at +0.6 volts when Q1 will turn on again. This however forces the base of Q2 to -5.9 volts (due to C1) thus turning Q2 off. This process continues back and forth until the push button is released. The circuit then stops in the state it was at the instant of releasing the button.

To add bias to the circuit RV1 can be adjusted to change the discharge time of C1 or C2 by up to 50%. In this case the two transistors will not be on for equal times and the results will be biased towards one side.

LEDs are included in the collector circuits of each transistor to indicate which transistor is on. If, for display purposes, a slower-running unit is required the values of C1 and C2 may be increased. If both are 10 microfarad electrolytic capacitors the rate will be about 1.5 seconds. Make sure if electrolytics are used that the positive terminal is connected to the collector of the transistor.

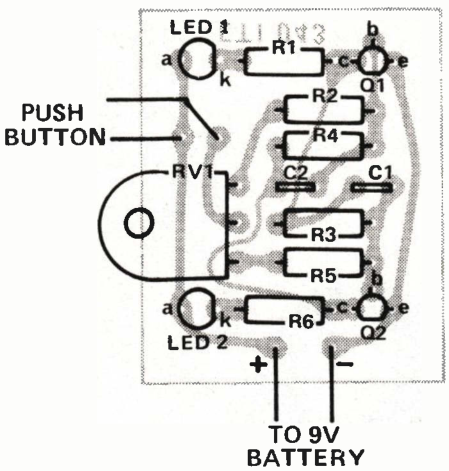


Fig. 2. Layout of the printed-circuit board version.

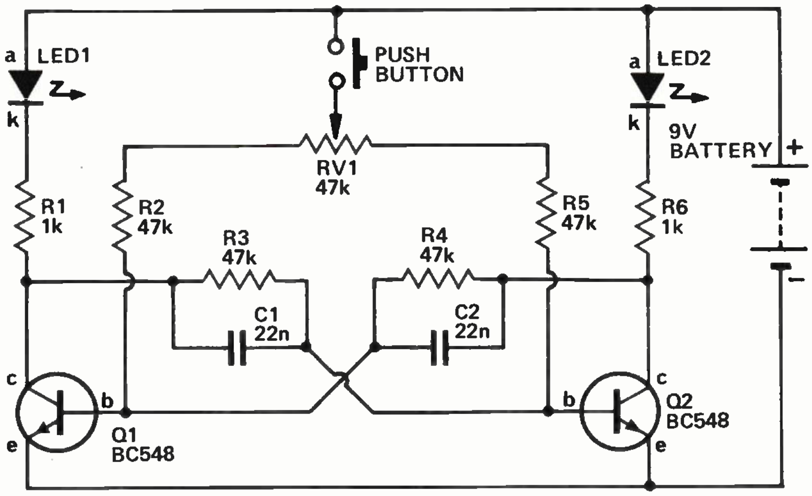


Fig. 3. Circuit diagram of the unit.

PARTS LIST – ETI 043

R1	Resistor	1 k ½w 5%
R2-R5	Resistor	47 k ½w 5%
R6	Resistor	1 k ½w 5%
RV1	Potentiometer	100 k trim type
C1,2	Capacitors	22 nF polyester
Q1,2	Transistors	BC548
LED 1,2	Light emitting diodes	

Push button-press to make 9V battery
Battery clip
Two 6 way tag strips

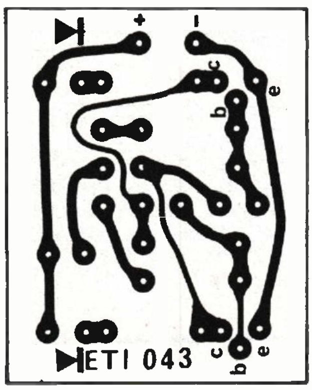


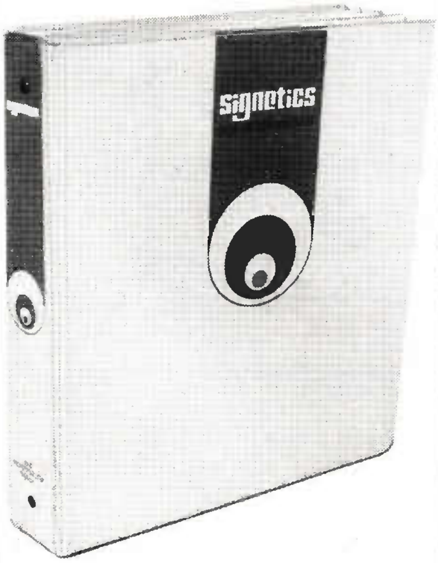
Fig. 4. Printed-circuit Board layout. Full size 50 x 40mm.

Construction

As the circuit is quite simple and symmetrical it can easily be assembled between two six-way tag strips as shown in Fig.X. Alternatively the unit can be assembled onto a small printed-circuit board such as that illustrated in Fig.Y.

The main points to watch are that the transistors are correctly orientated and that the LEDs are the correct way around.

The unit should not be switched on until it has been thoroughly checked – a transistor or LED can be destroyed if it is wrongly connected. Double-check the battery connection – a reversed battery can also destroy semiconductors.


signetics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INTEGRATED CIRCUITS
PHILIPS
2650
NOTEBOOK

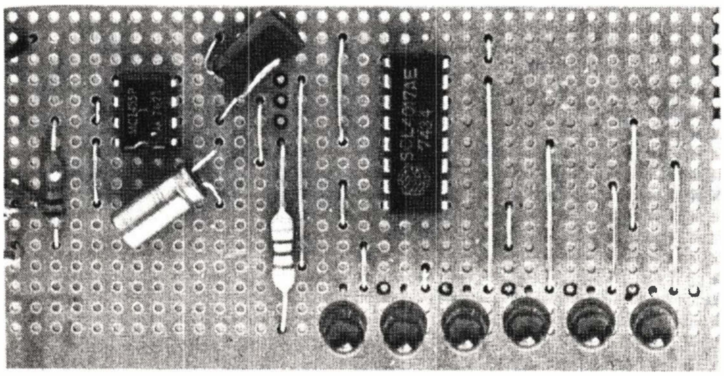
LED DICE

project electronics

A simple dice circuit using the 555 timer IC and a digital-logic device of the CMOS family.

THIS SIMPLE DICE PROJECT IS BASed on a CMOS (Complementary Metal-Oxide Semiconductor) integrated circuit counter which is stepped by the output of a 555 timer integrated circuit connected to run as an oscillator at approximately 6500 Hz.

When the button on the unit is pressed the 555 oscillates and the 6.5 kHz pulses which it generates at pin 3 are fed to the input of IC2 (pin 14). The integrated circuit, IC2, is a decade counter in which each of the count states (0 to 9) are brought out to separate pins. By connecting the seventh count output (pin 5) back to the reset input (pin 15) the counter is made to reset after every sixth count. The six count states of the IC which are used are each connected to a light-emitting diode (LED). As the IC counts it will switch on each of the six light emitting diodes in turn. Whilst the button is pressed the LEDs will be switched at a rate of 6.5 kHz and thus all LEDs will appear to be on due to the limited flicker-frequency response of the human eye.



The completed Veroboard version of the unit.

When the button is released the oscillator stops counting leaving one only of the LEDs alight. As the IC cycles through its six states the LEDs will each be on for the same interval. Thus the probability of being on when the button is released is the same for each LED. The LEDs may therefore be numbered from one to six and the device can then be used as a dice.

Construction

The integrated-circuit counter device belongs to the family of devices known collectively as CMOS (Complementary Metal-Oxide Semiconductor). The name is derived from the manufacturing process. This family of devices is at present widely used in digital circuits. Devices in the family range in complexity from the relatively simple to the extremely complex (for example, some calculator ICs made in CMOS may contain up to 5000 transistors).

Whilst CMOS devices are fairly rugged in-circuit, they are liable to be damaged by static discharges when handled out of circuit. For this reason they are supplied in either conductive foam, aluminium foil or specially-coated plastic containers which short all the pins together for protection. The CMOS should only be removed from its protective packing when you are ready to insert the device into the board. All other components should be mounted to the board first and the CMOS inserted last of all. Handle the pins of the device as little as possible and solder in place quickly and cleanly with a light-weight soldering iron.

The dice project may be assembled using the Veroboard layout as given or using the printed-circuit board alternative. If Veroboard is used the tracks must be cut in the positions indicated with a small drill bit. The components are then assembled to the respective board with the appropriate overlay.

The integrated circuits are marked by a small notch or dot at one end of the body. When inserting the IC make sure that this mark is aligned with the orien-

PROJECT ELECTRONICS

All projects published in this series have been designed and developed in conjunction with officers of the NSW Dept. of Education.

The full complement, together with accompanying explanatory material will be published in book form in mid-February 1977.

HOW IT WORKS – ETI 068

When the push botton is pressed the capacitor C1 is charged up via resistor R1. When the voltage on C1 reaches two thirds of the supply voltage (6 volts) a detector within the IC switches on an internal transistor in the IC, which shorts the capacitor to ground and discharges it until the voltage drops below one third of the supply voltage. When this happens another detector turns off the discharge transistor. The cycle now repeats, as the capacitor is allowed to recharge.

The time to charge the capacitor C1 from one third to two thirds of the supply voltage (that is from 3 to 6 volts with a 9 volt supply) is 150 microseconds (0.69 x 10,000 x 22 x 10^{-9} secs). The discharge time is only about 2 microseconds, due to the fact that the discharge transistor (internal to the IC) is a very low resistance when it is turned on.

While the capacitor is being discharged the output of IC1 (pin 3) drops from +9 volts to 0V and then returns to +9 volts when Cl is released. Thus during each discharge period a narrow pulse is generated at the output of the IC. That is, we have a 2 microsecond wide pulse every 150 microseconds which corresponds to an output frequency of about 6600 Hz.

The display for the dice is formed by six LEDs which are driven by IC2. This IC is a digital device and is a decade counter (it counts to ten) and a decoder in one package. It has ten outputs, one only of which is high (+9 volts) at any one time and all the others are low (0 volts). It also has a clock input and a reset input. When the reset is taken high the device is set to the state where the first of the outputs is high.

The output of IC1 is connected to the clock input of IC2 and every time there is a pulse from IC1 the output of IC2 which was high, will go low and the next output will go high (providing that the reset input is low). Thus the "high" shifts through the ten outputs of IC2 in sequence, at the same rate as the input pulses from IC1. The sequence of ten outputs recycles whilst there are input pulses.

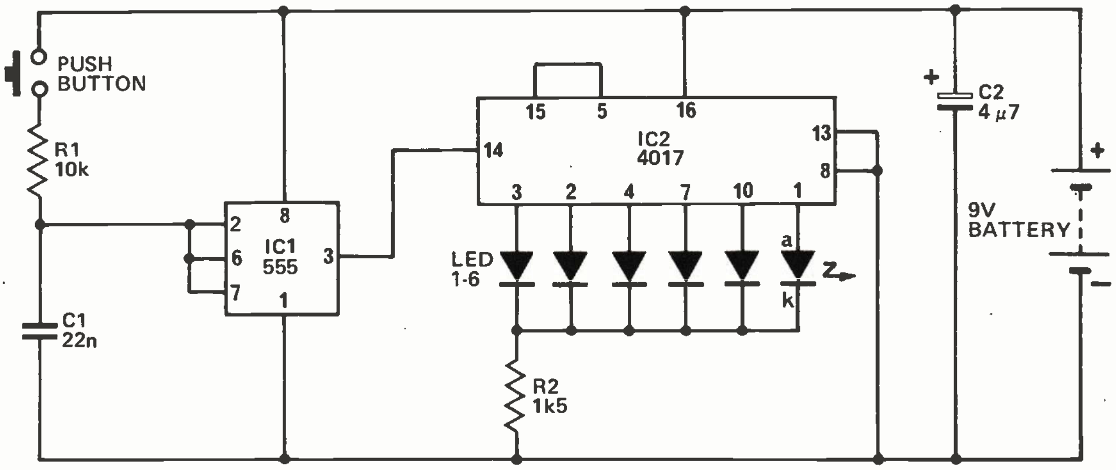
However a dice has only six surfaces so we require IC2 to county by six, rather than by ten. This is quite easily performed by connecting the seventh output of the IC back to the reset input. Now when the counter is clocked from output six to output seven, seven goes high and resets the counter. Once the counter resets the high is removed from output seven and the counter, back at output one, is free to count again. The time taken to do this is only about 100 nanoseconds (0.000 000 1 sec) and is therefore very difficult to see on an oscilloscope.

The outputs one to six of IC2 are each connected to the anode of an LED. The cathodes of the LEDs are all connected in parallel, via a common current-limiting resistor, to 0 volts.

To sum up the operation, when the button is pressed IC1 commences oscillating at 6.6 kHz and this clocks IC2 such that each of the LEDs is lit in sequence – the cycle repeating about 1000 times per second. When the button is released the oscillator will stop and one LED only will be lit. Human reactions are not nearly fast enough to be able to stop the dice at any specific point. The results will therefore be completely at random.

For checking purposes the action may be slowed down by putting a high value resistor across the terminals of the push button (even just the finger across the terminals will do). This will cause the oscillator to run at a low speed so that the changing of the LEDs can be seen.

Fig. 1. Circuit diagram of the LED dice.



tation mark provided on the component overlay. Make sure also that the electrolytic capacitor C2 is inserted with the correct polarity.

The light-emitting diodes will have their cathode terminals (k) marked in some way. Usually this is by means of a small flat on the plastic body of the component adjacent to the cathode lead or the cathode lead may be shorter than the other. Make sure that the LEDs are inserted with the correct polarity – if any LED fails to light when the button is pressed it is most likely that it is the wrong way round.

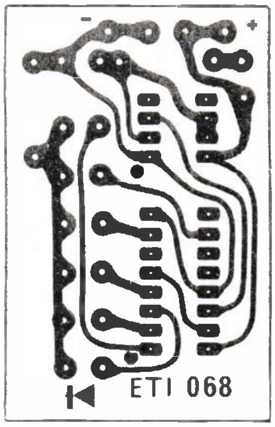


Fig. 2. Printed-circuit board layout for the LED dice. Full size 55mm x 35mm.

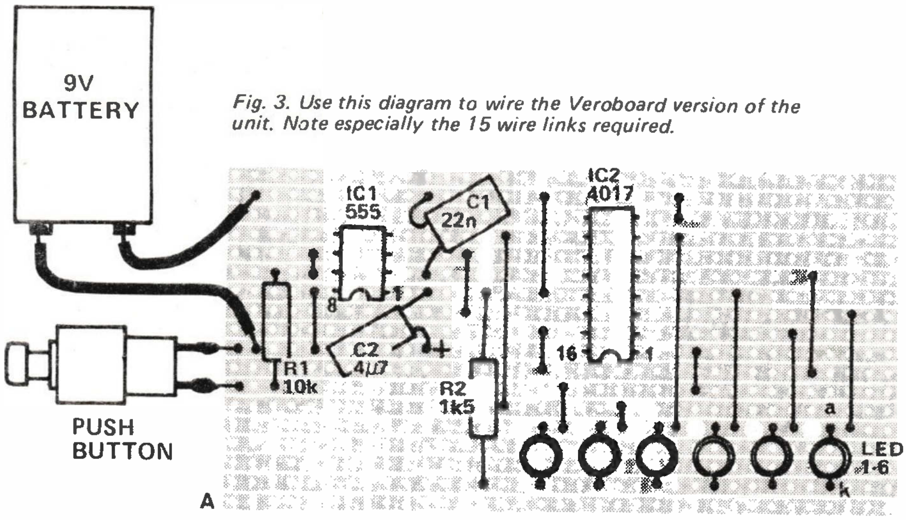


Fig. 3. Use this diagram to wire the Veroboard version of the unit. Note especially the 15 wire links required.

PARTS LIST — ETI 068

R1	Resistor	10k ½w 5%
R2	Resistor	1.5k ½w 5%
C1	Capacitor	22nF polyester
C2	Capacitor	4.7µF 25V electro
IC1	Timer	555
IC2	Counter	4017 (CMOS)
LED 1-6	Light emitting diodes	

Push button & press to make
9V battery
Battery clip
1.5" x 3.5" Veroboard 0.1" or
PC Board ETI 068

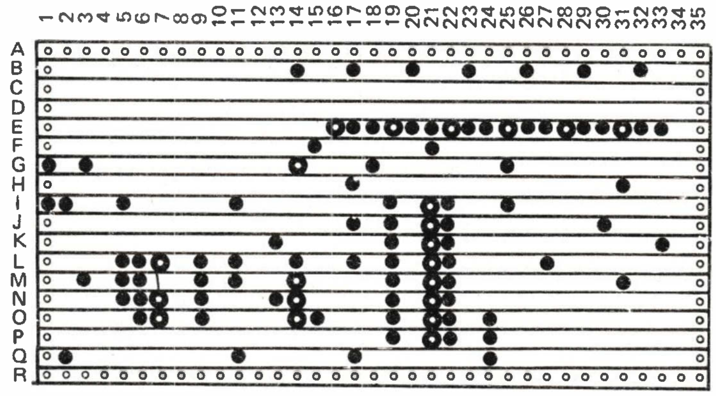


Fig. 4. Cut the Veroboard track in the places indicated by the pads with holes. The other dots are where soldered connections are made.

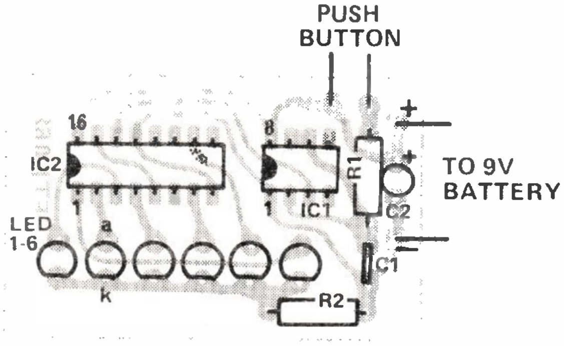
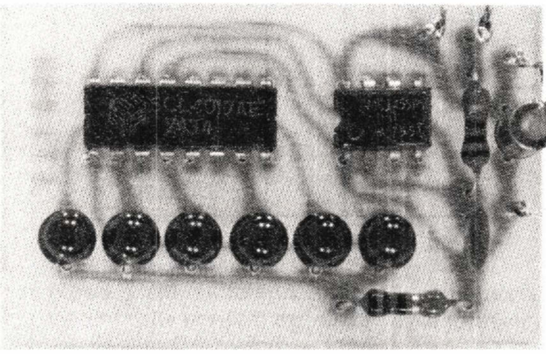
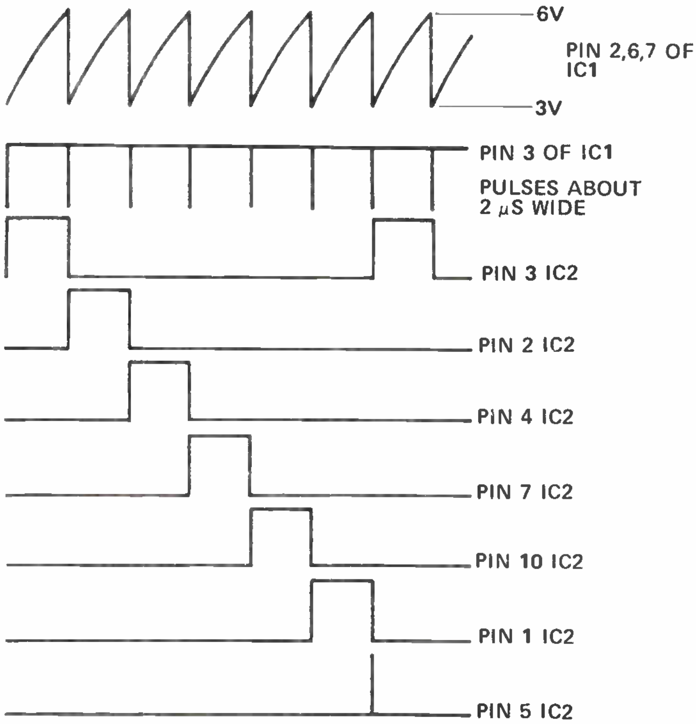


Fig. 5. How the components are mounted to the printed-circuit board.



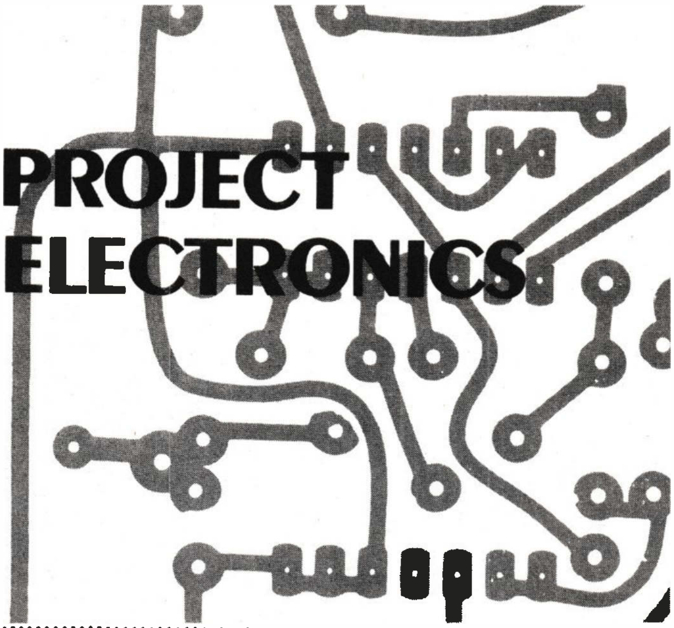
The completed printed-circuit board version of the LED dice.



The main waveforms of the LED dice unit.

APPLIED TECHNOLOGY PTY. LTD.

HOBBY NEWS
OCTOBER 1976



This series commencing in October ETI represents the ideal starting point for those who want to learn more about the fascinating world of electronics. Project Electronics is to become the basis of an electronics course in Australian schools and Applied Technology is proud to be a supplier.

As professional engineers we firmly believe that practical "hands on" experience is one of the best (and most pleasant) ways of increasing ones knowledge.

We have added these simple projects to our PROJECT KIT range and made them available to home constructors. Each of these kits includes our own exclusive fibre glass printed circuit board to simplify assembly, full instructions and application hints, all components and even a quantity of solder. All prices include postage and packing.

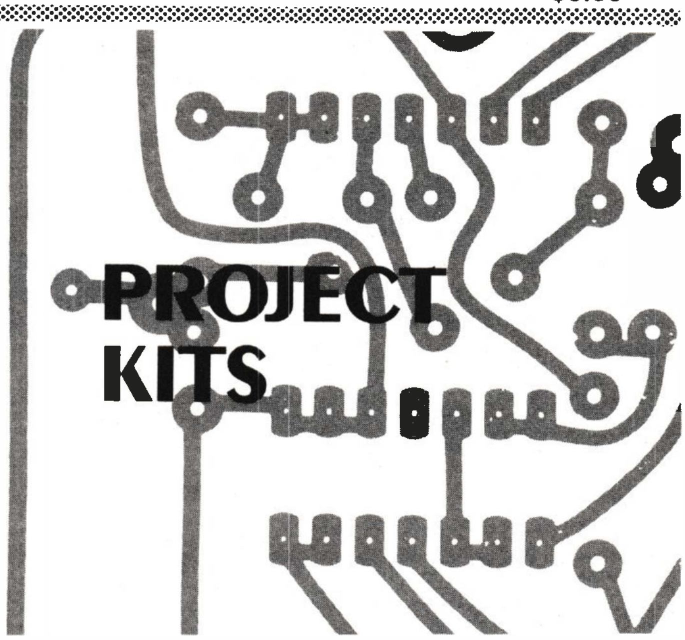
PK061	SIMPLE AMPLIFIER	$6.00
PK044	TWO TONE DOOR BELL	$5.00
PK043	COIN TOSSER	$3.50
PK068	LED DICE	$6.00

PROJECT KITS — now everyone can enjoy building solid state Electronic Kits.

This popular range of kits appeals to everyone. Each PROJECT KIT is supplied with a predrilled fibre glass printed circuit board, all components including solder and hookup wire and simplified assembly instructions. All prices quoted include postage and packing.

PK1000	General Purpose IC Amplifier	$5.00
PK2000	Variable Timer	$7.50
PK3000	Touch Switch	$7.75
PK4000	Burglar Alarm	$10.95
PK5000	3 DIGIT Readout Module	$19.50
PK5050	Digital Voltmeter Module	$8.50
PK5080	Frequency Meter Module	$11.50
PK7000	Spot-O-Light Display	$9.50
PK8000	Bar-O-Light Display	$9.50
PK9000	Digital Clock Module	$13.50
	(transformer for PK9000)	$7.50

For full details please refer to our catalogue in Eti August 1976.



SEMICONDUCTORS: VOLUME DISCOUNT PRICES

The semiconductor prices shown in our August catalogue backed with our extensive stocks and fast mail order service have, judging from the volume of orders received, been very well received by our customers. Don't forget we guarantee all devices and only buy from the leading manufacturers.

As an extra service we have now introduced volume discounts on any popular device where we have adequate stocks. Please write or phone for a free quotation.

APPLIED TECHNOLOGY PTY. LTD.

HOBBY NEWS
OCTOBER 1976

555 TIMER APPLICATIONS NOTES

The 555 timer is one of the most versatile IC's available to the home hobbyist. We have researched all the available literature from manufacturers such as Signetics, National Semiconductor, and Motorola and have compiled the Applied Technology 555 APPLICATION NOTE. This useful publication lists full data and gives probably the most comprehensive listing of applications for the 555 available today.

SPECIAL OFFER 5–555–4–3
(five 555 timers for $3)

Order five 555 timers for $3.00 and receive a free 555 APPLICATION NOTE. Note this offer price includes all postage and packaging.

NEW SHOWROOM & WAREHOUSES

As this HOBBY NEWS goes to press we are greatly extending our present showroom so that we can display our full range of kits to personal callers in a relaxed, informal atmosphere.

The mail order response to our catalogue in August ETI has been enormous. We have now established a separate warehouse facility to house our enlarged stock and kit production assembly line. Our printed circuit production unit is now being transferred to the warehouse and when fully operational we will have the most efficient kit production factory serving the Australian Hobbyist.

SATURN 5 TV GAME

The response to our Saturn 5 TV Game has been overwhelming and the current backlog of orders has resulted in a waiting time of about 6 weeks. We regret that we can not accept any more orders post-marked after September 30th, 1976. We trust you will understand.

MICROPROCESSOR PROJECT

We have now available all components for the ASCII to BAUDOT/BAUDOT to ASCII converter project using the SC/MP Introkit. By special arrangement with NS and Jim Rowe we are prepared to offer the specially programmed ROM for $40.00. This replaces the KITBUG ROM supplied with the SC/MP INTROKIT and this enables you to use a low cost BAUDOT TELETYPE to become a fully fledged ASCII machine. This probably represents the lowest cost approach to talk to microprocessors if one is unable to acquire one of those rare and expensive breeds such as a TELETYPE 33ASR!

SC/MP	Microprocessor Introkit	$89.50
ROM	ASCII/BAUDOT	40.00
S1883	UART	9.50
SOCKET	40 PIN FOR UART	1.60
4N28	OPTO COUPLER	1.50

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TRADING HOURS: 9–5 WEEKDAYS, 9–12.30 SATURDAY

project electronics

SIMPLE AMPLIFIER

This simple amplifier for the experimenter is based on discrete components.
It is a useful introduction to the basics of audio power amplifiers.

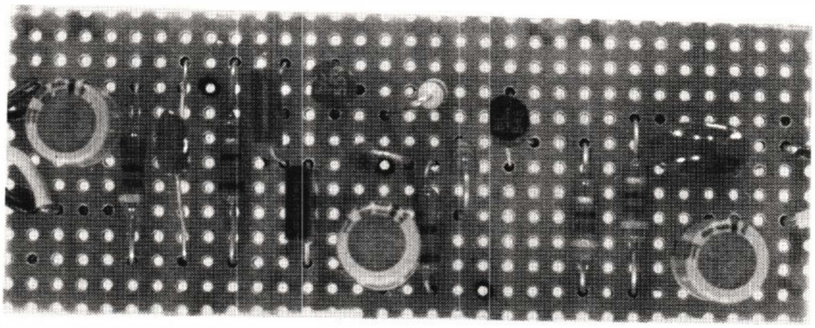
SIMPLE AMPLIFIER

AT THE PRESENT TIME THERE are numerous single-chip, integrated-circuit amplifiers on the market which offer power amplification of audio signals. Outputs are typically from 0.5 to 5 watts and very few additional components are required to make these devices perform. However such IC amplifiers are sometimes very critical with regard to the layout of components. A poor layout can cause the amplifier to oscillate and such oscillation will often destroy the amplifier IC.

Other hybrid devices (combinations of ICs and transistors within a single sealed package) are available with power outputs up to 100 watts. However, although such hybrid devices work well they are expensive and for most experimental applications such high powers are not required. It is generally adequate to have just sufficient power output and gain (amplification) to make audio signals from experimental circuits audible using a small speaker.

A small amplifier is therefore a useful device and, although a single integrated-circuit amplifier could be used, it will teach you quite a lot about transistors if you make your own from discrete components (transistors, resistors and capacitors etc). At the same time it will give you an understanding of the internal operation of audio amplifiers.

This small and inexpensive amplifier has been designed for use in general experimentation. It is much more stable than most integrated-circuit designs and its operation and circuitry are basically similar to those of higher power audio amplifiers.



How the completed unit looks when constructed on Veroboard.

Construction

As with all these simple projects layouts are given for construction on Veroboard or on a specially-designed printed-circuit board.

If the unit is constructed on Veroboard the tracks must be cut in the places shown in the diagram by rotating a small drill bit in the appropriate hole until the track is completely cut through. Before cutting however make doubly-sure that you have the right position for each hole.

Whether assembling on Veroboard or printed-circuit board the components must be fitted to the board as shown on the respective component overlay. Component orientation must be carefully watched. For example, the electrolytic capacitors usually have a wide black line

PROJECT ELECTRONICS

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The full complement, together with accompanying explanatory material will be published in book form in mid-February 1977.

SPECIFICATION ETI 061

Output Power Into 8 ohms	500 mW	Output Impedance	approx 3 ohms
		Gain	33 dB
Frequency Response		Input Impedance	33 kohms
C5 = 100 μF	200 Hz – 300 kHz		
C5 = 470 μF	45 Hz – 300 kHz	Input Sensitivity	500 mV

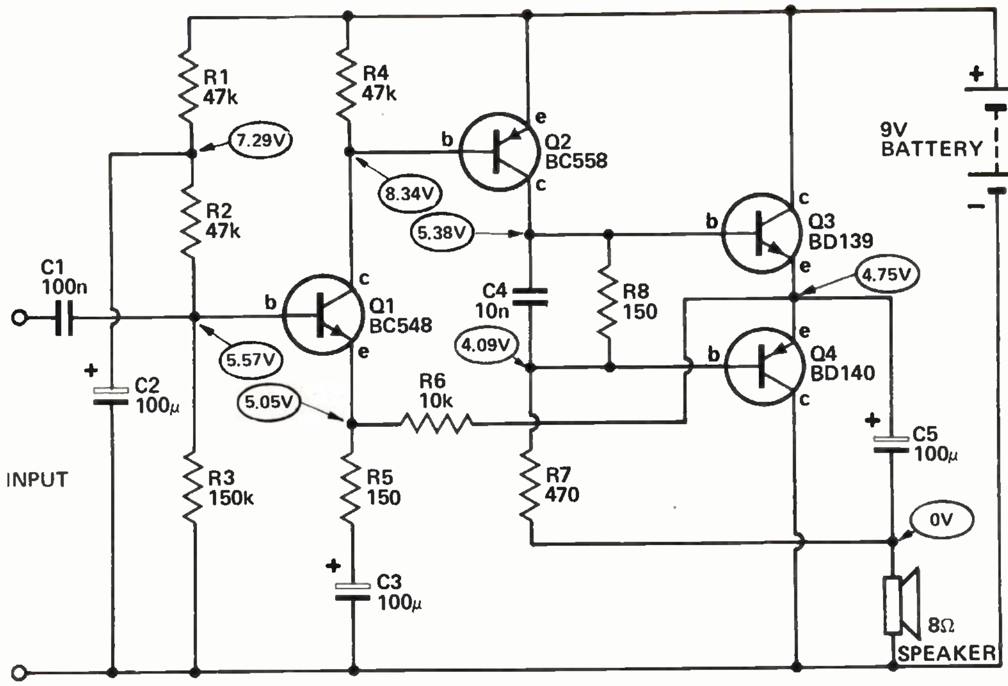


Fig. 1. Circuit diagram of the amplifier.

HOW IT WORKS – ETI 061

The operation of the amplifier may best be explained by dealing within three separate sections.
a. The amplifier Q2.
b. The buffer Q3,Q4.
c. The comparator Q1.

With any transistor the current flowing into the base determines the amount of current flowing in the collector circuit. The ratio of the magnitude of the collector current to that of the base current which controls it is known as the beta (β) of the transistor and values for this of 40 to 400 are typical. With a beta of 40 the collector current will be 40 times the current injected into the base. However when the transistor is used as an amplifier a problem occurs due to the fact that the realtionship is not perfectly linear and this gives rise to a phenomenon called distortion (ie the output is not a perfect replica of the input).

Transistor Q2 is used as such an amplifier to increase the level of the signal voltage at the input. However although the voltage of the input signal has been increased transistor Q2 cannot supply sufficient power on its own to drive the speaker. Transistors Q3 and Q4 therefore are used to buffer the output of Q2 so that the speaker can be driven. (A buffer provides a voltage gain of slightly less than one. This provides current gain, and therefore the signal power is increased but not its voltage level .

However, as we said before there is some distortion. To overcome this we take a portion (the level is reduced by R5 and R6) of the output signal back to transistor Q1, where it is compared to the input signal. If the two signals are not identical the transistor Q4 controls the transistor Q2 in such a way as to reduce the error, and hence this reduces the distortion.

The speaker is driven from the output of Q3 and Q4 via C5, which prevents the dc compartment of the output from appearing across the speaker. The resistor R7 provides the load for transistor Q2. This resistor (R7) is returned to the top of the speaker so that a more constant voltage appears across it as the output swings up and down. Doing this helps transistor Q4 handle the negative signal swings and also increases the gain of transistor Q2.

Resistor R8 is used to set up the bias voltages for Q3 and Q4, as no current will flow until there is 0.55 volts between base and emitter of each transistor. This helps to reduce another form of distortion known as crossover distortion which occurs in stages made up of two transistors in the circuit used for Q3 and Q4. Capacitor C4 is incorporated to prevent the possibility of high frequency oscillation.

The dc biasing of the amplifier (that is the dc operating point at the output) is set by the divider chain R1,R2 and R3 which sets about 5.6 volts at the base of Q1. Capacitor C2 prevents any variations in the supply rails from reaching the base of Q1. Transistor Q1 then acts as a comparator and maintains the voltage at its emitter at 0.55 volts less than that at its base. This sets the output voltage to about 4.75 volts on a nine volt supply.

The frequency response on the high frequency side is determined by the characteristics of the transistors themselves and is about 300 kHz. At the low end there are three RC networks which determine the response. The main one is output capacitor C5 together with the speaker resistance which gives a -3 dB point at about 200 Hz – quite adequate for small speakers. Increasing C5 to about 470 microfarad will extend the low end to about 50 Hz if required. The other networks are C3 with R5 (50 Hz), and C1 together with R3 in parallel with R2 at about 10 Hz.

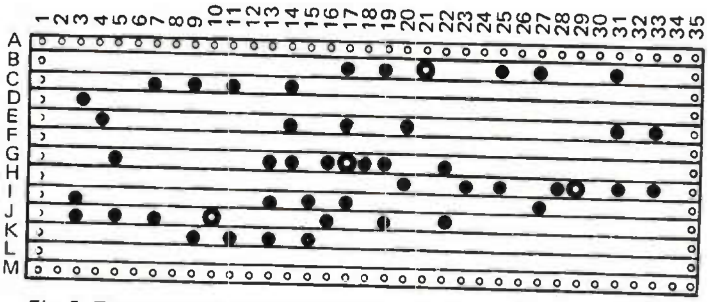
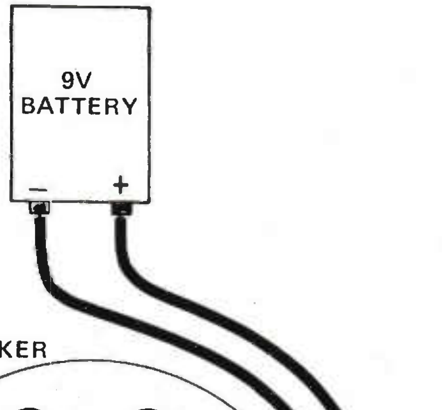


Fig. 3. The pads with holes through them indicate where the Veroboard track must be cut with a small drill as detailed in the text. The solid dots indicate where components are soldered to the tracks.



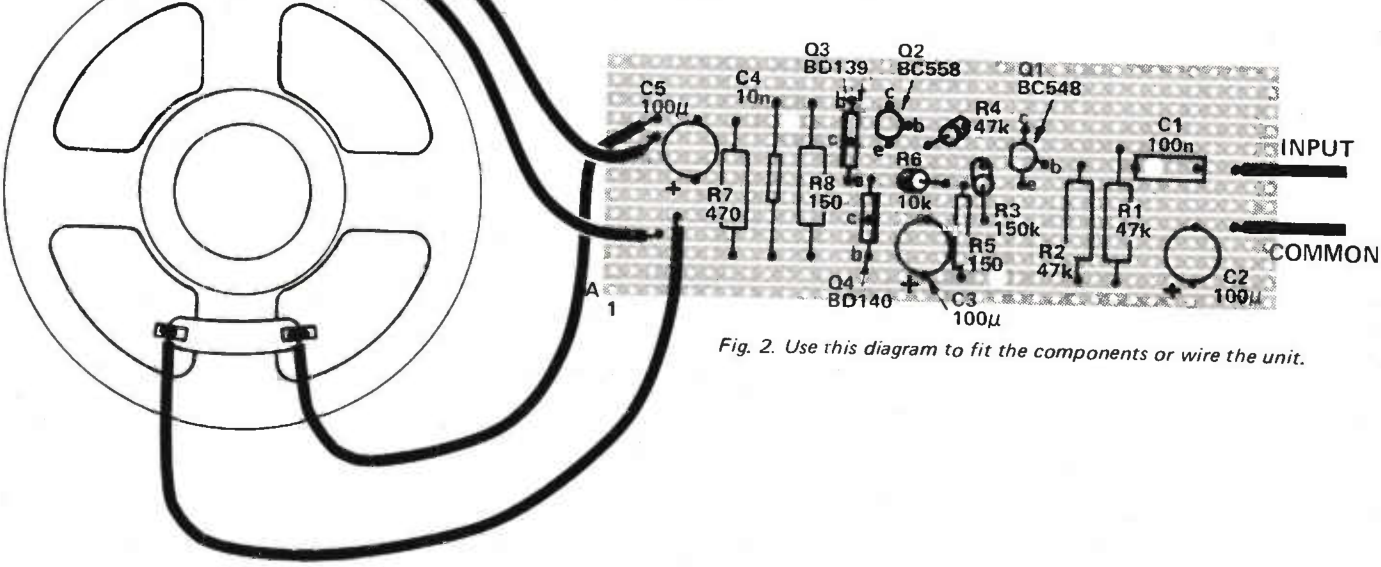
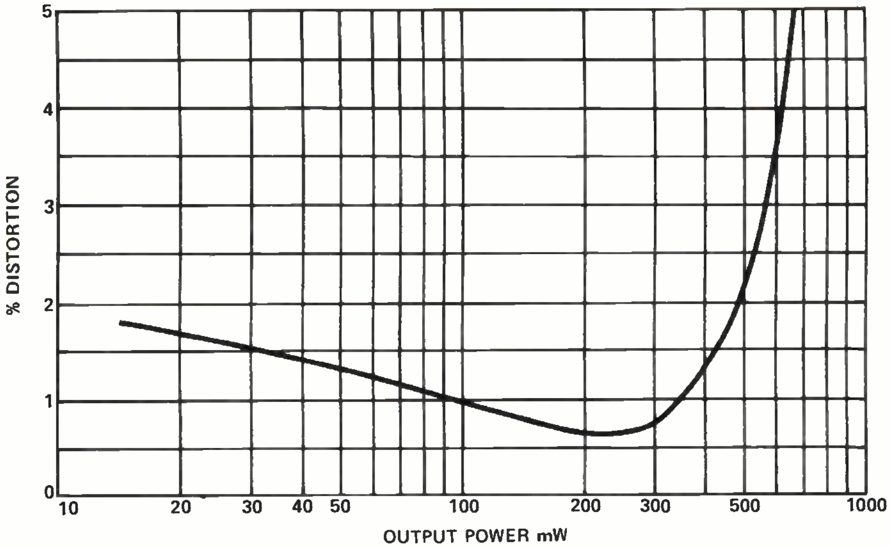


Fig. 2. Use this diagram to fit the components or wire the unit.



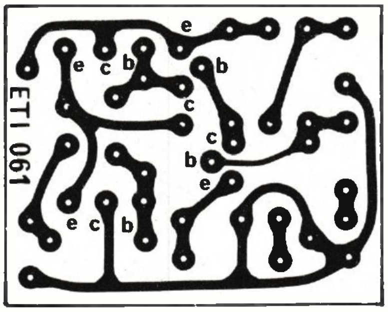
Graph showing relationship between distortion and power output.

Parts List ETI 061

R1,2	Resistors	47 k ½w 5%
R3	Resistor	150 k ½w 5%
R4	Resistor	47 k ½w 5%
R5	Resistor	150 ½w 5%
R6	Resistor	10 k ½w 5%
R7	Resistor	470 ½w 5%
R8	Resistor	150 ½w 5%
C1	Capacitor	100 nF polyester
C2,3	Capacitors	100µF 16V electro
C4	Capacitor	10 nF polyester
C5	Capacitor	100µF 16V electro
Q1	Transistor	BC548
Q2	Transistor	BC558
Q3	Transistor	BD139
Q4	Transistor	BD140

Speaker 8-16 ohm
9V Battery
Battery clip
1.2" x 3.2" Veroboard 0.1" or
PC Board ETI 061

Fig. 4. Printed-circuit board layout (copper side). Full size of this board is 40mm x 50mm.



on the side of the capacitor adjacent to the negative lead. On the overlay the positive lead of the capacitor is indicated by a '+' sign. Make sure that the polarities are matched up.

The pin connections of the transistors are also given and these must be carefully checked so that they are inserted the right way round. Note that the BD139 and BD140 transistors have a metal surface on one side but are otherwise symmetrically shaped. Make sure that this surface is pointing the correct way otherwise the pin connections will be wrong.

Solder the components into position using a light-weight soldering iron, being careful not to get bridges of solder between adjacent tracks (specially with the Veroboard).

Finally connect the battery clip and the leads to the speaker. The red lead of the battery clip is the positive lead and should be connected to the positive connection on the amplifier. Polarity of the leads to the speaker is unimportant.

Before connecting the battery do a thorough check to ensure that all components are in the right position and are correctly orientated and that all solder joints are sound and there are no solder bridges.

If a small battery is used, eg the Eveready 216, a 100 microfarad 16 volt electrolytic capacitor should be connected across the terminals of the battery to lower its effective impedance. This allows a higher output power before signal clipping occurs in the amplifier.

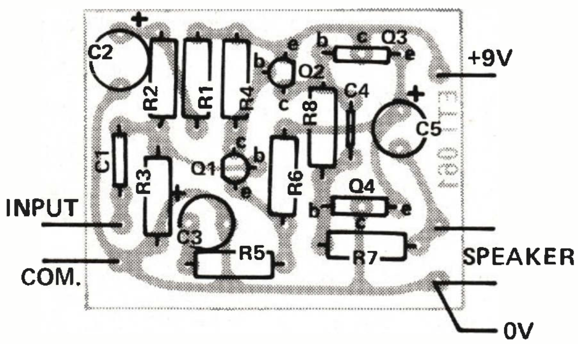
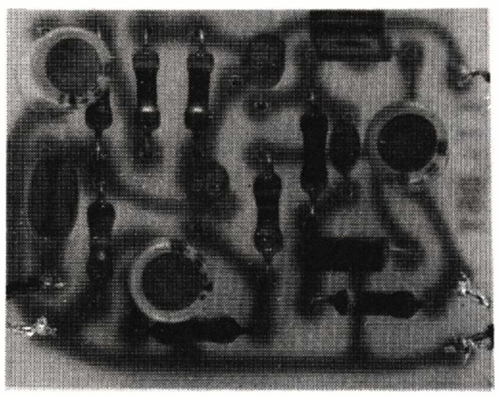


Fig. 5. This overlay shows how to fit components to the printed-circuit board.



KITS FOR ETI PROJECTS

We get many enquiries from readers wanting to know where they can get kits for the projects we publish. The list below indicates the suppliers we know about and the kits they do. These kits include hardware as well as electronic components. There are many suppliers who can provide you with all the electronics for a project (companies like Techniparts in Brisbane) so it is not necessary to buy a kit provided you can find a suitable case etc.

Any companies who want to be included in this list should phone Steve Braidwood on 33-4282.

Key to the companies:

- **A** Applied Technology Pty. Ltd. of Hornsby, NSW.
- **D** Dick Smith Pty. Ltd. of Crows Nest, NSW.
- **E** E.D. & E. Sales, Victoria.
- **J** Jaycar Pty. Ltd. of Haymarket, NSW.
- **N** Nebula Electronics Pty. Ltd. of Rushcutters Bay, NSW.

ETI 101	Logic Power Supply	E
ETI 102	Audio Signal Generator	E,D
ETI 103	Logic Probe	E
ETI 107	Widerange Voltmeter	E
ETI 108	Decade Resistance Box	E
ETI 109	Digital Frequency Meter	E
ETI 111	IC Power Supply	E
ETI 112	Audio Attenuator	E
ETI 113	7-Input Thermocouple Meter	E
ETI 116	Impedance Meter	E
ETI 117	Digital Voltmeter	E,A
ETI 118	Simple Frequency Counter	E,A
ETI 119	5V switching regulator supply	E
ETI 120	Logic Probe	E
ETI 121	Logic Pulser	E
ETI 122	Logic Tester	E
ETI 123	CMOS Tester	E
ETI 124	Tone Burst Generator	E
ETI 128	Audio Millivoltmeter	E
ETI 129	RF Signal Generator	E
ETI 131	General Purpose power supply	E,N
ETI 206	Metronome	E
ETI 218	Monophonic Organ	E,D
ETI 219	Siren	E
ETI 220	Siren	E
ETI 222	Transistor Tester	E
ETI 232	Courtesy Light Extender	E
ETI 234	Simple Intercom	E
ETI 236	Code Practice Oscillator	E
ETI 239	Breakdown Beacon	E
ETI 301	Vari-Wiper	E
ETI 302	Tacho Dwell	E
ETI 303	Brake-light Warning	E
ETI 309	Battery Charger	E
ETI 312	CDI Electronic Ignition	E
ETI 313	Car Alarm	E,D
ETI 401	Audio Mixer FET Four Input	E
ETI 403	Guitar Sound Unit	E
ETI 406	One Transistor Receiver	E
ETI 407	Bass Amp	E
ETI 408	Spring Reverb. Unit	E
ETI 410	Super Stereo	E
ETI 412	Music Calibrator	E
ETI 413	100 Watt Guitar Amp	E,J
ETI 413	x 2 200 Watt Bridge Amp	E
ETI 414	Master Mixer	E,J
ETI 414	Stage Mixer	E
ETI 416	25 Watt Amplifier	E
ETI 417	Amp Overload Indicator	E
ETI 419	Guitar Amp Pre-Amp	E,D
ETI 420	Four-channel Amplifier	E
ETi 420E	SQ Decoder	E
ETI 422	International Stereo Amp	E
ETI 422B	Booster Amp	E
ETI 422	50 Watt Power Module	E,D
ETI 423	Add-On Decoder Amp	E
ETI 424	Spring Reverberation Unit	E
ETI 425	Integrated Audio System	E
ETI 426	Rumble Filter	E
ETI 427	Graphic Equaliser	E,J
ETI 430	Microphone Line Amp	E
ETI 433	Active Crossover	E,J
ETI 435	Crossover Amp	E,J
ETI 436	Dynamic Noise Filter	E
ETI 438	Audio Level Meter	E
ETI 440	Simple 25 Watt Amp	E
ETI 441	Audio Noise Generator	E
ETI 443	Compressor-Expander	E,J
ETI 444	Five Watt Stereo	E,N
ETI 445	Preamp	E,N,D
ETI 446	Phaser	E,J
ETI 447	Audio Limiter	E,N
ETI 502	Emergency Flasher	E
ETI 503	Burglar Alarm	E
ETI 505	Strobe	E,D
ETI 506	Infra-Red Alarm	E
ETI 509	50-Day Timer	E
ETI 512	Photographic Timer	E
ETI 513	Tape Slide/Synchroniser	E
ETI 514	Flash Unit — Sound Operated	E
ETI 515	Flash Unit — Light Operated	E
ETI 518	Light Beam Alarm	E
ETI 522	Photographic Timer	E
ETI 523	Sweep Generator	E
ETI 525	Drill Speed Controller	E
ETI 526	Printimer	E
ETI 527	Touch Control Light Dimmer	E
ETI 528	Home Burglar Alarm	E
ETI 529	Electronic Poker Machine	E
ETi 533	Digital Display	E,A
ETI 534	Calculator Stopwatch	A,D
ETI 539	Touch Switch	E
ETI 540	Universal Timer	E
ETI 541	Train Controller	E
ETI 601		
4600	Synthesiser	J
3600	Synthesiser	J
ETI 602	Mini Organ	E,A,D
ETI 701	TV Masthead Amplifier	E,D
ETI 702	Radar Intruder Alarm	D
ETI 703	Antenna Matching Unit	E
ETI 704	Crosshatch/Dot Generator	A,D,E
ETI 706	Marker Generator	E
ETI 707	Modern Solid State Converters	E
ETI 740	FM Tuner	A
ETI 708	Active Antenna	E
ETI 710	2 metre Booster	E
ETI 780	Novice Transmitter	E

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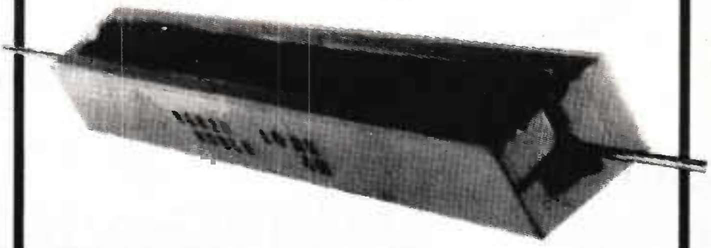

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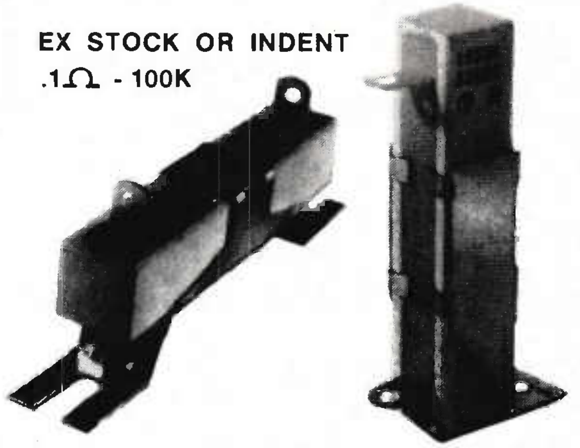

TECHNICAL LITERATURE AVAILABLE ON REQUEST

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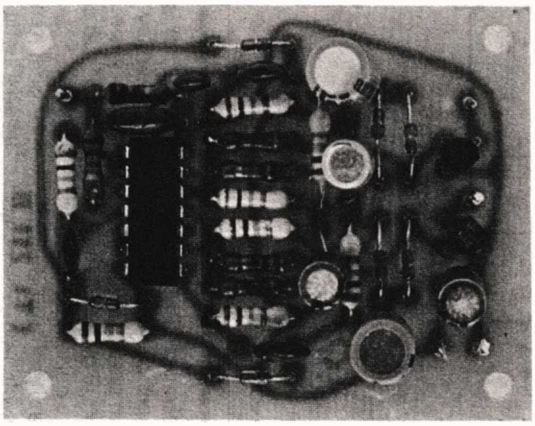
SOANAR GROUP

REMOTE CONTROL

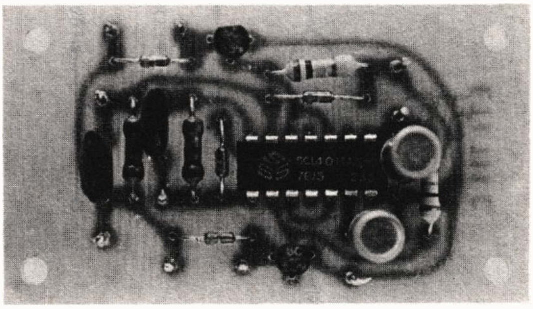
The fourth and final part of our 8-channel remote switch system. Having described the transmitter and receiver sections we now look at the receiver power supply and the relay drive circuits.

IN THIS FINAL ARTICLE ON THE Remote Switch' unit we describe the remaining sections of the receiver — the power supply and the relay drive circuits. There are two versions of the relay drive circuitry, the first (called 'Single Control') is used where a command on one channel is used to perform two different functions, on alternate commands. For example, when controlling a motor the first command on the channel causes the motor to go one way and a second command **(on the same channel)** causes the motor to reverse.

The second relay system (called 'Double Control') uses a command on one channel to switch a device 'on' and a second command **on a different channel** to switch the device off. The first system thus gives 'on' and 'off' by successive presses of a single button, whilst the second system uses separate buttons for 'on' and 'off'.



Finished printed-circuit board for the single-control driver.



Completed double-control relay driver.

Construction

The receiver and decoder are best built into a metal box together with the power supply. As there are only a few components in the power supply these are mounted onto a tag strip.

The relays will normally be operated remotely and it is therefore necessary to terminate the outputs of the decoder in a terminal block on the rear of the unit. The '0' volt and +12 volts should also be made available on this terminal block for use by the relay circuits.

The relay-drive units will normally be mounted close to the device being controlled and possibly housed in a small box attached directly to the controlled motor, etc. For this reason constructional requirements will vary greatly depending on the application and hence it is pointless for us to try to give housing details for these. Housing of the relay-drive boards is therefore left up to the constructor.

To connect the relay-drive units the '0' volt and +12 volt lines and the appropriate control channel lines from the decoder must be connected to the relay circuits using wiring which will not cause too much voltage drop. The voltage drop will depend on the length of line and on the size of the relay being used. If a number of relays are being used in the same location the power supply to them may be commoned to save wiring costs.

REMOTE CONTROL

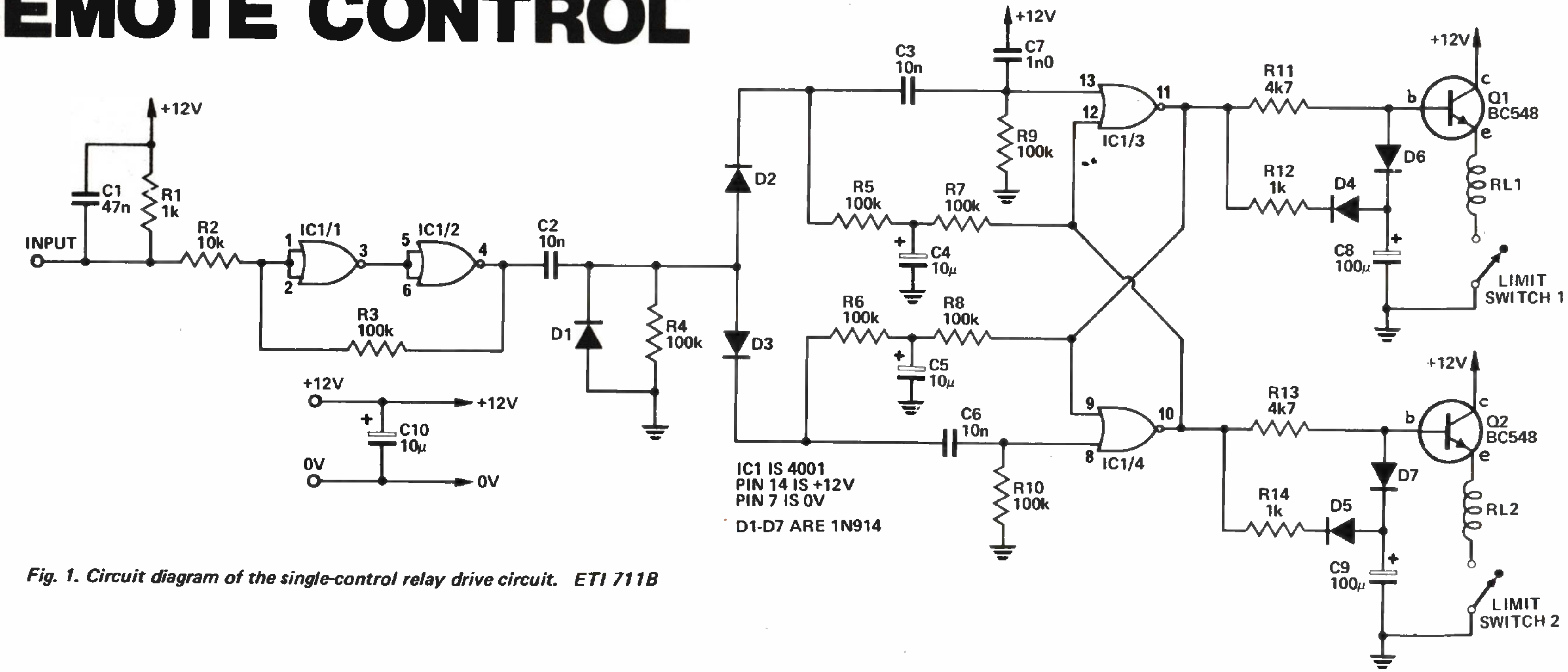


Fig. 1. Circuit diagram of the single-control relay drive circuit. ETI 711B

HOW IT WORKS — ETI 711

Single-Control Relay-drive Circuitry

By referring to the decoder circuit it may be seen that the output of the decoder is by a transistor with an open-circuit collector. The load for this transistor is resistor R1 which is bypassed by C1 to eliminate any possibility of signal pick-up which could occur with long leads. With a single press of the command button up to three pulses may appear at the input in a 100 millisecond period. These pulses are squared up by the schmitt trigger, formed by two sections of IC1, the output of which is differentiated by C2 and R4.

The other two sections of IC1 are connected as a flip-flop which has a steering network to ensure that it acts as a toggle. Capacitors C4 and C5 slow down the toggle rate so that the multiple input pulses do not trigger the flip-flop more than once in the one 100 millisecond period. Capacitor C7 is connected from plus twelve volts to pin 13 of IC1/3. This capacitor, at switch-on, feeds a pulse into IC1/3 thus ensuring that its output is always low after initial switch-on. The relays are driven by transistors Q1 and Q2 which are connected as emitter followers. An initial delay on switch-on occurs due to the action of capacitors C8 and C9. These capacitors are, however, isolated on switch-off by the action of diodes D6 and D7. After switch-off the capacitors are discharged by R12,D4 and R14,D5 to ensure that the full delay occurs when next switched on. The delay of about one second ensures that when reversing a motor some time is allowed for the motor to stop before it receives reverse drive.

If a light globe (or other device where only simple on/off operation is required) is being operated, only a single relay and its associated drive circuitry is required (Q1 and RL1). R12,D4,D6 and C8 may also be omitted.

If using motors limit-switches will invariably be required and these are simply connected in series with the relay coils.

Double-Control Relay Circuitry

This is a simpler circuit than that of the single-control unit and consists of two separate flip-flops which each drives a relay via a buffer transistor.

For the control of drive motors a stop position must be incorporated between the two different direction commands. With this circuit, when the motor is travelling in one direction and a reverse command is given before the motor has stopped, the motor will simply stop.

Another command must be given for the motor to reverse. However if the limit-switch is made, and the motor has already stopped — then only one command is required. Capacitors C3/4, resistors R3/4 and diodes D1/2 are incorporated to provide this action.

If lights or similar devices are being controlled this board may be used to control two separate units if required. This may be achieved by deleting C3, C4, R3,4 and D1,2 and by using input 1 and limit-switch 1 to control RL1 and input 2 and limit-switch 2 to control RL2.

Additional 1k resistors should be added from pins 6 and 8 to +12V to act as loads for the decoder.

Power Supply

This is simply a full-wave rectified and filtered power supply which provides 12 volts for the relays and 9 volts, via a further RC network, for the receiver and decoder boards.

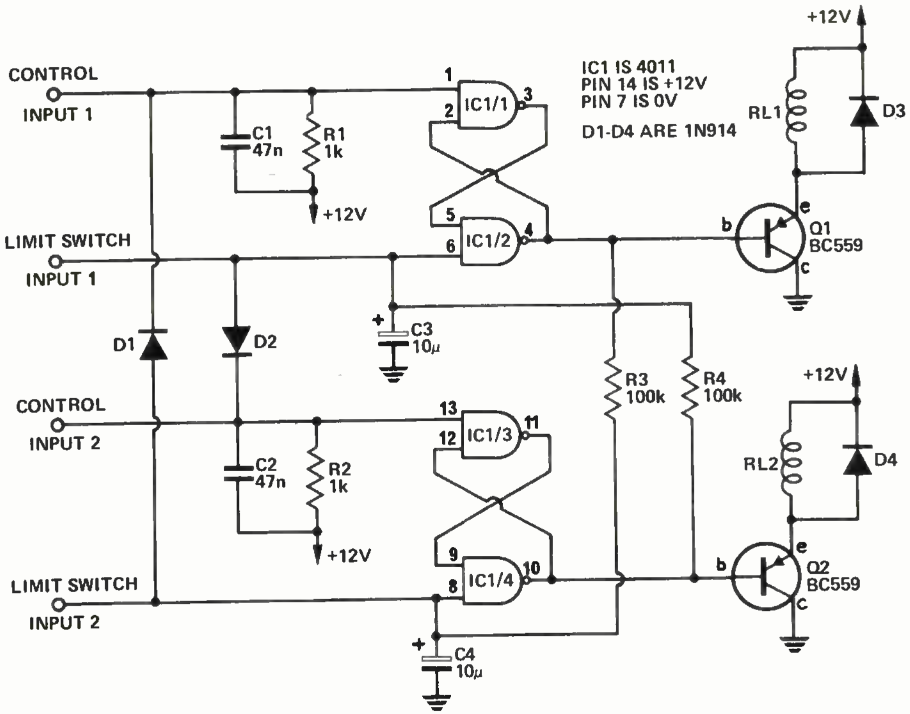


Fig. 2. Circuit diagram of the double-control relay drive circuit. ETI 711C

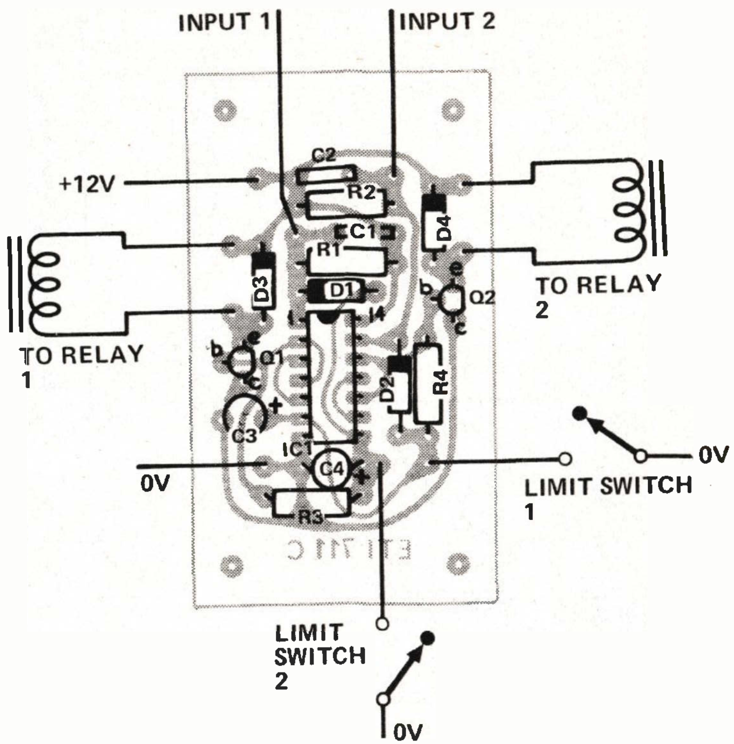


Fig. 4. Component overlay and interconnection diagram for the double-control relay driver.

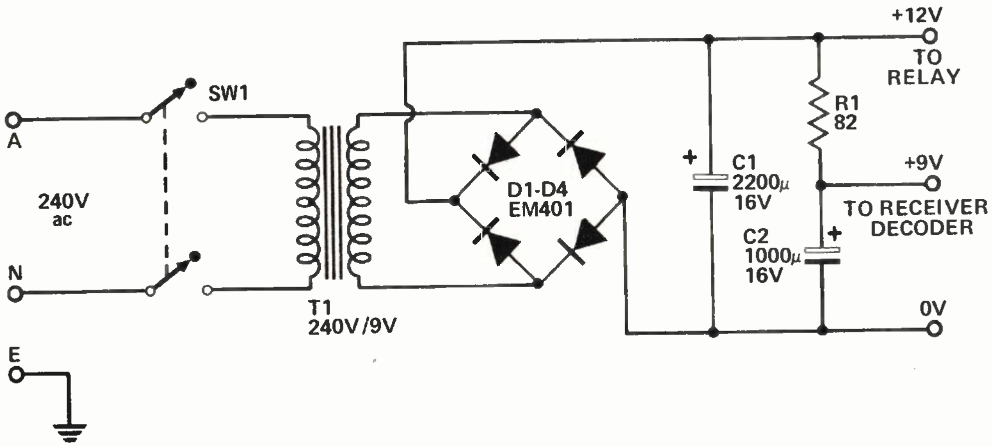


Fig. 3. Circuit diagram of the power supply for the complete receiver decoder. ETI 711P

Parts List ETI 711 B

Resistors all ½w 5%		C7	1n0 polyester
R1	1 k	C8,9	100 µ 16 V electro
R2	10 k	C10	10 µ 16 V electro
R3-R10	100 k		
R11	4k7	**Semiconductors**	
R12	1 k	D1-D7	IN914
R13	4k7	Q1,2	BC548
R14	1 k	IC1	4001 (CMOS)
Capacitors			
C1	47 n polyester	PCB	ETI 711 B
C2,3	10 n polyester	RL1,2	Relays 12V coil 150 ohm or higher. Contacts to suit requirement.
C4,5	10 µ 16 V electro		
C6	10 n polyester		

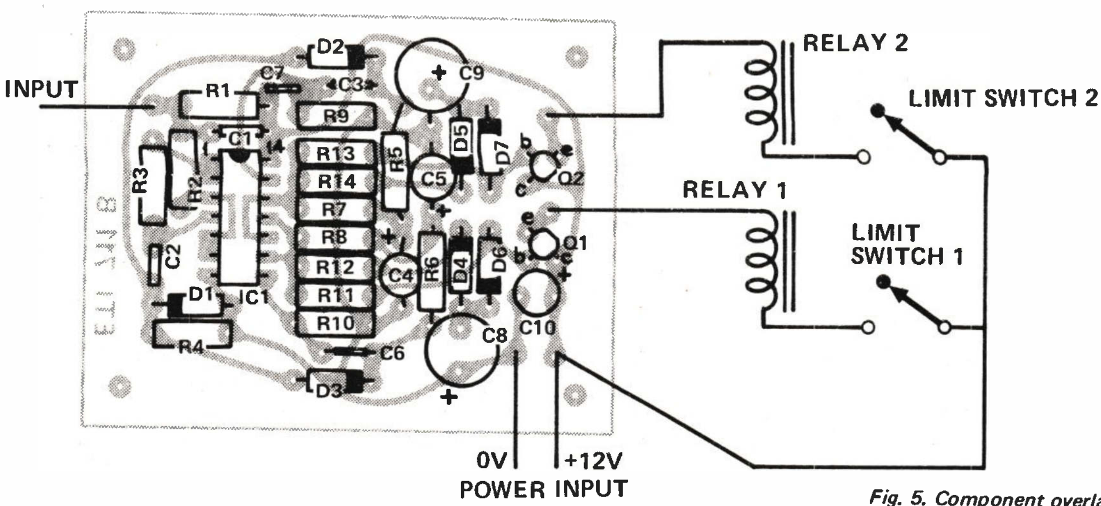


Fig. 5. Component overlay and interconnection diagram for the single-control relay driver. ETI 711B

Parts List ETI 711 C

Resistors all ½ w 5%

R1,2	1 k
R3,4	100 k

Capacitors

C1,2	47 n polyester
C3,4	10 µ 16 V electro

Semiconductors

D1-D4	IN914
Q1,2	BC559
IC1	4011 (CMOS)

PCB	ETI 711 C
RL1,2	Relays 12 V coil 150 ohm or higher. Contacts to suit requirement.

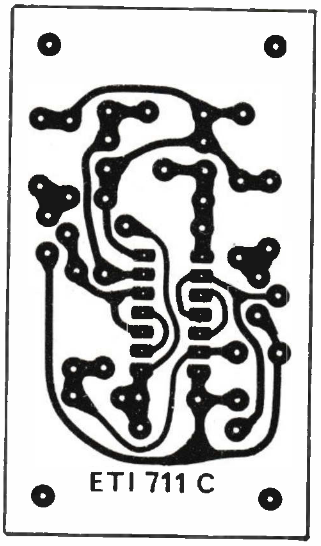


Fig. 6. Printed-circuit layout for the double-control relay driver.

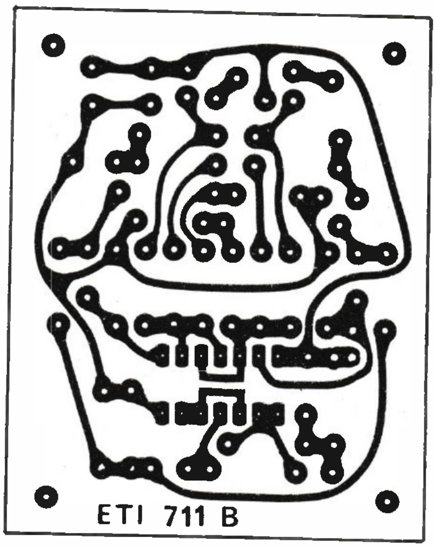


Fig. 7. Printed circuit layout for the single-control relay driver.

Parts List ETI 711 P

R1	Resistor	82 ohm 5% ½w
C1	Capacitor	2200 µF 16 V electro
C2	Capacitor	1000 µF 16 V electro
D1-D4	Diode	EM401 or similar
T1	Transformer	240 V/8.5-9.5 V DSE 2155 or similar

6 way tag strip

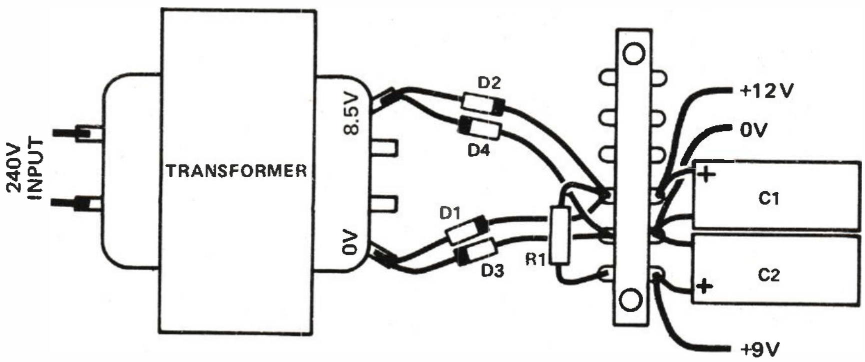


Fig. 8. Interconnection diagram for the power supply.

Beomaster 1900 – the beginning of a new chapter in the history of sound reproduction.

New high fidelity amplifiers are coming on the scene all the time. But this one will probably make all the really big Hi-Fi manufacturers wonder why it was Bang & Olufsen of Denmark and not themselves who came up with these remarkable ideas.

1. Newly developed electronic controls

The "Sensi-touch" electronic controls provide completely silent operation of volume and mode selections – no thuds, bumps or crackles as you switch from one to the other. Electronic control of primary functions guarantees there's no wear and tear whatsoever – provides greater reliability than traditional mechanical control systems – which, of course, rely on moving parts.

The principle behind the Bang & Olufsen system is that the finger acts as part of a condenser – the moment your finger touches the panel, the circuit is completed and the selected function activated. Only a light touch without force or movement is sufficient.

2. Totally electronic volume control = perfect volume regulation

The technology inside Beomaster 1900 is just as untraditional as the exterior. For instance, if a volume control needing only a light finger touch is required, a motor driven potentiometer or an electronic device can be used – B & O chose the latter.

This system – the most reliable in existence – is based on four photo resistors (called light dependent resistors – or LDRs) located around a light source controlling the adjustment of both channels. When you touch "volume up" the light given off is reduced and resistance (volume) increases – the opposite occurs when you "touch" the sound down.

A binary counting circuit triggers off to "count" as long as your finger is touching the panel. This ensures a smooth, precise regulation of volume.

Such simple operation requires less fiddling and adjustment – thus adding hours of extra listening pleasure.

3. FM reception – crystal clarity and less need for adjustments

The phase-lock loop stereo decoder (a new integrated circuit) replaces all the usual circuits and capacitors found in other receivers. It gives long term accuracy in stereo FM reception – less requirement for servicing – less need for adjustments. B & O's special muting circuit makes sure there's no tuning noise between stations. Four FM stations can be preset so their selection is then entirely electronic, and they are kept constantly in tune by the AFC control.

4. Beneath the sturdy aluminium lid, all secondary functions are easy to find!

- Apart from the pre-set FM stations, others can be selected with the manual tuning "spinner".
- A "loudness" function emphasizes the frequency ranges you would normally miss when playing at a low volume.
- Treble, Bass and Balance are adjusted by means of large sliding potentiometers – any adjustments are instantly indicated on the light-panel so that you always know what's happening.

Even in this area of "secondary function" there's no "flick, click, twist or tug" – just gentle "slide", "roll" or "spin" movements make all adjustments with absolute precision.

5. "Pre-set" volume adjustment – another unique feature

This device, which can be preset to "High, Medium or Low", makes sure the initial volume level will be the same whenever you turn the set on, no matter what the volume was the last time you turned it off. No other stereo amplifier offers practical convenience like this!

6. A computer test-bed "monitors" Beomaster 1900 for 48 hours

Every function of Beomaster 1900 has been calibrated and adjusted on a computer test-bed.

The computer successively measured 178 functions. When this is completed, the 1900 enters a testing station where power load is alternated between full output and zero for 48 hours. Sophisticated testing like this is why the Beomaster 1900 is always ready to give the performance you would expect from such advanced technology.

There are three kinds of people who will buy Beomaster 1900

Some will buy the Beomaster 1900 because it has the most sophisticated electronic control system available – so simple to operate and yet more reliable than "mechanical" amplifiers.

Others, however, will be impressed by its performance. The new FM tuning section with excellent receiving capacity combined with a powerful amplifier (2 x 30 watts RMS and less than 0.07% distortion at full power) provides the very best in sound quality.

The third type of B & O buyer will want a Beomaster 1900 as part of a completely matched audio system. Illustrated below is Beogram 1100 at $239; Beovox S45 loudspeakers at $398 a pair and Beomaster 1900 at $570

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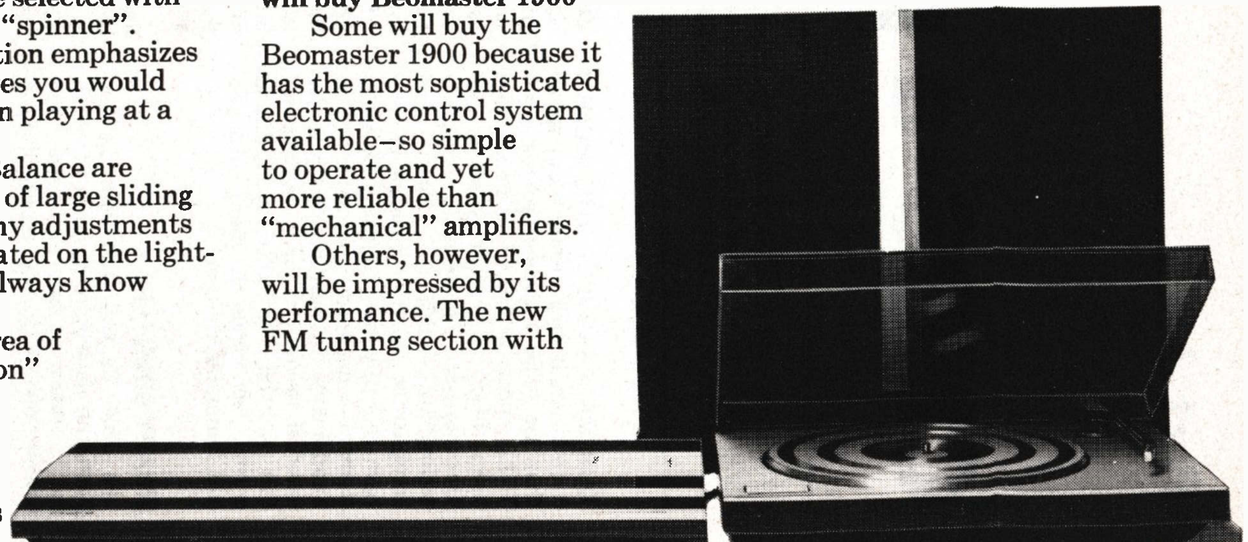


BO830

CMOS-a practical guide

Inherently rugged, CMOS logic has many advantages over other logic families — high noise immunity and uncritical power requirements are but two. This, the third article in this series deals with counters.

OUR MAIN SUBJECT THIS MONTH is counters. It might well be true to say that the range available (compared to TTL) reflects the advances which have been made in other branches of electronics, particularly display technology. BCD counters are conspicuous by their absence as they have generally been replaced by seven segment decoded counters. One disadvantage is a need in many cases for external drivers for LED displays but this will be eliminated when liquid crystal technology is more advanced and, hopefully, cheaper.

BINARY COUNTERS

As usual we will start with the less glamorous devices in the range which, in the present instance, are the straight-forward binary counters. First we should mention the general operating conditions required for all CMOS counters. The clock input rise and fall times should be less than 5 µs and the operating frequency limit is about 2.5 MHz at V_{dd} = 5 V rising to 5 MHz at 10 V. As far as the problem of drive current is concerned, it is advisable to consult the full data sheets for the device in question but it is reasonable to assume that no trouble is likely to be experienced if the requirement is less than 0.25 mA with a 5 V supply or 0.5 mA with 10 V.

Figure 1 gives the pin diagrams for CMOS seven, twelve and fourteen stage binary counters. The outputs are labelled B, with B_0 the most significant bit (i.e. giving greatest frequency division). It will be noted that three of the less significant bits are not available as outputs on the 4020A and this limits its usefullness in "divide by N" applications as we shall see later. The greatest division of the input frequency is 128 for the 4020A, 4096 for the 4040A and 16384 for the 4020A. In all cases the counters step on the negative transition of the clock pulse and the reset input sends all stages to logical zero independently of the clock when it is taken high. There is also a twenty-one stage counter (the 4045A) which produces two out-of-phase pulses at separate outputs for every 2097152 input pulses. It is intended for producing one second pulses from 2.097 152 MHz crystals for driving clock circuitry and similar applications.

While we are on the subject of major frequency division chains perhaps we should consider crystal oscillators very briefly. Fig. 2(a) shows one common set-up and it is worth noting that the configuration in Fig. 2(b) is the standard way of producing a simple analogue amplifier from a CMOS inverter.

DIVIDE BY N COUNTERS

There are times when it is required to divide a signal by other than some power of two and by using a 4024A or 4040A we may divided by any number from two to 128 and 4096 respectively, although extra components are required. Figure 3 shows two ways of achieving this end.

The circuit in (a) has the binary counter feeding a system of logic gates, the output of which goes high when the counter reaches N-1 (where N is the number the input frequency is to be divided by). This happens on the falling edge of the clock pulse because the counters are negative-edge triggered. On the next rising edge the flip-flop Q output goes low and when the clock goes low again the output goes high, generating a pulse of length equal to one half of the clock period which resets the counter. It is interesting to draw a timing diagram for this circuit and prove it works. It should be noted that although the actual output is a positive going pulse, a similar pulse of twice its length (i.e. one clock period) is available at the Q output of the 4013. A divide by 3600 counter which will provide one pulse an hour from a 1 Hz input is

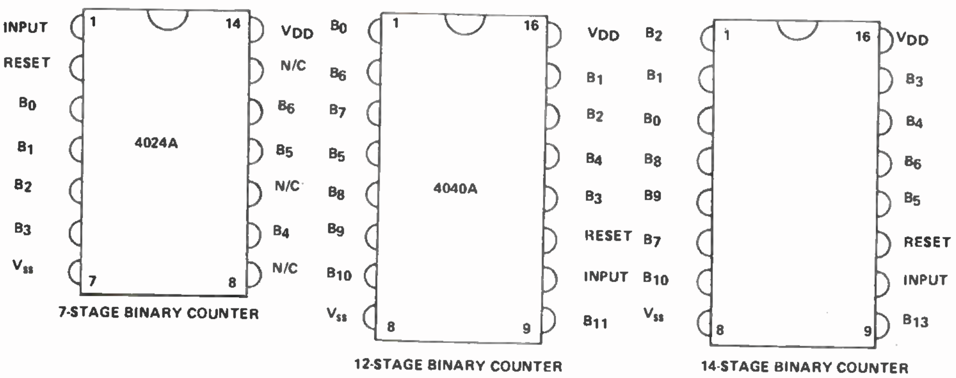
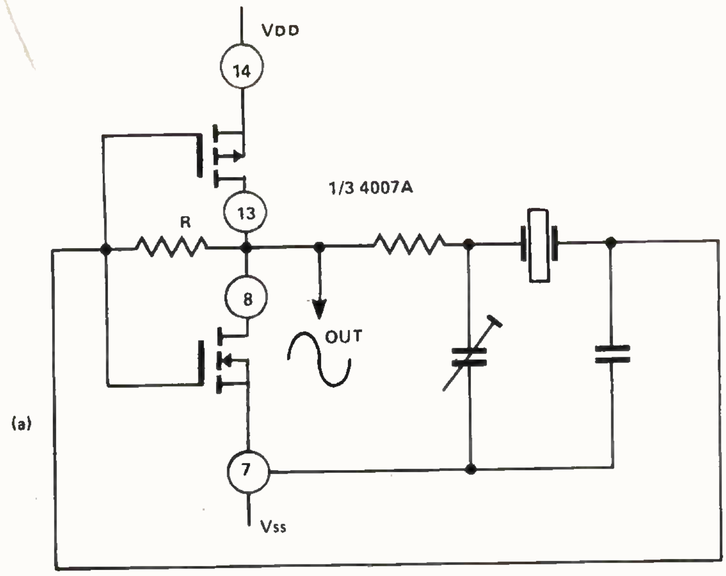


Fig. 1. Three CMOS binary counters.



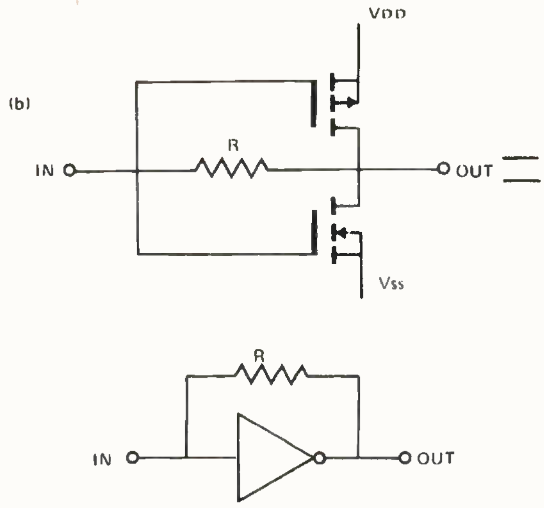


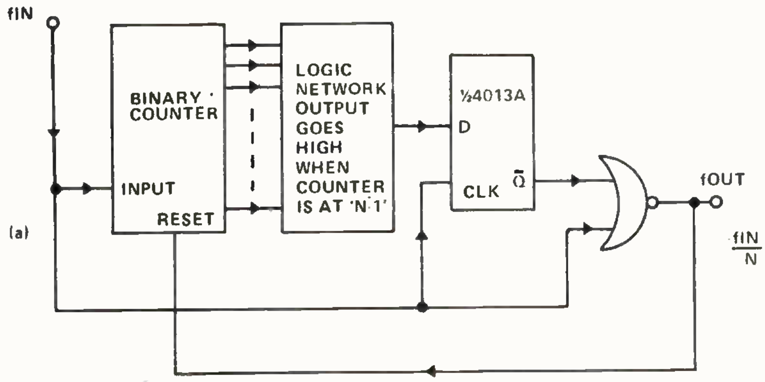
Fig. 2. (a) Basic crystal oscillator using CMOS for the active components.
(b) Simple analogue amplifier using a CMOS inverter.

shown in Fig.4 as an example of the technique.

The second mode has the advantage that the "N" count and not the "N–1" count is detected, but two logic networks are required; one to decide when the counter has reached "N" and another to identify the "all zeroes" state and reset the output. It is also a disadvantage in some applications that the counter spends a brief period in the "N" state. It is again interesting to draw a timing diagram and it is worth noting the cross-coupled NOR gates used as an R-S flip-flop. As an example a divide by twenty four counter is shown in Fig. 5 to produce one pulse per day from the one per hour output of Fig. 4 The circuit dissipation of both the counters would be very low (less than 1 mW) at this low operating frequency and the only note of caution to be sounded is that the counter and flip-flop should not both be triggered from the same edge of the clock pulse (i.e. one should be positive and the other negative edge-triggered).

A DECIMAL-DECODED DECADE COUNTER

All the old hands at TTL will doubtless be familiar with the 7490 decade counter and 74141 decimal decoder driver. The 4017A combines the count and decode functions in a single package but has the disadvantage of low output drive capability. Buffering the outputs with 4049A inverters will raise the available output to about five or ten milliamps at supply



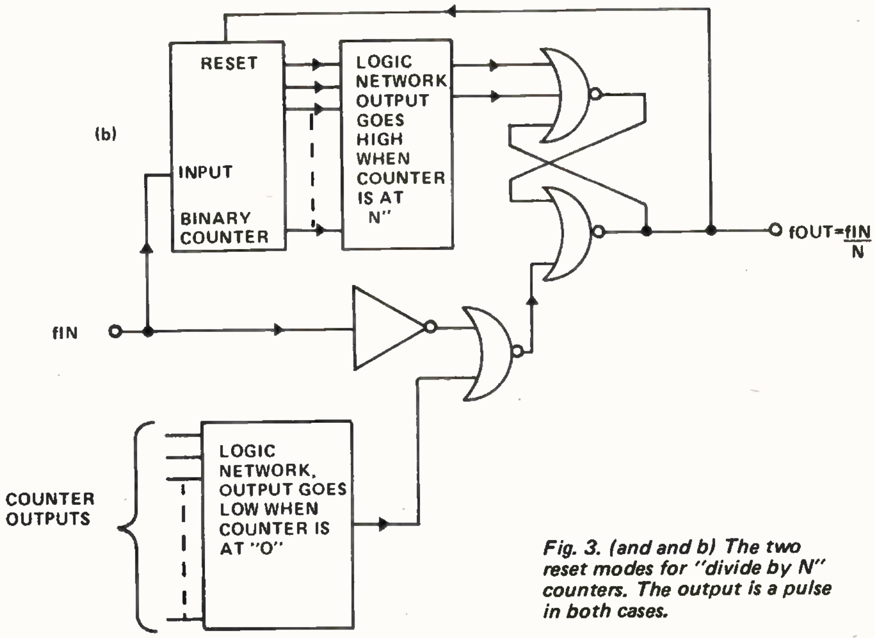


Fig. 3. (and and b) The two reset modes for "divide by N" counters. The output is a pulse in both cases.

CMOS-a practical guide

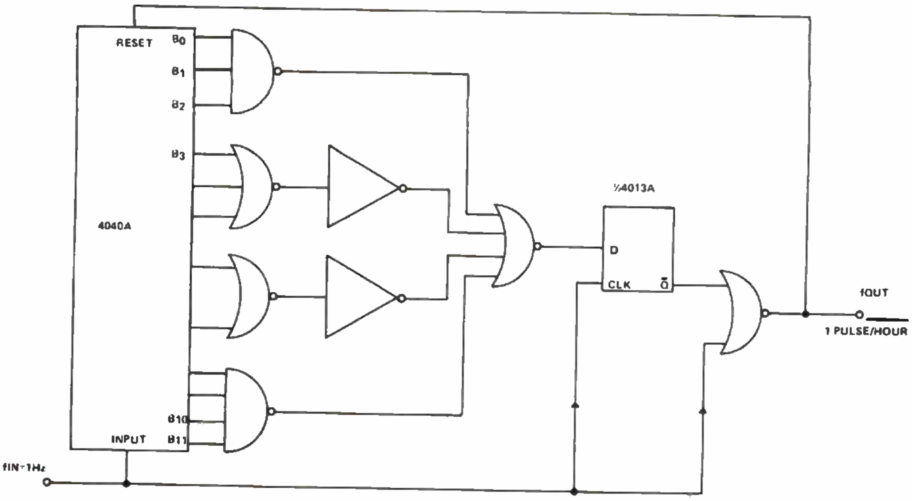


Fig. 4. A divide by 3600 counter using the first reset mode.

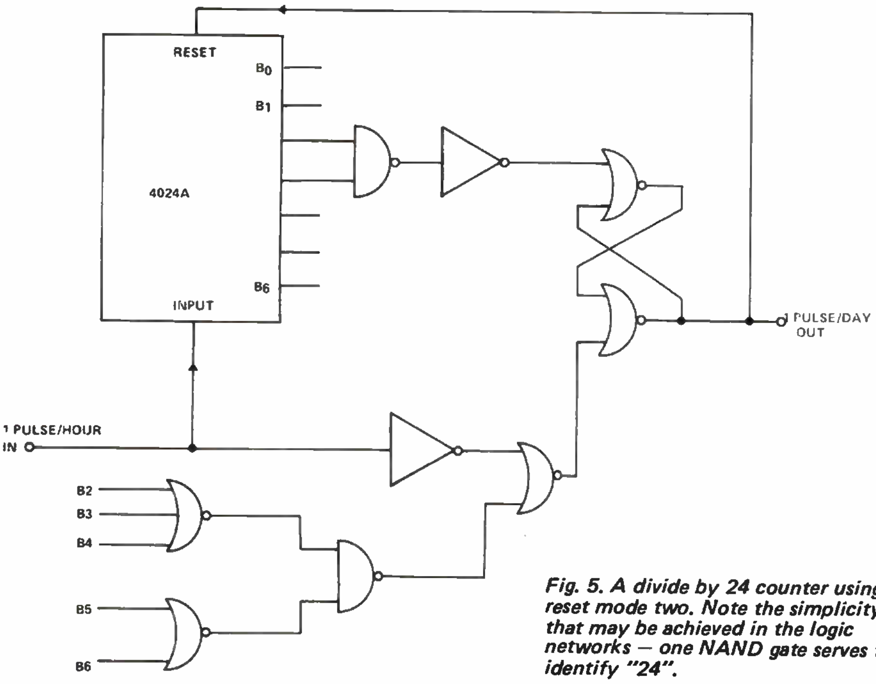


Fig. 5. A divide by 24 counter using reset mode two. Note the simplicity that may be achieved in the logic networks — one NAND gate serves to identify "24".

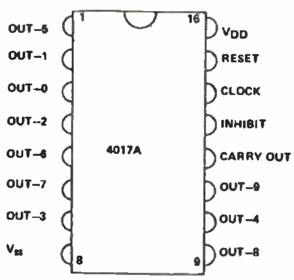


Fig. 6. Pin-out diagram of the 4017A decimally decoded decade counter.

voltages of five and ten volts respectively. The pin diagram is given in Fig. 6 and the counter advances one on the positive clock transition provided that the inhibit is held low. The reset operates asynchronously when taken high as usual. "Carry-out" may be used to clock the next stage in a multi-stage counter.

This device has fairly obvious applications in controlling switches in multiplying equipment as one and only one output is high at any one time. It is fairly clear also that we may extend the techniques of divide by N counters to cover these devices with the added bonus that they are switch programmable. Figure 7 shows this idea realised using reset mode two because of the ease of switching for N rather than N−1. This circuit has lost an inverter compared with Fig. 5b, this being the change necessary to adapt the circuit for counters and flip-flops which operate on the same clock transition. The sequence of counters could clearly be extended to any desired length and it is an interesting thought that seven of these counters (4017As) and the attendant gates could, when fed with a 1 Hz input generate pulses at any interval from two seconds to over three months! On a more practical note a most versatile digital frequency synthesiser would result if the circuit were used on a phase-locked loop configuration. Remember however that the output is a pulse and it would need squaring (one more flip-flop) before most phase comparators would accept it.

SEVEN SEGMENT DECODED COUNTERS

We mentioned earlier that CMOS IC design reflected the changes in display technology. Two particular examples of this phenomenon are the 4026A and 4033A decade counters with seven-segment outputs. The pin-out diagrams for these devices are shown in Fig. 8 and, as one might guess, the counters are identical, with the exception that the 4026A has a display enable function for use in multiplexing digits and an ungated C-segment output, whereas the 4033A has ripple blanking and a "lamp-test" facility. We shall consider the use of these special facilities when we have discussed the features common to both. The devices are positive edge triggered and advance only when the clock enable is low. The reset operates when taken high as usual and the segment outputs go high when they are active. Just as in the 4017A the signal at the "carry out" terminal may be used to clock the next stage in multi-decade applications.

In the same way as we have considered for other counters, the seven segment outputs may be identified by logic gates and the counters made to divide by any number. Figure 9 gives the information necessary and it should be noted that the "N−1 and flip-flop" method is used because the other method does not count through zero.

Now we will have to consider the

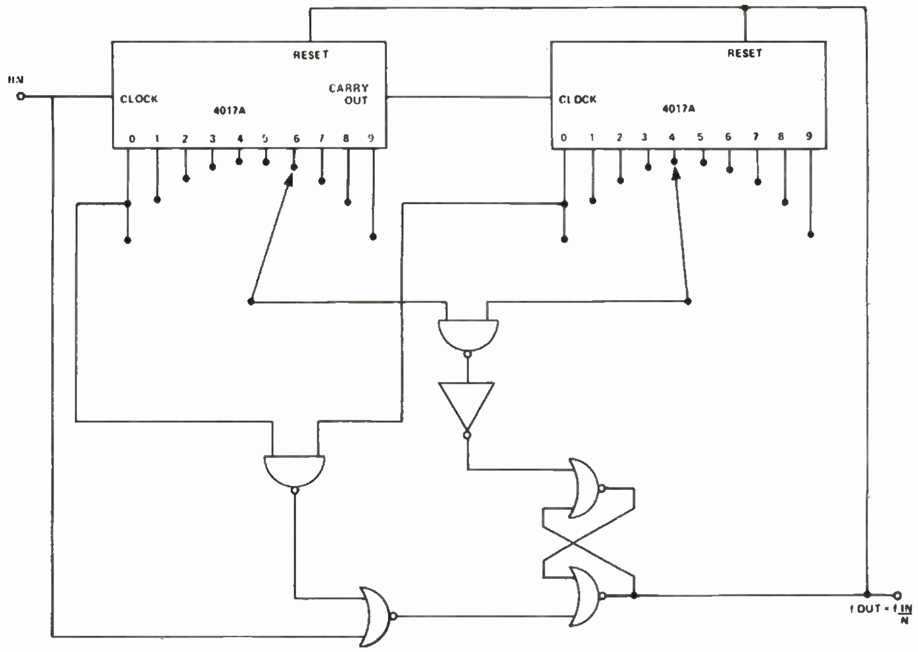


Fig. 7. A switch programmable divide by N counter for N = 2 to 99. Extension to higher N is obvious.

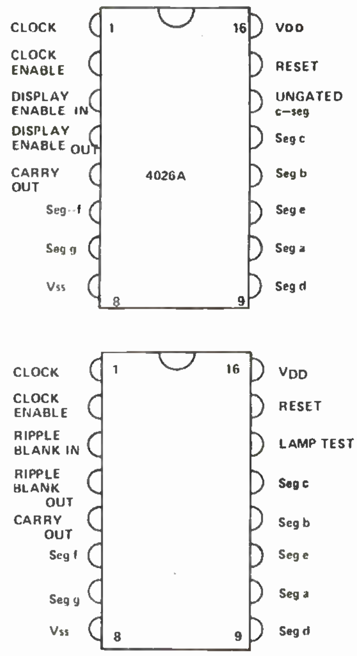
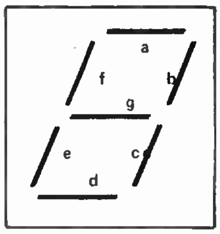
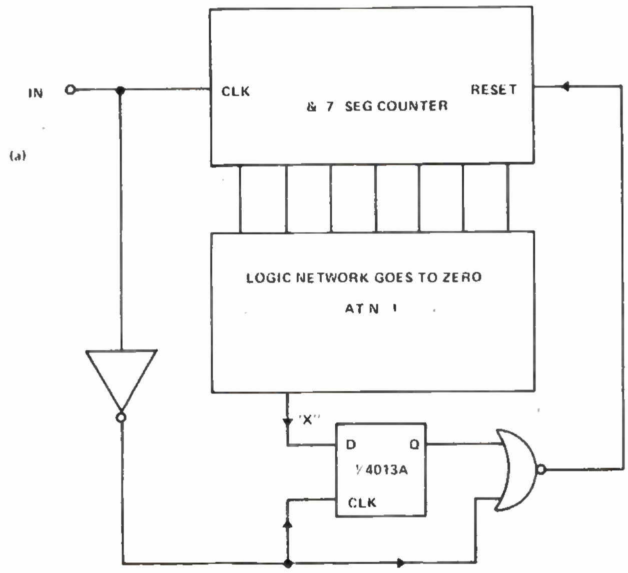


Fig. 8. Pin-out diagram for the 4026A and 4033A seven segment decoded decade counters. The labelling of the segments is also shown.





TO IDENTIFY	FOR COUNT OF	REQUIRED NETWORK
1	2	a seg → X
2	3	c seg → X
3	4	c seg, g seg → NAND → X
4	5	f seg, g seg → NAND → X
5	6	CARRY OUT → X
6	7	e seg, f seg, g seg → NAND → X
7	8	g seg, CARRY OUT → NAND → X
8	9	b seg, e seg, f seg, g seg → NAND → X

Fig. 9. (a) How to produce direct seven segment divide by N counters, (b) logic networks to identify each digit. The extension to a multi-decade version is simple.

CMOS-a practical guide

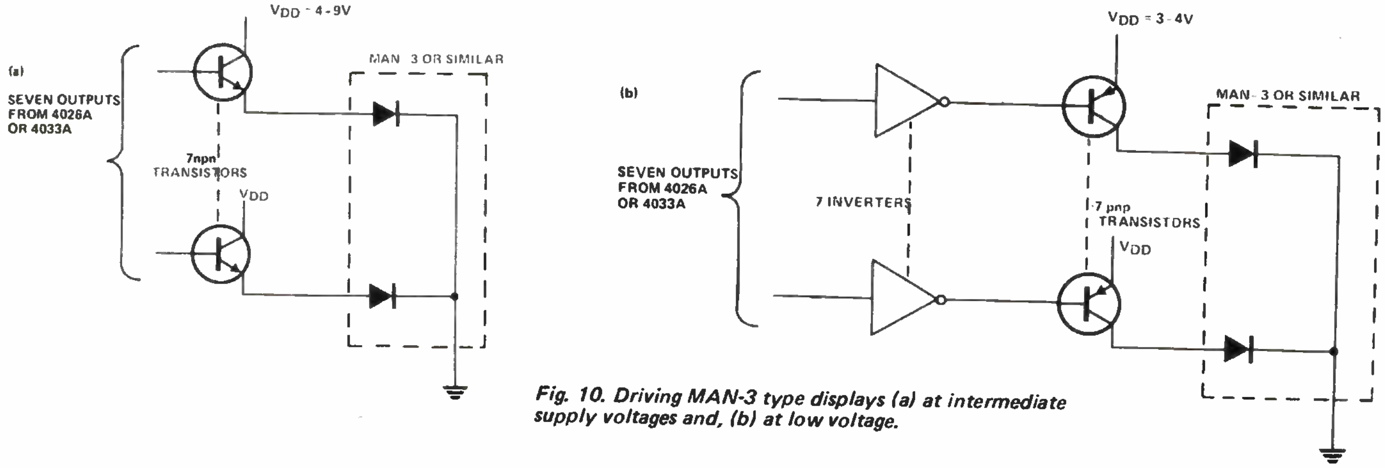


Fig. 10. Driving MAN-3 type displays (a) at intermediate supply voltages and, (b) at low voltage.

interfacing of displays with our seven-segment counters. LEDs like the MAN-3 which have a low current will interface directly with the outputs of the 4026A or 4033A and give a tolerable brightness with the available drive current (about 5 mA), provided that V_{dd} is more than 9 V. If we drop the voltage down to between 4 and 9 V transistors should be inserted, as shown in Fig. 10a, and if the supply drops even lower, the addition of inverting buffers is recommended. The seven transistors needed are generally the components of a single IC. Note also, the discussion on current limiting resistors to follow.

(to be continued).

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ELECTRONICS —it's easy!

PART 35

Chart recorders

IN GENERAL, chart recorders are designed to accept electrical voltage signals as these constitute the majority of signals produced by sensing equipment. Occasionally the chart recorder is more appropriately connected to a mechanical output without electrical signals being involved: in some circumstances there is no need for electrical circuitry.

Chart recorders are, therefore, electronic system units which accept a voltage signal converting it to an equivalent graphical representation on paper. The recorder can be put to use in any application where an electrical signal is produced. Examples are measurement of fluctuations of the power mains voltage, records of body currents in medical diagnosis and changes in temperature in a process plant. The earliest chart recorder was probably Lord Kelvin's 19th century paper-tape siphon-recorder used to record electric telegraph signals. Because of the large and varied demand for chart recorders, manufacturers have developed numerous alternatives. Figure 1 shows a number of recorders installed to monitor an oil rig.

In fundamental terms chart-recorders are electro-mechanical converters — electrical signals are changed into equivalent mechanical ones which are used to make a permanent record on a paper-chart. For this reason there are two aspects to a chart recorder — its mechanical design and its electrical design. For convenience we look at each more or less separately but in designing and operating the recorder the two are so closely related that the response depends on adjustment of both disciplines of thought.

Fig. 1. Chart recorders are used in many varied applications. The panels of this control room contain a number that are used by the operators to see how the process is behaving.

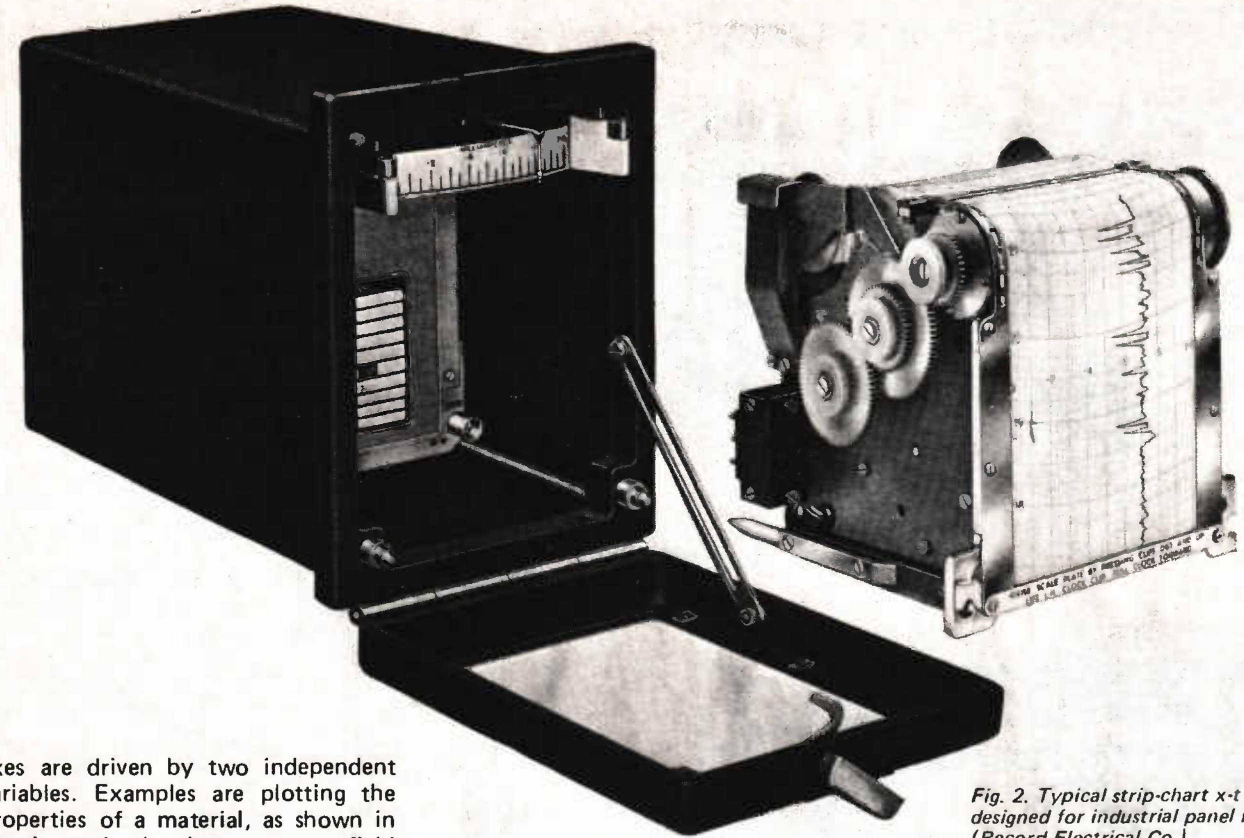
Chart Recorder Formats:— Chart recorders are designed to display a signal in a graphical form that is convenient to the user. There are two basic types: those which record one or more variables with respect to time (commonly called x-t recorders) and those which plot one variable against the other (x-y recorders).

Strip-chart:— In these recorders a continuous roll of suitably scaled paper is motor driven at constant speed past the marking head. The paper drive is usually driven by a synchronous or stepping motor as this ensures accurate paper-speed. Where mains supply is not available dc governed-motors and clockwork alternatives can be used. Chart speed changes are commonly obtained by altering gear ratios. Figure 2 shows the construction of a typical panel mounted strip-chart x-t recorder. The module shown withdrawn from the housing is the paper drive unit, the housing contains the electronic amplifier driving the pen which contacts the top of the paper when the drive unit is plugged in.

Strip chart recorders designed for bench top use are also common — Fig. 3. Some strip chart recorders take up the used paper by rolling it or by folding it in a concertina. The latter, known as z-fold, is very convenient when the need to refer to the record arises. Chart speeds vary widely — from metres per second in fast-writing recorders used to capture kilohertz bandwidth transients, down to millimetres per hour for industrial process and slow-scientific phenomenon recording. It is not usual, however, to find a range as wide as this in the one unit.

Process industry strip-chart recorders generally run at one speed only; units for scientific use usually have switched speed capability. The choice is decided by matching the resolution required with the amount of paper consumed.

Paper sheet:— The flat-bed style lends itself to x-y operations where the



axes are driven by two independent variables. Examples are plotting the properties of a material, as shown in Fig. 4, and charting antenna field strength versus position. In this style the recording paper is a single sheet which is attached to the platen. The pen moves both in the x and y directions. The paper may be held by clips or by electrostatic attraction. If the x axis input (horizontal) is fed with voltage that rises linearly with time (a ramp function) the x axis will move across the chart with time

Fig. 2. Typical strip-chart x-t recorder designed for industrial panel mounting. (Record Electrical Co.).

Fig. 4. Plotting an hysteresis curve for material under test in the large magnet shown at the rear.

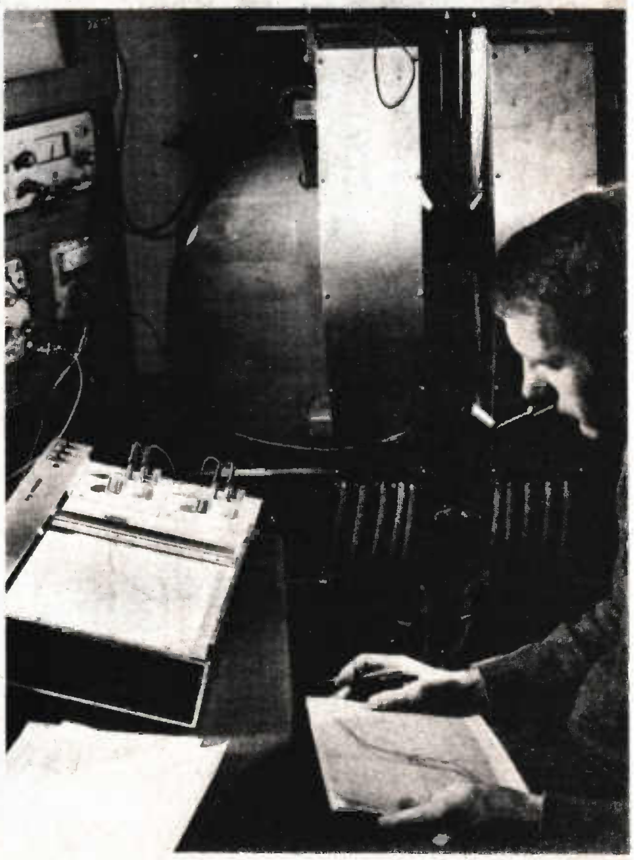
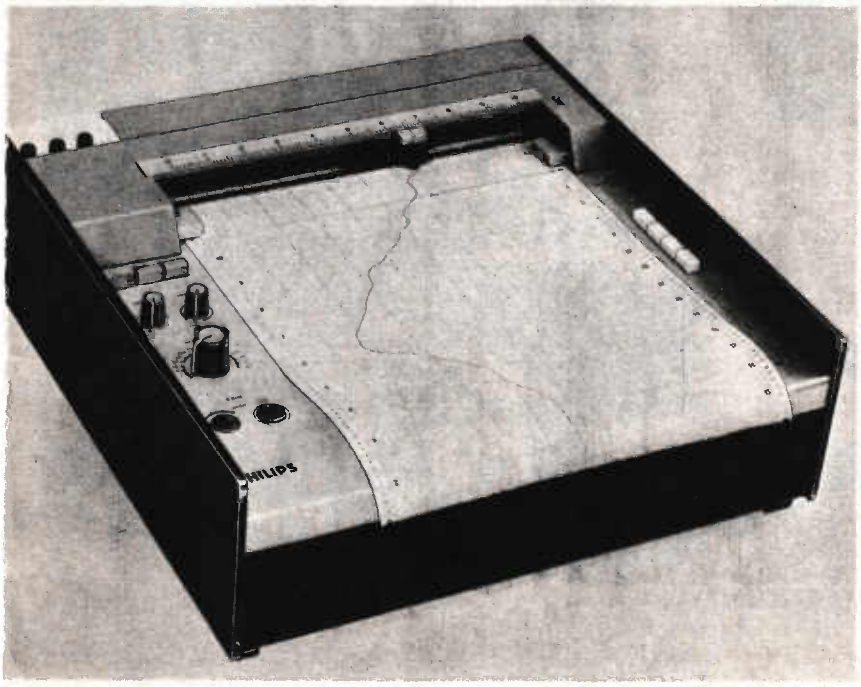


Fig. 3. Flat-bed strip-chart recorder (Philips).



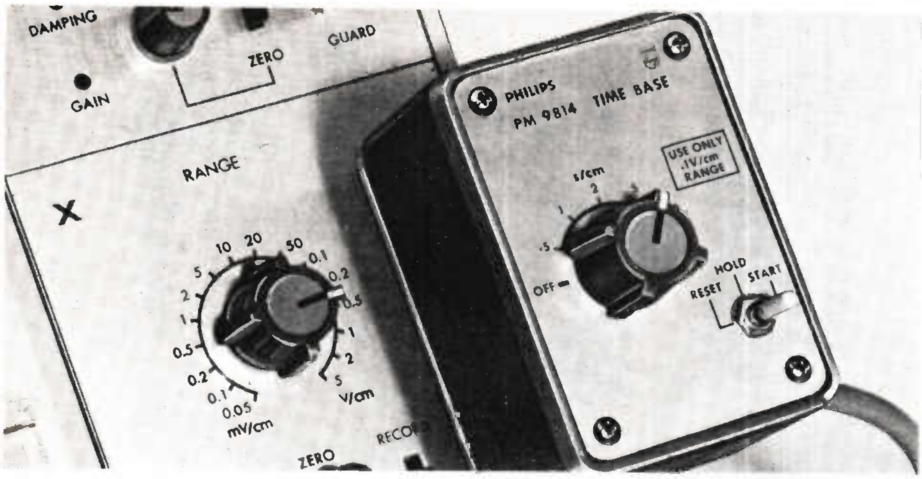


Fig. 5. Plug-in used to convert x-y flat bed recorder to x-t mode of operation.

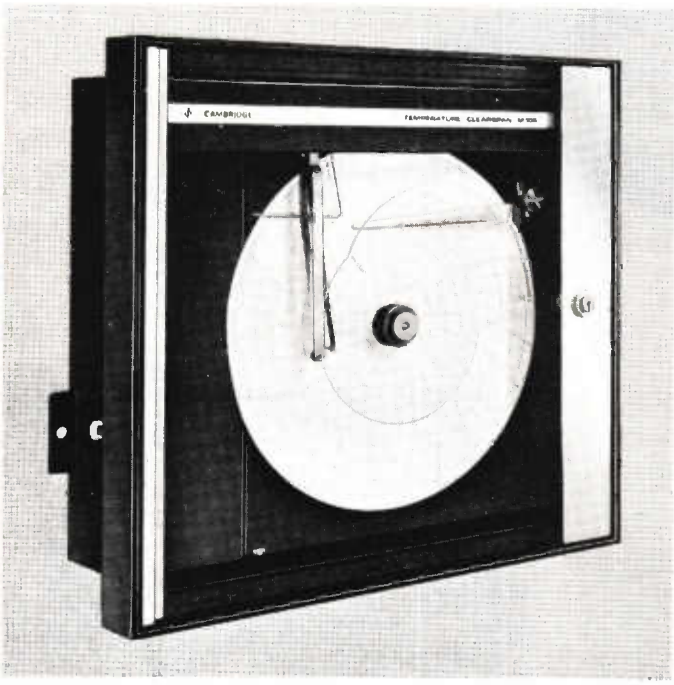


Fig. 6. Circular chart-recorder.

making the unit an x-t format recorder. Plug-ins generating appropriate ramps are often provided as an accessory — one is illustrated in Fig. 5.

Circular:— Where the Geometry of the measurement task is circular, such as recording out-of-roundness of a ground shaft, or where the measure has a cyclic time function, such as daily temperature changes, a circular form of chart is easier to use. The chart rotates under the marking device at a rotational velocity locked to the geometrical position or the appropriate sub-unit of time — hours, days, weeks and months. An example of a circular-chart recorder is given in Fig. 6.

The size of chart papers varies greatly from recorder to recorder. Strip charts are used from 50 mm width to around 800 mm with lengths as much as 150 m. The duration of the maximum record that can be taken on a roll is decided by the chart length and the chart speed. Flat bed units begin in paper size at about 200 by 300 mm ranging to huge computer-controlled automatic-draughting units with beds as much as 6 m x 4 m. Circular charts rarely exceed 300 mm diameter.

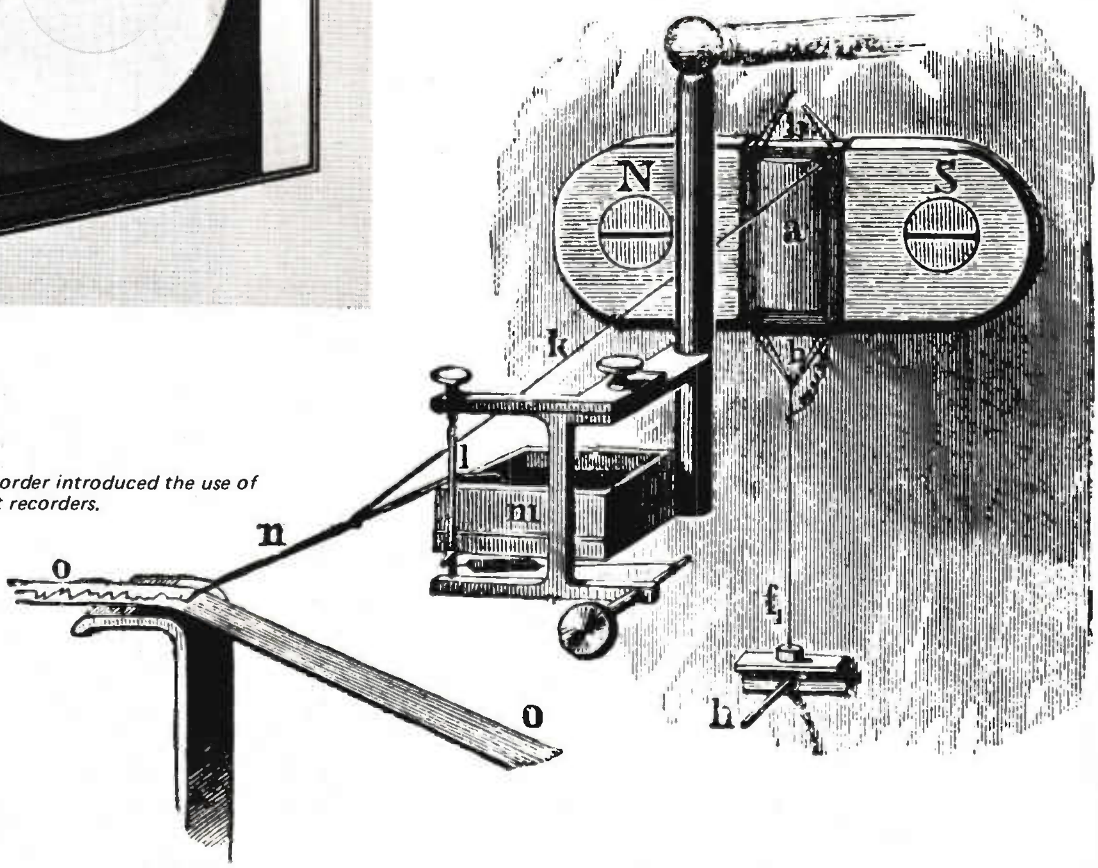
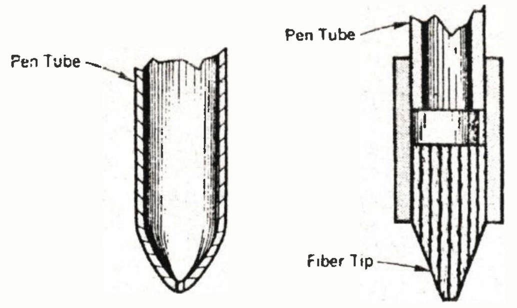


Fig. 7. Kelvin's 1873 siphon recorder introduced the use of continuous ink marking in chart recorders.



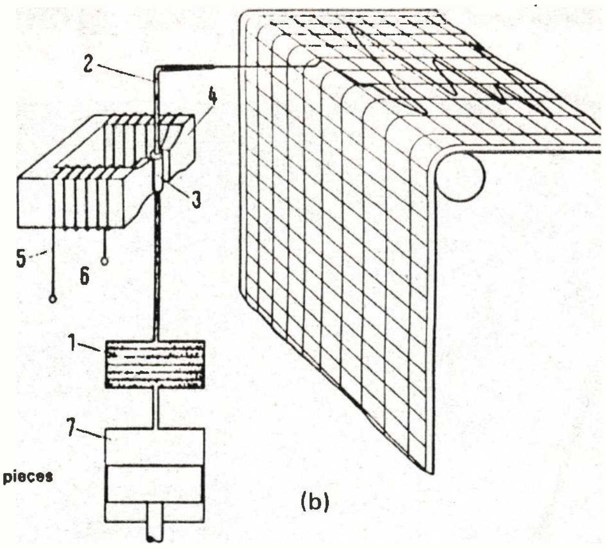


Fig. 8 (a). Capillary action ink pens.
(b) Schematic of pressurized ink recorder (Siemens).

Supply of chart papers can be difficult at times because stockists find difficulty in holding large stocks of the numerous options available. It is wise for the operator to hold a generous supply in hand at all times.

When reading values from paper charts care must be exercised in ensuring that inaccuracies caused by paper size changes, paper wander across its platen and marking mechanism offsets are allowed for. Good quality charts are a necessity with high-quality measurements.

PAPER MARKING TECHNIQUES

In these units an electronic amplifier coupled to a mechanical drive moves a mechanical point across the chart. It is then necessary to mark the paper in order to show where the point has travelled. Five commonly used techniques will be encountered.

Ink pen– Samuel Morse's telegraph recorder shown in Part 5 (Fig. 1) used a pencil to mark the paper strip. A limitation is that the lead wears away making a feed mechanism necessary. Ink can flow from a reservoir continuously: Kelvin introduced the siphon system in 1873 – see Fig. 7. This system is used extensively today in one form or other. Ink feed rate is a factor of the bore of the pen, paper absorbency and ink viscosity. Figure 8a shows pen details.

A second ink feed method uses a combination of gravity feed and capillary action through small bores. These are the ballpoint and fibre-tip pens. A third ink method pressurizes the ink, recording being performed by a very fine ink jet. This method is suitable for fast writing speeds (as high as 60 metres per second compared with around 1 m per second for unpressurized ink feeds). There is no

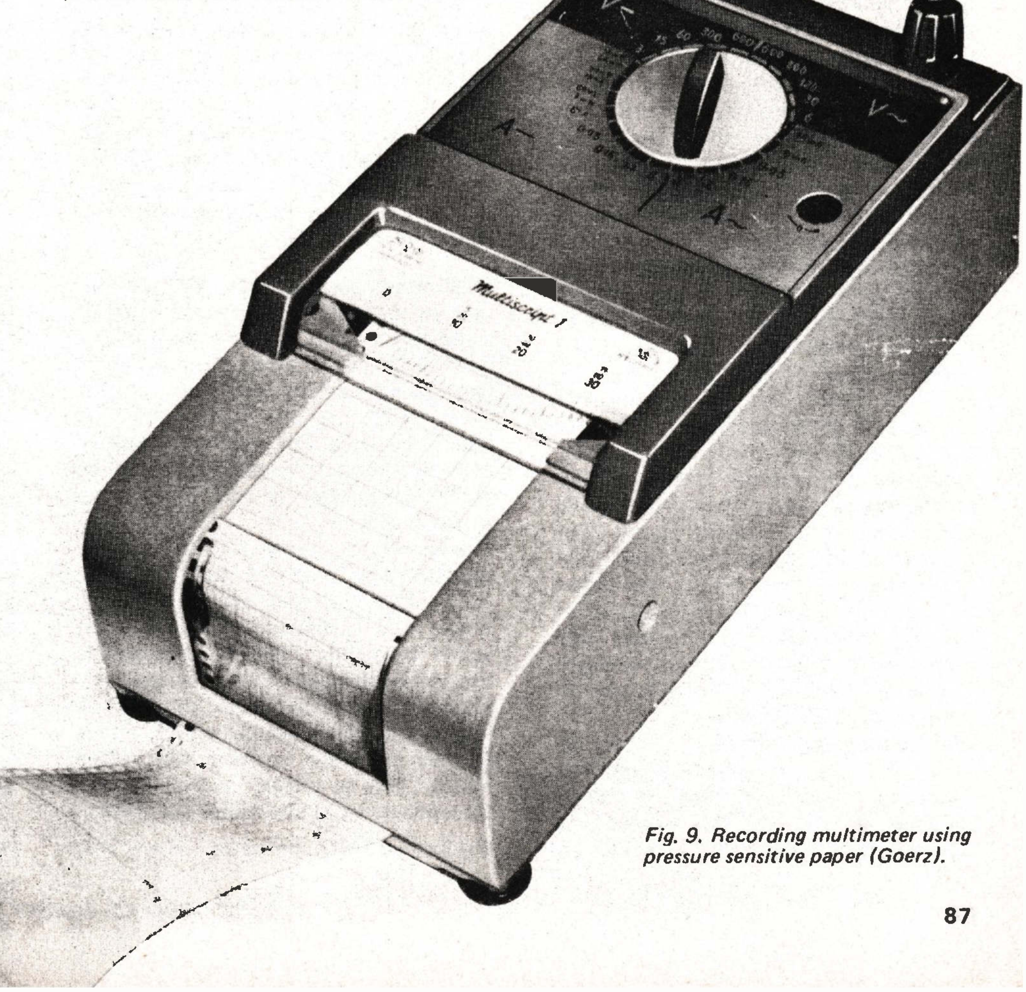


Fig. 9. Recording multimeter using pressure sensitive paper (Goerz).

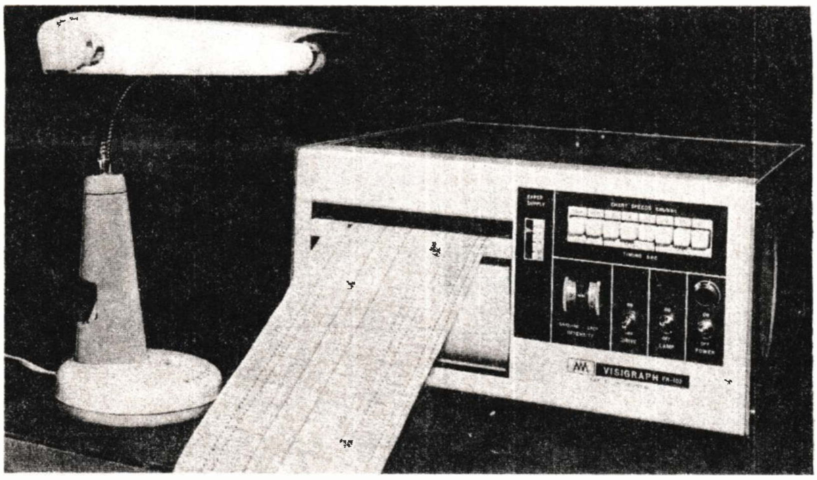


Fig. 10. UV recorders provide traces by exposure of photographic paper. Further exposure is needed to bring the latent image into view.

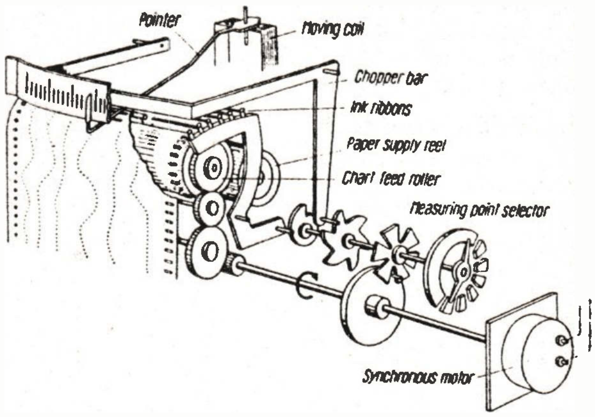


Fig. 11. Dotting recorders offer the advantages in slow-speed applications of being suitable for multi-channel multiplexing.

mechanical contact with the paper in pressurized systems, the fast writing rate arising because of the very small size of nozzle built into the deflecting system. Figure 8b shows the schematic of such a recorder. The pressure is automatically adjusted to suit the chart speed set.

The correct choice of ink and paper for the speed of operation is essential. Water-based inks are to be avoided as the record can be destroyed by accident. Fast drying inks are needed or else the trace may be rolled-up before the ink is dry. In short, although the alternatives to ink offer certain advantages we are still forced to use ink as the best all-round choice in many applications.

Pressure sensitive papers-- Black paper treated with tiny wax beads appears white until the beads are flattened to form a transparent cover window thereby exposing the black. Pressure sensitive papers are marked by the action of a gentle pressure exerted by the stylus. The relatively high contact-force needed restricts these to slow response application. Pressure-sensitive papers are more usually used with marking mechanisms that are periodically pressed against the paper to form a dot. Figure 9 shows a recording multimeter which uses this latter method of marking. Another limitation is that the record can be marked during handling.

Electro-sensitive papers: Some recorders use paper which is marked when an electric current is passed through it. The earliest was carbon impregnated; dielectric breakdown producing the mark by applying a high voltage between the stylus and the platen.

Another method electroplates onto the surface of paper made conductive by saturation with salts. It requires wet paper use but will operate with lower voltage levels than the above carbon paper method.

Zinc oxide reduced to free zinc is the process used in another kind of recording system. Metallized papers in which the metal film is fused to its paper backing are another. Yet another is based on providing a change in the paper surface which takes up toner (similar to the Xerox process) – it is fine for very fast systems but not those that occur slowly.

Heat senstitive papers: Yet another method of making the record is to use a heated stylus melting a wax-like coating on black paper. These papers can be manufactured with greater resistance to marking (during handling) than the pressure sensitive papers. Stylus temperature can also be varied with ease to suit the writing speed concerned.

Photographic paper: The earliest photographic systems used negative film. Such systems are still in use today but the majority of the highest speed recorders (30 kHz is possible) use ultraviolet light to expose specially treated paper. Exposure produces a latent (invisible) image which needs further exposure to form the visible image. This is shown in Fig. 10: the fluorescent lamp intensifies the traces.

Continuous versus dotting mechanisms: Fast writing speeds require continuous marking and for these the writing mechanism functions continuously. For very slow speed needs, as are found in process plant monitoring an alternative, in which a dot is produced on the paper at regular periods, has certain advantages. Figure 11 shows one form of mechanical arrangement. A separate motor, or pick-off from the chart drive causes a point to periodically press on the paper, marking it by the appropriate method used. By incorporating a geneva mechanism (one that rotates a shaft in steps) the input signal can be switched sequentially over a number of different signal channels (six and twelve are usual). Also synchronised to the channel changing action is an inking system that steps from colour to colour to provide a different coloured dot for each channel. Inking may be as shown (different ribbons) or may be provided as individual pads each soaked with ink. A multipoint dotting head wipes through this ink. One maker uses a multicolour single ribbon, akin to a typewriter ribbon.

Multi-channel operation is also provided in some continuous trace recorders. This is almost always achieved by incorporating separate recording heads for each signal. Figure 12 is a four pen recorder of the type in which the pens do not overlap: each trace is contained within a quarter of the full chart width. Multi-trace recorders in which each trace has the full paper width capability are also available. Mechanical drives have the disadvantage in that the traces must be slightly out of phase so that the pens can pass one another without fouling. Optical recorders do not suffer from this drawback.

RECORDING MOVEMENTS

We now look at the methods used to transduce the electrical input signal into an equivalent mechanical movement.

Moving coil mechanisms: Basically these use modified moving coil and pointer. The end of the pointer carries an ink pen or acts as a marking point when forced onto the chart paper in dotting styles (see fig. 11). Simple systems trace an arc across the chart giving a non-linear record. (curved markings on the paper overcome this but complicate the platen design). This can be linearized to provide better accuracy by various means such as that shown in Fig. 13.

Optical recorders also use a moving coil unit on which a mirror is mounted to reflect a high intensity focussed beam across the paper. These units have their origin in practical oscillographs designed by Duddell (to Blondel's ideas) at the turn of the century. The choice of galvanometer unit largely decides the frequency response. Today they are supplied as robust plug-in units like that shown in Fig. 14. The application, in many units, decides which galvanometer is used and the optimum terminating resistance value in order to know the deflection and sensitivity for a given frequency of signal. (Refer to reading list for guides). These recorders offer the ability to modulate the trace intensity producing 2-D half-tone chart records.

Potentiometric recorders: Around 1898 Professor Callendar devised his recording resistance pyrometer (Fig. 15) and in doing so provided instrumentation with the potentiometric or self-balancing recorder. This method makes use of a closed-loop system that causes the pointer to follow input signals. Referring to Fig. 16 the recorder has a drive motor mechanism which translates the pointer in one direction or the other depending upon the polarity of the signal driving the motor. Attached to the shaft driving the pen is a rotary resistance balancing potentiometer, as shown in Fig. 16a. Schematically this can be shown as a linear equivalent (the more recent design style used) as shown in Fig. 16(b). The potentiometer wiper moves across in unison with the pen and generates a changing

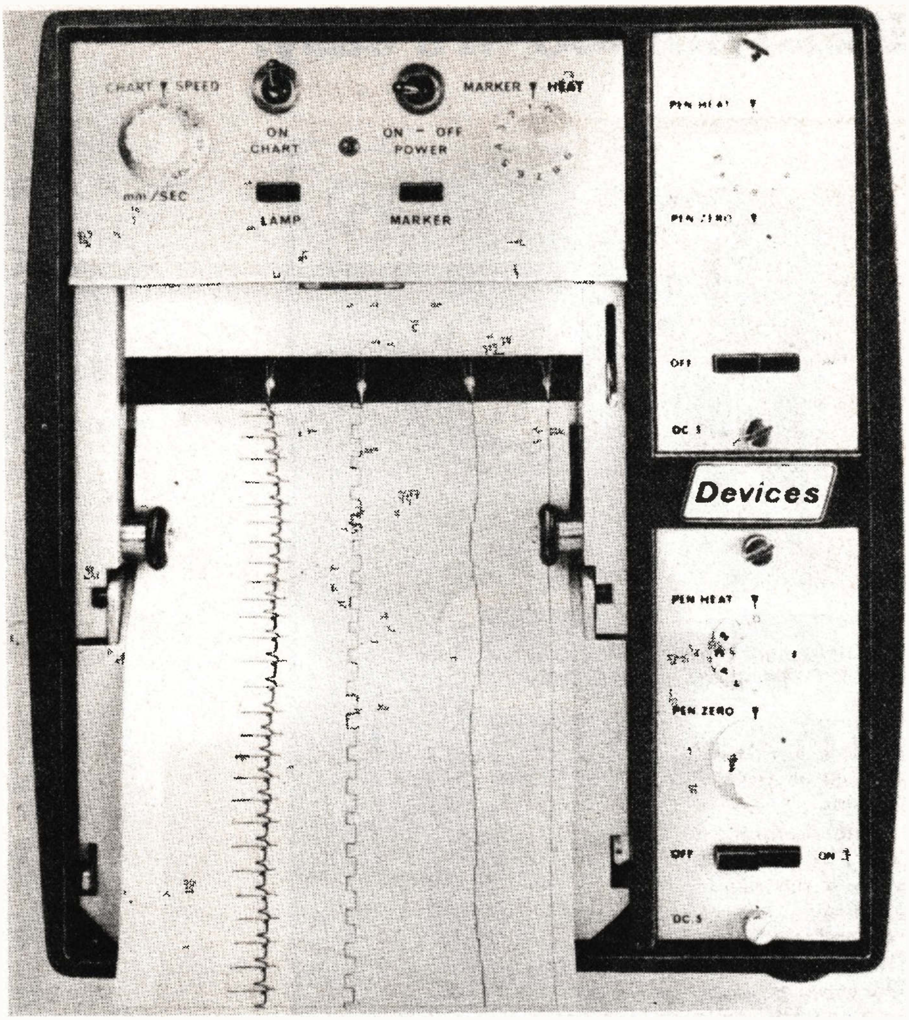


Fig. 12. High-speed four pen recorder. In this style the pens do not cross over each other limiting the trace width to a portion of the paper width.

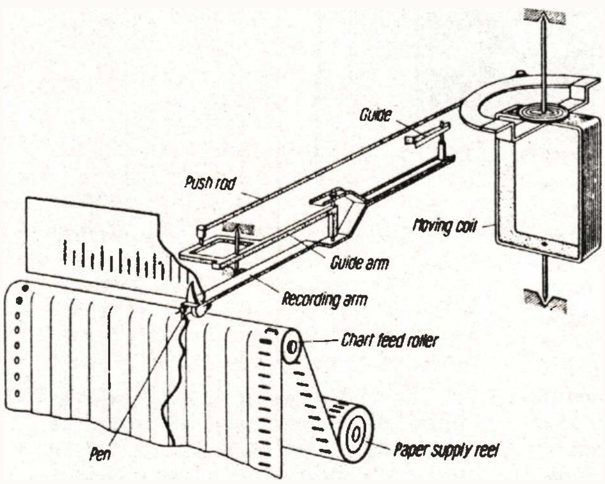


Fig. 13. Special linkages are used to linearize the non-uniform movement produced by a moving coil pen drive.

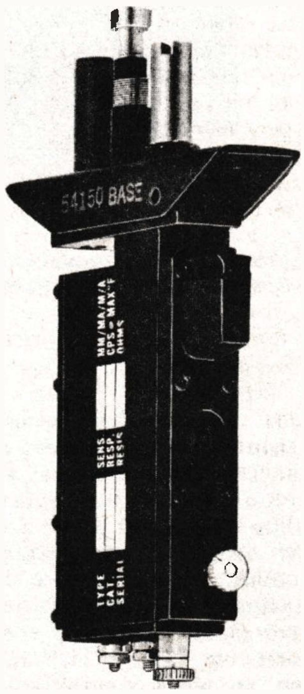


Fig. 14. Galvanometer unit for UV recorder (Hathaway Instruments).

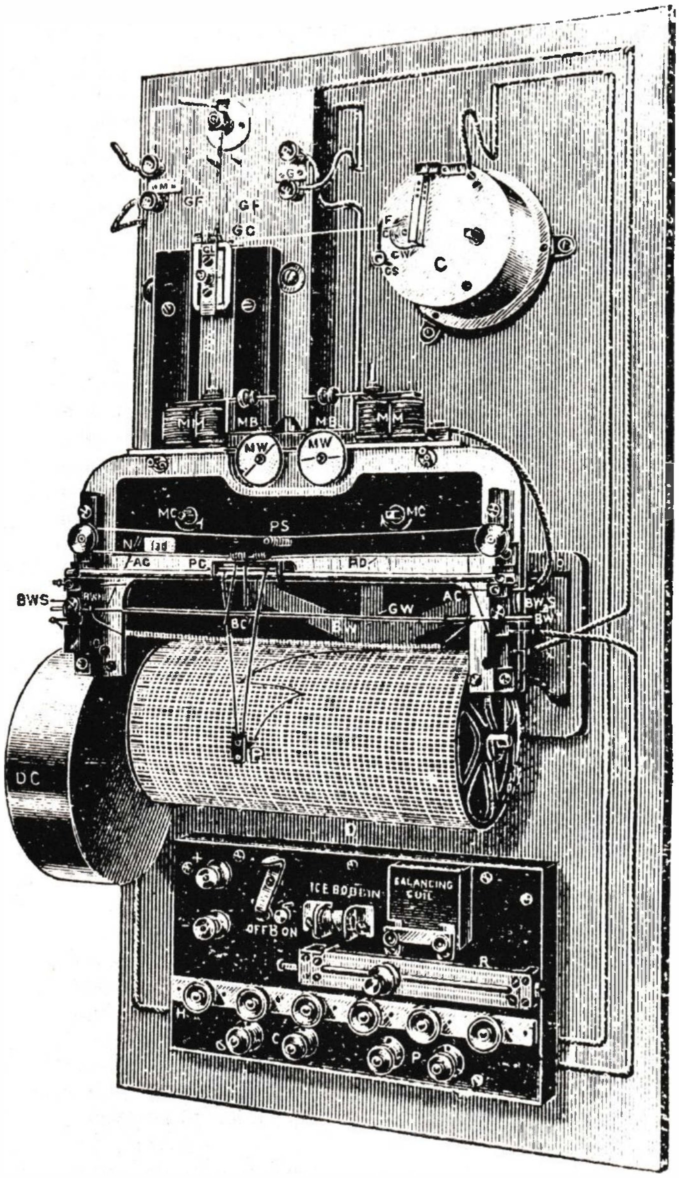


Fig. 15. Callendar's original potentiometric recorder was devised around 1898 to record furnace temperatures.

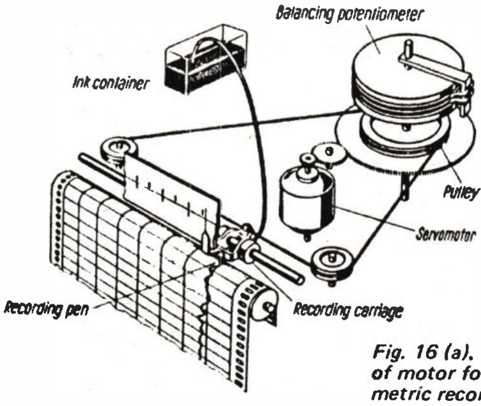
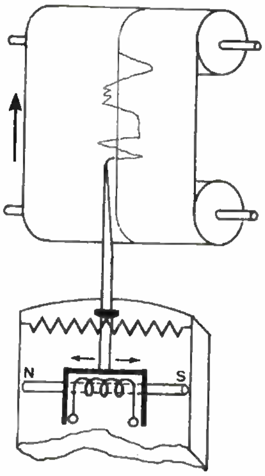
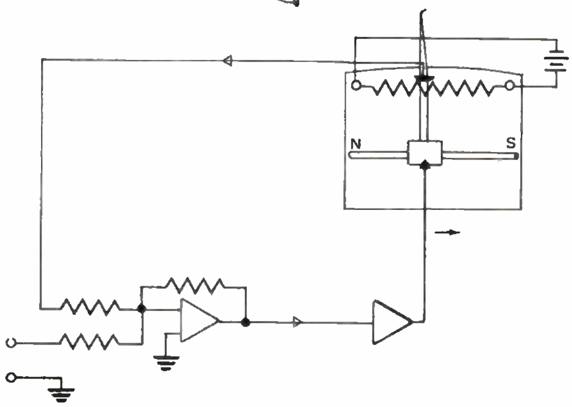


Fig. 16 (a). Arrangement of motor form of potentiometric recorder.



(b) Schematic using linear motor.



(c) Circuit schematic of potentiometric method (simplified.

value signal. The potentiometric system circuit layout is represented in Fig. 16(c). A reference voltage is supplied across the potentiometer. Voltage from the wiper is compared with the input signal voltage to be recorded. If a difference exists this constitutes an error which causes the drive motor to move accordingly to correct the error. The input signal and reference signals are suitably attenuated to provide the sensitivity needed at full-scale deflection.

The advantages of recorders such as those described above are that the mechanism plots a linear scale, and there is considerable power available to move the pen against frictional forces. The system, being potentiometric, draws little current once the unit has achieved balance and, as considerable drive power is available under closed-loop control, the pen response can be made tighter than for the open-loop pointer-type moving coil units. Sensitivity is decided more by the amplifier gain than mechanical constants. The majority of flat-bed recorders use this principle: at full trace movement their writing speeds can reach several metres per second. The method also overcomes the restriction on traverse length suffered by rotationally driven eecorder mechanisms. Although a simple dc servo control is shown, potentiometric recorders, especially those built before around 1970 more usually used ac control systems.

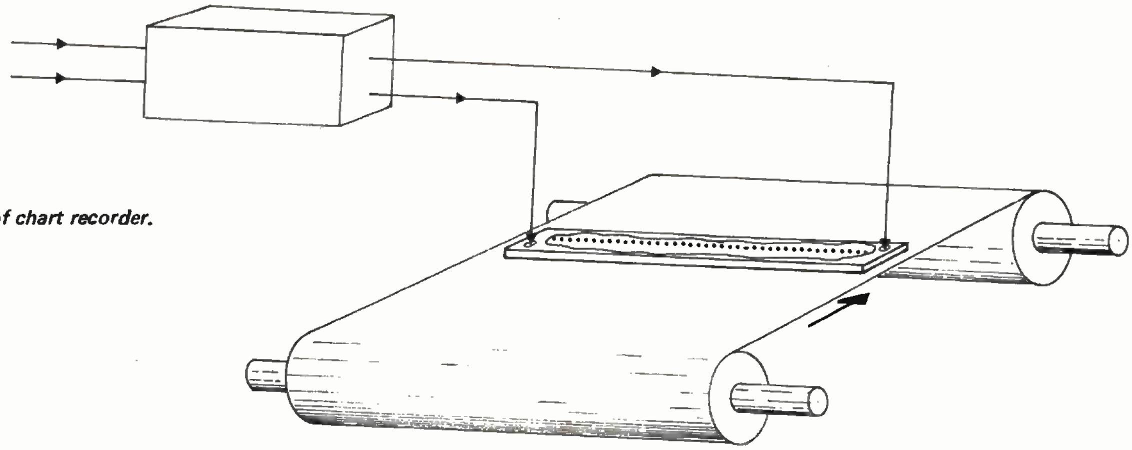


Fig. 17. Future style of chart recorder.

CRT — Fibre Optic Recorders: A recent design concept couples a CRT linear sweep trace to photosensitive paper via an optical fibre connection. This provides the highest response of all chart recorders so far available — dc to 1 MHz.

DYNAMIC RESPONSE

A point commonly overlooked is that chart recorders have a certain dynamic response and are effectively low-pass filters of the input signal. The response of a recorder to a sine signal, that is, the recorded trace, will look like the original but will lack adequate amplitude if the pen cannot follow fast enough. When quoting response rates it is therefore necessary to state amplitude as well as frequency. For example, moving-coil recorders with short pen arms — as in Fig. 12 — have a typical response that is flat from dc to 100 Hz at 10 mm peak-to-peak deflection for a sinewave. If the frequency is increased the recorder will still operate but the amplitude of a sinewave record falls off. Plots of complex waveforms may be severely distorted for the fundamental may be recorded at full amplitude with harmonics attenuated progressively. A square-wave input may be recorded as a near sine-wave if the response is inadequate. It is better to use a smaller signal amplitude in such cases.

Simple moving-coil chopper-type recorders will roll off from as low as 1 Hz. Ink jet units extend to 800 Hz: beyond that optical recorders are needed providing up to 1 MHz in the CRT design. Frequencies above this must be viewed by oscilloscopes using cameras to record the image.

Faithful response is also a function of amplifier characteristics. With the exception of simple moving-coil recorders most units have built-in amplification because the majority of signals to be recorded, have insufficient power to provide an adequate response. Recorder sensitivities may be fixed in manufacture, as in process industry dotting recorders, or have adjustable ranges. The manufacturers of recorders usually provide the amplifiers as part of the recorder, the purchaser only has to make the selection.

Event-marking recorders: In many recording applications the variable remains constant for more of the time than it varies. An example might be recording rainfall in dry areas. If the record must provide fine time-resolution the chart must run fast which means using immense lengths of paper for little data recorded. An approach, slowly finding acceptance, is to use a time/date printer which prints a value each time an increment of event occurs. Each increment print-out causes the chart to advance a unit. The result is a record chart completely filled with non-zero data. It is harder to interpret but much more efficient for spasmodic data situations. At present, however, this form of equipment is hard to procure commercially.

THE FUTURE

The design of recorders is decided largely by cost, reliability, sensitivity, and packaging to suit the application. Response and accuracy cost money. The weakest points of inexpensive recorders seem to be the reliability of the marking arrangement, and poor response. Optical recorders eliminate marking problems but still (with the exception of the CRT types) require fine electro-mechanical mechanisms to deflect the trace. We can confidently expect to see solid-state "deflection" systems marketed in the near future which are based on semiconductor technology. Units, like that depicted in Fig. 17, will use a linear array of LEDs to expose a spot on photographic paper in the appropriate place. This method would eliminate mechanical manufacturing problems, have excellent response characteristics and be readily multiplexed to provide multi-channel traces. Using LSI manufacturing methods, the cost of the array head and analog-to-digital converter would be minimal.

FURTHER READING

Books containing chapters on chart recorders include:

"Basic industrial electronic controls" J. H. Ruiter and R. G. Murphy, Rolf Rinehart and Winston, 1962.

"Measurement systems" E. O. Doeblin, McGraw-Hill, 1966.

"Principles of instrumentation", J. T. Miller, United Trade Press, 1968.

A brief survey of recorders is given in:

"Instruments-electric recorders", Siemens, September, 1968. Liquid jet osillographs are discussed in detail in Siemen's pamphlet MS7/200e, 1967 of that title.

A review of the merits of various writing systems is given in:

"Graphic recorder writing systems", D. R. Davis and C. K. Michener, Hewlett-Packard Jnl. October, 1968.

Chart inaccuracies are discussed in "Recording charts", L. Briggs Dunn, Instruments and Control Systems, July, 1969.

When using optical oscillographs the correct choice of galvanometer head and source impedance usually requires calculations to be made. (There is a trend toward elimination of this by providing suitable amplifiers). Manufacturers usually provide such detail. A paper "The Theory of recording galvanometers" by M. A. Le Gette, Consolidated Electrodynamics, Pasadena, California provides in depth detail.

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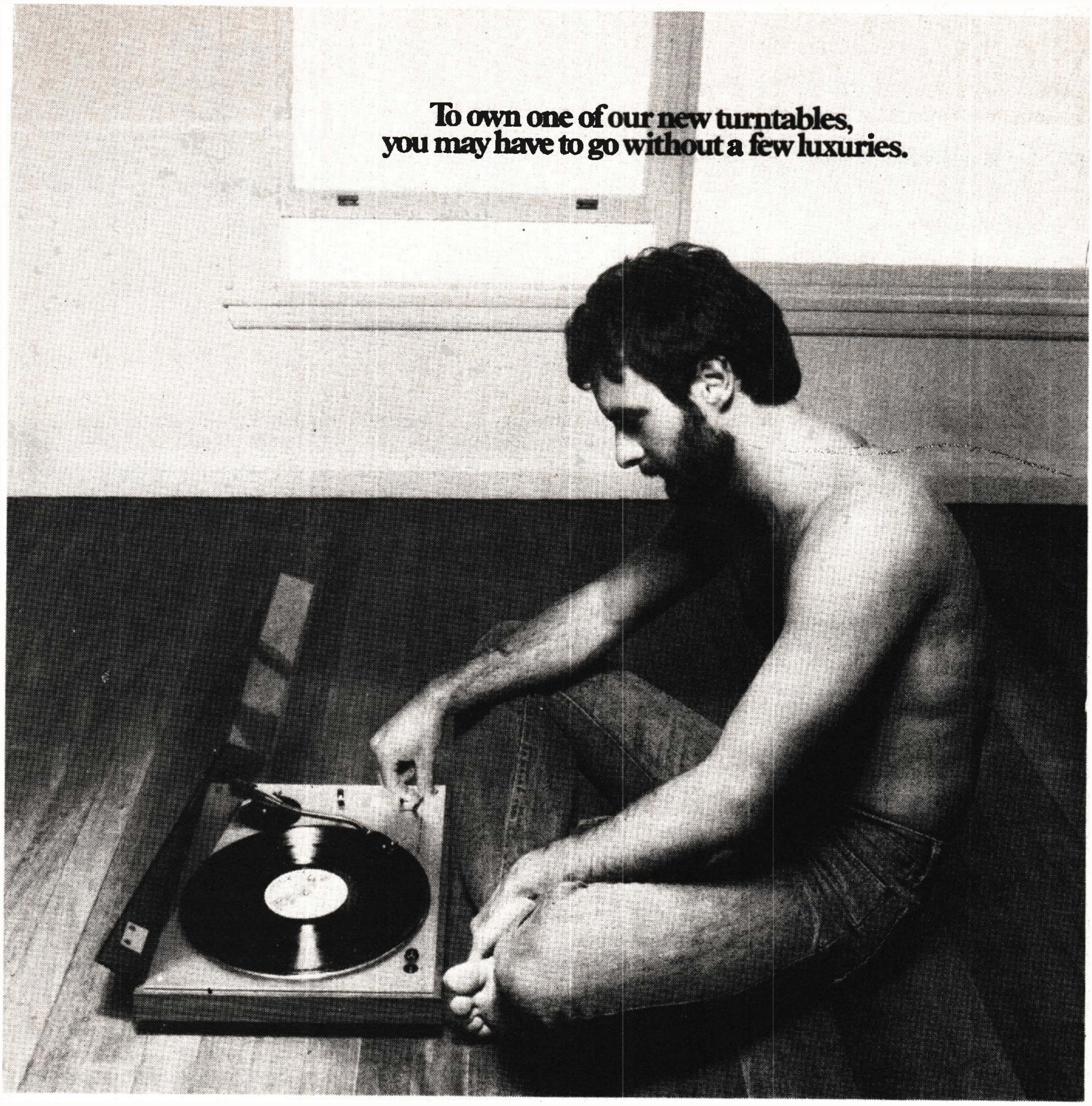

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Maximum rms Power	10W	20W
Output Load	8 ohms	8 ohms
Supply Voltage	34V or ±17V	46V or ±23V
Absolute Max. Supply Voltage	45V or ±22.5V	55V or ±25V
Supply Current (ave.)	0.50A	0.72A
Protective Fusing	1A Quick Blow	1A Quick Blow
Harmonic Distortion at Full Output	0.5% max.	0.5% max.
Maximum Input Voltage (p-p)	10V	10V
Voltage Gain Full Feedback (P_o = 1W)	30dB typ.	30dB typ.

Characteristic	S1-1030G	S1-1050G
Maximum rms Power	30W	50W
Output Load	8 ohms	8 ohms
Supply Voltage	54V or ±27V	66V or ±33V
Absolute Max. Supply Voltage	60V or ±30V	80V or ±40V
Supply Current (ave.)	0.86A	1.1A
Protective Fusing	1.5A Quick Blow	2A Quick Blow
Harmonic Distortion at Full Output	0.5% max.	0.5% max.
Maximum Input Voltage (p-p)	10V	10V
Voltage Gain Full Feedback (P_o = 1W)	30dB typ.	30dB typ.

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555 & 556 timing circuits

QUICK REFERENCE DATA
555 TIMER

Absolute maximum ratings		
Supply voltage	max.	18 V
Power dissipation	max.	600 mW
Characteristics		
(25°C, V_{CC} 5 to 15 V)		
Supply voltage		4.5 to 15 V
Supply current (low state) (V_{CC} = 5 V)	typ.	3 mA
(V_{CC} = 15 V)	typ.	10 mA
Timing error, initial accuracy	typ.	1%
Timing error, temperature drift	typ.	50 ppm/°C
Timing error, drift with supply voltage	typ.	0.1 %/V
Threshold voltage	typ.	1/3 V_{CC}
Control voltage level (V_{CC} = 15 V)	typ.	10 V
(V_{CC} = 5 V)	typ.	3.3 V
Output voltage drop (LOW)		
V_{CC} = 15 V; I_{SINK} = 10 mA	typ.	0.1 V
I_{SINK} = 50 mA	typ.	0.4 V
I_{SINK} = 100 mA	typ.	2 V
V_{CC} = 5 V; I_{SINK} = 5 mA	typ.	0.25 V
Output voltage drop (HIGH)		
V_{CC} = 15 V; I_{SOURCE} = 200 mA	typ.	12.5 V
I_{SOURCE} = 100 mA	typ.	13.3 V
V_{CC} = 5 V	typ.	3.3 V
Risetime/falltime of output	typ.	100 ns

The 555 timer is available from many manufacturers under codings like NE555, μA555, LM555, MC1455 and MC1555. Recent ETIs have carried ads pricing the device at around 60c to 90c.

The IC is a stable controller which produces very accurate time delays or rectangular-waveform oscillations. One external capacitor and resistor set the time delay, and in the oscillator mode one further resistor is all that is needed to give control of frequency and duty cycle.

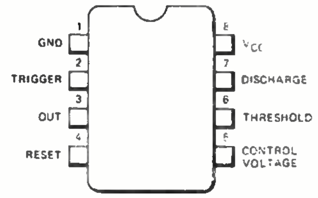
A trigger signal sets an internal flip-flop and starts the timing (the flip-flop immunises the device from further triggering). A reset signal can be applied to interrupt the timing cycle.

The output is capable of sinking or sourcing 200 mA to drive relays, indicators or further circuitry.

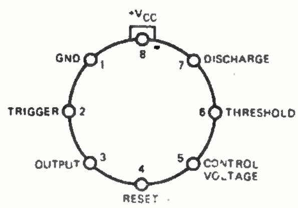
The 556 contains two 555s in one package, for sequential or multiple applications.

PINOUTS — 555

8-LEAD MINI DIP
(TOP VIEW)

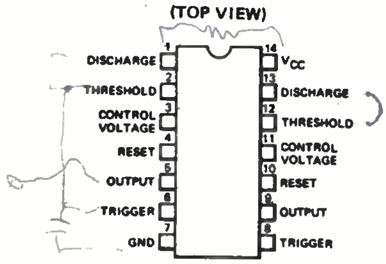


8-LEAD TO-100
(TOP VIEW)

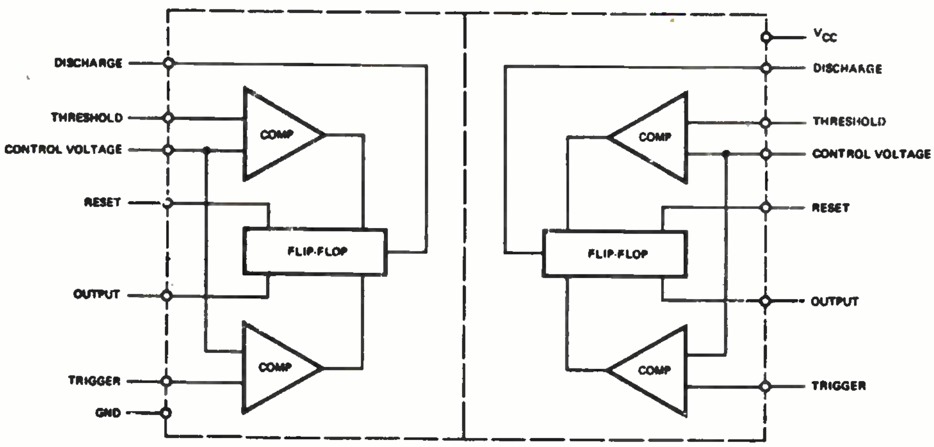


PINOUT — 556

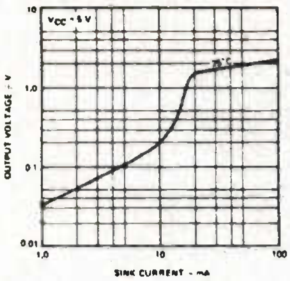
14-LEAD DIP
(TOP VIEW)



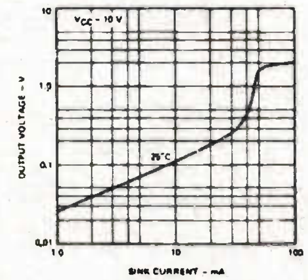
BLOCK DIAGRAM — 556



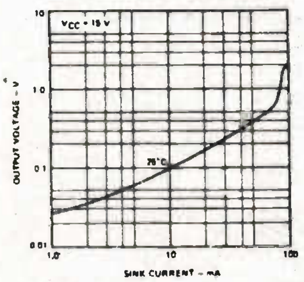
LOW OUTPUT VOLTAGE AS A FUNCTION OF OUTPUT SINK CURRENT



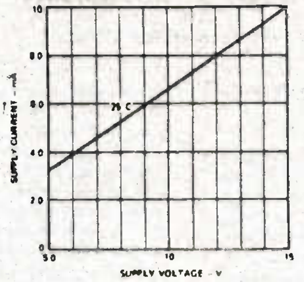
LOW OUTPUT VOLTAGE AS A FUNCTION OF OUTPUT SINK CURRENT



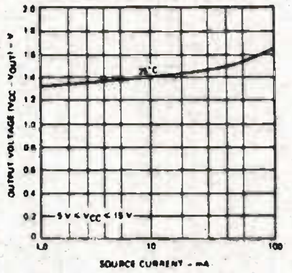
LOW OUTPUT VOLTAGE AS A FUNCTION OF OUTPUT SINK CURRENT



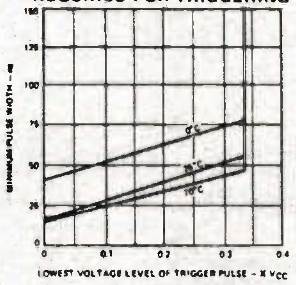
TOTAL SUPPLY CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



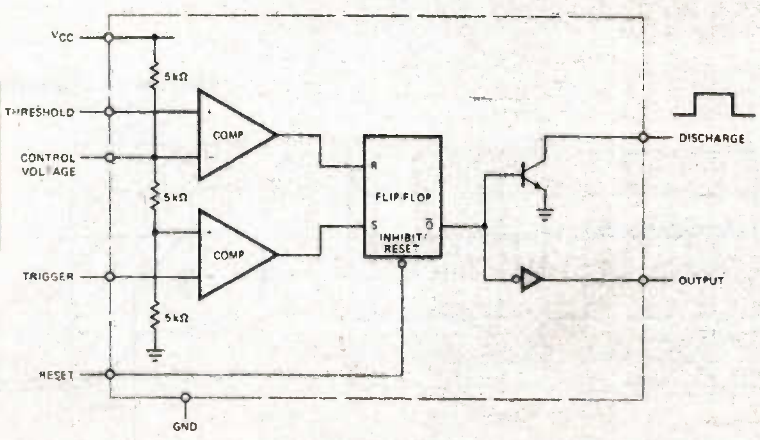
HIGH OUTPUT VOLTAGE AS A FUNCTION OF OUTPUT SOURCE CURRENT



MINIMUM PULSE WIDTH REQUIRED FOR TRIGGERING



BLOCK DIAGRAM– 555



ETI data sheet

555 & 556 timing circuits cont'

TYPICAL APPLICATIONS

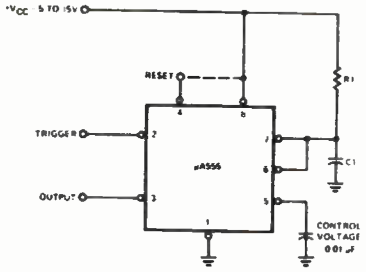
MONOSTABLE OPERATION

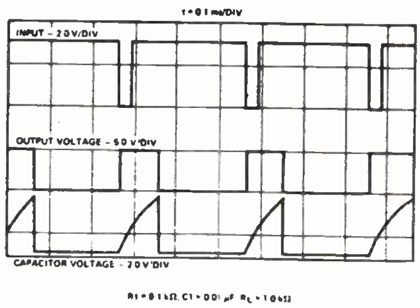
In the monostable mode, the timer functions as a one-shot. Referring to Figure 1 the external capacitor is initially held discharged by a transistor inside the timer.

When a negative trigger pulse is applied to lead 2, the flip-flop is set, releasing the short circuit across the external capacitor and drives the output HIGH. The voltage across the capacitor, increases exponentially with the time constant τ = R1C1. When the voltage across the capacitor equals 2/3 V_{CC}, the comparator resets the flip-flop which then discharges the capacitor rapidly and drives the output to its LOW state. Figure 2 shows the actual waveforms generated in this mode of operation.

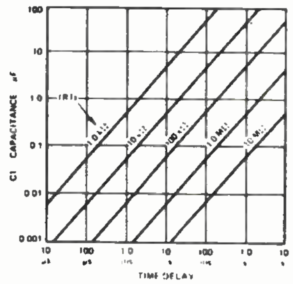
The circuit triggers on a negative-going input signal when the level reaches 1/3 V_{CC}. Once triggered, the circuit remains in this state until the set time has elapsed, even if it is triggered again during this interval. The duration of the output HIGH state is given by t = 1.1 R1C1 and is easily determined by Figure 3. Notice that since the charge rate and the threshold level of the comparator are both directly proportional to supply voltage, the timing interval is independent of supply. Applying a negative pulse simultaneously to the Reset terminal (lead 4) and the Trigger terminal (lead 2) during the timing cycle discharges the external capacitor and causes the cycle to start over. The timing cycle now starts on the positive edge of the reset pulse. During the time the reset pulse is applied, the output is driven to its LOW state.

When Reset is not used, it should be tied high to avoid any possibility of false triggering.





TIME DELAY AS A FUNCTION OF R1 AND C1



ASTABLE OPERATION

When the circuit is connected as shown in Figure 4 (leads 2 and 6 connected) it triggers itself and free runs as a multivibrator. The external capacitor charges through R1 and R2 and discharges through R2 only. Thus the duty cycle may be precisely set by the ratio of these two resistors.

In the astable mode of operation, C1 charges and discharges between 1/3 V_{CC} and 2/3 V_{CC}. As in the triggered mode, the charge and discharge times and therefore frequency are independent of the supply voltage.

Figure 5 shows actual waveforms generated in this mode of operation.

The charge time (output HIGH) is given by:

$$t_1 = 0.693\,(R1 + R2)\,C1$$

and the discharge time (output LOW) by:

$$t_2 = 0.693\,(R2)\,C1$$

Thus the total period T is given by:

$$T = t_1 + t_2 = 0.693\,(R1 + 2R2)\,C1$$

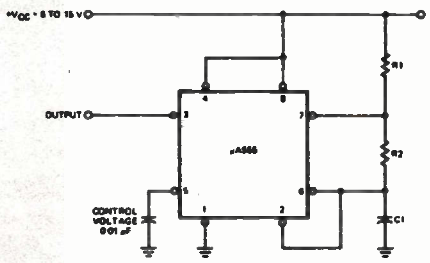
The frequency of oscillation is then:

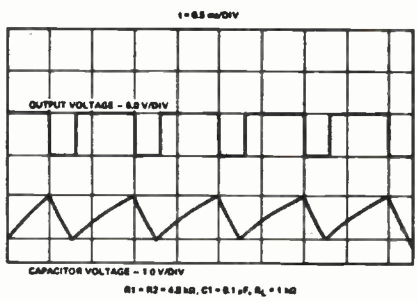
$$f = \frac{1}{T} = \frac{1.44}{(R1 + 2R2)\,C1}$$

and may be easily found by Figure 6.

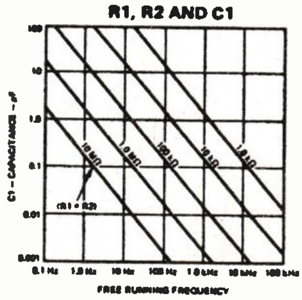
The duty cycle is given by:

$$D = \frac{R2}{R1 + 2R2}$$

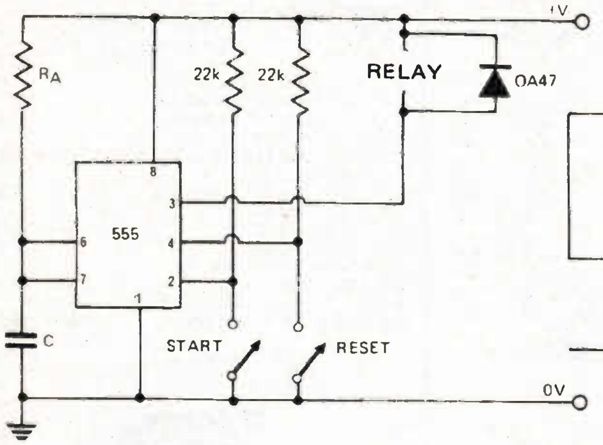




FREE RUNNING FREQUENCY AS A FUNCTION OF R1, R2 AND C1



APPLICATIONS— CIRCUITS



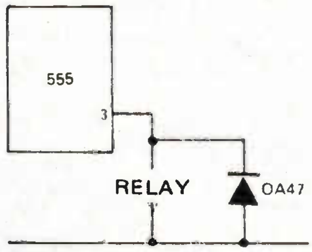


Fig. 1. Using the 555 to drive a relay. The delay period should be greater than 0.1s and the relay should operate in the 555 supply voltage and draw not more than 200 mA. Here the relay is normally closed — it opens for the delay period. Since the current required by the trigger pin (2) is only 0.5 µA for 0.1 µs, it can be triggered by pick-up of the voltage transient produced by the relay coil when it switches off (the result being a relay which doesn't actually open at the end of the timing period). Figure 2 shows how to connect a diode across the relay to prevent this trouble, but note that the diode has to act pretty fast: gold-bonded germanium types (such as 0A47) are the best, silicon types (like the 1N914) are unsatisfactory.

Fig. 3. The simplest 555 astable circuit uses one resistor, one capacitor and the 555. The charging and discharging times are both approximately 0.7RC. A relay may be connected (with suitable diode) between pin 3 and either supply rail. Alternatively the output may be set at audio frequency to provide a square-wave for testing audio gear.

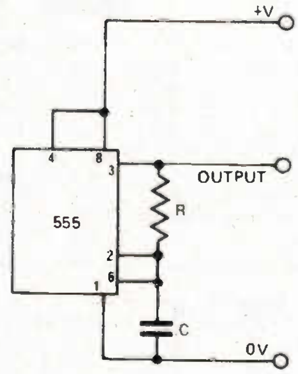
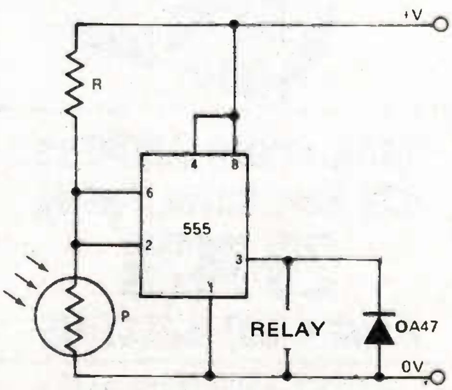


Fig. 4. Using the 555 as a comparator, in this case as a photosensitive switch. The switch-on threshold is reached when the voltage at pin 2 falls to a third of the supply voltage. The second threshold is reached when the voltage rises to two-thirds of the supply voltage — the relay then opens. Adjusting the resistor R will change the light-level for a given cadmium sulphide photo cell. The photocell may be replaced by a thermistor or other device which changes in resistance.

Because the output switches in and off at different levels you get a useful hysteresis effect. This stops any unwanted switching on and off as the light level hovers about the threshold level.



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100 "	25V	"	33	30	"
220 "	25V	"	55	50	"
470 "	25V	"	55	50	"
1000 "	25V	"	85	75	"
2200 "	25V	"	1.40	1.20	"
1 "	35V	Tag Tantalum	25	21	"
2.2 "	35V	" "	25	21	"
4.7	35V	" "	25	21	"
6.8	35V	" "	30	26	"
10	25V	" "	30	26	"
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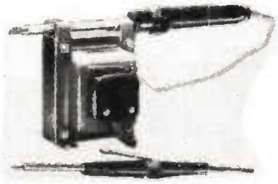
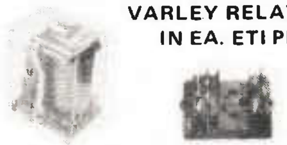


PRE PAK FOR RELAYS

VARLEY RELAYS AS USED IN EA. ETI PROJECTS



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CAB	12V	4CO	180 Ω		4.55	4.10	1.50
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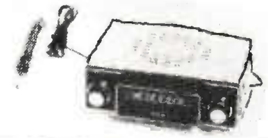

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DS2 DIN SOCKET CHASSIS MOUNT	30	25
DP3 DIN 3 PIN PLUG	45	40
DS3 DIN 3 PIN SOCKET CHASSIS MOUNT	35	30
DP5 DIN 5 PIN PLUG	48	43
DS5 DIN 5 PIN SOCKET CHASSIS MOUNT	40	35

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.
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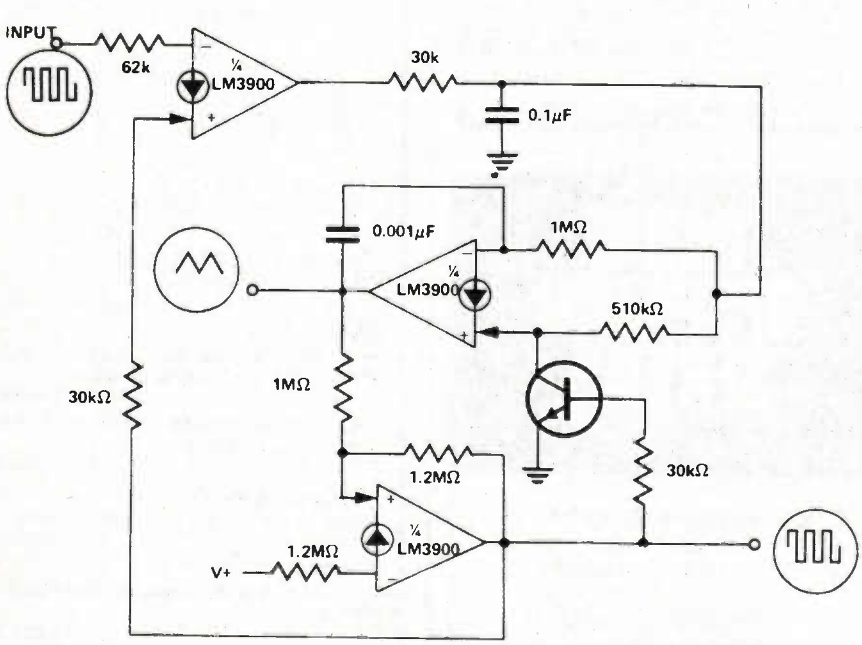
Economical phase locked loop



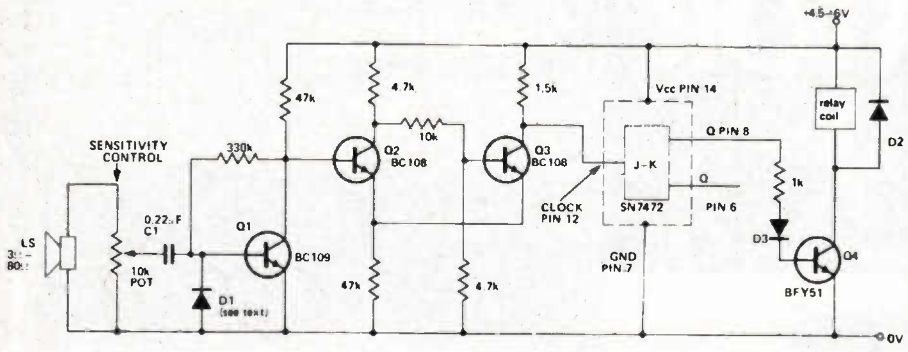
Integrated circuits which have been specially designed as complete phase locked loops are available, but many of them tend to be rather expensive devices. The circuit shows how the economical LM3900N integrated circuit can be used to build a phase locked loop which has a centre frequency of about 3 kHz.

The LM3900N contains four current differencing amplifiers in a single 14 pin dual-in-line package. Only three of these amplifiers are used in the circuit shown, so the fourth amplifier is available for other purposes. The price of the LM3900N is about a dollar, so it is one of the cheapest linear devices available. The special circuit symbol shown is used for the amplifiers in this device, since they are not a conventional type of operational amplifier.

If desired, the locking range of this phase locked loop may be increased by employing the fourth amplifier in the LM3900N in the input circuit to increase the signal amplitude.

Ideas for experimenters

Sound operated two-way switch

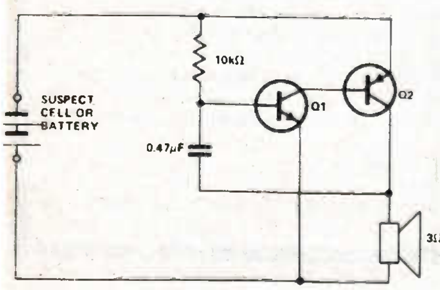


The circuit operates a relay each time a sound of sufficient intensity is made, thus one clap of the hands will switch it one way, a second clap will revert the circuit to the original condition. Q2 and Q3 form a Schmitt trigger. The JK flip-flop is used as a bistable whose output changes state every time a pulse is applied to the clock input (pin 12). Q4 allows the output to drive a relay.

Under quiescent conditions Q1 is on, holding the base of Q2 low and keeping the output of the Schmitt trigger low (Q3 collector). If a sharp noise is made (eg. a clap) it will generate a pulse in the loudspeaker which is fed through C1 and switches Q1 off. D1 prevents any large pulses damaging Q1. As Q1 switches off, its output goes high, causing the output of the Schmitt trigger to go high. When the clap is finished Q1 again conducts, causing the output of the schmitt trigger to go low. Therefore each clap causes a high pulse at the Schmitt trigger's output which is fed to the clock of the JK flip-flop causing its output to change state. This is used to turn a relay on and off. Because the circuit is only sensitive to sharp noises it is generally unaffected by talking or sounds caused by movement. (The sensitivity control can be adjusted to prevent such noises triggering the circuit if this does arise). A moving coil loudspeaker is used as a microphone as it can respond to sounds from any direction. It was found that any loudspeaker from 3–80 Ω worked in the circuit. The Q output of the JK flip-flop could be used as well, allowing two relays to be switched on and off complementarily.

The circuit has limitless applications like turning on a radio or controlling motorised toys by clapping. The diodes can be any general purpose silicon types (1N914 etc) and the relay a 5–6 V type with minimum resistance of 50 ohms.

Battery tester



This device tests the condition of dry cells. The circuit consists of a simple oscillator whose output frequency is relatively independent of supply voltage, but varies greatly with changes in supply impedance. Thus, with the component values shown, a fresh battery or cell will give a note of about 500 Hz, whereas an exhausted cell will give a note above 1 kHz. The device has been tested with battery voltages between 1.5 V and 14 V, using a 2N2923 as Q1, and an OC81D as Q2. The unit is undamaged by reversed supply potentials.

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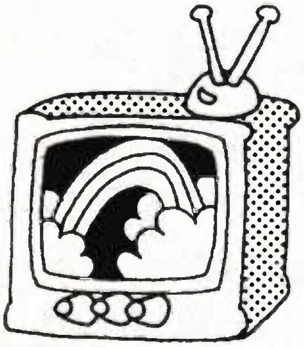

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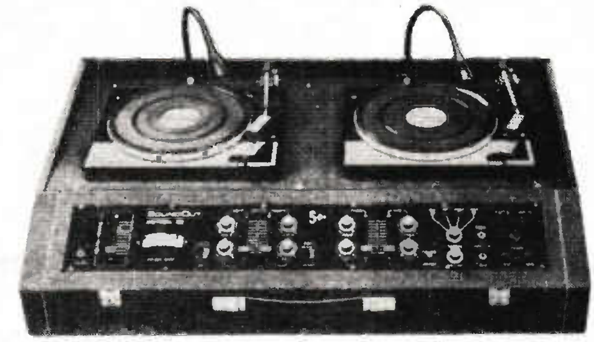

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Please Explain

This new feature is our response to the many requests we get from readers who want explanation or information on topics they read about in the magazine. If you have a question please send it to Please Explain, ETI Magazine, 15 Boundary Street, Rushcutters Bay, NSW. 2011.

Real Time

What is meant by the term 'real-time'?

J. J. Victoria.

Computers can be used to process data to help man make decisions. This is not a real-time application; real-time applications link the computer to the immediate environment. Incoming signals are monitored and the computer gives output signals as soon as it can so it is continually reacting with the system. Examples are systems to control chemical plants and airline booking systems. It is in some real-time applications that the speed of the computer becomes an important factor.

Crossover Amplifiers and power rating

In October 1975 ETI, there is an explanation of why a single power transformer (and power supply) is all that is needed to power the two complete 422 amplifier boards used with the active crossover:

"The frequency spectrum is split up between the high and low channels and hence each amplifier, although called upon to provide the same peak power, only has to handle half the average power. The transformer is thus quite capable of handling the total load as the system is still nominally 50 watts per channel."

I would be very grateful if you could explain this further. Surely if you have a power amp of 50 watts capability attached to each channel (high and low), then if the whole thing is not limited by the power supply, you have the capability of supplying 100 watts rms. In other words, if you fed an audio signal through a 50 watt rms amp and a passive crossover network, to a multi-unit speaker, you could only supply 50 watts to the speaker. If, on the other hand, you used an active crossover and two 50 watt power amps, then you could supply 50 watts at, say, 500 Hz for the low channel andalso 50 watts at, say, 3000 Hz for the high channel? So the net result when you play music (and not sine waves) would be something like 70 or 80 watts rms to each multi-unit speaker? Which would therefore need a beefed-up power supply to take full advantage of it?

A. C. Redwood, Victoria.

Your understanding of what would happen if you fed sine-wave signals from a signal generator into the two types of amplifier is quite correct — you can get twice the power from the dual system. But the situation is different when you use a music source. What limits the output of an amplifier in normal use is not the rms power level but the incidence of clipping.

TABLE 1

Comparison of single and dual (2 kHz crossover) ETI 422 amplifiers when sinewaves of equal amplitude start to clip.

SINGLE	peak output voltage at each frequency	rms output power at each frequency	Total rms output
500 Hz or 3 kHz	28 V	50 W	50 W
500 Hz & 3 kHz	14 V + 14 V	12.5 W + 12.5 W	25 W
200 Hz, 500 Hz, 3 kHz & 6 kHz	7 V + 7 V + 7 V + 7 V	3.1 W + 3.1 W + 3.1 W + 3.1 W	12.5 W
DUAL			
500 Hz or 3 kHz	28 V	50 W	50 W
500 Hz & 3 kHz	28 V + 28 V	50 W + 50 W	100 W
200 Hz, 500 Hz, 3 kHz & 6 kHz	14 V + 14 V + 14 V + 14 V	25 W + 25 W + 25 W + 25 W	50 W

This table shows how things change when we stop talking about sinewaves and rms output power. By using two sinewaves the total output of the single 422 falls to 25 W — this is the maximum output power before clipping sets in. The limiting factor is amplitude, in this case 28 V. By studying this table you will appreciate that a complex music waveform will have an rms power much less than that of a sinewave of the same peak voltage level. In the 422 clipping will occur with music outputs of four or five watts rms. Although we are talking about the ETI 422 these figures apply to any amplifier rated at 50 W output.

This is an amplitude limit on the waveform of the signal.

With a music input you get something like ten percent of the rms power of a sinewave with the same peak amplitude.

To answer the main point of the question, for the same acoustic watts output the power taken by each amplifier (single vs dual) from the power supply will be the same. But as you turn up the volume controls the dual amplifier will not start clipping a music signal when the single amplifier starts. You will be able to run the dual amplifier at higher levels and get more volume out before clipping (but you don't get twice the input on a music signal). It is in this region, where you exceed the output power of the single amplifier, that the dual amp draws more current from the power supply. However in normal listening situations the dual amp will not be pushed to this extent and the original power supply will suffice.

Even if the dual amp is driven almost to clipping the power supply in our design it will have sufficient spare capacity to cope provided that normal music signals are being used.

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74154	.98		
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7403	.15	7460		74156	.97
7404	.16	7464	.35	74157	.99
7405	.19	7465	.35	74158	1.79
7406	.20	7470	.30	74160	1.23
7407	.28	7472	.30	74161	.97
7408	.18	7473	.35	74162	1.39
7409	.19	7474	.28	74163	1.09
7410	.16	7475	.49	74164	.99
7411	.25	7476	.30	74165	.99
7413	.43	7483	.68	74166	1.25
7414	.65	7485	.88	74170	2.10
7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74171	.84
7425	.27	7493	.48	74180	.90
7426	.26	7494	.78	74181	2.45
7427	.29	7495	.79	74182	.79
7430	.20	7496	.79	74184	1.90
7432	.23	74100	.98	74185	2.20
7437	.25	74105	.44	74187	5.75
7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
7447	.79	74145	1.04	74198	1.73
7448	.79	74150	.97	74199	1.69
7450	.17	74151	.79	74200	5.45

LOW POWER

74L00	.29	74L51	.29	74L90	1.40
74L02	.29	74L55	.29	74L91	1.20
74L03	.23	74L71	.29	74L93	1.50
74L04	.29	74L72	.45	74L95	1.50
74L06	.29	74L73	.56	74L98	2.25
74L10	.29	74L74	.56	74L164	2.25
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74L30	.29	74L85	1.09		
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74LS04	.36	74LS42	1.40	74LS164	2.20
74LS08	.38	74LS74	.59	74LS193	2.20
74LS10	.36	74LS90	1.30	74LS197	2.20
74LS20	.36	74LS93	1.30		

HIGH SPEED

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74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
74H08	.25	74H50	.25	74H101	.58
74H10	.25	74H52	.25	74H102	.58
74H11	.25	74H53	.25	74H103	.60
74H20	.25	74H55	.25	74H106	.72
74H21	.25	74H60	.25	74H108	.72

SCHOTTKY

74S00	.38	74S08	.52	74S22	.38
74S02	.45	74S10	.38	74S32	.52
74S03	.38	74S20	.38	74S74	.38
74S04	.45				

8000 (NATIONAL)

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8092	.61	8230	2.19	8812	1.02
8095	1.25	8288	1.49	8822	2.19
8121	.80	8520	1.16	8830	2.19
8123	1.43	8552	2.19	8831	2.19
8200	2.33	8563	.62	8836	.29
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74C02	.26	74C76	1.34	74C161	2.66
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74C10	.35	74C154	3.15	74C195	2.26
74C20	.35	74C157	1.76	80C95	1.15
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Reasonable abbreviations, such as 25 Wrms, count as one word.

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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 12th of the month preceding the month of issue. Please, please write or preferably type your adverts clearly, using BLOCK LETTERS.

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send your ad to — ETI MiniMart, Modern Magazines, 15 Boundary Street, Rushcutters Bay, NSW 2011.

FOR SALE Sanyo reel to reel video recorder, camera, zoom lens accessories, National Ranger as monitor, exc. cond. $750. J. Hodgson, 5A Mall Crt, Blackburn, Victoria. Ph: 893-112.

LEADER L.S.G. 532 T.V.F.M. Swemar signal generator in excellent condition $160. Ph: 660-6716, George Soumelides, 132 Johnston St, Annandale, Sydney.

FERROGRAPH Model 7504DHW tape deck with Dolby. Excellent condition. Two years old. $950 o.n.o. King, 8 Borral St., Woomera, S.A., 5720. Phone Woomera 737-883.

HAVE A COX o.02cc Pee Wee engine, fuel, Thunderbolt model, plane to suit, $14.99 and GT Scateboard $14.99. Phone (03) 232-3665 after 4 o'clock, ask for Bill.

AKAI GX400DSS 2/4 channel professional standard tape deck plus 70 10½" & 7" reels of unused master recording tape. Phone Adelaide 42-2065 for details.

FOR SALE Kenwood QR-666 Communications Receiver 1706 Hz to 30 MHz continuous. Excellent condition $220 o.n.o. Scott Brown, 17 Ramsay Ave, West Pymble 2073. Phone 449-2631.

BSR/C142 Automatic manual turntable base and cover complete fitted with Goldring ES-70S magnetic cartridge $60.00. E. Gill, 249 Sawtell Road, Boambee, via Coffs Harbour, 2450 NSW.

TO SELL: Kraft three channel radio control, as new, complete, aerials, wiring, etc. $120. Jon Holmes, 35 Park Road, Beaufort, 3373 Vic. Ph. 221.

I WISH TO BUY an MSP hi-flux 8" Ω woofer. Information on where one could be found would be helpful. Telephone 99-4510. 61 Weatherall Rd, Cheltenham Victoria 3192, Rick Forbes.

WANTED TO BUY — Handbook, circuit diagrams, and/or any relevant information to suit Velco oscilloscope. Model: GRO50. Send: Elmar Schuler, P.O. Box 168, Cairns, Qld., 4870.

INFORMATION on old Valvestester — Paton model VCT-2. Need operation manual, anything on how to operate. John Meldrum, 1 Barbara Boulevarde, Seven Hills, Phone 621-5041.

ETI414 MASTER MIXER Cannon inputs. Extra tape — source monitoring sectionwith tone controls. Best offer. T. Dalziell, 2 Crews Place, Wanniassa, 2903. Ph: (062) 31-8735.

FOR SALE. B.W.D. 539c oscilloscope dual trace D.C720M. Four months old $350. Write or phone Ernie Elu, 18 Smith Road, Camberwell, 3124. Phone (03) 81-0574.

RCVR, AM FM, 56 to 108 MHz, 174 to 217 MHz. AC/DC powered. Owners manual. $29. Jeff Lyons, 130 Glebe Point Road, Glebe 2037.

DUMONT SCOPE X, Y, Z, amps $60. Good condition. Take other equipment in exchange. Halpin 81-4724, 12 Swinburne Ave, 3122 Vic.

FOR SALE. New CO-1303A TRIO Oscilloscope. Phone 602-9873. $130.00. A. Renton, 198 Newbridge Rd, Moorebank, N.S.W. 2170.

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FOR SALE. ETI 1972—1975 $35. AMP 5 W.C.H. $25. T.V. 3 in 1 stereo 470. 417 Forest Rd, Bexley, N.S.W. Phone 59-5572.

RESISTORS ¼W & ½W 2c. Capacitors 5c up. Upright electro's from $1.50. Limited values. Send S.A.E. to D. Marzolla, 51 Macquarie St, Leichhardt, NSW, for info.

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FOR SALE. 80 W Pico special soldering iron. Mains operated, can be converted to other wattages $12. Nick Sofianidis, 81 Holborow Street, Croydon Park, N.S.W. 2133.

SELL, DRAKE R4-C communic. receiver with noise blanker, accessory X'tals, phone 86-8201 A.H. or Michael Stevenson, "Attunga", RMB 59, Harden, N.S.W., 2587. $350 or nearest offer.

WANTED TO BUY. Practical Electronics Sept '73, May '74, Oct. '74. Name your price. I. Maclean, 3/22 Ulm St, Coburg North, Vic. 3058.

STOLEN ETI4600 synthesiser, black vinyl, separate keyboard. Also Sony 854/4S 4-track tape recorder 10" reels. Uninsured, sadly missed. Good reward. No questions asked. 387-7595 Sydney, Steve.

SONY TC570 reel to reel tape recorder with S.O.S., stereo, mono. Three speeds including 7.5ips. Original condition. $250. 9/150 Grange Road, Fairfield, Vic.

BACK ISSUES Electronics Australia 1958 to 1971, 133 magazines, $15. Greg Edwards, 52 Cardinal Ave, Beecroft, 2119, Sydney, 84-6140 A.H.

RADIO COMPASS RECEIVER R101/ARN6 handbook, control box, receiver mounting rack wanted. Lionel Sharp VK4NS, 19 Kelso Street, Chermside, Queensland 4032.

INFO WANTED. Diode ring modulator Anzac MD108 mentioned in Plessey SL600 series applications manual. Sanders, 11 Macken St, Oatley, 2223. Work 531-3145, Home 579-3848.

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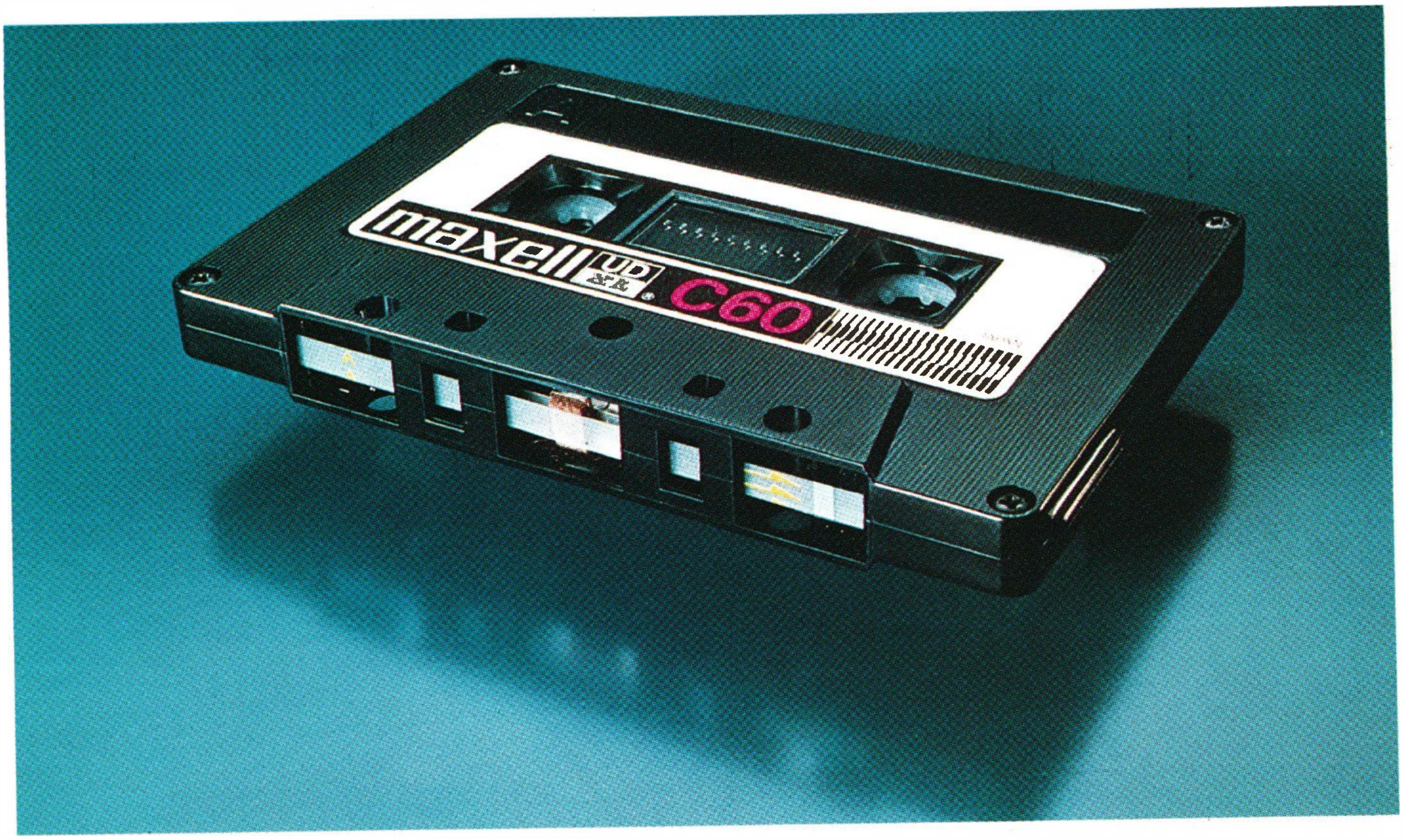
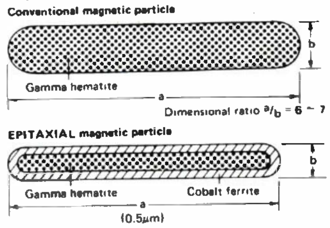
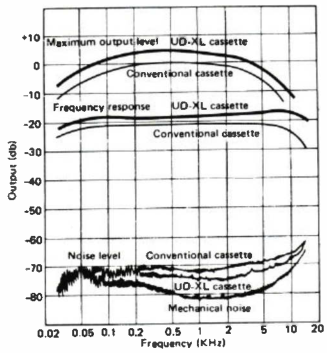


Introducing the revolutionary UD-XL EPITAXIAL cassette

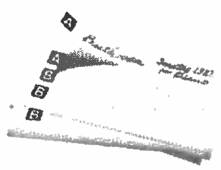
Developed by MAXELL this completely new EPITAXIAL magnetic material combines the advantages of the two materials (gamma-hematite and cobalt-ferrite): the high sensitivity and reliable output of the gamma-hematite in the low and mid-frequency ranges and the excellent performance of the cobalt-ferrite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



Compared to chrome tape, sensitivity has been improved by more than 3.5dB. Because EPITAXIAL is non-abrasive, it extends to the life of the head. Consequently, the UD-XL delivers smooth, distortion-free performance during live recording with high input. When using UD-XL it is recommended that tape selector be in the NORMAL position.



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.

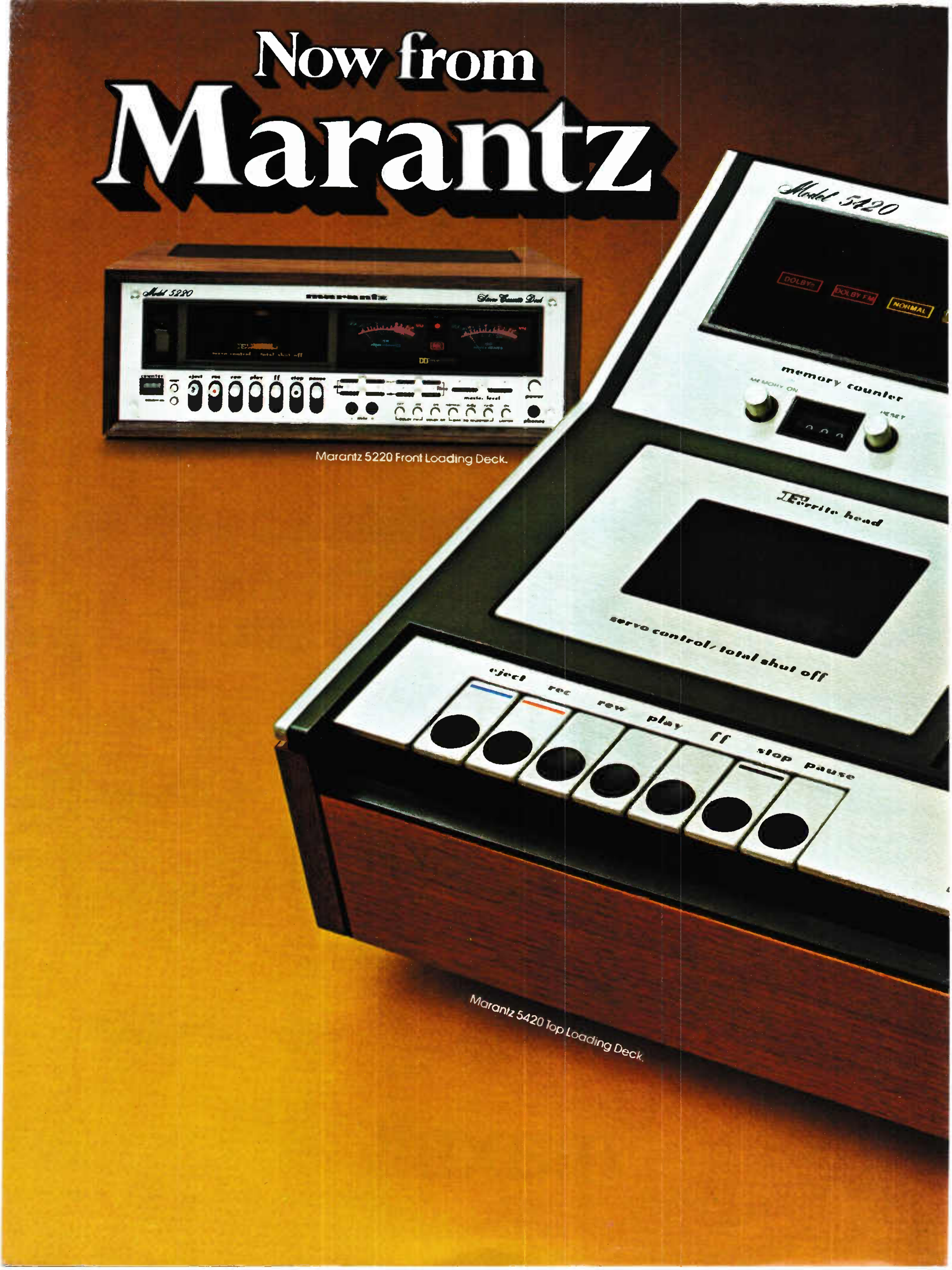


Another good idea of the UD-XL cassette is a replaceable self-index label. Simply peel off the old label and put on a new one when you change the recording contents. No more mess on the label.

maxell®

For further information please write to Maxell Advisory Service, P.O. Box 49, Kensington, N.S.W. 2033.

WT.GO. 76M



Marantz 5220 Front Loading Deck.

Marantz 5420 Top Loading Deck.

Direct-drive performance brings out the best in any record.

PL-510A

From cover to cabinet, the PL-510A was created to deliver the performance needed for today's ultra-fidelity records. Right from the start, direct-drive gets you closer to the original sound by reducing the parts between the motor and the music. The turntable platter is directly connected to the shaft of the servo-controlled motor. Motor rotation is actually turntable rotation. As a result, wow and flutter is measured at no more than 0.03% (WRMS) and the S/N ratio is more than 68dB (DIN B).

Performance is further enhanced by the high-trackability S-shaped tone arm. Precision angular contact bearings enable accurate groove tracing even with light stylus pressure cartridges.

In order to maintain the integrity of this engineering achievement, the PL-510A employs a unique "double float" mounting system. Turntable and tone arm assemblies are secured to a rigid sub-chassis which is in turn spring floated from the anti-howling monocoque cabinet. Exterior vibrations are effectively absorbed by large rubber insulators and tonal quality is perfectly preserved.

	Type	Drive System	Wow & Flutter		S/N Ratio	Cartridge
PL-510A	Manual	Direct-drive	No more than (WRMS)	0.03%	More than 60dB (JIS), 68dB (DIN B)	Not included
PL-117D	Fully-automatic	Belt-drive	No more than (WRMS)	0.07%	More than 50dB (JIS), 63dB (DIN B)	Induced magnet type (PC-135)
PL-15R	Auto-return	Belt-drive	No more than (WRMS)	0.08%	More than 47dB (JIS)	Moving magnet type (PC-12)
PL-12R	Manual	Belt-drive	No More than 0.1% (WRMS)		More than 47dB (JIS)	Moving magnet type (PC-12)

Other advanced features include: electronic speed change at the touch of a button and ±2% fine speed adjustment, illuminated strobe, an anti-skating device, direct readout counterweight and a lateral balancer.

With all these great ideas built-in, it's easy to see how Pioneer's PL-510A direct-drive turntable will bring out the best in all your records.

Pioneer Electronics Australia Pty. Ltd.
178-184 Boundary Road, Braeside, Victoria 3195 Phone: 90-9011, Sydney 93-0246, Brisbane 52-8231, Adelaide 433379, Perth 76-7776.

PIONEER
leads the world in sound.

Marantz 5120 Top Loading Deck.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NORMAL
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master level
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RIGHT
panpot system
power
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mic1
mic2