APRIL 1976 $1.00*

electronics TODAY INTERNATIONAL

THREE COLOUR TV's TO WIN!

NEW SERIES: DATA SHEETS

INSIDE - 84 PAGE DICK SMITH CATALOGUE

Registered for posting as a periodical – Category C

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

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

With features only expected on more expensive units, such as wow and flutter of 0.5 WRMS thanks to the DC motor with FG (frequency generator) servo-controlled circuits.

How's this for a list of features. Practical, purposeful features like

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

and the list just goes on.

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

WARRANTY AND SERVICE BY HACO

For a National Technics Catalogue please write to: National Technics Advisory Service, P.O. Box 49, Kensington, N.S.W. 2033

National **Technics** by National

WT GD 105 T

APRIL 1976, VOL. 6 No. 4

electronics TODAY INTERNATIONAL

PROJECTS

FEATURES

REVIEWS

NEWS & INFORMATION

COVER: We have three Toshiba colour TV's to win! Turn to page 18 for full details.

*Recommended retail price only.

A MODERN MAGAZINES PUBLICATION

Why you need 220 watts of power to listen to soft music.

SA-9900

Stated simply, Pioneer's new SA-9900 stereo amplifier was created to faithfully reproduce music at any volume you desire. At 110 watts RMS per channel, it doesn't matter whether you're trying to liven up a party or just warm up your sweetheart. Through a precision blending of Pioneer's advanced electronics, total harmonic distortion is never more than 0.1%. As a result, you hear all the sounds of all the music you play —clearly—even the soft ones.

And while the SA-9900 is easy to listen to, it's also easy to use. A newly designed chassis places all the output terminals on the left side and all the input terminals on the right. Separated to eliminate any signal interference and convenient for access to cord connections.

The SA-9900 stereo amplifier. Another example of technical know-how and constant research applied to meet the listener's needs. After all, isn't that what you've come to expect from Pioneer audio equipment.

At Pioneer, we uphold that trust with almost 40 years of exclusive commitment to audio excellence. And from our vast resources as one of the world's leading audio specialists, we are privileged at this time to offer the SA-9900 as the best in an entire line of outstanding stereo amplifiers. Stop by and see your local dealer for a demonstration. You'll get an earful of truly great music—any way you like it—loudly or softly.

Pioneer Electronics Australia Pty. Ltd.,
178-184 Boundary Road, Braeside, Victoria 3195, Phone: 90-9011, Sydney 93-0246, Brisbane 52-8213, Adelaide 433379, Perth 76-7776

PIONEER®
leads the world in sound.

news digest

ELECTRONICS TODAY – FIVE YEARS OLD

The Australian edition of Electronics Today was started in April 1971 – just five years ago.

One year later the magazine made Australian publishing history by establishing a subsidiary edition in the UK – this was the first time that such a move had ever been attempted – and followed this up later that year with a French language edition published in Paris. Both overseas editions have proved remarkably successful and like our parent edition here in Australia have a record of ever-increasing circulation and reader acceptance.

Five years is not a long period in our type of journalism – so we're not turning this issue into a panegyric of self-congratulations. However we felt that we could not let the occasion go totally unmarked so this issue contains a grand contest in which there are three colour TVs as prizes, plus two new main features. And there's more to come in the near future.

So thank you – readers and advertisers alike for your kind support and encouragement. Especially thank you to those countless people who have written and telephoned us to wish us well for the future. It's really appreciated.

TEACH YOURSELF BRAILLE – NEW METHOD

A new do-it-yourself method of learning braille has been developed in Britain. Already it is being used by hundreds of blind people, aged between 11 and 78, who are now able to learn to read at their own pace in their own homes. The main advantage of the system is its simplicity, as it can be used by anyone with access to a portable tape recorder.

Developed by Dr Michael Tobin, of the Research Centre for the Education of the Visually Handicapped at the University of Birmingham, the system comprises two pre-recorded C120 cassette tapes and a braille booklet divided into 20 lessons. Dr Tobin who has studied the problems of teaching braille to blind children and newly blinded adults, set out to find a method which would overcome the shortage of teachers, or the pupil's dislike of joining group classes.

He established that learners did best by starting with a large braille cell and then he created a programmed learning system using a braille booklet and tape-recorded instructions. The learner listens to the instructions on the tape, and then carries them out using the booklet. The advantage is that the lesson can be repeated as often as the pupil wishes.

There is no copyright on the system and the cassettes together with the booklet can be reproduced by blind organisations throughout the world.

For further information contact:

Royal National Institute for the Blind, 224 Great Portland Street, London, England,

SIGNIFICANT DEFENCE OFF-SET CONTRACT AWARDED TO STC

A significant electronics contract under the Australian Government off-set programme has been awarded to Standard Telephones and Cables Pty Limited.

The contract, valued at $235,000 calls for the assembly and testing of power units for tactical computers for the Royal Australian Navy designed by

Univac Defence Systems in Minneapolis, USA. Univac is one of the largest suppliers of tactical computers to the US Navy.

The contract is significant as it is a direct result of efforts by the Australian Government and, in particular, the Department of Defence to obtain off-set orders for the Australian electronics industry in relation to the current services re-equipment programme.

The "off-set" contract programme means that when an Australian Government Department lets a prime contract to an American or other overseas company, the contract conditions usually require that the company allows a certain percentage of the value of the contract to be placed back with Australian industry subject to Australian tenders being competitive with overseas prices.

By this means, the Government hopes to achieve advancement of technology within local industry and improved local support for the equipment being purchased.

STC Executives are confident that success with this off-set contract will lead to the placement of even more significant off-set contracts within Australia, thus extending the Australian electronic industry's capability to better serve this country.

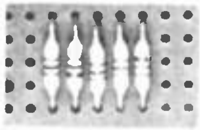
The power unit equipment will be manufactured at STC's Liverpool facility.

PRICE INCREASE

Despite considerable increases in our own expenses we have, for some time, managed to keep the price of ETI at 75 cents.

But now inflation has not only overtaken us — it's way out of sight! So with the greatest reluctance we have increased our cover price to a recommended retail price of $1.00. We trust you'll understand . . . . .

MINIATURE HALF-WATT RESISTOR



IRH Components has introduced a metal glaze type GLP resistor. The miniature ½ watt rated resistor has a maximum surface temperature rise of 50°C, the physical dimensions of many other 1/8 or 1/4 watt resistors but a full 1/2 watt rating at 70°C ambient.

The smaller size allows 10mm lead spacing as standard for horizontal printed circuit board mounting — reducing demand on expensive PC board real estate. Even greater packaging density can be achieved by vertical mounting.

HIGH POWER RF BEAMED OVER ONE MILE

More than 30 kW of RF energy frequence has been successfully beamed over 1.6 km by scientists at the USA's Jet Propulsion Laboratory.

The 2 388 MHz beam was generated by a 450 kW klystron and transmitted via a 26 metre parabolic antenna.

The transmitted beam was received by an array of 17 flat receiver panels containing over 4500 tuned dipoles and special rectifiers that converted the RF energy to dc at an overall efficiency of 82%

An earlier experiment — in 1964 — was performed by Raytheon's William C. Brown who kept a small helicopter aloft for ten or so hours by powering it with energy from an RF beam.

The only previously known successful experiment was that of Nikola Tesla (funny how that name keeps coming up) who in 1899 lit a bank of 200 lamps at a distance of 42 km via energy beamed from an RF transformer (Tesla coil).

The transformer operated at the almost incredible voltage for 1899 — of 12 million volts. Frequency is believed to have been about 100 kHz.

news digest

CHANGES AT ETI

Since our very first issue back in April 1971 all but ten or so of our published constructional projects have been designed by one man — Barry Wilkinson.

Now Barry has decided to extend his activities. Barry Wilkinson and ETI Technical Editor Brian Chapman have joined forces to form a new technical design and manufacturing company called Nebula Electronics Pty Ltd.

Part of Nebula's activities will be to design and develop ETI's projects — so Barry's design expertise will continue to be one of ETI's main attractions. Nebula will also be entering the kitset market — and will supply selected kits and specialised components associated with ETI projects.

Nebula will also undertake specialised on-off design and development for professional organisations. The company's address is Nebula Electronics Pty Ltd, 4th Floor, 15 Boundary St, Rushcutters Bay, NSW. Telephone 335850. That's just one floor above us.

EARLY WARNING FOR FIRES

A new fire-detection device is claimed to be 100 times more sensitive than existing warning systems has successfully completed a series of trials in Melbourne. The device is so sensitive it can detect smoke from a burning match. An inbuilt analyser also prevents false alarms.

The detection system was designed from a device developed by the CSIRO to measure the density of bushfire smoke. It was adapted for use in office buildings by its inventor, Mr. David Packham of the CSIRO Division of Mineral Chemistry and Mr. Len Gibson, the Australian Post Office (Telecom) Fire Protection Officer for Victoria.

The device, known as a nephelometer, gains its effectiveness from its ability (unlike other detection systems) to work in the return air duct of air conditioning systems. Any smoke generated in the building is drawn into this duct. The slightest trace of smoke causes the disturbance of a light beam emitted from a special lamp. This scattered light is then picked up by a special detector which activates a signal. The size of the signal depends on the amount of scattered light and therefore the amount of smoke.

The early warning system is especially useful after hours when buildings are not manned but air conditioning systems remain operating.

Mr. Packham explained that if a small quantity of smoke is detected over a period of one minute, the monitor moves to a "yellow alert", signifying an abnormal amount of smoke. If the yellow alert continues and thicker smoke is detected, an "orange alert" is declared and the premises are inspected. The inspection could find that an overheating power transformer or some other mechanical or electrical failure resulted in smoke emission.

If a *large* signal is transmitted to the monitor a "red alert" exists. An alarm sounds and the fire brigade is called automatically — red alert can be nothing other than a fire.

Following the successful use of the systems in the Melbourne telephone exchanges, Telecom is expected to install the CSIRO invention in most of its major city and suburban exchanges.

The CSIRO has applied for patents on the device both in Australia and overseas. It is expected that a commercial manufacturer will soon be licensed to mass-produce the systems.

DIGITAL QUARTZ LIQUID CRYSTAL CHRONOGRAPH

Seiko has introduced digital quartz chronograph with liquid crystal display. The new unit combines the Seiko quartz timekeeping mechanism with a highly sophisticated electronic stopwatch.

When reading standard time, the dis-

(Continued on page 13)

Presenting a remarkable range of products... a remarkable philosophy.

The world's reviewers agree that each of the products presented here represents true state-of-the-art, design, engineering and performance.

None is cheap, but each item is realistically priced considering the standards achieved and maintained.

And that brings us to our Remarkable Philosophy.

We feel our equipment and your interests are worthy of the finest demonstration facilities, the most expert installation and the advice of interested, knowledgeable and honest consultants who will help you . . . not pressure you.

To this end we have appointed a small number of Hi-Fi Specialists to bring you Stanton, Fons, S.A.E., Monitor Audio and Neal state-of-the-art components.

We invite you to audition this remarkable equipment at the selected Hi-Fi specialists listed overleaf.

STANTON

STANTON pickups are the almost unanimous choice of recording studios, Radio Stations and TV stations.

They are unique in that they offer spectacular performance without fragility. They also lead the field in consistency—a quality lacking in most pick-ups.

From the illustrious Calibration Standard 681 EEE through the 681 EE and 500 EE to the Broadcast 500A (so popular with radio stations) there is a Stanton pick-up to meet the most exacting need.

Stanton 681 EEE, the New Calibration Standard .... Stanton's finest Cartridge.

Stanton 681 EE, for application where slightly greater tracking pressure than 681 EEE is required.

Stanton 500A, the Broadcast Standard Cartridge as used by the majority of radio stations throughout Australia.

the remarkable products...

fons

FONS is a new name to the world of hi-fi. Built in Scotland, the Fons CQ30 turntable has such exciting features as:—

- ☐ D.C. Servo controlled motor with gold plated commutator and silver plated brushes.
- ☐ Speeds, push button selected for 33, 45 and 78 RPM but continuously variable from 29 to 100 RPM.
- ☐ Hyper-concentric bearing typically better than ± 0.000076mm.
- ☐ Rumble typically -79dB.
- ☐ Wow and Flutter better than ± 0.03%.
- ☐ Anti-feed back phase cancellation suspension system.

Fons claim that the virtual absence of wow and flutter, rumble and vibration lead to a noticeably cleaner sound, and direct comparisons with other units certainly confirm this. In fact, direct comparison with another highly regarded unit using the same Stanton 681 EEE cartridge showed a dramatic improvement.

Neal 102

Neal 103

NEAL

Neal is a name new to Australia but it has established a formidable reputation in the U.K. for quality, ruggedness and performance stability.

The Neal Transcription Cassette Recorder is the product of people who have many years experience in the design and manufacture of tape recording equipment.

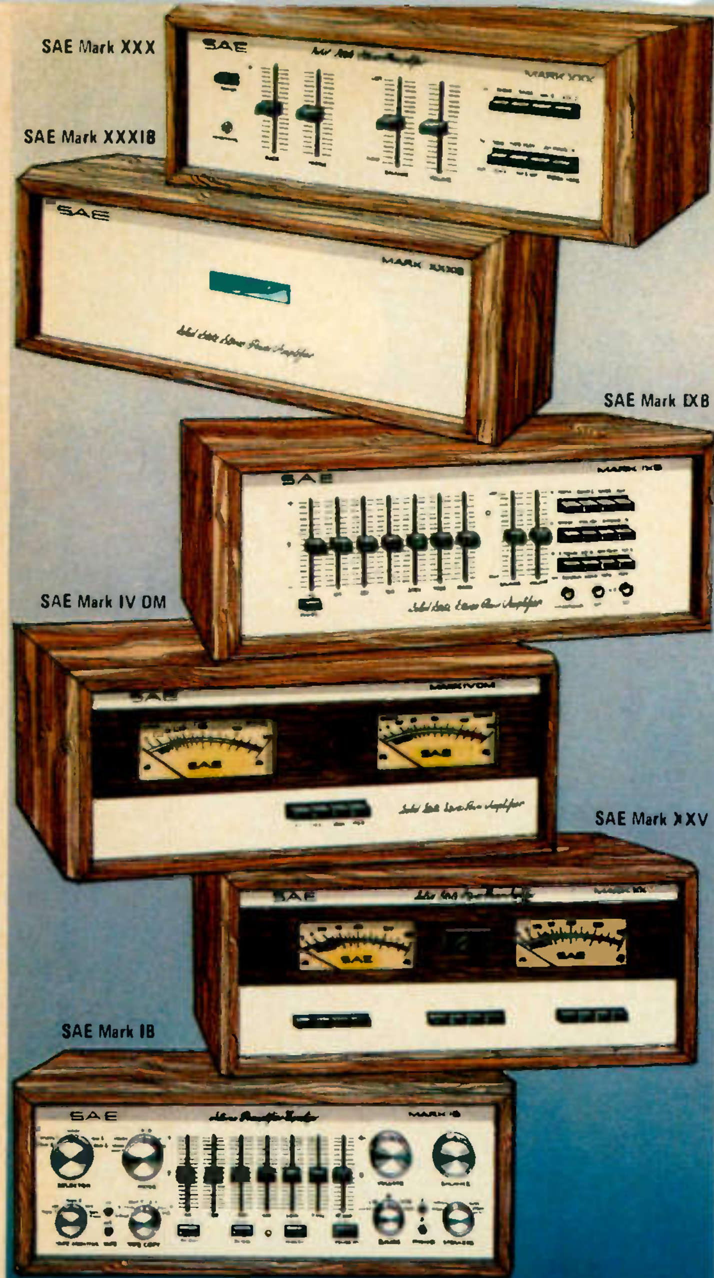
The one word that sums up their design and their product is "integrity". You will find no miracles, no way-out designs, no change for the sake of change, just an obsession with doing everything the right way.

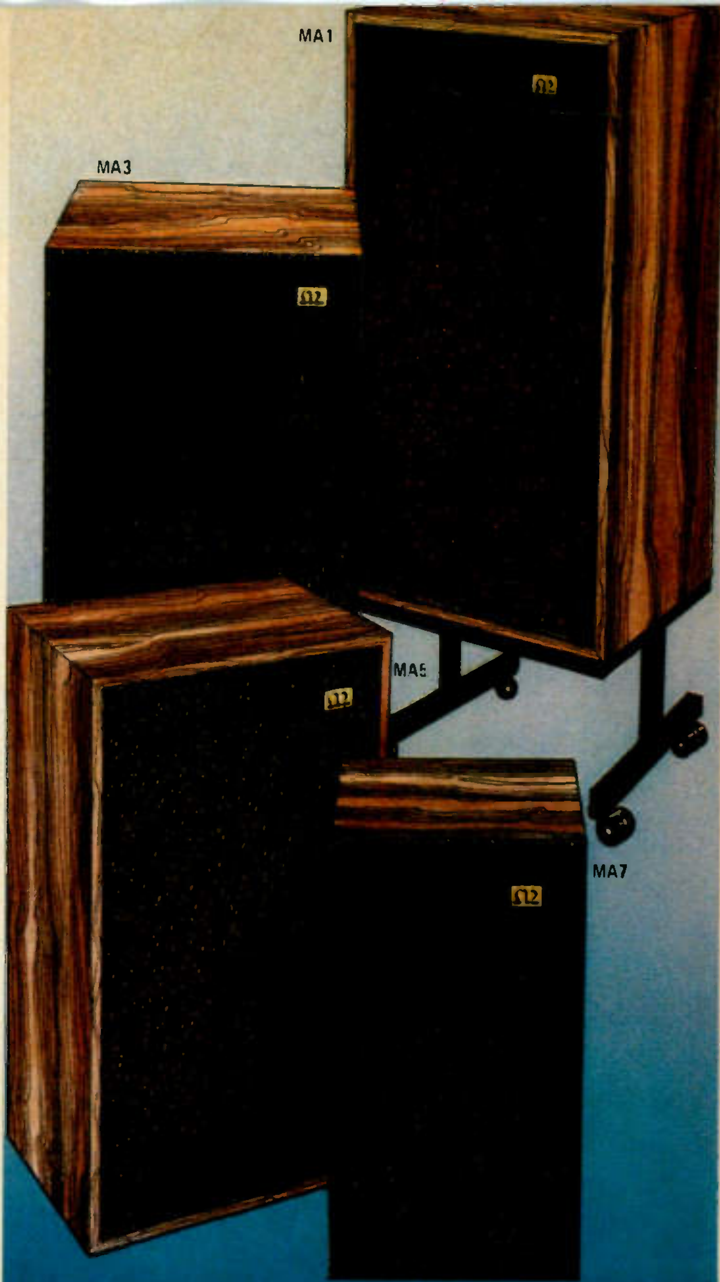
Separate preamplifiers are used for each of the three stereo inputs to reduce noise. This also allows three stereo (or six mono) inputs to be mixed.

Bias is readily adjustable to optimize performance from any tape thanks to Neal's exclusive Varitape facility.

Neal are the only cassette recorder company in the world to offer the ultimate quality control check. A cassette actually recorded on the machine you buy. This is your guarantee of quality.

"Hi-Fi for Pleasure" (August 1975) consider the Neal 103 as being "the obvious choice of the serious enthusiast or semi-professional".





SAE

S.A.E. Preamplifiers, Power amplifiers and Equalizers have taken the professional field by storm. The acceptance of S.A.E into their ranks has been almost unprecedented.

Mark XXX Preamplifier with Mark XXXIB Power Amplifier brings you Connoisseur Sound at budget prices. All unnecessary items have been omitted in the pursuit of the highest possible performance to price ratio.
The S.A.E. Mark XXXIB was tested by "High Fidelity" in May 1974, at 0.031% THD 20HZ to 20KHZ at 50 watts output per channel.

Mark IXB Preamplifier with Mark IVDM Power Amplifier. This combination brings you a versatile Equalizer Pre-amplifier with a power amplifier that was described in the "Popular Electronics" May, 1975 review as "True state-of-the-art performance with distortion levels that cannot be measured with any but the most advanced laboratory instruments." "For all purposes the Mark IVDM is a distortionless amplifier". Actual measurements were 0.005% at Rated 100 watts per channel and only 0.1% at 190 watts per channel!

Mark XXV Power Amplifiers. This is surely today's ultimate amplifier. It is rated at 300 watts per channel, both channels driven, into 8 ohms, and S.A.E. ratings are almost unreasonably conservative! Built-in forced air cooling ensures long life for all components.

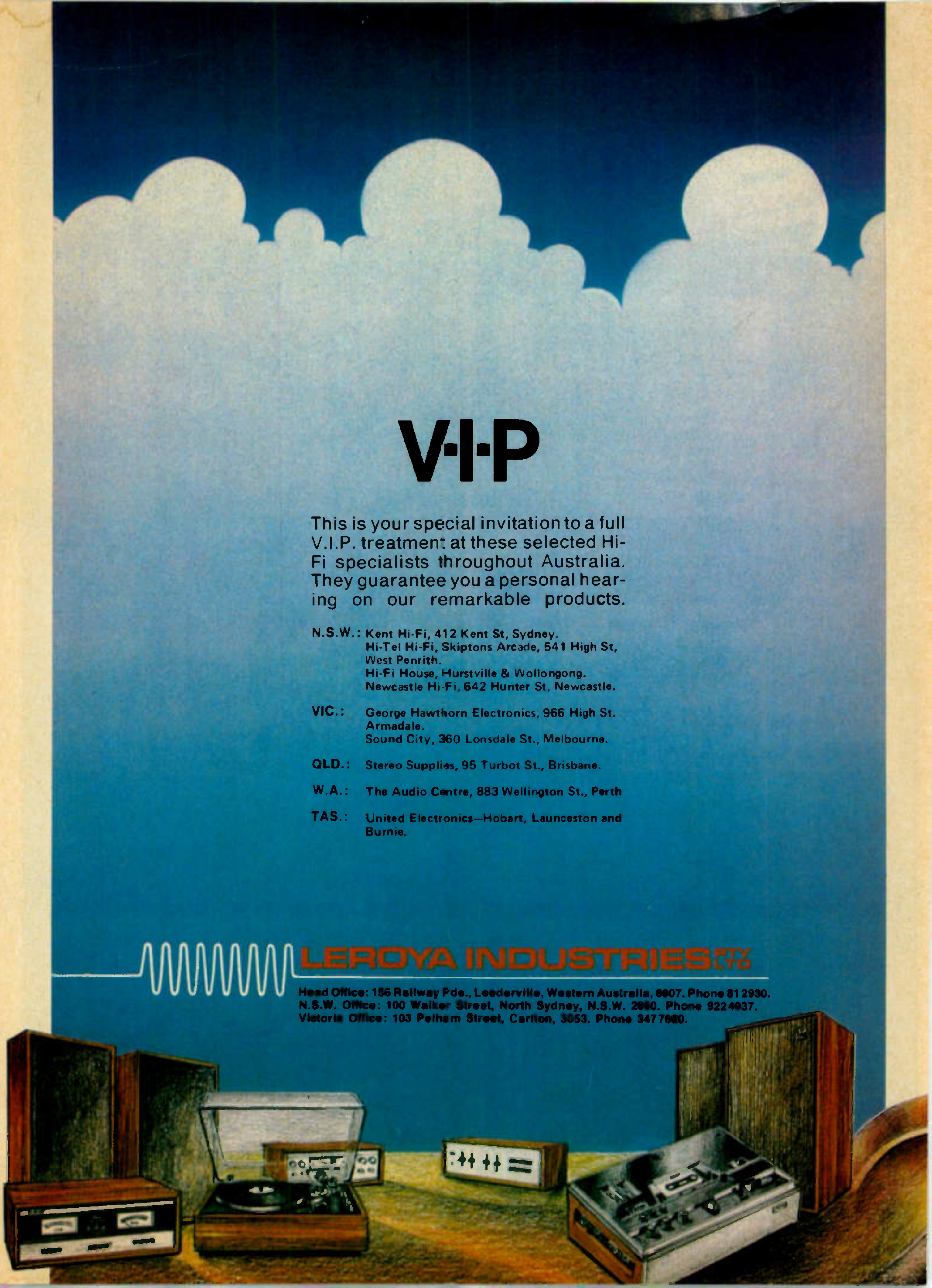
Mark IB Preamplifier was designed for those who have, or intend to have, very complete audio installations.
"Stereo Review" October, 1975, says "When it comes to operating and control flexibility, the S.A.E. Mark IB has few peers."
The harmonic distortion, excluding hum which "was far below audibility" was 0.0075% at all frequencies up to 20,000HZ.

Monitor Audio

MONITOR AUDIO is another new company. It has leapt to prominence in only two years. In the "Practical Hi Fi Audio" October 1975, comparison of ten loudspeakers including Spendor BCI, B & W DM4, Kef Cadenza, IMF Super Compact, the Monitor Audio MA5 Series 11 was chosen as best of all. Its very low colouration, sweet-sounding treble, openness, and tight extended bass endeared it to the reviewers.

Similarly the tiny MA7 was chosen as the best of five speakers in a test conducted by "Popular Hi Fi" (June 1975) although it was the smallest and cheapest of the units tested.

At the top of the range is the mighty MA3 which retains the qualities that have established Monitor Audio at the pinnacle of loudspeaker design and manufacture, but combining these—possibly for the first time—with a power output which is awesome and a level of bass distortion which must set new standards.
"Practical Hi Fi and Audio" May 1975, measured the third harmonic distortion of the MA3 at 100 HZ at "close to 1 per cent" at 96dB sound pressure level. At the critical midrange the distortion is between 0.3% and 0.6%.
They go on to say "The first impression one gets when listening to the MA3 is one of physical presence, and this quality seems to be independent of the closeness of recording. This may be attributable to the exceptional smoothness of its midrange unit together with the use of a very analytical tweeter."
All we ask is that you give them a hearing.


V·I·P
This is your special invitation to a full V.I.P. treatment at these selected Hi-Fi specialists throughout Australia. They guarantee you a personal hearing on our remarkable products.
N.S.W.: Kent Hi-Fi, 412 Kent St, Sydney.
Hi-Tel Hi-Fi, Skiptons Arcade, 541 High St, West Penrith.
Hi-Fi House, Hurstville & Wollongong.
Newcastle Hi-Fi, 642 Hunter St, Newcastle.
VIC.: George Hawthorn Electronics, 966 High St. Armadale.
Sound City, 360 Lonsdale St., Melbourne.
QLD.: Stereo Supplies, 95 Turbot St., Brisbane.
W.A.: The Audio Centre, 883 Wellington St., Perth
TAS.: United Electronics—Hobart, Launceston and Burnie.
LEROYA INDUSTRIES PTY LTD
Head Office: 156 Railway Pde., Leederville, Western Australia, 6007. Phone 81 2930.
N.S.W. Office: 100 Walker Street, North Sydney, N.S.W. 2060. Phone 922 4937.
Victoria Office: 103 Pelham Street, Carlton, 3053. Phone 347 7620.

(Continued from page 8)

play indicates the hour and the minute, the date, and AM or PM. The large, bright liquid crystal display can be seen in any light. In the dark, a built-in lamp can be activated to illuminate the face.

When split-second timing is required, the display can be switched to read in minutes, seconds, and tenths of seconds. Two buttons start, stop and reset the stopwatch. Unlike most conventional wrist chronographs, the built-in stopwatch on the Seiko unit is capable of performing multiple tasks. A lap timing feature allows the display to be frozen while internal timing continues. And a special 'one-two finish' feature allows the times of both the winner and runner-up of an event to be recorded, even if it's a very close contest.

The electronic stopwatch can also be used to measure elapsed time up to one hour.

Seiko Watch Sales
490 Kent St
Sydney 2000

FCC AMPLIFIER RULING REVISED

The recent ruling of the US Federal Trade Commission regarding amplifier testing has been revised.

The original ruling specified that amplifiers must be warmed up for one hour prior to testing at one third maximum load. This ruling was impractical for most high-powered hi-fi amplifiers, which never operate under such conditions in real life, and caused major and unnecessary restrictions on claimed power ratings.

In the revised ruling amplifiers may be warmed up in a series of power bursts — going through as many on/off cycles as may be necessary to accumulate an hour of 'on' time.

CALCULATOR THAT TALKS

A calculator that speaks has been introduced by Telesensory Systems of Palo Alto, California, USA.

The unit called 'Speech Plus' enunciates each entry as it is made and then announces the answer. The unit has a vocabulary of 24 words.

The advantage claimed for the speech facility is that it enables the user to perform a series of entries and calculations without continuously looking at the read-out.

FLUX-CORED SOLDER FOR ALUMINIUM JOINTS

Multicore Solders has applied for world patents for a flux-cored solder composition, called Alu-Sol 45D silver loaded solder, which is claimed to have excellent corrosion resistance and a melting range of only 178 to 270°C.

Joining aluminium and its alloys has previously been considered impossible except by welding or high temperature brazing with very aggressive fluxes. It is difficult to heat aluminium to the high temperature required — for such treatment distorts the aluminium. Lower temperature brazing and soldering has not been effective, the filler metals used having been incompatible with aluminimum and the joints having failed subsequently due to electrolytic corrosion.

The new solder easily solders wrought aluminium and its alloys containing up to 3 per cent magnesium or 1.5 per

news digest

cent each of magnesium and silicon, and aluminium-copper. Cast aluminium can be soldered if the rough case surface is machined off. Other solderable metals include tin-plate, copper, brass, nickel, stainless steel and zinc alloy diecastings.

Multicore Solders Aust Ltd, PO Box 150, Ermington NSW 2115.

SEMICONDUCTOR APPLICATIONS MANUAL

A revised and updated edition of the popular 92-page Applications Manual covering the Plessey SL600 series of semiconductors designed specifically for radio communications is available through the Components Division of Plessey Australia, PO Box 2, Villawood 2163 for $2.85 a copy.

First published in the UK in 1972, the new edition will satisfy an extensive Australian demand for full information on the Plessey range.

NEW MINIATURE CASSETTE

An ultra-small tape cassette measuring only 33.5 by 50.2 by 8.1 millimetres has been developed by Olympus Optical Co of Japan for use with a new series of tiny pocket sized cassette voice recorders that that company are already producing. A similar machine using the same cassette is also being produced by Matsushita. Sony too are planning to enter this market.

The tiny recorders operate at a tape speed of 24 mm a second.

CALCULATOR TO WIN!

THIS MONTH our Unitrex contest features the model 901SN. This is a scientific calculator with scientific notation permitting the solution of problems ranging from 10^{99} to 10^{-99}.

The unit has an nine digit display in arithmetic mode, five digit mantissa and two digit exponent in scientific notation.

Functions include — computing trigonometric, inverse trigonometric, logarithmic exponential and convenience functions ($1/x$, x^2, $\sqrt{x}$, π) etc. The keyboard consists of momentary keys and a static mode select switch for choosing angle values in degrees or radians.

That's a lot of computational power for its recommended retail price of $39.95.

Here's a chance to win one of these units. It's not a new problem but it is one the answer to which often surprises those who've never thought about it before — or worked it out for themselves.

Twenty six people work in an office in Melbourne.

What do you think the chances are that two or more of these people will have their birthday on the same day?

Just ring the answer on the entry form that you think is the closest.

All answers, which must be received before May 15th, will be put into a barrel and drawn one at a time until a correct answer is received. That first correct entry will be the winning one.

Entries should preferably be sent on the official entry form printed on this page. If like many of our readers you'd sooner not cut up your ETI just copy the entry form on to a sheet of paper. Do please remember to include your name and address. Entries close May 15th 1976.

The winner will be announced in ETI as soon as possible.

RESULT OF FEBRUARY CONTEST

Winner of our February contest was Mr B. Fergie of Brighton, Victoria.

Thirty five contestants sent in entries with absolutely correct answers to the main question — which concerned the monthly payments and interest payable each year on a loan of $9387 over four years at 11.25%.

Most contestants failed to realise that the interest payable each year falls very considerably.

The correct answers to this part of the question are — monthly payments — $243.75

interest 1st year	$956.59
interest 2nd year	$723.36
interest 3rd year	$462.49
interest 4th year	$170.71

The second part of the contest which we used as a tie breaker asked entrants to estimate how long it took our technical editor to obtain the correct answer (having first worked out the routine) on a basic four function machine. And secondly how long it took him using a Unitrex 901F.

Our winning entrant estimated the times as 207.5 secs and 38.5 secs respectively. The actual times were 181.5 secs and 32.4 seconds respectively.

So congratulations Mr. Fergie, you'll have your Unitrex 901F financial calculator very soon.

Send to Calculator Contest (April)
Electronics Today International, 15 Boundary St, Rushcutters Bay, NSW. 2011.

The chances are 5%, 10%, 14%, 21%, 25%, 33%, 39%, 45%, 50%, 63%

Name ....

Address ....

.... P/Code .....

Permit Number TC 7407.

At AKAI, we concentrate on being better. Not bigger. So you'll probably find bigger hi fi ranges than ours.

But you'll have your work cut out finding a better range. For quality. Performance. And reliability.

All our equipment is listed below. And each and every piece of hi fi equipment distributed by AKAI Australia is covered by the Complete Protection Plan†. Which simply means 12 months full parts and labour warranty on all Tape Equipment, 2 years full parts and labour warranty on all Amplifiers, Turntables and Speakers and a lifetime warranty on all GX Tape Heads.

So, whether you're new to hi fi, or an old hand at it, you'll find something exactly right. We'll stack our reputation on it.

PORTABLE	**$**
CT-5	175.00
CASSETTE RECORDERS	
CS-34	280 00
GXC-39	380 00
CASSETTE DECKS	
CS-34D	220 00
GXC-39D	360 00
GXC-75D	498.00
GXC-325D	550 00
GXC-710D	439.00
CARTRIDGE RECORDERS	
GXR-82	395.00
CR-80SS*	528.00
CARTRIDGE DECKS	
GXR-82D	345.00
CR-80DSS*	435.00
OPEN REEL RECORDERS	
1730SS*	535.00
GX-1820	660.00

OPEN REEL DECKS	
GX-230D	550 00
GX-265D	710.00
GX-270D	685.00
GX-400D	1445.00
GX-400DP	1365.00
GX-400DSS*	1593.00
GX-600DP	770 00
GX-630D	810.00
GX-630DB	910.00
GX-630DSS*	1090.00
GX-1820D	605.00
4000DB	379.00
AMPLIFIERS	
AA-5210	215.00
AA-5210DB	299.00
AA-5510	299.00
AA-5810	375.00

RECEIVERS	
AA-810	250.00
AA-810DB	310.00
AA-1020	330.00
AA-1020DB	455.00
AA-1030	375.00
AA-1040	430.00
AA-1050	465.00
AA-1070	760.00
AS-1080	845.00
AS-1080DB	990.00
TUNER	
AT-550	260.00
TURNTABLES	
AP-001C	155.00
AP-003	235.00
AP-005	290.00
AP-006	330.00

N.B. All turntables complete with cartridge, stylus, base and lid.

SPEAKERS	**(per pair)**
SW-30	75.00
SW-35	119.00
SW-42	150.00
SW-126	245.00
SW-136	310.00
SW-156	385.00
SW-176	580.00

* 4 channel

DB in model name signifies Dolby System

Prices quoted are the recommended retail prices only

† The AKAI Complete Protection Plan warranty does not cover equipment purchased outside Australia

AKAI

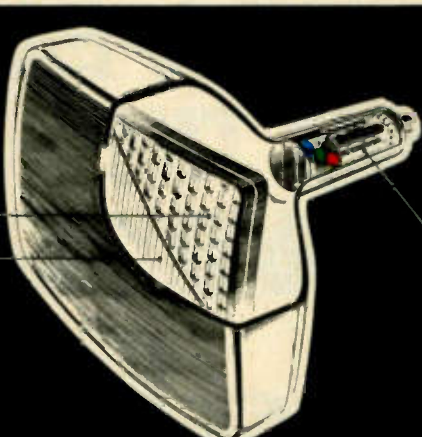
The name you don't have to justify to your friends.

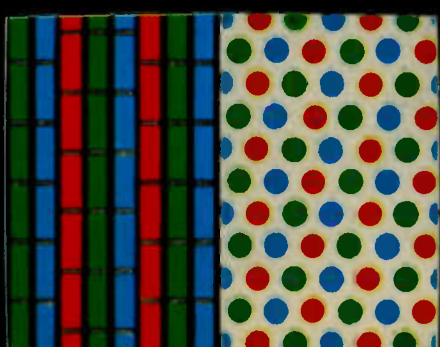
70620


THE CELESTIONS
ARE COMING
LOUDSPEAKERS
FOR THE
PERFECTIONIST
?
Celestion

ELECTRONICS TODAY - TOSHIBA

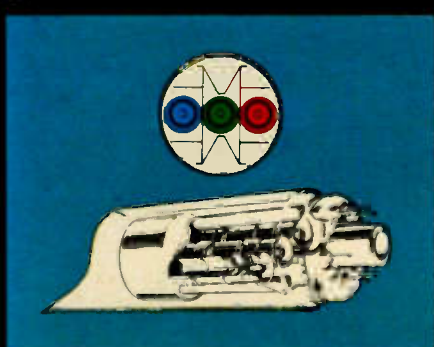
GRAND CONTEST





Toshiba "BLACKSTRIPE" Picture Tube

Usual Colour Colour Picture Tube



Toshiba's Special In-line Electron Beam Gun

Specifications

Picture size:
33.5cm measured on diagonal of viewable picture area
Frequency range:
Receivers all Australian channels VHF and UHF.
Tube and semiconductors:
1 picture tube, 8 ICs, 18 transistors, 37 diodes
Power source:
AC 240/250 V, 50 Hz
Power consumption:
78W
Audio output:
1.0W (max.)
Speaker:
7cm x 10cm (oval)
AGC system:
Keyed
Dimensions:
47.8cm (W) x 34.1cm (H) x 40.7cm (D)
Weight:
17.5 kg
Design and specifications subject to change without notice.

HERE ARE THREE SEPARATE CHANCES to win one of Toshiba's magnificent portable colour TV's. On the following pages are three competitions. Each is self-contained and quite different from the others. Entrants may enter any or all of the contents. Each contest will be judged independently but if one contestant wins more than one contest, only one prize will be awarded to that contestant — the runner-up will then receive the prize.

The contest is sponsored jointly by Electronics Today International and Toshiba — who have most generously donated the prizes.

PORTABLE colour television never looked better — both for cabinet design and performance. It never looked better, because the Toshiba C-412 Portable Colour Television comes to you in a beautiful white cabinet to tone in with any home's decor. For performance the Toshiba C-412 uses Toshiba's unique BLACKSTRIPE™ Picture Tube to assure you of crisp colours and long lasting brilliant images.

The BLACKSTRIPE™ picture tube is the perfect answer for achieving beautiful natural colour. With the BLACKSTRIPE™ tube, there is no loss of sharpness in images you see on the screen because only the necessary phosphors are illuminated. This lets you enjoy images with maximum natural brilliance — without glare.

Another outstanding feature of the Toshiba C-412 is the new 'in-line electron beam gun'. There is nothing like it when it comes to beaming out natural colour.

On the rare occasions when your Toshiba C-412 receiver requires servicing, replacement and repair is fast and easy. This is because the module suspected of containing a fault is removed and a replacement module is slotted in its place. It is as simple as changing a stereo cassette or cartridge.

TOSHIBA

Japan's first electrical equipment factory was started almost exactly 100 years ago. Its founder, Hisashige Ghi-emon Tanaka was born 75 years previously - in 1799.

Ghi-emon's company was the beginning of the great Toshiba organisation which today is one of the largest in the world and has acquired a world-wide reputation of innovative and advanced technology.

Today Toshiba products are exported to more than 120 countries worldwide. Most popular among the great variety of products are television receivers, stereo sets, electronic ovens, air conditioners and electronic calculators. In addition to these, orders are increasing for large-scale and heavy electric equipment.

Three 820 000 HP water turbines, the world's largest, were recently supplied to the United States; a large-capacity, high-voltage power generating system for Canada included transformer and 282 000 kW water turbines; and two steam turbine generating equipment of 660 000 kW each plus six 283 000 kW water turbines were built for Australia.

Other important exports include broadcasting equipment supplied to Brasil and Malaysia, large quantities of X-ray equipment and linear accelerators for medical use; and other sophisticated, technologically advanced equipment to the United States and other countries.

CONTEST RULES

This contest is open to all persons normally resident in Australia with the exception of members of the staff (or relatives thereof) of Modern Magazines (Holdings) Ltd, Australian Consolidated Press, Wilkes Pty Ltd and/or associated companies.

Entries should be addressed to, ETI/Toshiba Contest, Electronics Today International, 15 Boundary St, Rushcutters Bay, NSW 2011.

Closing date for the contest is May 31st 1976. Entries received within seven days after May 31st will be accepted as long as they are postmarked May 31st or before.

The contests will be judged by the Editor and Assistant Editor of Electronics Today International. Their decisions will be final. No correspondence can be entered into concerning their decisions.

In the event of one or more tied results the finalists' entries will be thoroughly mixed and then drawn by the Editor.

It should be noted that each contest is a totally separate entity — the results achieved in one will in no way affect the score in another — nor will they in any way influence the final judging.

Winners will be advised by telegrams sent on the same day that the results are known. The names of the winners, together with the winning answers, will be published in the first possible issue of Electronics Today International.

Contestants must enter their names and addresses where indicated on each contest — they must *also* complete and return the official entry form and must answer the questions on that form (page 23 of this issue). Photostats or clearly written copies of the various contests will be accepted but we *must* have the *original* of page 23 with each set of entries.

Remember the entry form on page 23 covers one, two or all three of the contests. However if you wish to submit multiple entries (or sets of entries) for any particular contest you will of course need extra copies of the magazine so that you can send page 23 with each set.

A reader survey form is printed on the *back* of page 23. We would very much appreciate it if you would complete this when sending in your entry but we would however like to stress that completing the survey form is in no way a condition of entering the contest/s.

Who-What-Which-Why

Here are fifteen questions several of which have multiple parts.

All single-part questions have a maximum obtainable score of ten, multi-part questions have a maximum obtainable score of five per part.

Although we're probably about to be proven wrong by half the entrants we don't really expect that any entrant will have a perfect score, so if you can't find the answers to some of the questions just have a guess. You could well be right!

Needless to say the entry with the highest total score is the winner. In the event of a tie the conditions described in the contest rules will be applied.

Contest No.1

A1 Why is a transistor so-called? (i.e. from which two or more words is the name derived?)

. . . .

. . . .

A2 Who invented the Wheatstone Bridge?

. . . .

. . . .

A3 Born in 1768 he accompanied Napoleon on his expedition to Egypt (in 1798). He was a member of the French Academy of Sciences. The techniques he developed are today particularly relevant to electronics. Can you analyze who he was?

. . . .

. . . .

. . . .

A4 Who said 'Evil communications corrupt good manners'?

. . . .

A5 The moving coil principle as applied to microphones and loudspeakers is generally accredited to Rice and Kellog (1926). There were however at least two earlier patents in this field. Who were the people or companies who filed these patents — and in roughly which years.

. . . .

. . . .

. . . .

. . . .

A6 "The moment man cast off his age-long belief in magic, science bestowed on him the blessings of the Electric Current". Who wrote that?

Huxley	☐	Emerson	☐
Fromm	☐	Carlyle	☐
Shaw	☐	Giradoux	☐

A7 Who opened the window to the study of what — and which unit appropriately bears his name?

. . . .

. . . .

A8 What is The Comma of Pythagoras?

. . . .

When

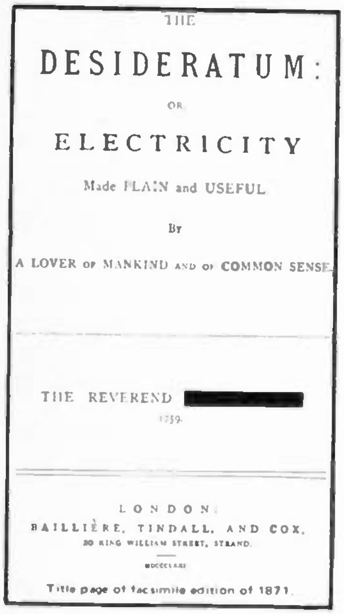
A9 Briefly, what is Barkhausen noise?

. . . .

. . . .

A10 This man is better known for his religious activities — he also wrote this book — who was he?

. . . .



THE

DESIDERATUM:

OR,

ELECTRICITY

Made PLAIN and USEFUL

By

A LOVER OF MANKIND AND OF COMMON SENSE.

THE REVEREND [redacted]

1759.

LONDON:

BAILLIÈRE, TINDALL, AND COX,

20 KING WILLIAM STREET, STRAND.

Title page of facsimile edition of 1871.

A11 By what title was John William Strut better known — and in which field of endeavour did he primarily make his scientific reputation?

. . . .

. . . .

A12 From a mathematical viewpoint, mechanical mass, electrical inductance and a volume of air contained in an enclosure each represent the same quantity. Without using mathematics explain what the quantity is.

. . . .

. . . .

A13 Did the first galvanometer use electromagnetic — or electrostatic-detection?

. . . .

A14 The terms cation, anion and ion were coined to help explain the electrolysis process: they began the doctrine of electronics. In what year and by whom were the terms proposed?

. . . .

. . . .

A15 Who was 'the Princess of Parallelograms?'

. . . .

Who was her tutor? . . . .

What was her husband's name and title?

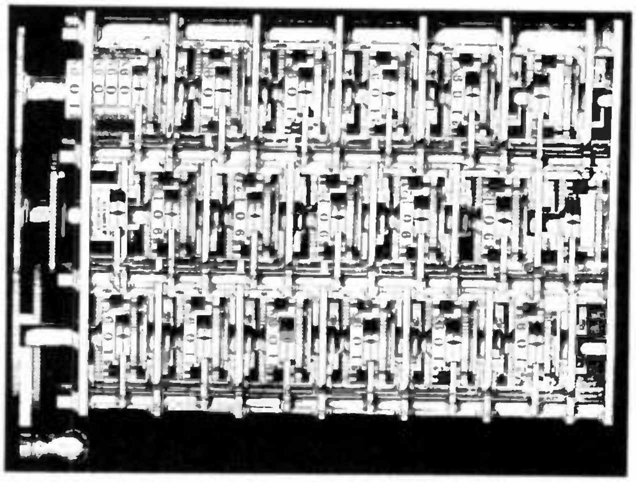
. . . .

Who was her daughter's executor? . . . .

What do all the above questions have to do with the picture below?

. . . .

. . . .



Name . . . .

Address . . . .

. . . .

. . . . .Postcode . . . .

Permit Number: TC 7407

...a pair of long-nosed fliers

Contest No.2

. . . a pair of long-nosed fliers.

Duck Smith

The control element is in fact in a fridge.

Electronics emitted from the heated cathode piss across the anode.

Engineers at Motorola are urging their customers to consider using germanium devices.

Ultra-high selectivity is obtained by using a double super-heat system

. . . a pulse is provided so that an oscilloscope can be concreted to the instrument.

Mozart wrote a concerto for the first abo.

the amplifier is guaranteed for three tears.

In the explosion method, the shock wave generated by a charge is made to travel through an argon filled box . . . the resultant compression of the argon gas causes it to emit intense radiation in the ultra-violent region.

slugged relazy coils

NEW DETERGENT FOR DRUNKEN DRIVERS

. . . such an arrangement is now known as a double-sided snadwich motor.

A WELL KNOWN AUSTRALIAN CAMERA MAGAZINE RECENTLY distinguished itself in the introduction to an article on photography for beginners by printing the lead picture back to front.

And no one in the publishing business even smiled – because it can happen to any of us and it can happen only too easily. It's extraordinary how errors can creep into the printed word. Even more extraordinary how they stay unnoticed until after the magazine is printed – when they glare from the page like a beacon.

Every single page of Electronics Today is very thoroughly checked on at least three separate occasions before printing. Our projects are checked by three different people at separate times.

Yet still errors occur!

It's an old old problem going back right to the early days of printing. "The Fates", said Santayana, "like an absent-minded printer, seldom allow a single line to stand perfect and unmarred".

Sometimes an attempt to correct a fault will introduce another. A picture might be improved by increasing its size – but, as happened to us back in 1972, the printer may now print the larger picture back to front. Shakespeare knew all about this. In King Lear he said "Striving to better, oft we mar what's well'.

Even the most respected of publications contains the occasional error. That most authoratitive of journals 'Sciences' (published by the New York Academy of Science) once confessed that 'the object captioned the great icosidododecahedron is actually the great icosicosidodecahedron'. If you don't believe it check their September/October issue of 1972.

Errors creep in primarily because magazines are handled by a large number of people – such as compositors, platemakers, printers etc – who whilst being conscientious and careful – have no specialised knowledge of the subject matter.

It is totally obvious to ourselves and to our readers when a pc board pattern is printed back to front. But to a printer it's not – and whilst it's never happened to us so far, one otherwise respected electronics journal once had every pc board layout printed back to front throughout an issue because a printer corrected what he assumed was an editorial mistake.

For every error which does creep in there's a dozen or so that we find in time. Some of these are quite funny and sometimes we're sorely tempted to leave them in.

Over the years we've made a note of some of the odder or funnier 'literals' (as they're called in the industry).

Some of these are reproduced on this page. Here's a chance to see what was *almost* printed. PLUS a chance to win a Toshiba Colour TV by telling us what you think each faulty item *should* have read. Using the same sequence as in our original just rewrite each separate item as you think it *should* have been – and in fact as each finally appeared.

The comical Walsh driver can be clearly seen at right

Having the loudspeaker sound originate near the original source provides a more natural effect for the audience – and avoids fusing the performer.

SINEWAVE POWER SAUCE

LEARNING THE NORSE CODE

The output of IC5 is negative however and must be invented by IC6.

Suspend the coil from a horse-show magnet

chassis earth bug

A plastic cover is fitted to provide damage to the output transistors.

Basic variable sin circuits.

Name: . . . .

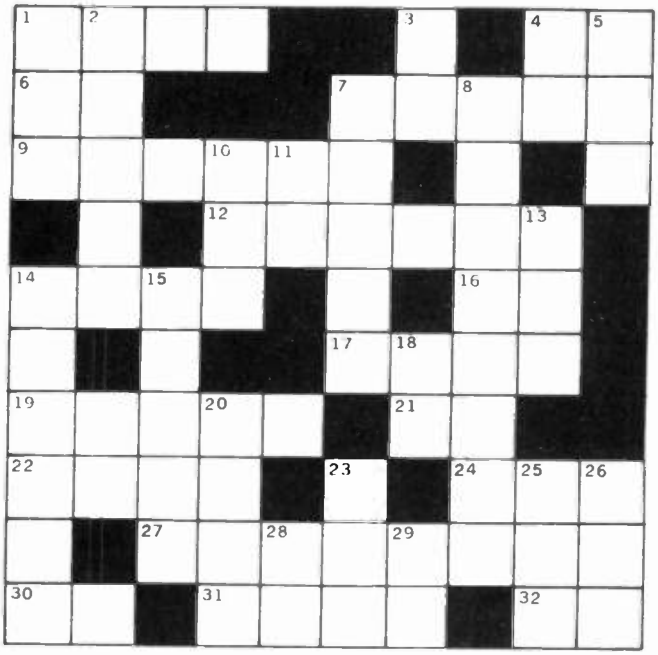
Address: . . . .

. . . . Post Code . . . .

Permit number TC7404

Jumbo less six Contest No.3

All answers are numbers — not words. Decimal points and leadings zeros are ignored.



ACROSS

1. *TTL decade counter*
4. *Half of 29 down*
6. *How many symphonies did Mozart write?*
7. *Frequency ratio of two adjacent notes in musical scale*
9. *Speed of light — miles/second*
12 *Standard atmosphere (S1)*
14. *Proton-to-electron mass ratio*
16. *1011111 in decimal.*
17. *2N ———— a popular power transistor*
19. *TV line frequency (PAL system)*
21. *63 in octal*
22. *CMOS dual JK master/slave flip flop*
24. *1313.6° Fahrenheit in SI system*
27. *It should be induced how you would react to 2 _ FL*
30. *Carbon used for dating*
31. *Intel microprocessor IC*
32. *Last but not lucky*

DOWN

1. *Jumbo less six — an operational amplifier*
2. *How many joules in an international calorie?*
3. *It's violet and black*
4. *Atomic number of a policeman*
5. *Most sensitive wavelength to standard eye*
7. *Voltage of Weston standard saturated cell*
8. *One radian in decimal degrees*
10. *Twice the number of BC108s*
11. *Cross twice and add C.*
13. *Eight-pin timing IC*
14. *Ratio of peak to rms in a sine wave*
15. *5 dB as a power ratio*
18. *James Bond has lost nothing*
20. *Base of Naperian logarithms*
23. *An operational amplifier — to be precise from National*
25. *A square cricket team*
26. *Absolute zero*
28. *The roaring — — s*
29. L

Permit number TC 7404

Official Entry Form

I have read and agree to abide by the contest rules published on page 19 of this issue.

NAME ....

ADDRESS ....

....

....

.... Post Code ....

PLEASE SEND IN THE WHOLE OF THIS PAGE

Please answer these questions relating to the Toshiba colour TV's offered as prizes. The answers to these questions can be found by studying page 18 of this issue.

TOSHIBA COLOUR TV

What advantages are claimed for Toshiba's Black Stripe picture tube? ....

....

Will the C-412 receive *all* Australian TV channels — including UHF channels?

What particular feature ensures that the C-412 receiver can be speedily serviced. It has been described as 'simple as changing a ....'. Fill in missing words.

The electron beam gun in the Toshiba C-412 is an '.................... Add missing words.

Survey '76

Our survey in July 1974 provided us with a great deal of useful data as a result of which we made a number of changes.

We would now once again very much like to know what readers think about our present format — particularly regarding our constructional projects. We would like to hear from readers who like things just as they are (if we have any!) as well as those who would like to see some changes.

As a token of our appreciation we will draw 12 of the received forms at random and award one year's free subscription of ETI to the senders of each.

Please rank our constructional projects in your order of preference. If two or more categories are of equal interest use same ranking number in each.

Test equipment ☐
Simple projects ☐
Car equipment ☐
Audio ☐
Amateur radio ☐
General ☐
What other types of project would you like to see

. . . .

. . . .

Are our projects generally —
too simple ☐
about right ☐
too complex ☐

Do you buy parts for your projects
In kit form ☐
As and when required ☐

There are many possible projects such as garage door openers, yacht and aircraft radio control etc etc for which we can readily supply electronic, but not mechanical details (as the latter will vary a great deal from one application to another. Would you still nevertheless like to see such projects published — albeit in semi-complete form. Please grade your interest on a scale of 0—10. (0 = zero interest).

Please tell us any way in which you think our projects could be improved.

. . . .

. . . .

What is your occupation? . . . .

. . . .

Comments — ETI generally . . . .

. . . .

. . . .

. . . .

. . . .

Please circle the applicable number or numbers in each question.

1/ How did you get this copy of Electronics Today?

Bought yourself at newsagent 1
Comes on subscription 2
Bought by someone else in household 3
Someone (outside family) passes it on 4
Other means 5

2/ Usually, how many issues of Electronics Today do you read?

Less than 3 copies a year 1
3-6 copies a year 2
7-9 copies a year 3
More than 9 copies a year 4

3/ How many people other than yourself read this copy of Electronics Today?

1	4	7	Nil	0
2	5	8	Not sure	X
3	6	9+		

4/ What happens to this copy of Electronics Today?

Keep it for a while 1
Pass it on 2
Throw away 3

5. How many of the advts do you read in Electronics Today?

Most 1
About three-quarters 2
About half 3
About a quarter 4
Very few 5

Generally, how often do you look at each of the following:
Please circle the applicable number against each of the magazines listed.

		Do not read	Less than 3 copies a year	3-6 copies a year	7-9 copies a year	More than 9 copies
6/	REVS	1	2	3	4	5
7/	Two Wheels	1	2	3	4	5
8/	Motor Cycle News	1	2	3	4	5
9/	Modern Motor	1	2	3	4	5
10/	Wheels	1	2	3	4	5
11/	Motor Manual	1	2	3	4	5
12/	Modern Boating	1	2	3	4	5
13/	Seacraft	1	2	3	4	5
14/	Modern Fishing	1	2	3	4	5
15/	Australian Angler	1	2	3	4	5
16/	Fishing News	1	2	3	4	5
17/	Electronics Today	1	2	3	4	5
18/	Electronics Australia	1	2	3	4	5
19/	Hi Fi Review	1	2	3	4	5
20/	Australian Hi Fi	1	2	3	4	5
21/	Camera and Cine	1	2	3	4	5
22/	Australian Photography	1	2	3	4	5
23/	Wireless World	1	2	3	4	5
24/	Practical Electronics	1	2	3	4	5
25/	Practical Wireless	1	2	3	4	5
26/	Elementary Electronics	1	2	3	4	5

27/ Sex

Male 1
Female 2

28/ Salary (Gross)

Less than $8,000 p.a. 1
$8,000—$9,999 2
$10,000—$14,999 3
$15,000—$19,999 5

29/ Educational Level

School Leaving Certificate 1
Matriculation 2
Higher School Certificate 3
Technical College 4
University 5
Post-graduate 6

30/ Age

Under 16 1
16—20 2
21—25 3
26—30 4
31—35 5
36—40 6
41—45 7
46—50 8
51—55 9
56—60 0
61 and over X

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Address . . . .
. . . .

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OF 1,000,000 (ONE MILLION) SEMI-CONDUCTORS. MUST BE CLEARED AT THE MOST STAGGERING PRICES EVER OFFERED — THESE DEVICES ARE MAINLY UNMARKED AND SLIGHTLY BELOW SPEC'S, BUT ARE GUARANTEED USABLE.

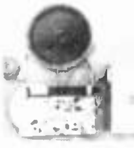
ALL EM SERIES DIODES ARE MARKED AND FULLY GUARANTEED. TAKE YOUR CHOICE WITH THESE SPECIAL PACS. POST & PACKING 50c per pack.

PAC No.	CONTENTS	PRICE
SC. 1	3 100 V 3 amp Rectifiers, 3 100V 5 amp TO5 Rectifiers & 3 2N3055-1 Power Transistors	$1.00
SC. 2	100 Assorted TO18 & TO5 NPN & PNP Silicon Transistors	$2.50
SC. 3	5 TO66 (2N3054 Series) Transistors & 5 MS3055-1 (Marked) Power Transistors	$0.90
SC. 4	100 100V 3 amp Plastic Rectifiers	$4.50
SC. 5	100 100V 5 amp TO5 Metal Case Rectifiers	$5.00
SC. 6	20 2N3055-1 (Unmarked) Power Transistors	$3.00
SC. 7	20 MS3055-1 (Marked) Power Transistors	$3.50

PAC No.	CONTENTS	PRICE
SC. 8	10 each of the following:— 100V 3 amp Plastic Rectifiers, 100V 5 amp TO5 Metal Case Rectifiers, 2N3055-1 Power Transistors, TO66 Power Transistors, TO18 Silicon Transistors, TO5 Silicon Transistors (NPN & PNP) (Total 60)	$5.00
SC. 9	50 EM402 Diodes, 200V 1 amp	$3.00
SC. 10	50 EM404 Diodes, 400V 1 amp	$3.75
SC. 11	50 EM406 Diodes, 600V 1 amp	$4.00
SC. 12	50 EM408 Diodes, 800V 1 amp	$4.25
SC. 13	50 EM410 Diodes, 1000V 1 amp	$4.75

SPECIAL PRICES CAN BE QUOTED FOR 1000 off ON ANY DEVICE SHOWN. A BONUS GIFT OF 50 EM401 DIODES WILL BE ADDED TO ALL ORDERS OF $25 AND OVER. (Only applies to SC1-SC13 packs).

7 TRANSISTOR + 2 DIODE RADIO BY BENDIX



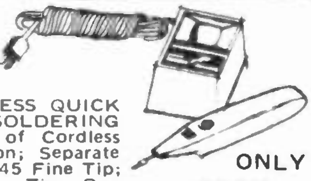
Completely ready wired with volume control and switch. Large tuning dial and complete with 3½" 8 ohms .6 watt speaker. Battery container included. (Batteries not included) — READY TO GO!!

M.S.C's CRAZY PRICE!!

$3.85 EA PLUS P&P $1.00

2 FOR $6.50 P&P $1.50

ANOTHER GREAT IDEA FROM THE STATES

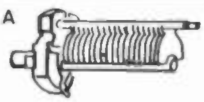


The WAHL 'Iso-Tip' CORDLESS QUICK CHARGE INDUSTRIAL SOLDERING KIT. Model 7700. Consists of Cordless 'Quick Charge' Soldering Iron; Separate Recharging Stand; One No: 7545 Fine Tip; One No: 7546 Heavy Duty Tip; One Instruction booklet. Special features include: Complete Portability — Solders up to 125 Electronic Joints Per Charge: No AC leakage — No Grounding necessary: Soldering Heat in 5 Seconds: NEW SPECIAL PREMIUM QUALITY Long-Life Nickel Cadmium Batteries (Outlast Standard Batteries) GUARANTEED FOR ONE YEAR.

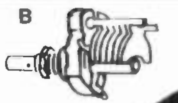
ONLY FROM US AT **$39.95** ea P&P $1.00

NOT TO BE CONFUSED WITH SIMILAR AND CHEAPER IMITATIONS ON THE MARKET.

A



B

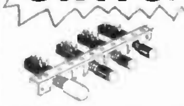


AIR SPACED VARIABLE CAPACITORS.

NEW

Top quality brand by JACKSON BROS. (UK) Superior made with silver plated vanes & ceramic end plates.
Type 'A' 150 pf (Screwdriver adjustment) **$1.25 each P & P 50c.**
Type 'B' 50 pf with 1" x ¼" spindle. **$1.75 each P & P 50c.**

SWITCHES AT BARGAIN PRICES

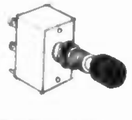


ONLY **$2.50 ea. P&P 40c**

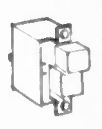
"Schadow" miniature modular push-button switch assembly. 4 x DPDT, 3 momentary and 1 hold. Solder lugs and complete with 4 chrome faced buttons.

Lamp lighted power push button switches. With 1 micro switch. Type NB-SL red lens. Only **$3.00 P&P 75c.**
As above but with 2 micro switches and green lens. Type NB-DL. Only **$3.50 P&P 75c.**

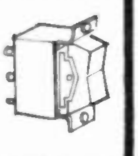
Push-button switch. Lug terminals. D.P.D.T. momentary lock, 250V AC 5A 125V AC Type SB-63A. **$1.10 P&P 20c ea**



Push-button switch — dual buttons in double white or white and red lug terminals. D.P.D.T. reciprocal. 6A 250V AC. Type SDB-122. Only **$1.95 ea. P&P 20c ea.**



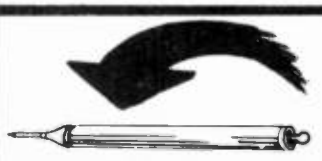
See-Saw switch. D.P.D.T. on/off/on momentary white button. 5A 125V AC or 3A 250V AC. **95c ea. P&P 20c ea.**



'Mulon' precision micro switch with pin plunger S.P.S.T. normally open/normally closed. Type MGA-100P. **Only 65c ea. or 5 for $3.00 P&P 20c ea. or 5 for 75c.**

WOW! LOOK AT THIS OAK MINIATURE ROTARY SWITCH

Precision engineered for precision work. ONCE IN A LIFE-TIME OFFER . . . compare M.S.C.'s Prices with our nearest cheapest competitor and save yourself a BOMB. ALL NEW . . . ALL PERFECT. Standard ¼" shaft. 2 Section. 8 Pole 2 Position or 6 Pole 4 Position. $1.75 each or 2 for $3.00. P&P 60c



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Powerful trouble shooting signal injector.
Model SE-260.
Complete with batteries.
ONLY $8.95 P & P 50c

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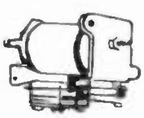

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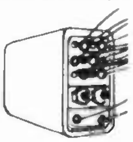

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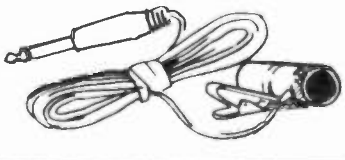

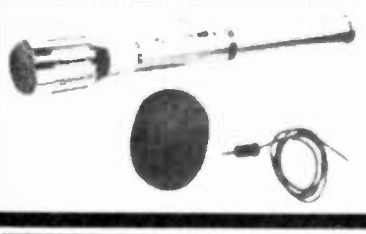

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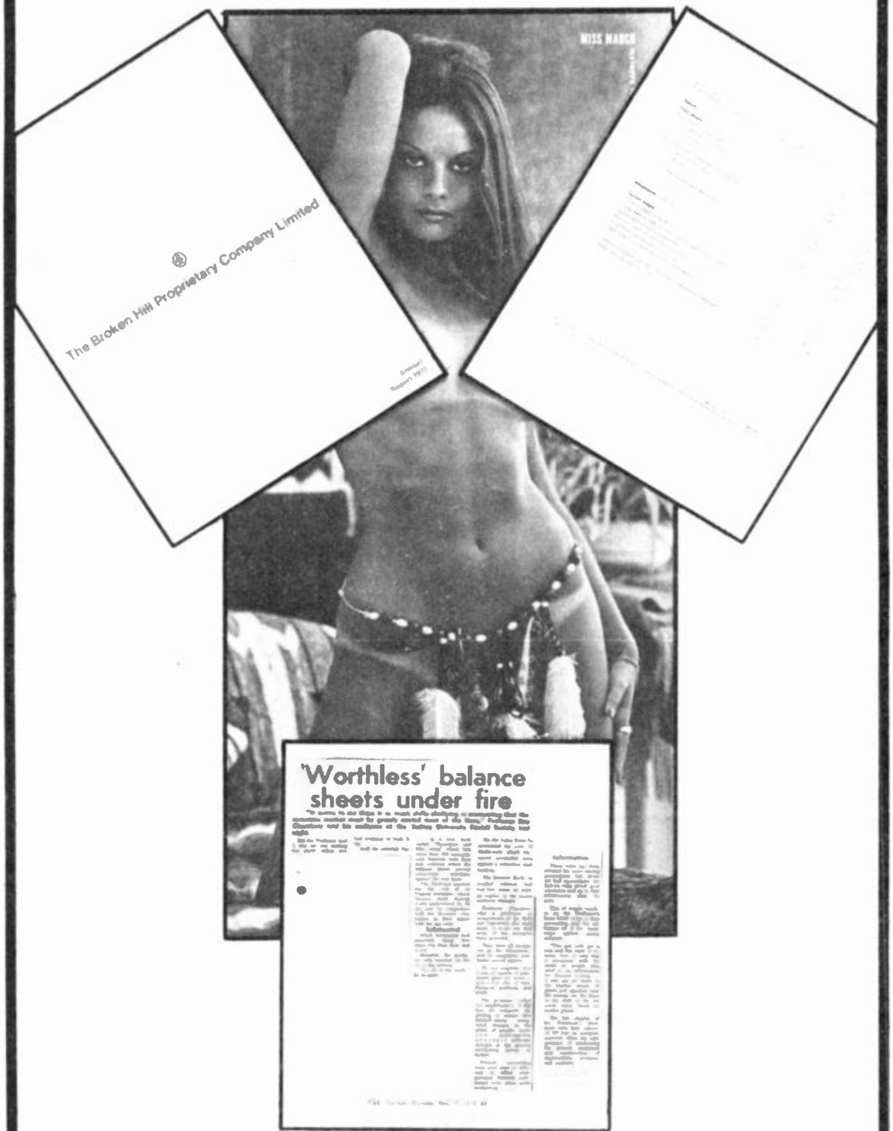
Measurements

Misunderstandings, misuse, mistakes, mirth and misrepresentation — this article is written by Dr. Peter Sydenham, University of New England, Armidale, NSW.



The company balance sheet — what the numbers reveal is interesting but what they hide is vital. (Courtesy John Staunton)

FROM the very beginning man has been a measurer. It is not hard to reason that he inherited the basic ability from the lower forms of life, for living creatures that cannot assess a situation and act for the better eventually die out or become subservient in some way.

Once a particular kind of measurement has been established as necessary, two things can happen. It either remains as is, being adequate for the daily need, or alternatively, constant effort is made to improve it in order to gain the benefits that might accrue from a better determination. Measurements are useful as tools of control of the routine, or as the basis for gaining new knowledge.

WHAT IS A MEASUREMENT?

To some people measuring implies attaching sophisticated black boxes to a system in order to obtain data about it. Others see the opposite — the use of simple tools such as a ruler to put data to an object. Both are right in a narrow sense. A first basic rule is that *measurement is the comparison of an unknown magnitude of a quantity with an agreed standard declared as the unit, the measure coming forth as the difference expressed in numerical form.*

The most basic number is a binary kind having just two states. The crudest measurement we can thus make is one that provides a yes or no, smaller or larger, up or down, go or no-go, true or false types of answer. Enormous effort can be expended to obtain (or try to obtain) such an answer in many cases. Indeed, it is this kind of measurement that is often the hardest to make. Politicians would give the earth to be able accurately to predict the outcome of an election, social-scientists would be enthralled at the prospects of certainty of success of implemented crime-control measures, geographers seek to know which factors affect what.

As the understanding of a subject is improved — by the use of simple tests

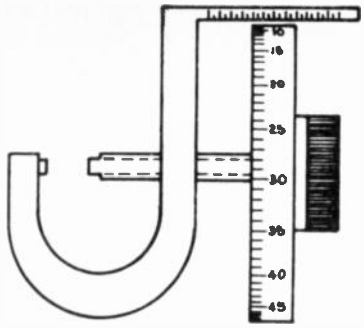


Fig. 2. Adding a huge drum to the dial of a screw micrometer increases its resolution but not necessarily the precision and accuracy of measurements made.

giving yes-no type answers — it becomes possible to deploy more and more advanced techniques of hardware and software. The difference between the standard and the unknown (called the measurand) becomes expressible in continuous rather than two-state number terms. For example, the battery in the car will not turn the starter motor because its voltage is *too low* (the two-state situation has been extended by a superlative). Measurement using a voltmeter enables us to say that the battery output is only 6.6 V instead of 12.0 V (the designer's standard requirement now expressed in numbers on a continuous scale).

It would seem that the ability to use sophisticated measurement processes is a large part of the criteria in deciding if a subject is scientific or not — that is of course, provided the numbers really *mean* something — see Fig. 1.

BASIC MEASUREMENT TERMS

Even though we have not yet talked in terms of sophisticated measurements or measuring equipment, the above explanation begins to reveal the need for some definitions of certain facets arising in the intercomparison process. (We need more standards to define standards!)

The misuse and abuse of basic terminology is rife. A first group of terms relates to the description of results provided by the process.

Resolution — at the finest scale available from a particular process of comparison — is the ability to resolve between successive increments in the chosen scale. A person using a mercury-thermometer might be able to resolve, say, 0.1°C intervals, subdividing these intervals into two divisions by eye gives a resolution of 0.05°C. By adding an optical magnifying system (or mechanical gain in, say, a micrometer — as depicted in Fig. 2) which has an inscribed scale at its focal plane, it is possible to raise the resolution 10 times or higher.

The unexperienced, unenlightened measurer will often quote this fact as a measure of how good a device is for measuring with but having resolution may not mean much in reality. It is very much the first basic requirement of comparison, but if it lacks accuracy the answers can be quite wrong. For example, if the optical magnifier on the thermometer has a badly ruled scale or optical distortion each increment will not be equal. Furthermore, the thermometer is supposed to measure temperature but, in fact, pressure of the air or liquid around it will also cause the mercury to rise or fall a little.

As another example, consider the balance-sheets issued as financial statements of the healthiness of commercial enterprises. Accountants are loath to round off, so statements involving millions of dollars may be listed down to the final dollar or even cent! The resolution is, therefore $1 (or one cent) but no one seriously believes that this is always, if ever, the level of accuracy. For in such statements many costs (seemingly exactitudes) are pure guesstimates plucked from experience or designed to hide the real value of resources and returns. We come back to accuracy in a moment.

Precision — Two men argue as to which is the better rifle-shooter. It is to be settled by a contest on the range. The standard of excellence is to place the shots into the bulls-eye of the target but the game places the contestants sufficiently far back from the target that this is not easy to achieve. If it were, and each man placed all shots in the bulls-eye, the only assessment made would be that both were equally good. This situation lacks resolution to discriminate between them; the range is increased to increase the resolution. Thus emerges an important second rule of measurement — *there must be adequate resolution to a measuring process or little will be learned from the measurement.*

Each fires his group of shots and the two sets are intercompared. The first thing to be seen is that one group

Measurements

• The foregoing profits are stated after deducting all charges and expenses, providing for depreciation and making such other provisions as the directors considered necessary The adjustments made by us to the profits are set out in the following statement

	1957	1958	1959	1960	1961	1962 (½ year)
	£	£	£	£	£	£
Net earnings of the group as shown by the consolidated accounts, arrived at after allowing for the interest of outside share holders in retained earnings, but before allowing for the undermentioned dividends	1,622,850	2,006,971	2,083,561	2,017,998	1,652,011	1,060,182
Less, Dividends paid by subsidiary com panies to outside shareholders	7,278	7 278	7,270	7,260	7,200	3,600
	1,615,572	1,99,693	2,076,291	2,010,738	1,644,811	1,056,582
ADD						
Appropriations of profit charged in the Companies' profit and loss accounts by the directors, before arriving at net earnings	586,471	537,077	560,710	370,000	212,954	55,000
Amounts charged against profits by the directors to provide for the increased cost of replacing plant in the future, but regarded by us as appropriations of profit for the purposes of this report . .	350,000		100,000	100,000		
Net amounts set aside from profits by the directors as provisions (including income tax provisions) which have sub sequently proved to be in excess of re quirments	474,937	241 836	121,571	6,106	78,146	[illegible]
Adjusted net profits of the group	£3,026,980	£2,778 606	£2,858,572	£2,486,844	£1,935,911	£1,100,835

Fig. 3. This statement appeared in a prospectus of a company. It seems profits can be adjusted at will!

lies in a smaller total enclosed area on the target — as shown in Fig. 4a — but (in our chosen case) none is in the bulls-eye. The other shooter, on the other hand, has shots which are contained in a much larger circle, with one actually in the bulls-eye, as shown in Fig. 4b. The argument begins as to who is the better shot. The better shooter is probably the first, not the second, for his precision, that is, his ability to keep on the same spot, is much better than the other person. *Precision then, as the third rule, is the measure of scatter of values obtained in a test.*

In this case the first shooter would be able to make a correction to his sight or allow for cross wind in order to move his group over to put more on the bulls-eye than the other person. The less precise shooter could not improve his accuracy. This leads us to what is accuracy in measurement.

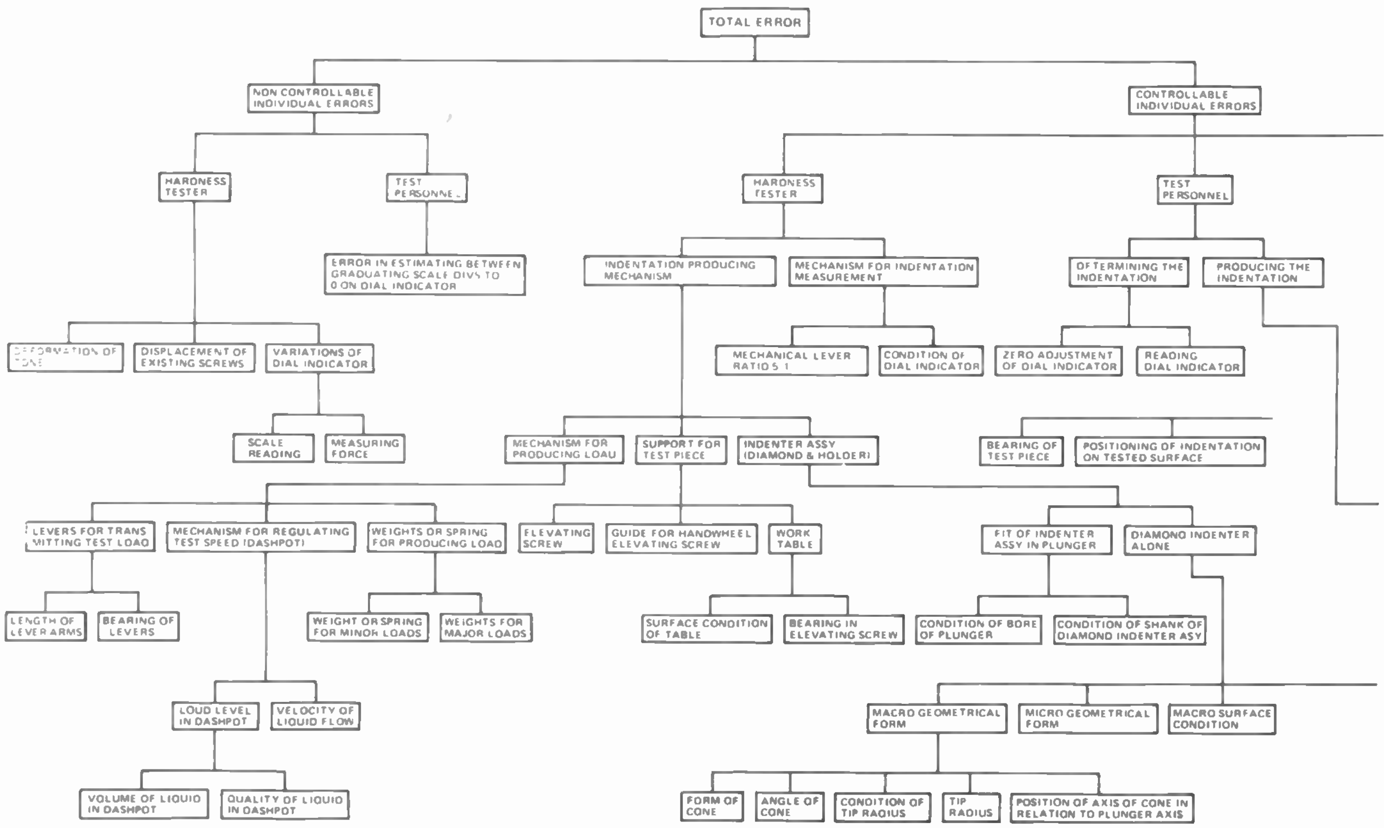
Accuracy — In the shooting exercise the aim of each shooter was to reduce the distance between his individual shots and the bulls-eye — which is defined as the standard in this determination. The measurement that gives the closest value to the agreed standard is the most accurate. But in the example above the less precise shooter is, in fact, the most accurate if they decide that the averaged central position of the group is the criteria chosen.

In electrical terms a voltmeter may provide precise values but be very inaccurate due to a bent pointer or an altered value series ballast resistor.

Thus a fourth rule can be seen: *Precision and accuracy are quite different descriptive terms.* These are too often confused. Excellent precision does not imply equally fine accuracy and vice versa. It is always necessary to provide adequate resolution in order to determine the desired fineness of precision and to state the accuracy precisely enough.

TYPES OF ERRORS

The numerical value between the standard value and the measurand is termed the measurement error. Error



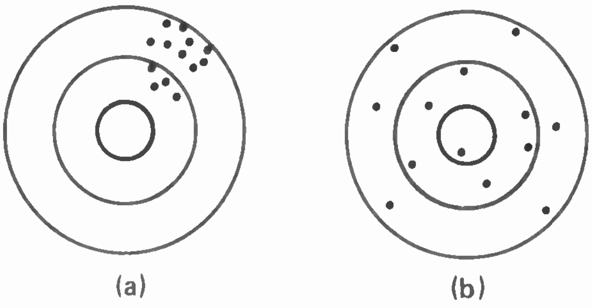


Fig. 4. Rifle-shooting is a good example illustrating the concepts of precision and accuracy.
(a) A precise group of shots that is not as accurate as could be — the mean position is not on the bulls-eye.
(b) An imprecise group which has an accurate mean centred on the bul';-eye.

magnitudes may affect the degree of precision and the accuracy obtained. They arise from many different sources, ranging from clearly identifiable processes, to never-identified mechanisms. Ideally, the measurer desires to eliminate all errors but the fact of life is that the closer we investigate a process in order to improve its resolution, precision and accuracy, the more errors loom up. Numerous sources of error can be identified with even the simplest of processes. Several years ago a study was made of the make-up of total error of a simple measurement (in principle at least) involving the pressing of a hardened point into a surface to measure its relative hardness by the degree of penetration — the Rockwell-C hardness test in this case. Something close to 40 sources of error were identified (as shown in Fig. 5).

There are three main classes of error into which similar errors can be typified. Each has to be eliminated, reduced or lived with in different ways. A fifth rule of measurement is that *errors limit the usefulness of a measurement* and need to be reduced to tolerable levels.

Systematic errors — these are the derivations of values that always occur in the same way, and for which a corrective value can be applied to get the right value once the magnitude of the error is known. The rifle shooter resets his sights, the bent pointer is straightened. Or, the voltage reading can be corrected by adding the difference due to a bent pointer, or multiplied by a constant to make up for a wrong value series ballast resistor. It is, however, not necessary to know what *causes* the systematic error, only what its rules of occurrence are so that it can be allowed for. A calibration chart enables a meter reading to be corrected (Fig. 6). Knowing the rules, a correction can be applied to individual measurements to improve the accuracy of individual values.

Random errors — In strong contrast are errors that appear as the name implies, with random amplitude and sign. It is by definition impossible to predict what the random error will be on an individual value basis — the best that can be done is to place a level of probability of such and such a value arising at a certain time. In other words, seen as a group rather than a single occurrence of errors, it is possible to be reasonably certain about the value of such parameters as the *mean value* of the group and the *spread* of the group, but never the facts about the individual until it has occurred.

Random values follow statistical laws for collections of events. The most common occurrence of random error is with the so-called Gaussian distribution (also called top-hat or normal distribution). This form of error has a symmetrical profile for the plot of probability of occurrence of a value versus value changing as shown in Fig. 7. The peakiness of the curve is a measure of the spread of values and from the mathematical laws of this type or error it is possible to define a term that expresses the peakiness — the standard deviation (or s.d. or δ). In practical terms a s.d. of 1 means the limits $\pm 1\delta$ contain 68 per cent of values, $\pm 2\delta$ limits contain 95 per cent and $\pm 3\delta$ limits contain 99.7 per cent. If the chance of a value occurring is 50 per cent within a given limit and 50 per cent outside this limit then the probable error — has a value of 0.67δ.

It is conventional practice to quote the random error of a process in terms of the standard deviation as this conveys the tightness of the random error in the measurement situation.

A trap that exists, however, is that not all random processes are Gaussian in distribution. Nuclear radiation particle occurrence, for instance, has a lop-sided distribution (Poisson) and another quite different set of mathematical formulae describes the chance of occurrence of values. In the majority of cases Gaussian statistics apply — white noise for example in electronic circuits.

Personal errors — To be correct these reduce to random or systematic causes of error, but by treating them as a specific group the deleterious effects of human observation are emphasised. There are numerous sources of personal error. The

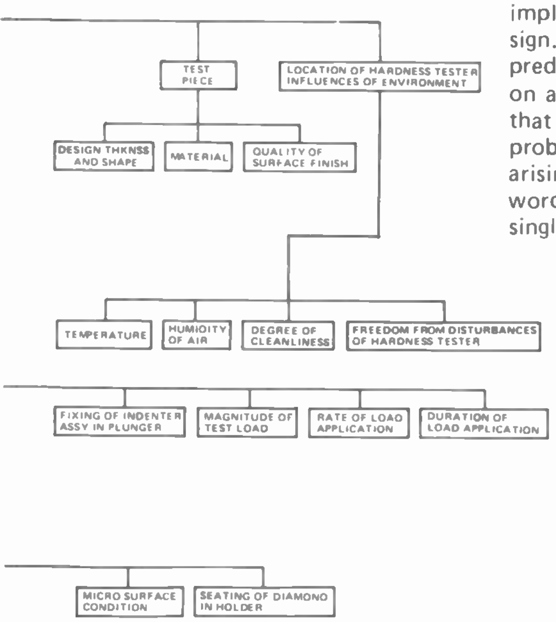


Fig. 5. Personal errors involved in using a simple technique of pressing a point into a surface to measure its hardness.

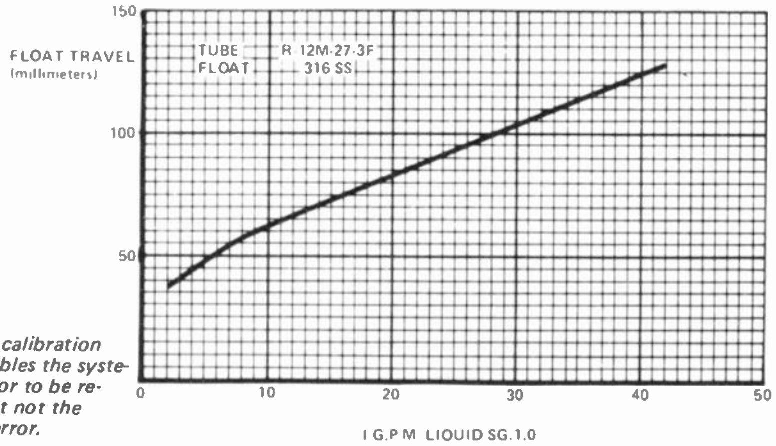


Fig. 6. A calibration chart enables the systematic error to be reduced but not the random error.

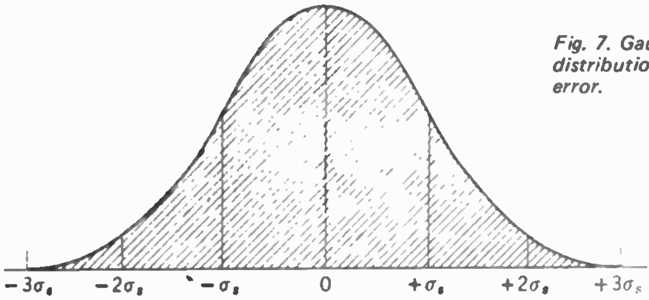


Fig. 7. Gaussian or top-hat distribution of random error.

individual making the measurement may view a scale line at a different angle to another person thus introducing parallex error, the way of driving an adjustment screw dial may be different to another — moving from the opposite direction to the mark or at a different speed could introduce slightly differing values from one observer from another. In surveying practice it is quite normal for the theodolite or level operator to repeat the observation from the opposite direction. This reduces systematic errors of calibration by differential cancellation, thus reducing the personal error. Measurement in studies not using hardware sensing are particularly rife, for personal judgment is usually involved.

TRACEABILITY

We saw above how a standard must be created as the sole legitimate value of the unit, and how a measurement was made by comparing the unknown against this.

If the standard varies, then so does the measurement value. In the case of physical standards such as length, mass and time it is possible to provide some defined physical apparatus that acts as the standard. In some disciplines this is not so easy. Biological experiments use a control group — a group of test subjects that do not undergo the test given to the test group — as the temporary standard. In economic studies even the concept of a control group is hard to create, for we cannot ask half the country's population to stay the same economically and isolated at the same time as the other half have their financial situation altered. We would probably learn more about economic procedures if we could!

Whatever the standard it must be adequately constant for a long enough duration and be usable. For physical standards the demand for use is so great that it is necessary to have a sole fundamental standard controlling many working standards in each country, these controlling, in turn, the field standards used by individual laboratories. These control the value of the unit actually used in practice. Thus we can have as many as five or six steps between the fundamental standard and the working instrument. Each stage loses some accuracy so international standards must be maintained in the highest state possible by a national laboratory devoted to this task — the National Measurement Laboratory in Australia, the National Physical Laboratory in Britain, the National Bureau of Standards in the USA, etc.

Clearly if this tree of standards were not strictly controlled any individual unpoliced link could upset the sequence. The process of traceability is used to ensure that a measurement (at least with high-performance instrumentation) is traceable right through to the fundamental standard with the loss in accuracy being designed at each level. This concept is vital to the maintenance of standards in practical use.

MIRTH

Looking back in time, man's measurement endeavours include some highly amusing methods of producing standards. One early standard of length for the inch was 'three barleycorns, round and dry'. Another standard of length was prescribed by taking the first 16 men as they came out of church, making them standard with their left feet end to end — this gave a standard 'rod'. Not quite as bad as it may seem for at least a vaguely reproducible average was obtained. But the last man out defined the foot! In 1800, in Germany, there were 112 different size standards used to define just one common unit of length.

A peculiarity still with us today, concerns the gallon — the US gallon being smaller than the British Imperial gallon. In fact the US gallon is the earlier British gallon — the Pilgrim Fathers used the then-smaller Imperial gallon when they emigrated to the Americas in the 15th century. The Americans retained the original standard (more or less) but the British one was subsequently re-defined.

A 14th century treatise related an English penny — called Sterling — as the same weight as 32 grains of wheat. Thus in a very round-about way 20 pence make an ounce, 12 ounces a pound, eight pounds make a gallon of

Continued on page 35

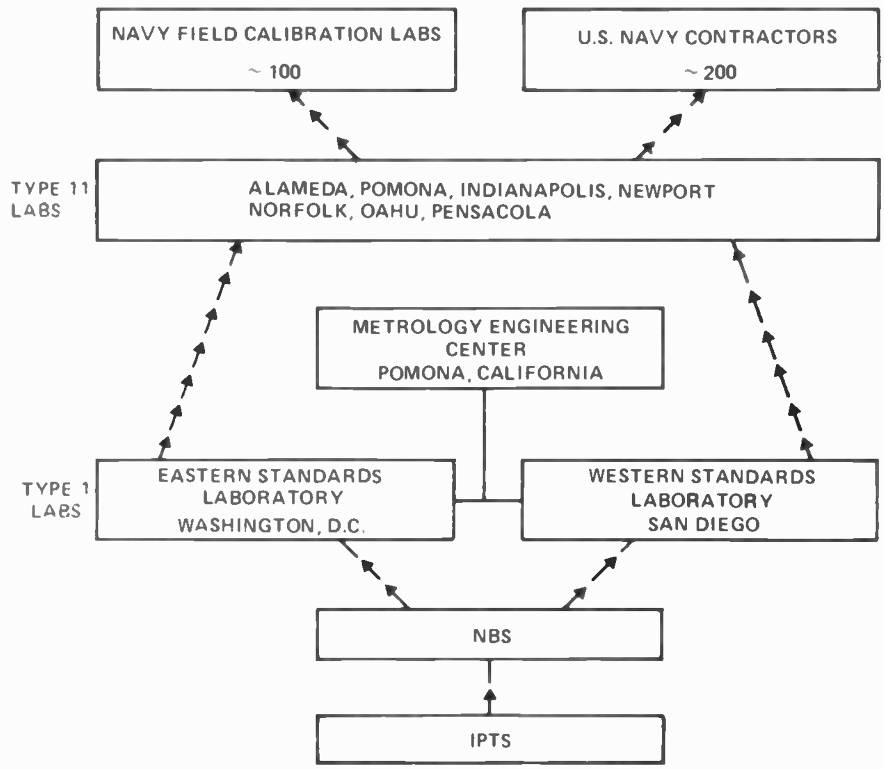


Fig. 8. Traceability relies on a hierarchy of standards reaching from the actually used measuring instruments to the fundamental sole standard. This is the calibration chain for U.S. Navy temperature standards.

wine and eight gallons make a bushel of London. No wonder Londoners still buy winkles (small sea snails) and shrimps by the pint measure!

Some units had, and still have, great names! A nitometer was once used to measure light-intensity in units of "nits". Even today we retain the cross-sectional area of capture of nuclear particles as a "barn".

And Kaysers are not nylon stockings but a measure of wavelength of radiation.

Early methods used to create a seemingly unchangeable standard were also often interesting. Like length, for instance. The metre was originally proposed as a small proportion of the distance of a quarter way round the earth's circumference. But this presented innumerable problems when tried in practice. Around the same time (the end of the 18th century) it was also thought that a pendulum swinging with 1 s period would be adequate to define a metre length.

Today some of our basic standards are still based on physical apparatus that is subject to damage or change. The standard (prototype as it is called) kilogram is still a piece of metal held in Paris. Most standards, however, can now be reproduced from a stated description of an apparatus which can be used to replicate the standard to within extraordinarily fine limits. Length for instance is defined as so many wavelengths of radiation from a Krypton discharge lamp.

Some extraordinary anomolies in measurement occur in every-day life — the most frequent being of a kind that imply an accuracy that does not exist.

- A recipe in a recent issue of an Australian magazine dutifully translated 'take 5 oz of flour' as 'take 141.75 grams' and half a pint of milk as '.354 litres'.
- Motoring magazines frequently quote standing quarter mile (or 400 metre) acceleration runs to three decimal places of one second. Yet one overseas magazine to my certain knowledge measures the required distance simply by a member of the staff pacing it out!
- A 'hundred thousand ton' ship was recently described in a daily paper as displacing '101,606.44 kilograms' — leaving aside that this contained an error of several orders of magnitude — the conversion implied that the original displacement was known almost exactly.
- After hearing that an aircraft was 'one minute late' I'm still trying to determine at precisely which point in its journey that an aircraft officially 'arrives'.
- Until very recently the altitude record for aircraft (and balloons) was recorded to two decimal places of a metre. Yet the actual height recorder was an aneroid instrument with an accuracy at best of plus or minus 0.1 per cent — thus the actual recorded height would not have been known to within 50 to 100 metres!
- A British millionaire was recently described as being worth $1.612 million dollars!

A recent advertisement for a certain make of car — one that would be expected to be more careful over advertisements, says: "The car responds as quick as adrenilin". This is an entirely meaningless expression. It states nothing of substance. The same advertisement states that the car is "20 per cent safer than the safest car on the road". How do we measure safety in quantitative number terms? It is also said to have "precise rack and pinion steering" — let's hope so! And later: "Every one of its over 5000 parts is the result of adaption and re-adaption of . . . s" pioneering safety programme. It is very doubtful if every single one has been such — if so the designers need sacking for never getting there first-time in their design. Finally, "you need greater reserves of power to outdistance danger" — what a meaningless jumble of measurement statements! ●

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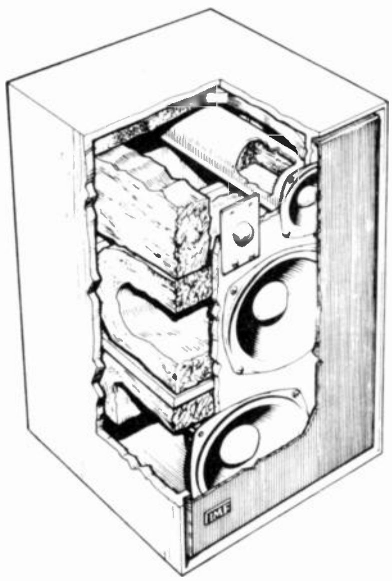

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(B) Medium loss, medium stability e.g. paper, plastic film, high-K ceramic.
(C) Polarised capacitors e.g. electrolytic, tantalum.

MICA CAPACITORS

Mica capacitors have low RF losses right through to UHF and very good capacitance stability. They are suitable for use in RF circuits up to 500 MHz and are recommended for use in oscillators and filters where their stability characteristics are almost unrivalled. Mica capacitors of appropriate size can handle large RF currents and high voltages and are often used in transmitting applications.

Mica capacitors are usually larger than ceramic capacitors of equivalent value but their temperature stability characteristics are usually better.

Moulded Mica or "Postage Stamp" — the most common form is the "Postage stamp" style, so named because of its size and shape. Often cheaper than real postage stamps and taste better when licked! General purpose mica capacitors have good stability and can be obtained with high voltage and high RF current ratings. They are constructed of layers of foil interleaved with mica (referred to as "stacked mica") or layers of metallized mica. Obtainable in values between 10 pF and 0.1 μF. They may be marked 'M.S.' to indicate Stacked Mica.

Silvered Mica — usually labelled with an S.M. marking, not to be confused with Stacked Mica capacitors. These have very high stability and are recommended for use in oscillators, filters and other critical applications requiring highly stable capacitance. Tolerance is also very good, usually specified to ± 5% but in practice often better. Generally obtainable in values from 4.7 pF to 3300 pF.

Metal-Clad Mica — a square or rectangular-shaped capacitor having a metal clamp holding the stack of interleaved plates of foil and mica. This form of construction has low lead inductance and can handle high RF currents. It is used for dc blocking and bypassing in RF circuits.

Button Mica — named after their shape.

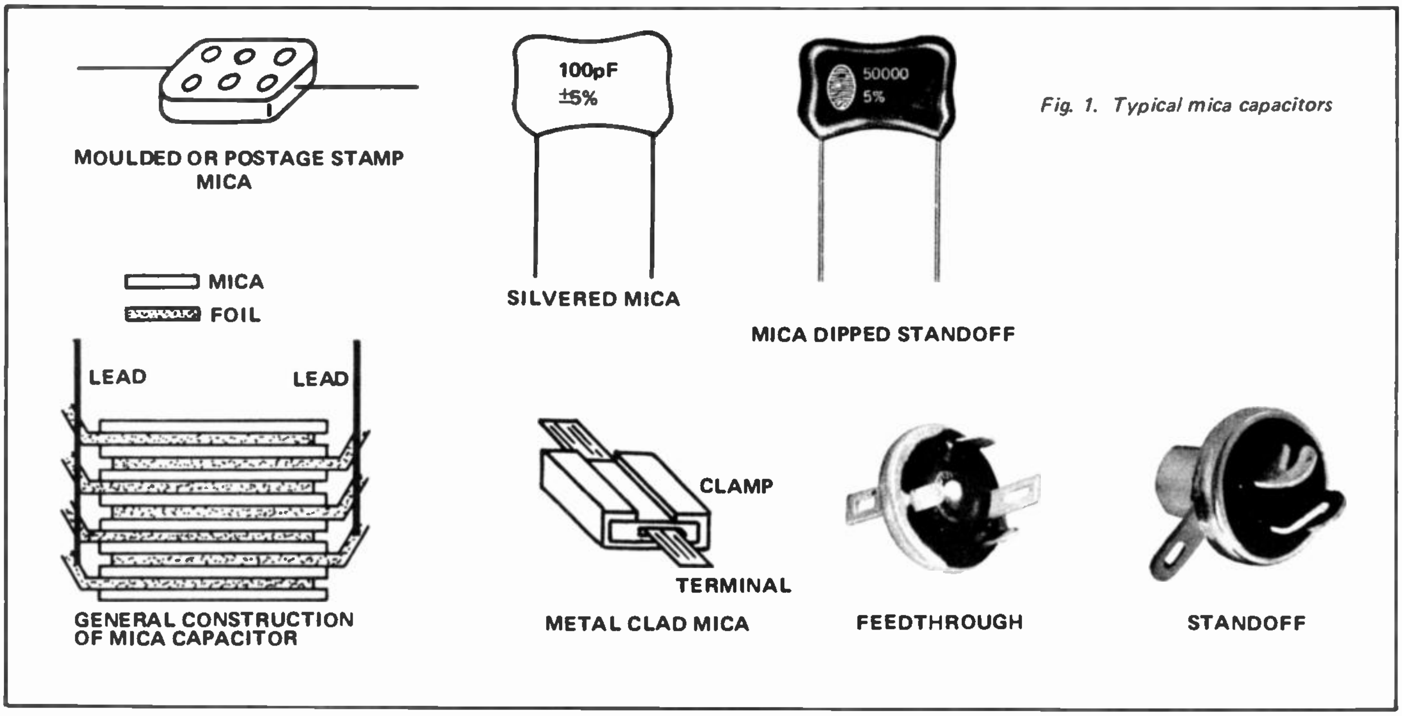


Fig. 1. Typical mica capacitors

Characteristic	Capacitance range (pF) 0.4-2	2.2-3.9	4.7-10
NPO – N330	±250 ppm	± 120 ppm	± 60 ppm
N470 – N750	± 250 ppm	± 120 ppm	± 120 ppm
N1500 – N5600	same as 10 pF and over		

TABLE 1

Very good RF bypasses. Made in standoff and feedthrough styles. They have very low inductance connections and are used for RF bypass, filter, and tuned circuit applications up to UHF.

The feedthrough style provides a bypassed connection through a chassis while the standoff style provides a direct bypass or bypassed tie point. Obtainable in values between 5 pF and 10 000 pF.

Dipped Mica – this style is encapsulated by dipping in resinous material below atmospheric pressure. They have improved electrical characteristics and higher reliability than moulded types. Obtainable in values from 10 pF to 0.1 μF.

CERAMIC CAPACITORS

There are two basic types of ceramic capacitors – low permittivity ("Low-K") and high permittivity ("High-K"). They have widely different characteristics.

Low-K ceramics have low loss and exhibit small, linear changes of capacitance with temperature. They are useful up to 1000 MHz and are made for both low voltage and high voltage applications.

High-K ceramics provide large

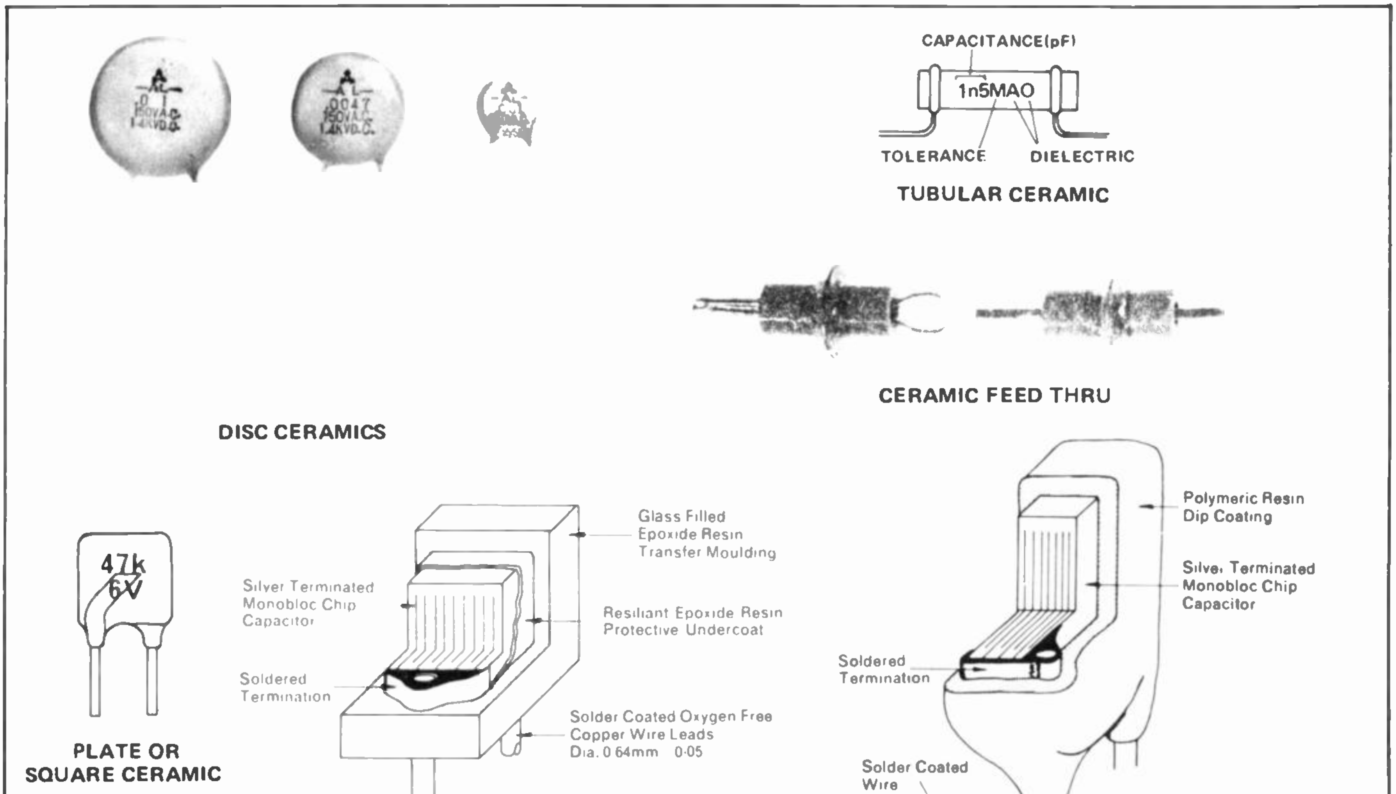


Fig. 2. Ceramic capacitors.

	Paper metalized	Paper film/foil	Polyester metalized	Polyester film/foil	Polycarbonate metalized	Polycarbonate film/foil
Insulation resistance (in megohms)	3×10³	2×10⁴	5×10⁴	10⁵	5×10⁴	10⁵
Tolerance	10	5%	5%	5%	5%	2%
Temperature range °C	–30 to 100	–30 to 100	–55 to 125	55 to 125	55 to 125	–55 to 125
Size per CV*	small	large	small	small	small	small
Stability	fair	fair	fair	fair	fair	fair
Capacitance range (µF unless indicated)	0 01 to 100	0 001 to 100	0 001 to 10	100 pF to 0 01 µF	0 001 to 100	5 pF to 0 01 µF
Voltage (ac) / (dc)	250 630 / 500–5000	250 630 / –	63 400 / 100 1500	90–160 / 160 400	40 250 / 63–1000	63–160 / 100 400
Temperature coefficient PPM/°C	300	300	400	400 (non linear)	150	–50 to –100
Appr. resonance MHz	0 1	0 1	0 1	1	0 1	1

	Polypropylene metalized	Polypropylene film/foil	Polystyrene	Ceramic disc/tube	Ceramic monolithic	Mica	Electrolytic aluminium foil	Electrolytic foil	Electrolytic tantalum solid & wet
Insulation resistance (in megohms)	10⁵	5×10⁴	10⁶	10²	10⁴	10⁵	← variable →		
Tolerance	5%	2%	0 625%	10%	20%	0 5%	10%	10	5
Temperature range °C	40 to 85	40 to 100	–40 to 70	55 to 125	–55 to 125	55 to 125	–20 to 80	40 to 125	–40 to 150
Size per CV*	small	small	large	small	small	small	very small	small	
Stability	fair	excellent	excellent	fair	fair	excellent	fair	very good	excellent
Capacitance range (µF unless indicated)	0 001 to 100	100 pF to 0 47 µF	100 pF to 0 6 µF	5 pF to 1µF	0 001 to 10	5 pF to 0 01 µF	typically 1–22 000	1 1000	3500 max
Voltage (ac) / (dc)	250 440 / 750 1000	63 500 / 100 1500	63–1000	63 250 / 63 10 000	– / 63 450	– / 63–630	– / 6.3–500	– / 6 3–300	– / 1–50
Temperature coefficient PPM/°C	–170	–120	150	non linear positive to 1000 neg		100	1500	1000 (non linear)	200–1000
Appr. resonance MHz	0 1	1	1	10	100	1 0	0 05	0 1	0 1

*CV product of capacitance and voltage

Table 2. Capacitor Comparison Chart.

capacitance values in small space. Their losses are dependent on applied ac and dc fields. They exhibit large, non-linear changes in capacitance against temperature. As a consequence they find application as decoupling and bypass capacitors (discussed later).

Low-K Ceramic Capacitors. Low-K ceramic capacitors are manufactured in a range of temperature characteristics. They are sometimes referred to as "temperature compensating" capacitors as they can be used to compensate for temperature changes in other circuit components. This property is particularly useful in RF oscillators and filters.

The temperature characteristic or coefficient, is quoted in parts per million per °C (ppm/°C), either positive or negative e.g. a capacitor marked 100 pF/P100 will *increase* its capacitance by 100 ppm for each degree centigrade increase in temperature. For a temperature rise of 10°C it will increase its capacitance by 0.1 pF. As a further example, a 1000 pF capacitor will *decrease* its capacitance by 1500 ppm for each degree centigrade rise in temperature. For a temperature rise of 10°C, its capacitance will drop by 15 pF.

Low-K capacitors are also produced having an extremely small temperature characteristic. These are known as NPO ceramics ("Negative-Positive Zero"). Their stability rivals that of silvered mica capacitors.

The graphs in Fig. 3 indicate the range of standard characteristics manufactured. The nominal value of ceramic capacitors is specified at 25°C. It should be noted that the change in capacitance is not strictly linear, having a small curvature, at low temperatures it becomes more negative. The tolerance on the temperature characteristic ranges from ± 30 ppm for NPO capacitors, to ± 1000 ppm for N5600. Below values of 10 pF stray capacitances begin to have a marked effect on the temperature characteristic and the tolerances are widened as shown in Table 1 (page 39).

The temperature coefficient of silvered mica capacitors is usually about +20 ppm/°C but may be as low as +5 ppm/°C which is somewhat better than NPO ceramics.

Low-K ceramic capacitors are made in disc, square and tubular forms. They are obtainable in a range of working voltages from 50 V to 15 kV. They are useful in RF circuits up to three or four hundred megahertz. Above this frequency, leadless unencapsulated "chip" capacitors are used.

POLYSTRENE CAPACITORS

Polystrene capacitors are one type of plastic film capacitor. They are constructed usually by interleaving strips of foil and polystyrene film, the alternate strips of foil being staggered to provide connections. The assembly is then rolled up to form a tubular shaped capacitor. See Fig. 4. They exhibit low loss and good stability and are manufactured in a range of working voltages from 100 volts to 630 volts. They exhibit a small negative temperature characteristic of about 150 ppm/°C and are sometimes used as temperature compensating capacitors. Their main application is in tuned circuits and as coupling capacitors up to about 100 MHz. The higher values (0.01 μF and above) are sometimes used in bypass and decoupling applications.

Polystyrene capacitors are affected by heat, greases and solvents. Care must be taken when using them to keep them away from heat sources (e.g. power resistors). Exercise care when soldering. Flux solvents and other chemical solvents will dissolve the capacitor, with disastrous effects.

PAPER CAPACITORS

Paper capacitors are medium loss, medium stability capacitors that were once widely used. They have been largely replaced by plastic film types for most purposes but are unsurpassed in high voltage dc and low frequency ac power applications.

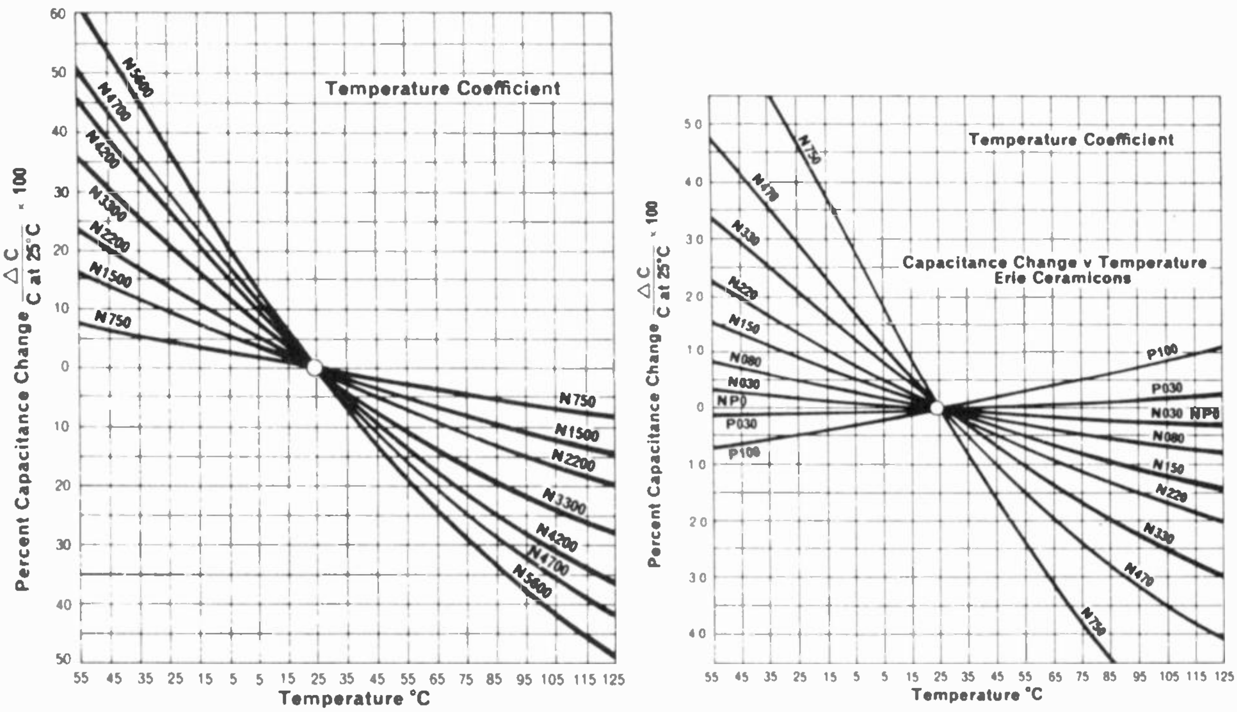


Fig 3 Characteristics of ceramic capacitors

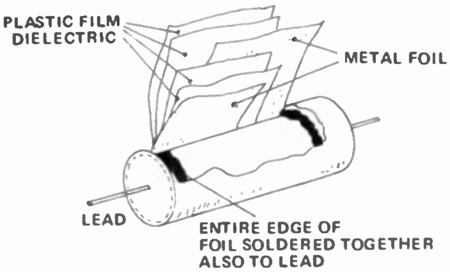
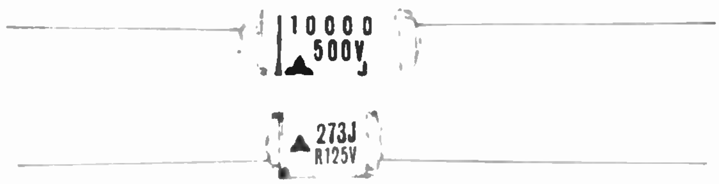
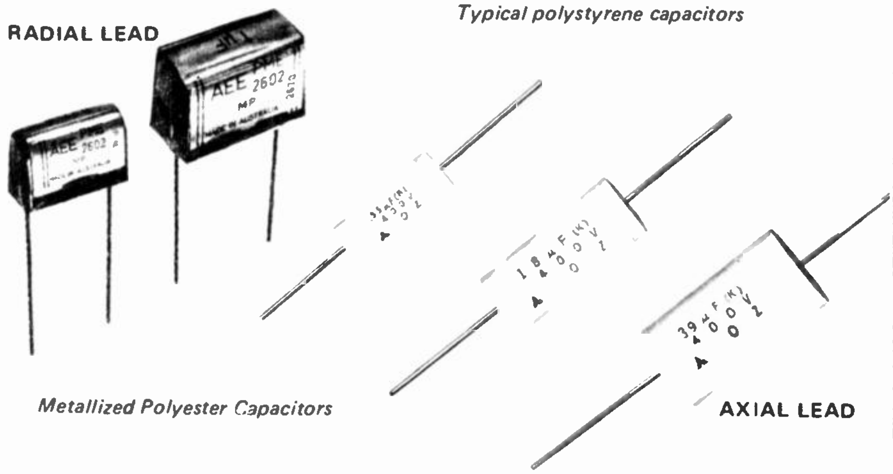


Fig 4 How polystyrene capacitors are made



Typical polystyrene capacitors



Metallized Polyester Capacitors

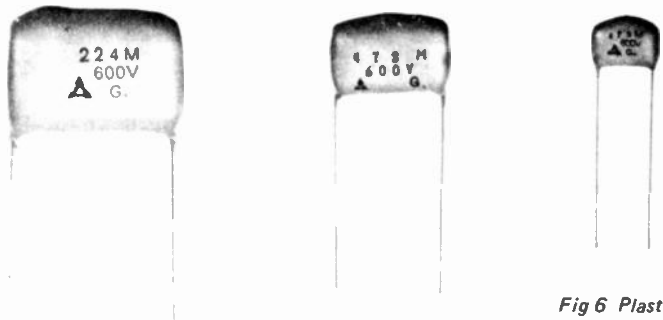


Fig 6 Plastic film capacitors

There are two basic types of construction, the metal foil type and the metallized type. The metal foil type is constructed by winding together interleaved layers of foil and impregnated paper similar to plastic film capacitors, see Fig. 4. This type is best for high voltage and high current applications, a common form being the paper "block" capacitor. See Fig. 5. They are available in voltage ratings up to 4000 V and will withstand considerable charge-discharge currents. The metalized type has the impregnated paper dielectric coated with a thin layer of aluminium or zinc. This form of construction results in a capacitor of relatively smaller physical size.

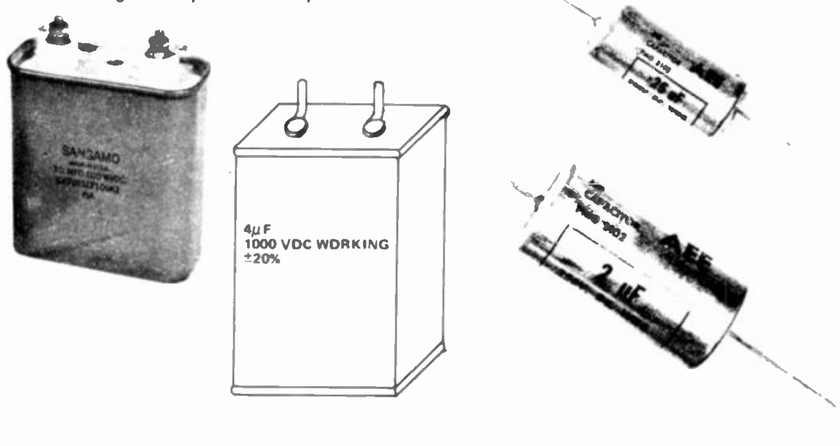
The paper dielectric is impregnated with another dielectric substance to replace the water content inherent in paper and to prevent the absorption of moisture. A variety of natural oils or waxes, or synthetic chemicals, is used.

Encapsulation of the capacitor assembly is usually by moulding in resin or encasing in hermetically sealed metal cans as is done with block capacitors.

PLASTIC FILM CAPACITORS

Plastic films are widely used in capacitor manufacture due to their high reliability and low cost. They have medium loss and medium stability characteristics except for polystyrene capacitors which have already been discussed. Many types of plastic film are used but these fall into three general groups:— polystyrene, polyester and polycarbonate.

Fig 5a Paper block capacitors



The common form of construction uses strips of aluminium foil interleaved with the plastic film dielectric, alternate layers of foil being staggered to provide lead connections. The assembly is then rolled-up to form a tubular-shaped capacitor. Some types are wound flat to form a flat rectangular-shaped capacitor which enables it to be packed more densely on a printed circuit board. They are referred to as 'flat film' capacitors.

Metallized film construction is also extensively used with plastic film capacitors, resulting in physically small dimensions. These capacitors have largely replaced paper capacitors in most low voltage applications owing to their superior electrical characteristics and considerably smaller size.

Plastic film capacitors are generally encapsulated in a tough, impervious plastic or resin or in a metal case.

The polyester films used are generally of the polyethylene type (Mylar, Melinex etc) or polypropylene, and for most purposes they have similar properties to polycarbonate films. The latter though, has less loss and exhibits

Continued on page 44.

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Ceramic Discs	.01uF	25V		0.05
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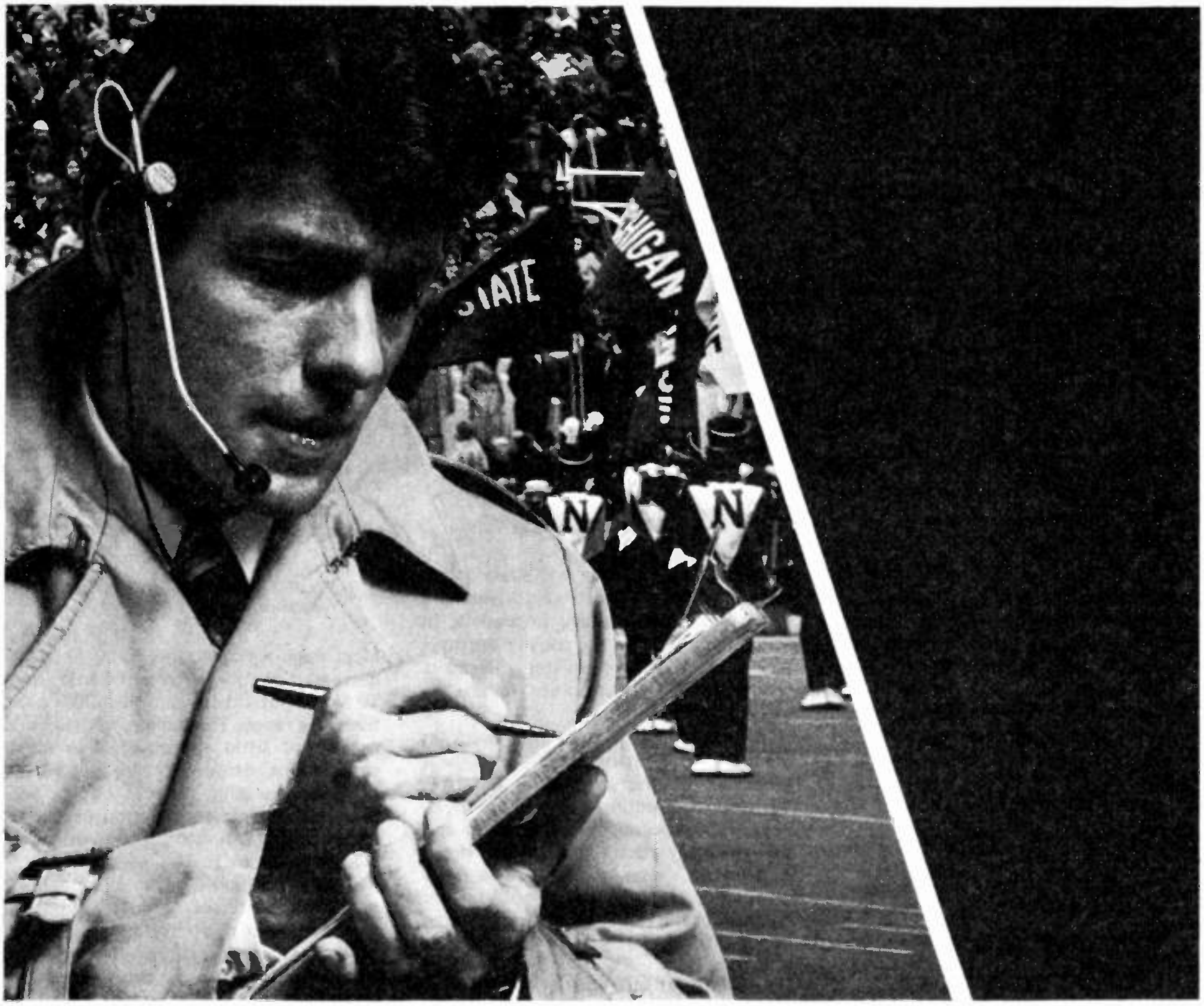

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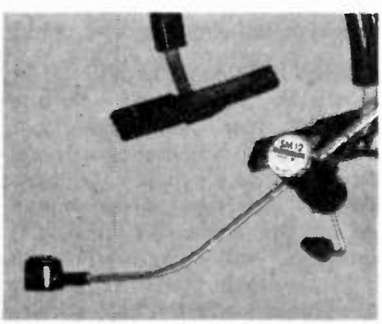

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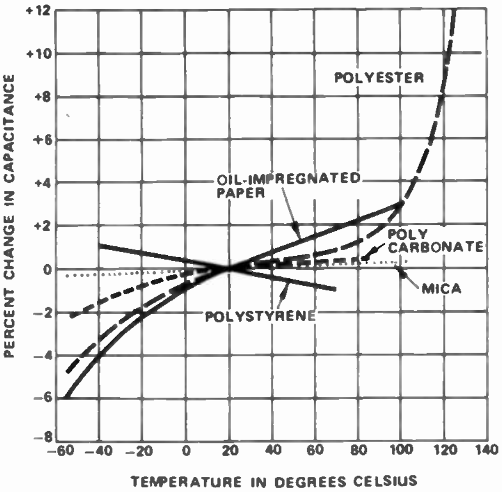


Fig. 7. Temperature versus change in capacitance.

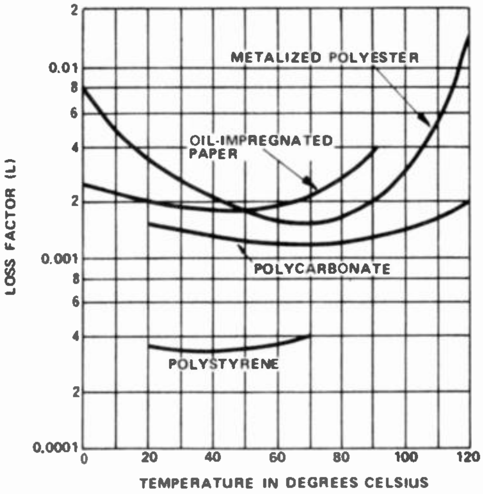


Fig. 8. Temperature versus loss factor.

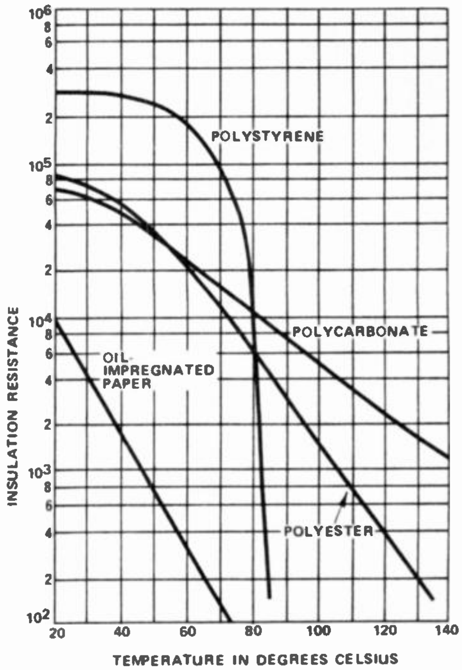


Fig. 9. Temperature versus insulation resistance.

less change in capacitance with temperature. Polyester capacitors are available in ratings up to 100 Vdc (or 250 V rms ac), Polycarbonate capacitors are usually only available in ratings up to 400 Vdc.

A comparison of the temperature, loss factor and insulation resistance of various capacitors is given in Figs. 7, 8, and 9.

A small defect, such as a hole, in the dielectric of a capacitor will allow an arc between the electrodes when a sufficiently high voltage is present. In foil capacitors, the arc usually destroys more of the surrounding dielectric, resulting in catastrophic failure — usually a short circuit.

This disadvantage does not occur in metallized capacitors. The heat generated by the arc rapidly vaporizes the electrode section, clearing the short. A very short pulse of current occurs and the voltage across the capacitor drops and then rises again in a few microseconds. Usually, no further damage results. The process is illustrated in Fig. 10.

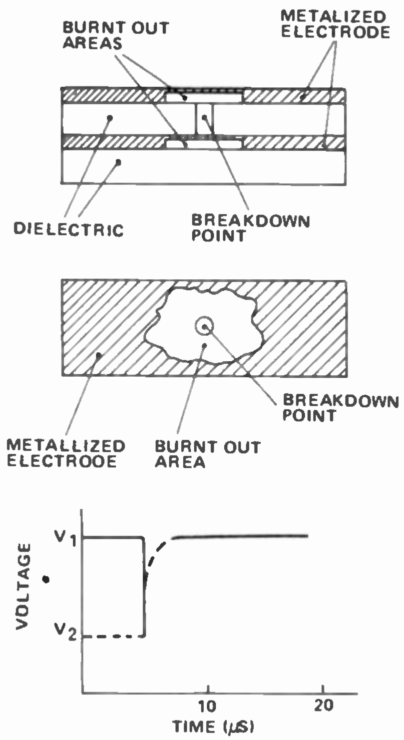


Fig. 10. Process of self healing of a metallized dielectric capacitor. The voltage trace is typical during the process.

HIGH-K CERAMIC CAPACITORS

High-K ceramic capacitors provide large values of capacitance in a very small space. Owing to their method of manufacture they have appreciable loss and show large non-linear changes in capacitance with temperature. Primarily for these reasons they largely find application in bypassing and dc blocking. They change capacitance with applied dc and ac voltage, showing a decrease in capacitance with increasing dc voltage which ranges from 14% for the relatively low permittivity high-K ceramics to 80% for the higher permittivity ceramics. Ac voltage effects are the reverse of dc, giving an increase in capacitance with increasing voltage. This may be only 2% for the lower permittivity ceramic or up to 80% with the higher permittivity types.

High-K ceramic capacitors also change capacitance with frequency. The change is primarily dependent on the particular ceramic used, rather than high or low permittivity. They decrease in capacitance with increasing frequency. Most high-K capacitors only show a decrease of 5% between 1 kHz and 10 MHz, but others can drop 20% over the same range. These characteristics are usually of little consequence in most applications. However, care should be exercised in using them as bypass and decoupling capacitors around oscillator circuits. Plastic film capacitors or low-k disc ceramics are to be preferred.

In general, high-K ceramic capacitors have less internal inductance than plastic film or paper capacitors, as well as smaller size and are preferred in bypass applications. Disc or plate style ceramic capacitors are suitable for bypass applications from 10 MHz to 100 MHz. High-K ceramic capacitors are also made in button feedthrough and bypass styles for bypass applications to 1000 MHz. The tubular style is suitable in bypass applications to 50 MHz while the ceramic feedthrough is useful to 500 MHz. See Fig. 2 for illustrations. The large value (1000 pF — 0.47 μF) 'chip' or 'block' style, which has very low lead inductance, is very useful for bypassing in digital circuitry.

ELECTROLYTIC CAPACITORS

Electrolytic capacitors consist basically of two aluminium foils interleaved with an absorbent paper and wound tightly into a cylinder. Contacts are provided by tabs of aluminium attached to the foils. The winding is impregnated with electrolyte and housed in a suitable container, usually an aluminium can, which is hermetically sealed (Fig. 11).

A dielectric layer of aluminium oxide is 'formed' electrolytically on the

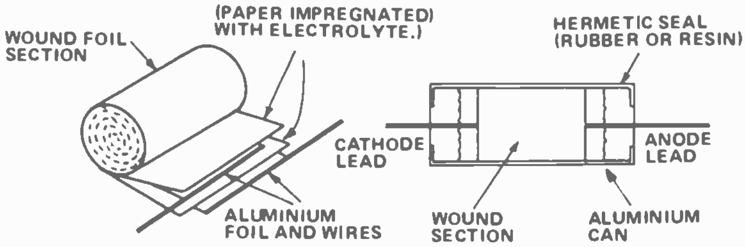


Fig. 11. Construction of typical electrolytic capacitor.

surface of one aluminium foil which acts as the positive plate, or anode, of the capacitor. The electrolyte serves as the second plate of the capacitor and also to repair any flaws in the oxide film when the electrolyte is polarised. The second foil, usually called the cathode foil, provides contact to the electrolyte. Since this film will have a thin oxide film, due to natural oxidation, it will also possess very high capacitance. The thinness of the oxide films, and their high breakdown potential, is responsible for the very high capictance values per unit volume and high working voltages of electrolytic capacitors.

As a result of their construction, these capacitors are polarised and require the anode terminal to be at a positive potential to the cathode terminal. Most types will only withstand a reverse voltage of 1 V or 2 V for short periods and about 1.5 V peak-to-peak ac without a depolarising voltage.

There are two types of electrolytic capacitor, the plain foil type and the etched foil type. The plain foil construction is described above. The etched foil type is constructed similarly to the plain foil except that the aluminium oxide on the anode and cathode foils has been chemically etched to increase its surface area and permittivity. It results in a capacitor which is physically smaller than a plain foil type of equivalent value but has the disadvantage of not being able to withstand high ac currents, compared with the plain foil type.

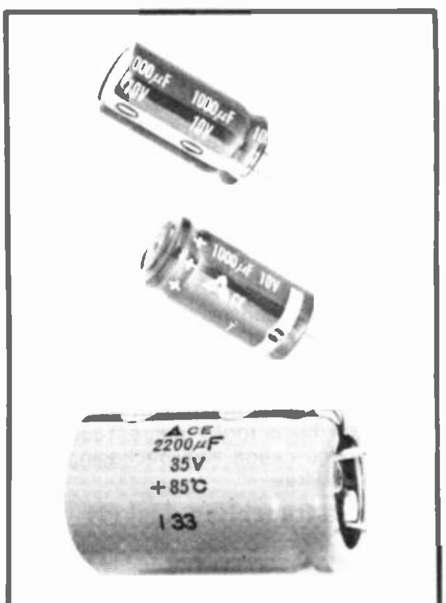


Fig. 12. Electrolytic capacitors.

Etched foil electrolytics are best used in coupling, dc blocking and bypass applications. Plain foil types are better suited as reservoir capacitors in power supplies.

Electrolytic capacitors are usually manufactured to a tolerance of −20 +100% or −50 +100% (they really are!).

The capacitance value and leakage current both increase with temperature. The leakage current increases with applied dc voltage, this increase becoming more rapid at voltages in excess of the rated working value. This can lead to increased heat dissipation in the capacitor which will, in turn, increase the leakage current, leading ultimately to destruction

Most electrolytics are rated to withstand a short voltage surge about 15–20% greater than the rated working voltage. e.g: a capacitor rated at 450 V may be marked 450 VWdc (volts, working, dc), 525 V surge.

Electrolytics can be used below their rated voltage. There may be a slight increase of capacitance with time. Leakage current is usually considerably reduced, resulting in an increased service life.

In manufacture, the internal negative connection may be taken directly to the case or to a tag on the insulated end disc. In this case the capacitor winding is inserted in the case without surrounding insulation so that, even though the negative tag is not directly connected to the case, it is not deliberately insulated from it and leakage current can flow between the case and negative terminal. These capacitors are usually covered in shrunk-on plastic sleeve to insulate the can.

Electrolytic capacitors are made in a range of voltage ratings from 10 V to 600 V.

NON-POLARISED ELECTROLYTICS

These capacitors are constructed using several foils in one winding and connected 'back-to-back'. They are usually larger than polarised capacitors of equivalent value. Since double the foil area than is normally required is used they have increased leakage current. Ac voltage without a dc polarising voltage is permissible, the value depending on ripple current ratings and the frequency.

These capacitors are used as speaker coupling and crossover network capacitors. They are obtainable in values from 1 μF to 100 μF.

TANTALUM CAPACITORS

These capacitors use tantalum oxide as a dielectric. This has a much greater permittivity than aluminium oxide resulting in high value capacitance in relatively small space. Owing to their construction, they are also used as polarised capacitors.

There are three different types of tantalum capacitors, each having different construction. These are the tantalum foil type, the solid tantalum, and the wet-sintered tantalum. The tantalum foil type is similar in construction to electrolytic capacitors but the electrolyte and anode and cathode terminals use different materials.

Solid tantalum capacitors use solid maganese dioxide (which is a semiconductor) as the electrolyte, and a tantalum anode. The cathode connection is formed by coating the electrolyte with graphite and silver. These capacitors may be encapsulated in capacitors may be encapsulated in epoxy resin, polyester sleeve with epoxy seals, or a can with epoxy seals.

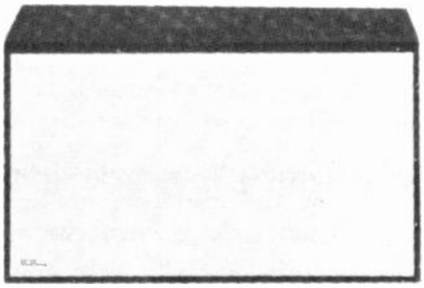
Tantalum capacitors are rated at much lower voltages than electrolytic capacitors. Their small size makes them very suitable for use in transistor circuits. Low leakage current and better capacitance stability than electrolytics are two features which make them suitable for timing applications.

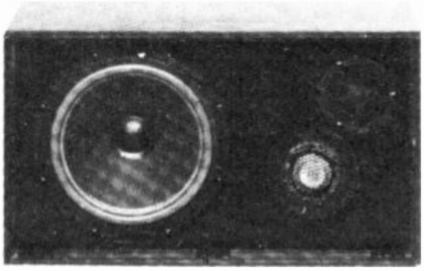
Tantalum capacitors are generally available in values between 0.1 μF and 100 μF. Tolerance is usually +50% −20%. Solid tantalum capacitors are available in voltage ratings from 3 V to 100 V. Wet sintered tantalums are available up to 125 V rating and foil tantalums up to 450 V.

Next month — all the various capacitor codes etc.

THE AR 3a/IMPROVED an evolutionary new SPEAKER SYSTEM

AR
Acoustic Research
A TELEDYNE COMPANY





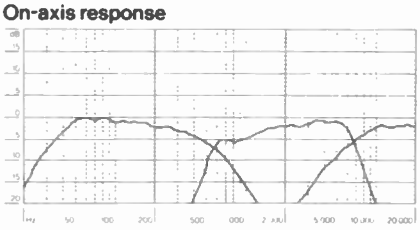
The AR-3a/Improved is the best home speaker system we know how to make. It has been designed to reproduce music as accurately as present-day knowledge of acoustics and electronics permits.

In addition to incorporating the 305mm (12in) bass driver with which AR introduced acoustic suspension to home listeners, the AR-3a/Improved also uses the two miniature hemispherical dome speakers developed for the AR-3a to offer an unprecedented degree of accuracy at middle and high frequencies.

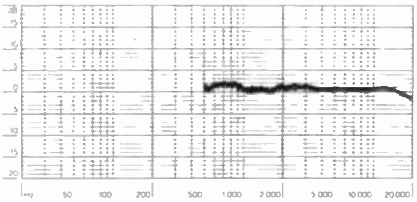
Concepts and techniques developed for the AR-LST and other AR speaker systems have now enabled AR engineers to improve the spectral energy characteristics of the AR-3a and further reduce its already small degree of coloration, while retaining all the virtues of the original design. These improvements have been accomplished by means of significant changes in the design of the crossover: all other components, including driver units and cabinet, are exactly the same as those of the AR-3a.

The AR-3a/Improved is capable of a more linear spectral energy output than was the AR-3a. A two-position switch makes it possible to tailor this characteristic for maximum realism under either reverberant or relatively damped listening conditions.

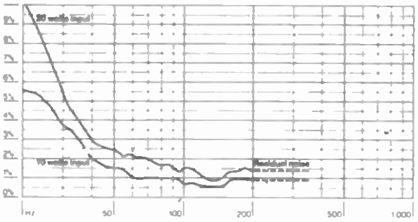
On-axis response



Acoustic power output



Woofer harmonic distortion



Drive units: 305 mm (12 in) acoustic suspension woofer, 38 mm (1½ in) midrange hemispherical dome, 19 mm (¾ in) high-frequency hemispherical dome

Crossover: 575 Hz, 5000 Hz
Impedance: 4 ohms nominal

Controls: Midrange and high-frequency driver level controls

Amplifier: Up to 100 watts per channel
Size: 356 x 636 x 289 mm deep (14 x 25 x 11⅜ in)
Weight: 24 kg (53 lb)
Woofer resonance: Free air 18 Hz, in enclosure 42 Hz
Volume of enclosure: 48.2 litres (1.7 cu ft)

'... the best speaker frequency response curve we have ever measured using our present test set-up ... virtually perfect dispersion at all frequencies ... AR speakers set new standards for low-distortion, low-frequency reproduction, and in our view have never been surpassed in this respect'. *Stereo Review*

'On any material we fed to them, our pair of AR-3a's responded neutrally, lending no coloration of their own to the sound ... the speakers sounded magnificent, filling the place with a lot of clean, musical sound and an excellent stereo image ... Our tests of the AR-3a simply confirm the manufacturer's design aims and claims for this system'. *High Fidelity*

'The harmonic distortion at bass frequencies was outstandingly low ... The high-frequency dispersion is the widest of any speaker we have tested ... a new high standard of performance at what must be considered a bargain price'. *Audio*

'Acoustic Research have achieved what they set out to do – a first class loudspeaker by any standard'. *Hi-Fi News*

'Finest bass performance I have heard or measured'. E J Jordan, *Wireless World*

The AR guarantee
The workmanship and performance in normal use of AR speakers are guaranteed for 5 years from the date of purchase. This guarantee covers parts, repair labour, and freight costs to and from the factory or nearest authorized service station. New packaging if needed is also free.

The acoustic research 3A improved is now on demonstration at these franchised dealers:

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Hi-Fi House
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Autel Systems
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Melbourne
Brash's
Denman Hi-Fi
Douglas Trading
Instrol Hi-Fi
Pantiles Hi-Fi
Mordialloc Electrical

Geelong
Sound Spectrum
(E & B Wholesale)

Perth
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Leslie Leonard
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Australian Distributors
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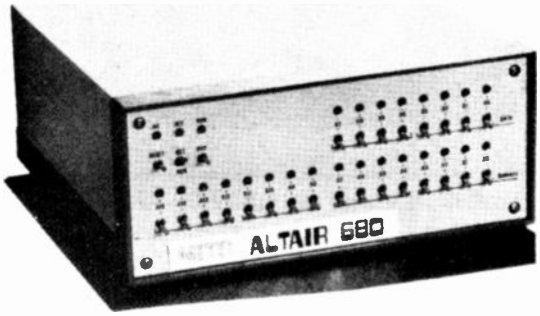
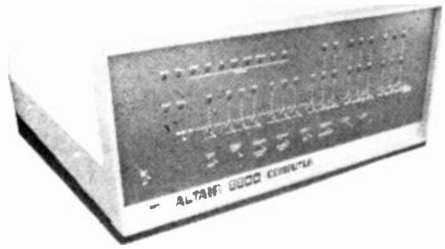
$390 COMPUTER*!!

In January of 1975, MITS (Micro Instrumentation & Telemetry Systems, U.S.A.) stunned the Computer world with the announcement of the Altair 8800 Computer that sells for under $500.00 in form.*
TODAY MITS IS ANNOUNCING THE ALTAIR 680 COMPUTER THAT SELLS FOR UNDER $390.00 in kit form.

*in kit form – plus sales tax if applicable.





The Altair 8800 is a superbly engineered, variable word length computer. Its byte orientation structure was designed to give the Altair the most efficient utilization possible – an efficiency only found in the most advanced Computers. It has a cycle speed of 2 microseconds; it can directly address 65k bytes of memory and 256 input/output devices; and has 78 basic machine instructions with variations over 200 instructions. The Altair has been designed with buss orientation to be easily expanded and easily adapted to thousands of applications. It is ideal for teaching, commercial and industrial applications. Yet, it has the power and versatility for the most advanced data processing requirements. Its basic memory of 256 words of static RAM memory can be extended to 65,000 words of directly addressable memory, static or dynamic memory, PROM or ROM memory, or a floppy disk system which can store over 200,000 bytes of information on a flexible disc with a data transfer rate of 250K bits/sec. Using standard MITS interface cards the Altair can be connected to MITS peripherals (computer terminals, line-printers, audio cassette interface, character alpha numeric display, teletype, Interface Card between Computer & TV set to generate action games, 8 channel Analog-to-digital converter Cards etc. etc.

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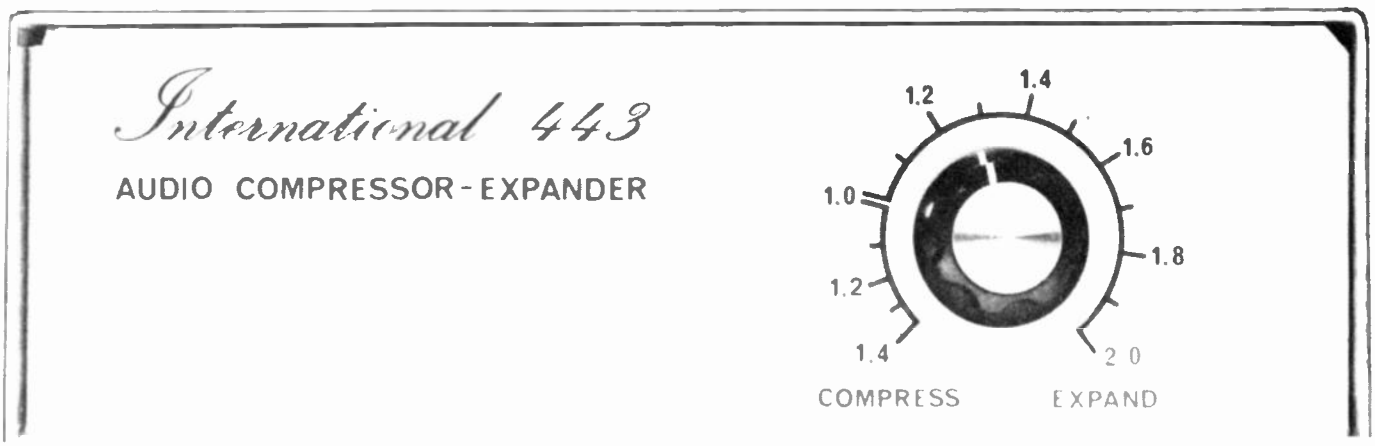
Audio expander compressor

Increase dynamic range of tape recordings and/or reduce record surface noise with this versatile unit. This project is based on an original design by Frank Gillespie of Findon, South Australia.



MANY OF US HAVE TAPES IN either the reel to reel format or on cassettes which have poor signal to noise ratio. It is not that we necessarily made a bad job of the recording in the first place, but rather the limitations of our equipment and tape were generally just a little bit too much compared with what is available today. And because the signal to noise ratio is so poor, many of these tapes (and quite a few records as well) tend to lie on the shelf because of their audible inadequacies. Apart from this it is by no means unknown for commercially pre-recorded tapes and records to be below an acceptable standard.

Many people arbitrarily think that this problem is what the Dolby system is intended to resolve. But this is not so. The Dolby system helps *maintain* the original signal to noise ratio when recording from one medium to another but it has very little to offer when faced by *existing* inadequacies.

Another problem that plagues many of us is the poor dynamic range of our tape recorders or of the pre-recorded material that we buy. For example, the majority of cassette recorders are hard pressed to offer even a 55 dB dynamic range. Many of them offer little more than 40 dB. As if this were not bad enough, very few records have a dynamic range exceeding 50-55 dB and even this is considerably degraded after a dozen or so playings in a dusty environment.

One at least partial solution to these problems is the use of dynamic volume expansion, and units are available commercially that do just this.

The dbx 117 dynamic range enhancer reviewed in ETI in January 1975 performed remarkably well — to the extent that one of our readers decided to design a dynamic volume expander — starting from basic principles.

It was decided that the cost of incorporating root mean square detection was not justified — so absolute mean detection was used instead.

Our reader's unit was then passed over to our development laboratory who made minor changes to the circuitry and designed suitable metalwork etc.

The final unit described here is relatively inexpensive to build, yet its performance is quite adequate for all practical purposes. It is sufficiently versatile to interface with most existing audio equipment, at nominal signal levels from about 25 millivolts to 1 volt.

CONSTRUCTION

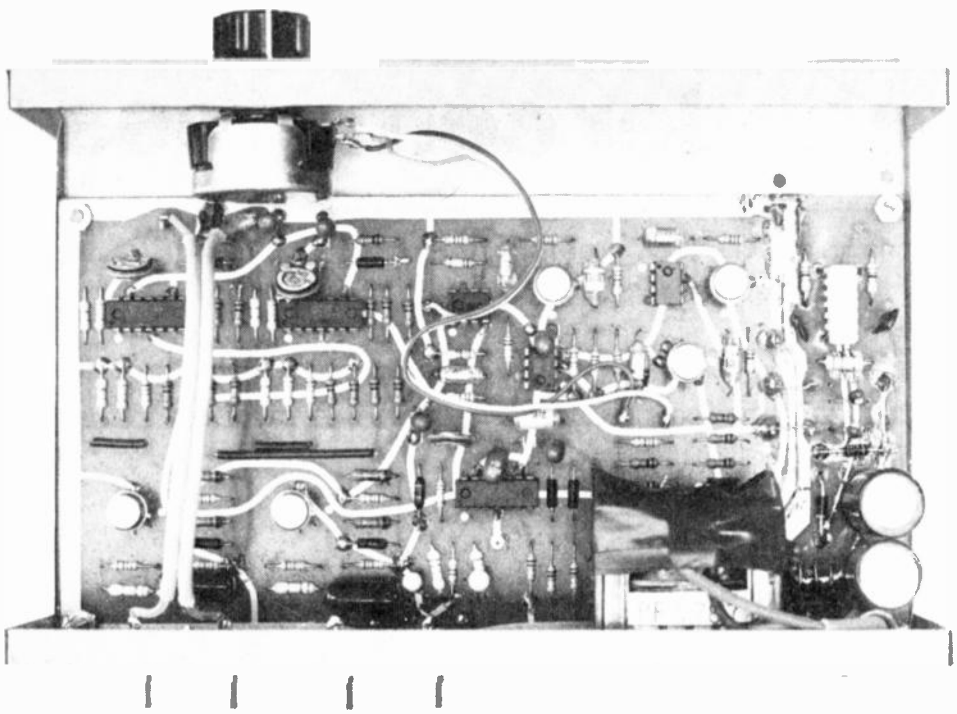
Due to the relative complexity of the circuit a double-sided printed-circuit board has been used to simplify the construction, and we strongly recommend that this board be used. A single-sided board could be used but it would be much larger and would require a great number of wire links.

Begin construction by assembling the components on to the board following the component overlay. Take particular care with the orientation of components as marked on the overlay. When soldering component leads to the top of the printed-circuit board use a soldering iron which has a small tip and use a small gauge of solder (1 mm recommended). Take care not to bridge solder between the IC pads. It is easy to miss soldering connections on the component side of the board and these should be double checked.

Take care to insert the electrolytics with the polarity as marked on the overlay and even more care with the orientation of the diodes. A reversed diode can result in the destruction of one of the dual transistors.

The resistors in the signal side of the circuit and those in the current-sink circuit should be 2% or better.

Audio expander compressor



Alternatively they may be selected from 5% values. In selecting values an ordinary multimeter (operated at about the centre of the range suffices). The resistors in question are all those values between R37 and R65.

For best results the two 12 volt zeners should also be matched but in practice any slight discrepancy may readily be compensated by using the normal stereo-balance control.

As explained below, capacitor C5 should be chosen in accordance with the particular compromise that suits the user of the unit. Alternately a switch may be used to select different values. A value of 1 microfarad for C5 allows compression or expansion to follow the signal amplitude so rapidly that the ear is unlikely to detect the attack or release, which is virtually complete in about 20 milliseconds. However, with this value, low frequency signal components (50 Hz or lower) will not be averaged out in obtaining the gain-control voltage, and severe intermodulation and 3rd harmonic distortion will result. At the other extreme, a value of 4.7 microfarads for C5 will prevent such distortion right down to the lower audible limit, but the attack and release time (about 100 milliseconds) is long enough so that the control effects can be audible, although not necessarily unpleasant. Nevertheless for the small compression or expansion ratios which should be most used, a value of C5 equal to 4.7 microfarads will be found quite acceptable by most people.

Potentiometer RV1 is a trimpot used to match the signal levels of the compressor-expander with those of the associated equipment.

The box use in our prototype measured 200 x 125 x 63 mm and, although a little crammed did adequately hold the unit. The next larger box available was thought to be too big. The printed-circuit board is mounted at the rear of the box to allow room for the front-panel potentiometer to be mounted. The board is mounted on 6 mm spacers and the transformer is then mounted directly onto the rear panel together with the RCA input and output sockets.

POWER SUPPLY

The output of the transformer is rectified by a full-wave bridge to provide ±22 volts as set by the zener diodes. The voltages obtained from the MC1468 voltage regulator are near enough to the nominal ± 15 volts for correct operation of the compressor-expander.

SETTING UP

With the power supply connected (check for correct polarity), apply a strong (about 1 volt) audio signal to both stereo inputs, while the point marked 'X' is shorted to ground. Monitor the left channel output with a high sensitivity meter (or amplifier) and adjust RV3 to the point where the output *just* disappears. Repeat with the right channel and RV4. This procedure balances out the input offset voltage of the current sinks, and ensures that the audio gain will be controlled correctly at the low end. Remove the input signal and the short circuit.

Potentiometer RV1 is a trimpot, this is set by the following procedure:

(1) Connect the compressor-expander to its associated equipment, and supply an input of moderate level (e.g. music of average loudness). Potentiometer RV1 should be fully clockwise when viewed from the input edge of the board.

(2) Turn the compress-expand control to full compression, and adjust RV1 to bring the output up to its original level (loudness).

(3) Turn the compress-expand control towards the expansion end, and note any obvious change in output level.

(4) If a decrease in level occurs, turn RV1 slightly anticlockwise; if an increase occurs, turn RV1 slightly clockwise.

(5) Repeat steps (3) and (4) until the level remains reasonably constant over the whole range of compression and expansion. Note that this adjustment is subjective, and it does not need to be done with any great accuracy.

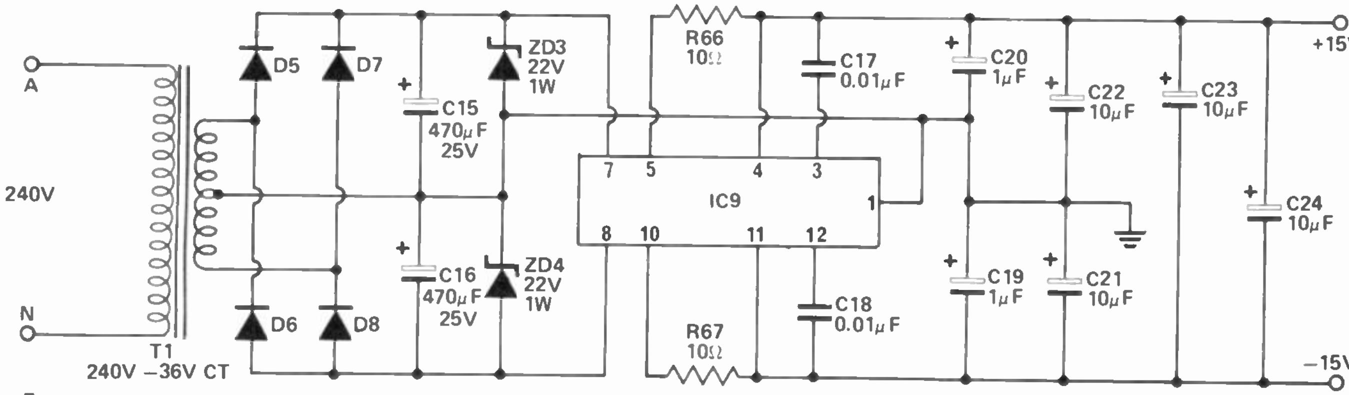
If RV1 cannot be adjusted as described, it means that the signal level is outside the optimum range of the compressor-expander. Somewhat higher signal levels can be accommodated by increasing the value of R1 and R2 whilst for lower signal levels, R4 should be decreased. If correct adjustment of RV1 is obtained well towards the anticlockwise end, then an improved signal-to-noise ratio results if R34 and R36 are increased to 18k, and the stereo outputs are each attenuated by a 470 ohm/3.9 k divider. However, this modification is not essential.

With no input signal applied adjust RV2 such that the voltage at its wiper is zero volts. Now fit the knob such that the pointer lines up with the 1.0 calibration. Check that the potentiometer travel approximately matches the scale. If not reverse the two outside leads of RV2.

HOW TO USE

The use of a compressor-expander need not be confined to those situations where such a device is really needed. Practically all tapes and many records become more listenable with a small amount of expansion. On the other hand, background music is far less obtrusive if the volume is compressed to some extent. The key to listening pleasure lies in the handling of the compress-expand control. Don't move it far from the 1.0 position unless there is some definite reason.

One final word of warning — on full expansion this device is quite capable of outputting a signal of 10 volts. It would be wise to ensure that your amplifier is capable of accepting this voltage without damage if full expansion is ever used.



NOTES
D5–D8 ARE EM401 OR SIMILAR
ZD3,ZD4 ARE 22V 1W ZENERS
IC9 IS MC1468L,SG4501N, XR1568

Circuit diagram for the power supply section. (On the same board as the circuitry of Fig. 1).

PARTS LIST – ETI 443

Resistors

R1-2	– 15k	½ watt	5%
R3	– 5k6	"	"
R4	– 47 ohm	"	"
R5-6	– 22 k	"	"
R7-8	– 10 k	"	"
R9	– 22 k	"	"
R10-11	– 10 k	"	"
R12	– 4k7	"	"
R13	– 22 k	"	"
R14	– 100 k	"	"
R15	– 150 k	"	"
R16-17	– 2 k2	"	"
R18-19	– 1 M5	"	"
R20-21	– 22 k	"	"
R22	– 10 k	"	"
R23	– 820	"	"
R24	– 2 k2	"	"
R25	– 150 k	"	"
R26-27	– 1 M5	"	"
R28-29	– 2 k2	"	"
R30	– 100 k	"	"
R31-32	– 270 k	"	"
R33-36	– 1 k5	"	"
R37	– 12 k	2%	"
R38	– 1 k5	"	"
R39	– 12 k	2%	"
R40	– 27 k	"	"
R41	– 470 k	"	"
R42	– 27 k	"	"
R43	– 470 k	"	"
R44	– 12 k	2%	"
R45	– 1 k5	"	"
R46	– 12 k	"	"
R47	– 27 k	"	"
R48	– 470 k	"	"
R49	– 27 k	2%	"
R50	– 470 k	"	"
R51-52	– 10 k	"	"
R53	– 22 k	"	"
R54	– 15 k	"	"
R55-56	– 10 k	2%	"
R57	– 22 k	"	"
R58	– 100	"	"
R59-60	– 10 k	"	"
R61	– 22 k	"	"
R62	– 15 k	"	"
R63-64	– 10 k	"	"
R65	– 22 k	"	"
R66-67	– 10 ohm	5%	"

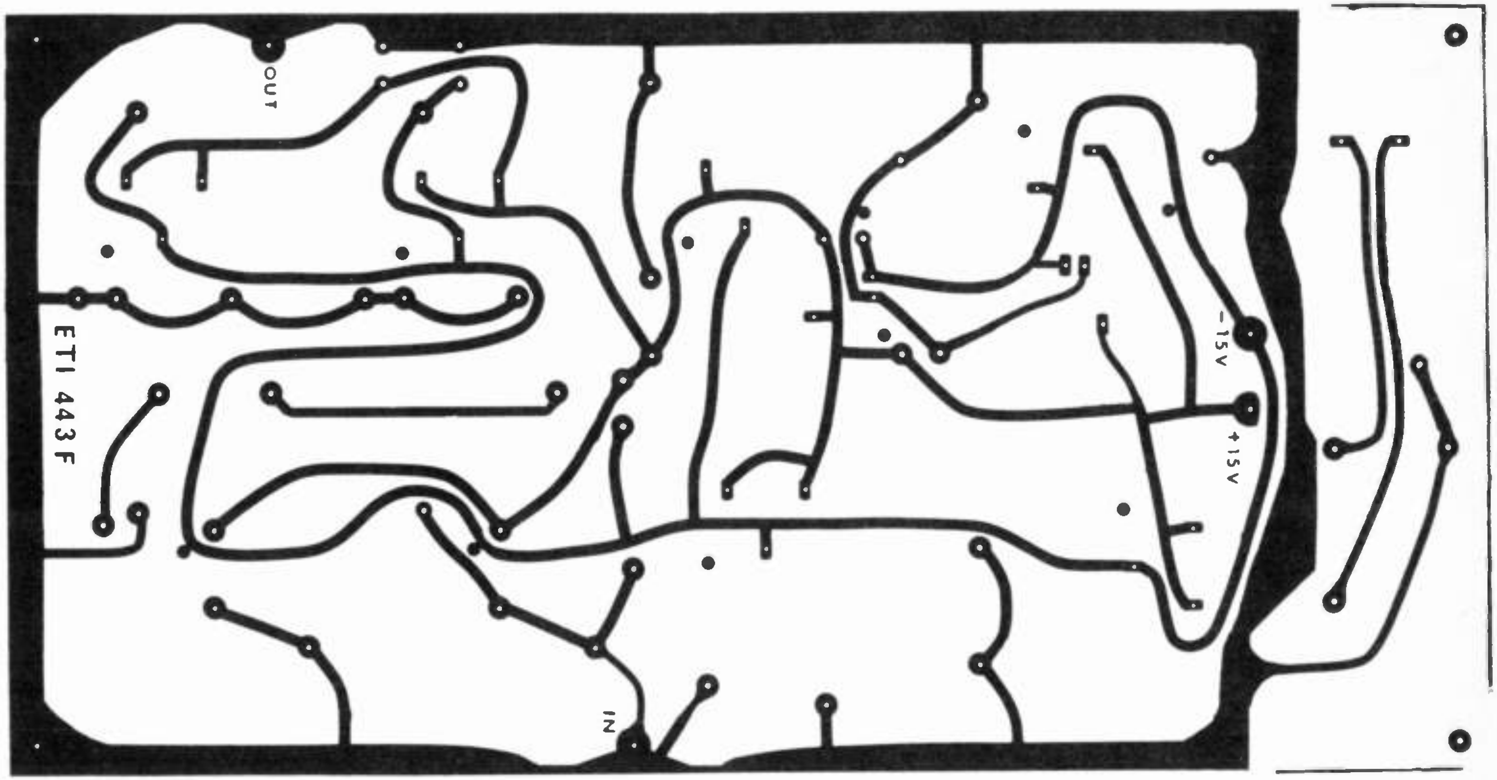


Fig. 4. Printed-Circuit layout of the component side of the board.

*The 2% resistors may be selected from 5% valves.

Resistor Summary
2 x 10Ω, 1 x 47Ω, 1 x 820, 6 x 1.5 k, 5 x 2.2 k, 1 x 4.7 k, 1 x 5.6 k, 13 x 10 k, 4 x 12 k, 4 x 15 k, 10 x 22 k, 4 x 27 k, 2 x 100 k, 2 x 150 k, 2 x 270 k, 4 x 470 k, 4 x 1.5 M

Variable Resistors

RV 1	– 2 k trim
RV 2	– 5 k wire wound rotary
RV 3-4	– 10 k trim

Capacitors

C1-2	– 4.7μF 25 V tantalum
C3-4	– 10μF 25 V tantalum
C5	– 4.7μF 25 V "
C6-7	– 330 pF
C8	– 22 pF
C9-10	– 150 pF
C11	– 22 pF
C12	– 33 pF
C13-14	– 0.47μF polyester
C15-16	– 470μF 25 V electro
C17-18	– 0.01μF polyester
C19-20	– 1μF 25 V tantalum
C21-24	– 10μF 35 V "

Dual Transistors
TP1-TP4 LM114, 2N2920A, 2N3424

Integrated Circuits

IC1-2-7-8	– LM 747
IC3	– LM 308
IC4-5-6	– LM 301
IC9	– MC 1468L, SG 4501N, XR 1568

Diodes

D1-D4	– IN 914 or similar
D5-D8	– EM 401 or similar

Zener Diodes

ZD1-ZD2	– 12 V 400 mW
ZD3 - ZD4	– 22 V 1 W

Miscellaneous
240V/36V CT PF 3787
PC Board ETI 443
4 RCA sockets
Power cord and plug
Four 6 mm spacers
Chassis and cover 200 x 63 x 125 mm
Front Panel
Knob

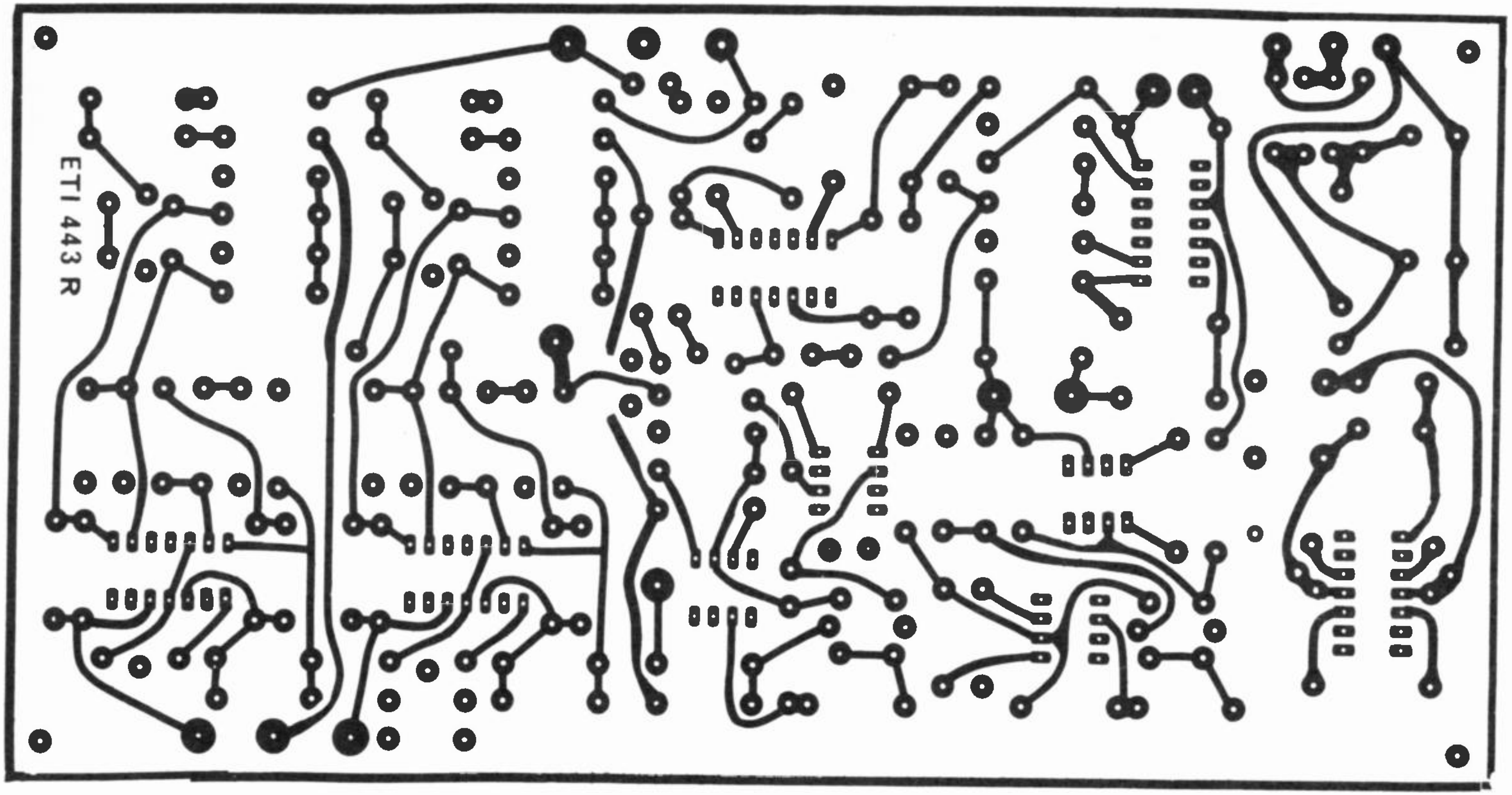
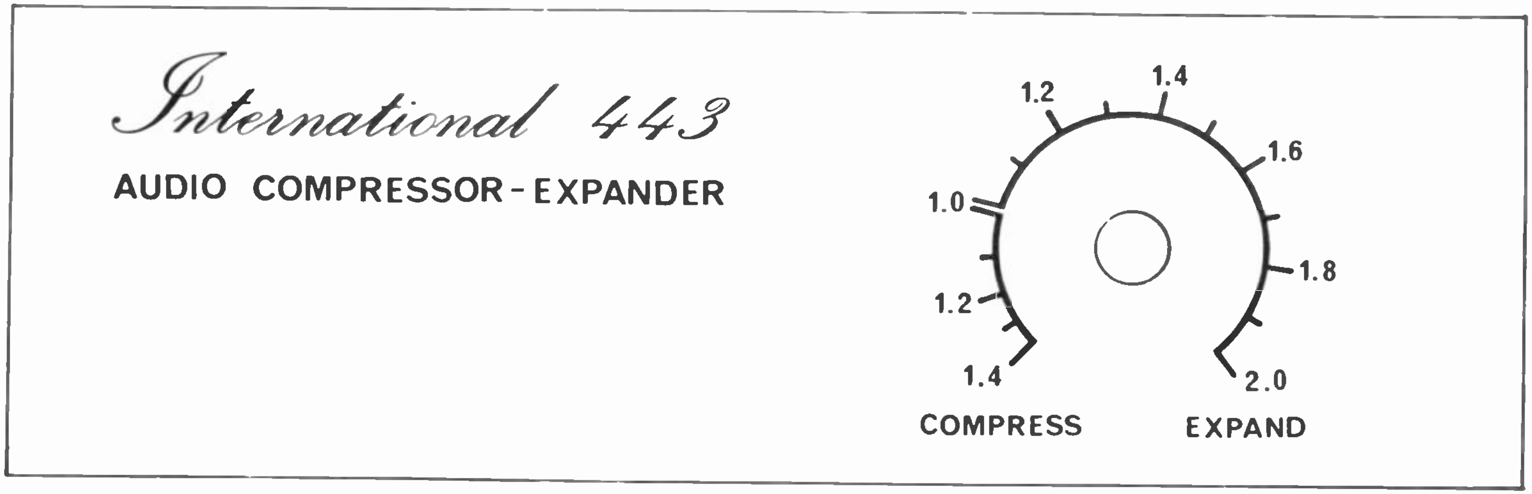
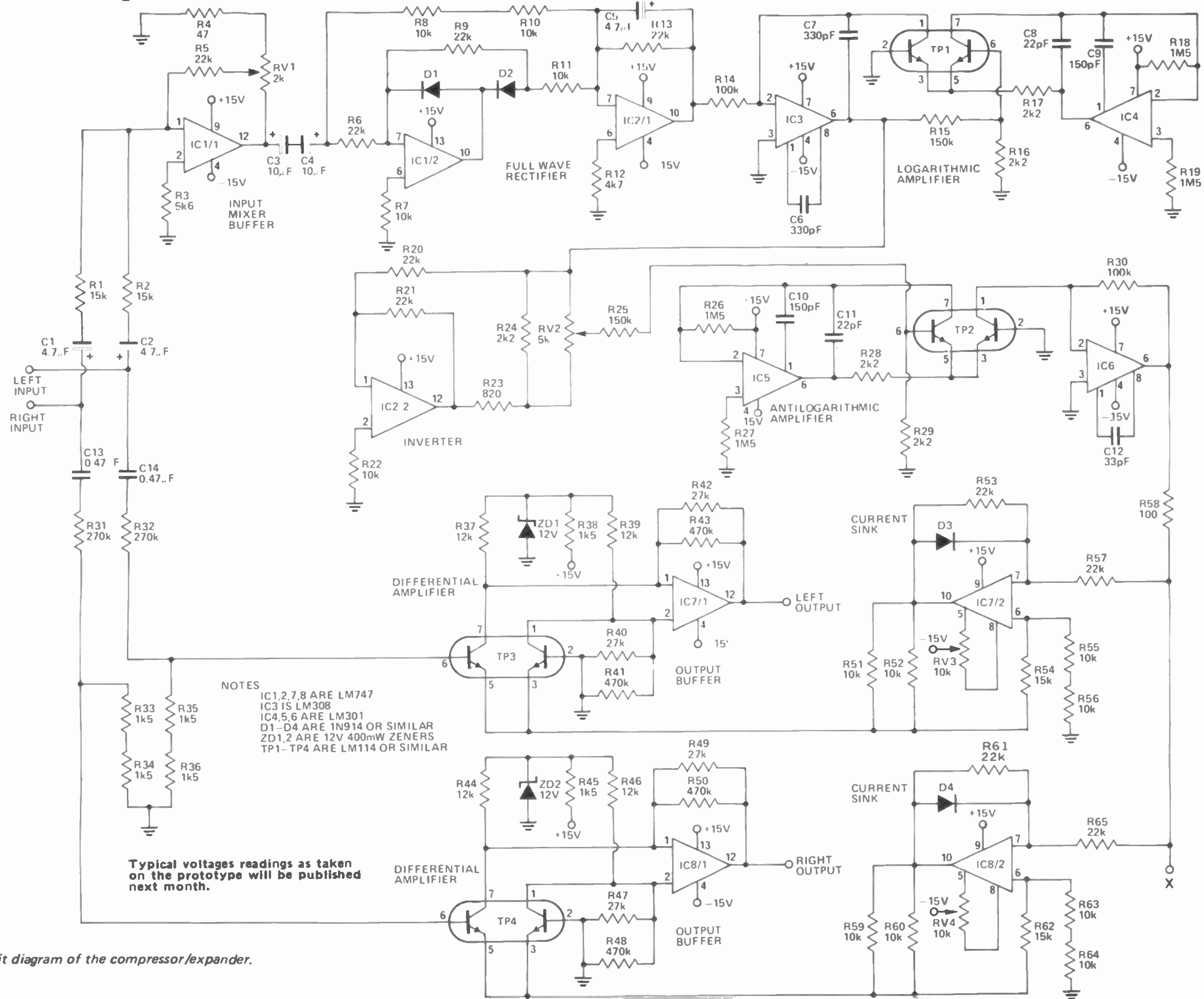


Fig. 5. Printed-Circuit layout of the non-component side.



Front panel layout shown full-size.

Audio expander compressor



NOTES
IC1,2,7,8 ARE LM747
IC3 IS LM308
IC4,5,6 ARE LM301
D1–D4 ARE 1N914 OR SIMILAR
ZD1,2 ARE 12V 400mW ZENERS
TP1–TP4 ARE LM114 OR SIMILAR

Typical voltages readings as taken on the prototype will be published next month.

Circuit diagram of the compressor/expander.

HOW IT WORKS – ETI 443

The heart of an audio compressor-expander is invariably a voltage controlled amplifier; that is, an amplifier whose gain is set by means of an applied dc voltage. This dc voltage itself must be derived from the amplitude of the audio input signal, averaged over some preset period, and modified to give the required compression or expansion characteristics. In the circuit of Fig. 1, each portion of the circuit is identified according to its function. These portions, in turn, are grouped into three main sections; an ac to dc converter, a power function generator, and a stereo analogue multiplier.

The two channels of stereo input are mixed in buffer amplifier 1C1/1, and the gain of this stage is set so that an output of about 1 volt is given by a signal which corresponds to moderate loudness. Amplifiers 1C1/2 and 1C2/1 are used to obtain precision full-wave rectification of the mixed input, and the resulting positive dc voltage is stored in capacitor C5. The choice of value for C5 is important, and it will be discussed in detail later on.

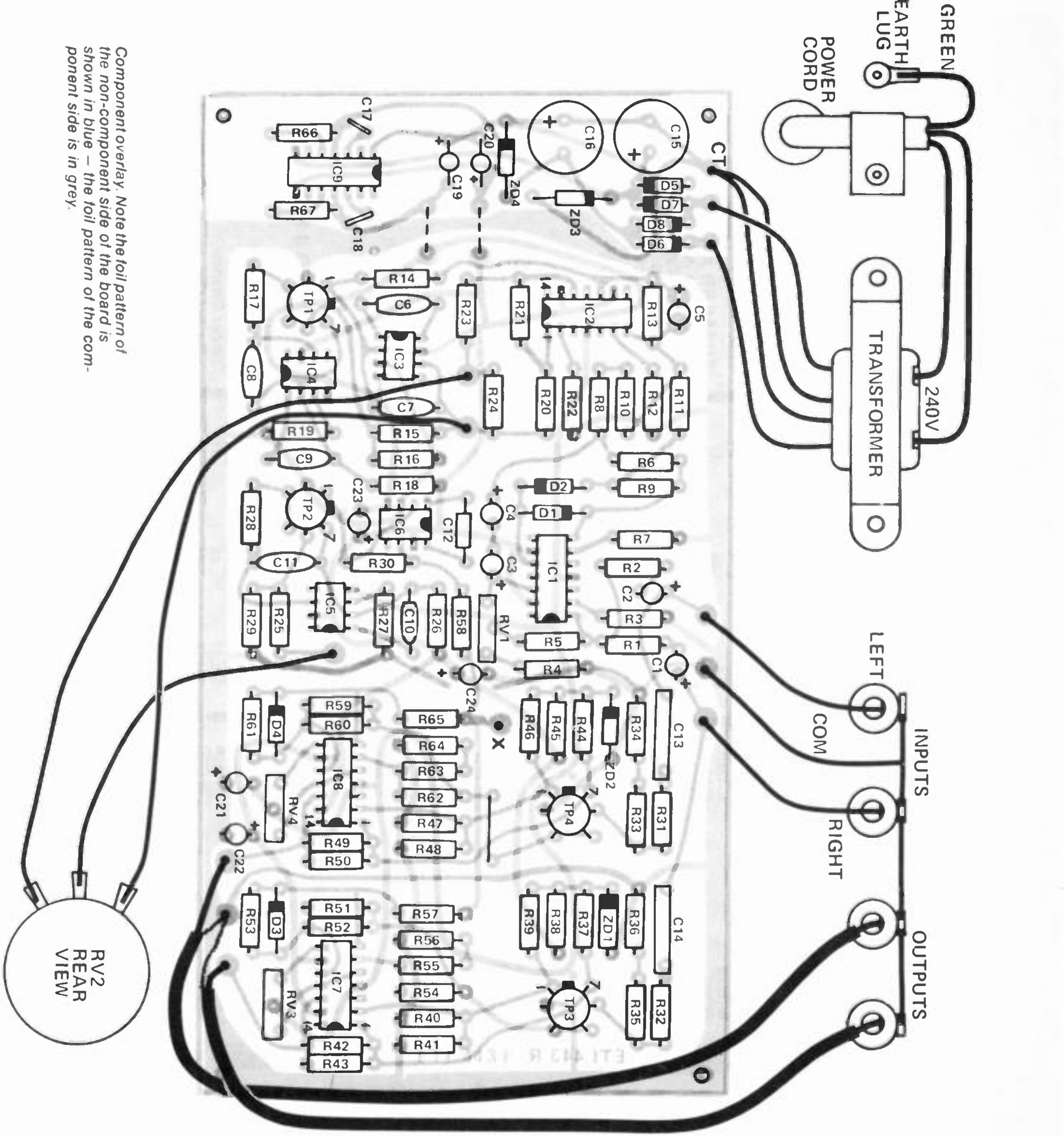
Amplifiers IC3 and IC4 together with the transistor pair TP1 constitute a logarithmic amplifier. With the components shown, the behaviour of this amplifier is described by the equation:

$E_{out} = -4.15 \log E_{in}$

The inverse of E_{out} is obtained from amplifier 1C2/2 and by connecting the compression-expansion control potentiometer as shown between the input and output of this stage, any voltage between E_{out} and $-0.3E_{out}$ can be obtained. 1C5, 1C6 and TP_2 are combined as an antilogarithmic amplifier (or exponential), which is the exact inverse of the logarithmic amplifier so that the effect of all these operations on the input signal is to give a positive dc output voltage, equal in magnitude to the input voltage raised to the power k, where k can have any value from –0.3 to 1.

In the analogue multiplier sections, this voltage ($E_{in}{}^k$) is converted to current by amplifiers 1C7/2 and 1C8/2, thus setting the effective gain of the differential amplifiers TP_3 and TP_4. These are directly coupled into the output buffers 1C7/1 and 1C8/1, so that the stereo signals reaching the outputs have been amplified by a factor which depends on the average amplitude of the signals, and the compression-expansion control setting. The actual voltage gain can vary from 0.0004 to 14, which represents a power gain range of 97 dB.

Component overlay. Note the foil pattern of the non-component side of the board is shown in blue – the foil pattern of the component side is in grey.



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SEMI CONDUCTORS

	$ c
AF126	.98 each
BA219	.39 each
BA102	.60 each
BB105G	.45 each
BC107	.40 each
BC108	.40 each
BC109	.40 each
BC177	.50 each
BC178	.50 each
BC179	.50 each
BC548	.40 each
BC549	.40 each
BC558	.40 each
BC559	.40 each
BC639	.60 each
BC640	.60 each
BD139	1.00 each
BD266A	2.73 each
BD266B	3.26 each
BD267A	2.73 each
BD267B	3.26 each
BF115	.64 each
BF180	.90 each
BF199	.50 each
BFR84	1.44 each
C103YY	2.20 each
C106B1	2.16 each
C106DI	1.64 each
C106Y1	1.20 each
C122D	2.30 each
EM404	.30 each
MJE2955	3.50 each
MJE3055	3.20 each
MPF102	1.25 each
MPF105	.98 each
MPF106	.98 each
SC141D	2.00 each
SC146D	3.00 each
TT800	1.00 each
TT801	1.00 each
BD140	1.00 each

VALVES

	1 to 9 Each	Mixed 10 Ea.
1B3	1.71	1.55
1S2	1.08	.97
6AL3	1.09	.98
6AN7	2.38	2.16
6AQ5	1.31	1.18
6AU4	1.61	1.45
5AU6	1.13	1.02
6AX4	1.61	1.45
6BA6	1.50	1.36
6BE6	1.75	1.59
6BL8	.99	.89
6 BM8	1.17	1.06
6BQ5	1.52	1.38
6BQ7	2.04	1.85
6BX6	1.42	1.29
6CA7	3.47	3.17
6CM5	1.67	1.52
6DQ6A	2.69	1.44
6DX8	1.52	1.38
6EA8	1.53	1.39
6EB8	1.87	1.71
6EJ7	1.30	1.18
6EH7	1.30	1.18
6ES8	1.76	1.60
6GV8	1.65	1.51
6GW8	1.63	1.49
6M5	2.00	1.82
6N3	2.57	2.44
6N8	2.20	2.00
6U8	1.52	1.38
6U9	2.03	1.85
6V4	1.22	1.12
6V9	3.28	2.99
6X4	1.17	.97
6X9	2.03	1.85
6X9	2.24	2.04
12AU7	.85	.77
12AX7	1.90	1.73

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C120	Low Noise	2.45	2.30	2.20
C46	Ultra Dynamic	1.85	1.75	1.65
C60	Ultra Dynamic	2.05	1.95	1.85
C90	Ultra Dynamic	2.40	2.30	2.20
C120	Ultra Dynamic	3.20	3.10	2.90
C60	Ultra Dynamic Royal	2.40	2.30	2.20
C90	Ultra Dynamic Royal	3.00	2.85	2.70

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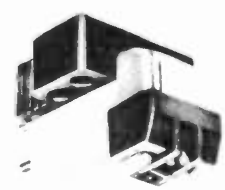
Tracking Force:	1 – 2.5 grams.
Stylus:	Diamond, Conical, radius 16 microns.
Overall Dimensions:	21 x 17 x 17.6mm
Mounting:	12: 7mm or ½".



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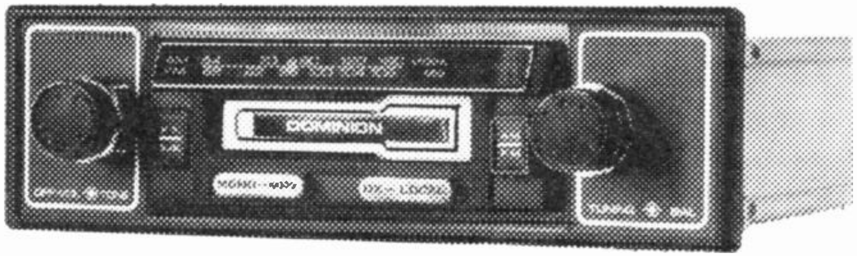

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New ETI Service Feature

electronic component data sheets

If desired these pages can be removed from the magazine and bound into a standard ETI magazine binder — obtainable from our Subscription Department for $4.50 (plus $1.10 postage in NSW or $1.50 all other States);

ETI data sheet

Here is a new ETI feature — a regular data sheet service, so arranged that the section may be easily removed from the magazine if required.

We hope to provide details of several devices each month — although there may be some months when space limitations will prevent our including this feature.

Details will be limited to essential practical data together with brief specifications.

We will be including details of all types of semi-conductor devices — from the basic transistors covered this month — up to the more exotic forms of integrated circuits.

BC 107-109 Low power Amplifier

QUICK REFERENCE DATA

			BC107	BC108	BC109
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20 V
Collector current (peak value)	I_{CM}	max.	200	200	200 mA
Total power dissipation up to T_{amb} = 25°C	P_{tot}	max.	300	300	300 mW
Junction temperature	T_j	max.	175	175	175 °C
Small signal current gain at T_j = 25°C					
I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	240
		<	500	900	900
Transition frequency at f = 35 MHz					
I_C = 10 mA; V_{CE} = 5V	f_T	typ.	300	300	300 MHz
Noise figure at R_S = 2 kΩ					
I_C = 200 µA ; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.			1.4 dB
		<			4 dB
f = 1 kHz; Bw = 200 Hz	F	typ.	2	2	1.2 dB
Collector current (dc)	I_C max.				100 mA
Thermal Resistance					
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=			0.5 °C/mW
From junction to case	$R_{th\ j\text{-}c}$	=			0.2 °C/mW
Saturation voltages 1)					
I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	typ.		90 mV	
		<		250 mV	
	V_{BEsat}	typ.		700 mV	
I_C = 100 mA; I_B = 5 mA	V_{CEsat}	typ.		200 mV	
		<		600 mV	
	V_{BEsat}	typ.		900 mV	
Collector capacitance at f = 1 MHz		typ.		2.5 pF	
I_E = I_e = 0; V_{CB} = 10V	C_c	<		4.5 pF	
Emitter capacitance at f = 1 MHz					
I_C = I_c = 0; V_{EB} = 0.5 V	C_e	typ.		9 pF	

V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature

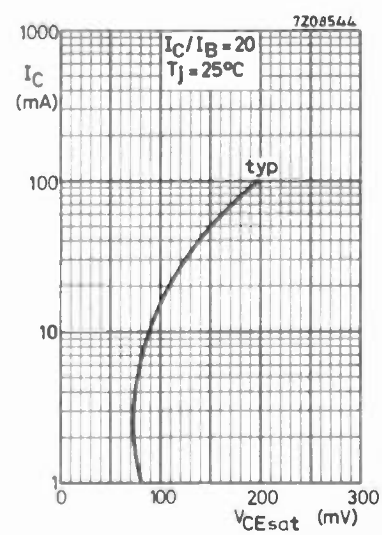
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C
DC current gain					
I_C = 10 µA; V_{CE} = 5 V	h_{FE}	>		40	100
		typ.	90	150	270
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420
		typ.	180	290	520
		<	220	450	800

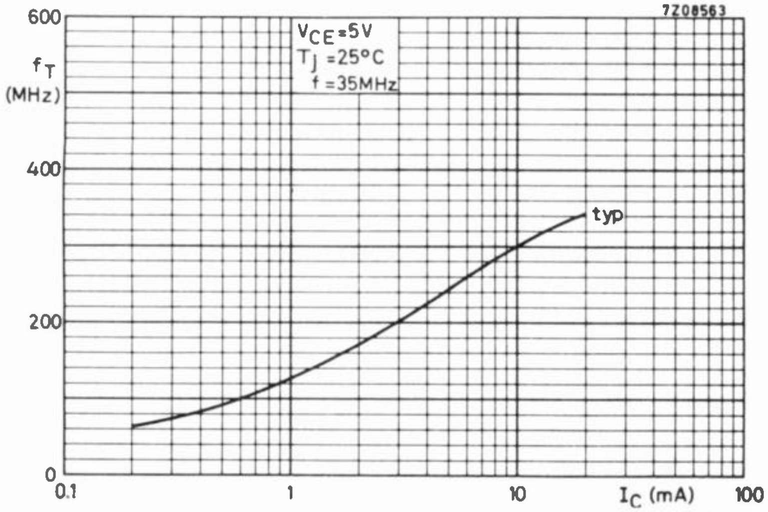
The BC 107-109 series are npn low power transistors commonly used in audio frequency applications. They are housed in TO-18 metal cases with the collector connected to the case. Their pnp complement is the BC 177-179.

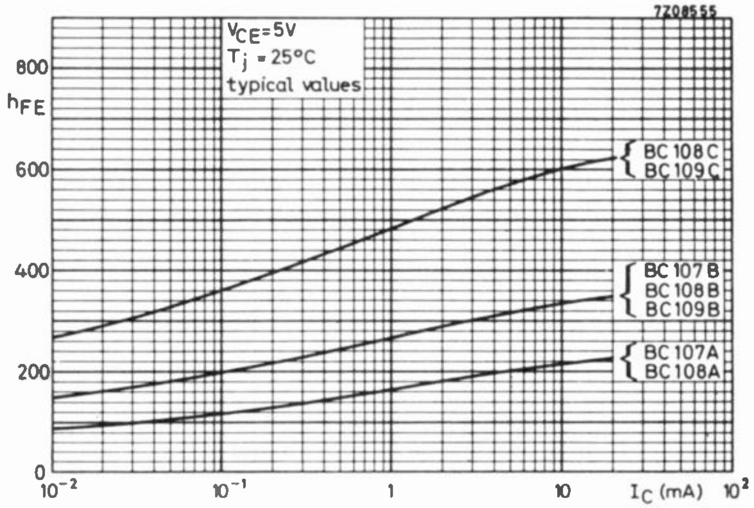
The BC107 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The BC108 is suitable for a multitude of low voltage applications e.g. driver stages of audio pre-amplifiers, and in signal processing circuits of television receivers. The BC109 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

Each type is made in forms A, B and C — the main difference being in gain (h_{FE}). The A version has the lowest gain — the C version has the highest. Details are included in the Quick Reference Data panel.

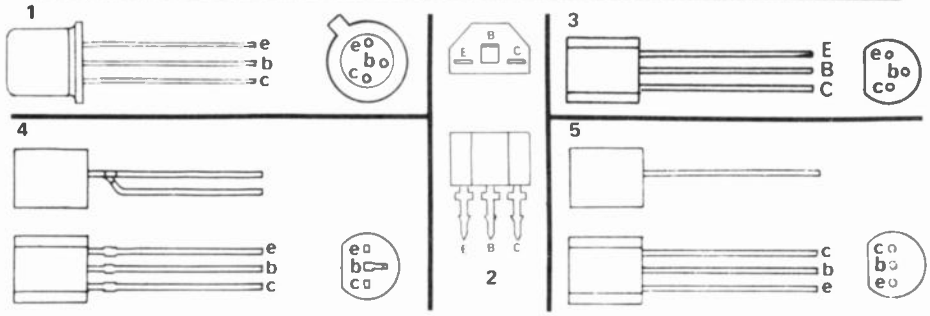






	Transistor types			Connections
	BC107	BC108	BC109	1
Electrically similar types	BC147	BC148	BC149	2
	BC237	BC238	BC239	3
	BC547	BC548	BC549	4* 5‡

NOTE: * Philips types only ‡ all others



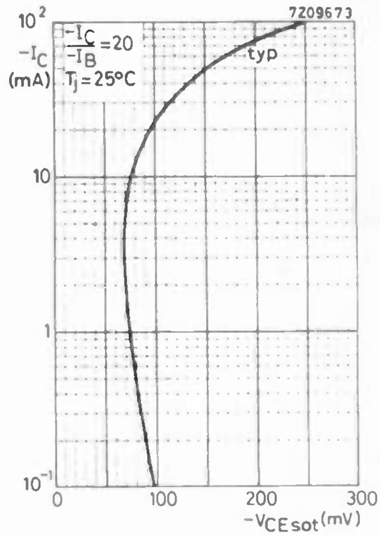
ETI data sheet

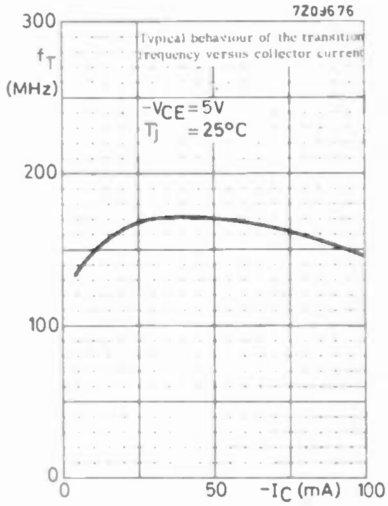
BC 177-179 Low power AF amplifier

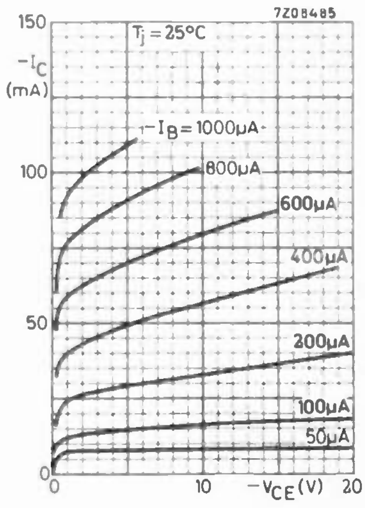
The BC 177-179 series are pnp low power transistors commonly used in audio frequency applications. They are housed in TO-18 metal cases with the collector connected to the case. Their npn complement is the BC 107-109.

The BC177 is a high voltage type primarily intended for use in driver stages of audio amplifiers, and in signal processing circuits of television receivers. The BC178 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers. The BC179 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

As with the BC 107-109 series each BC 177-179 type is manufactured in forms A, B or C — the main difference being in gain (h_{FE}). The A version has the lowest gain — the C version has the highest. Details are included in the Reference Data panel.



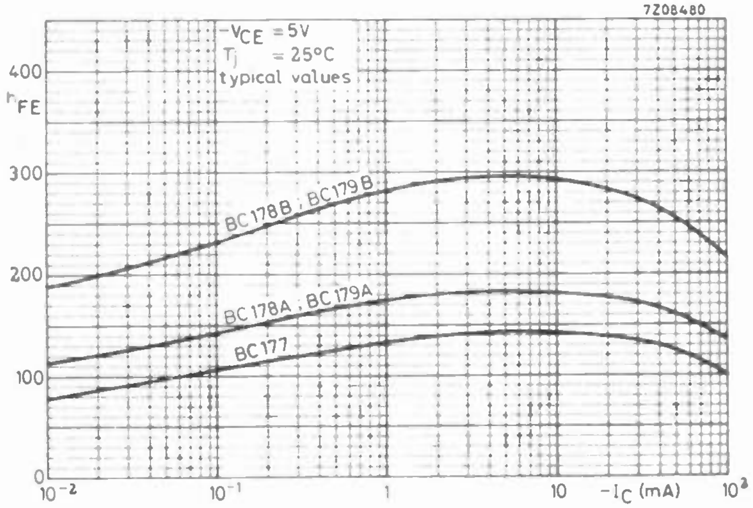




QUICK REFERENCE DATA

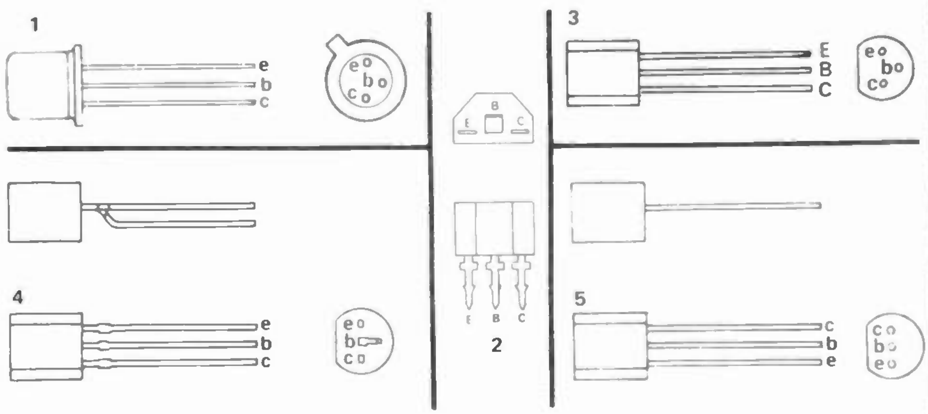
			BC177	BC178	BC179
Collector-emitter voltage ($+V_{BE} = 1$ V)	$-V_{CEX}$	max.	50	30	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20 V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200 mA
Total power dissipation up to Tamb · 25°C	P_{tot}	max.	300	300	300 mW
Junction temperature	T_j	max.	175	175	175°C
Small signal current gain at $T_j = 25°C$ $-I_C = 2$ mA; $-V_{CE} = 5$ V; f = 1 kHz	h_{fe}	>	75	75	125
		<	260	500	500
Transition frequency at f = 35 MHz A-$I_C = 10$ mA; $-V_{CE} = 5V$	f_T	typ.	150	150	150 MHz
Noise figure at $R_S = 2\ k\Omega$ $-I_C = 200\ \mu A$; $-V_{CE} = 5V$ f = 30 Hz to 15 kHz	F	typ.			1.2 dB
		<			4 dB
f = 1 kHz; Bw = 200 Hz	F	<	10	10	4 dB
Collector current (dc)	$-I_C$	max.			100 mA
Thermal Resistance From junction to ambient in free air	$R_{th\ j\text{-}a}$	=			0.5 °C/mW
Fron junction to case	$R_{th\ j\text{-}c}$	=			0.2 °C/mW
Saturation voltages $-I_C = 10$ mA; $-I_B = 0.5$ mA	$-V_{CE\ sat}$	typ.			75 mV
		<			300 mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{BE\ sat}$	typ.			700 mV
	$-V_{CE\ sat}$	typ.			250 mV
	$-V_{BE\ sat}$	typ.			850 mV
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.			4.0 pF

			BC177	BC178A BC179A	BC178B BC179B
DC current gain $-I_C = 2$ mA; $-V_{CE} = 5V$	h_{FE}	typ.	140	180	290



	Transistor types	Connections
	BC 177 BC 178 BC 179	1
Electrically similar types	BC 157 BC 158 BC 159	2
	BC 307 BC 308 BC 309	3
	BC 557 BC 558 BC 559	4* 5‡

Note: * Philips types only ‡ all others



ETE data sheet

BD 135-139 General purpose npn transistors

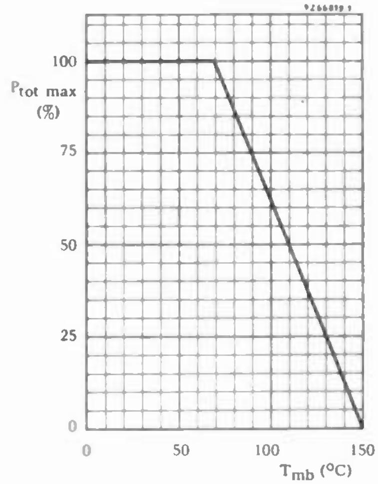
QUICK REFERENCE DATA

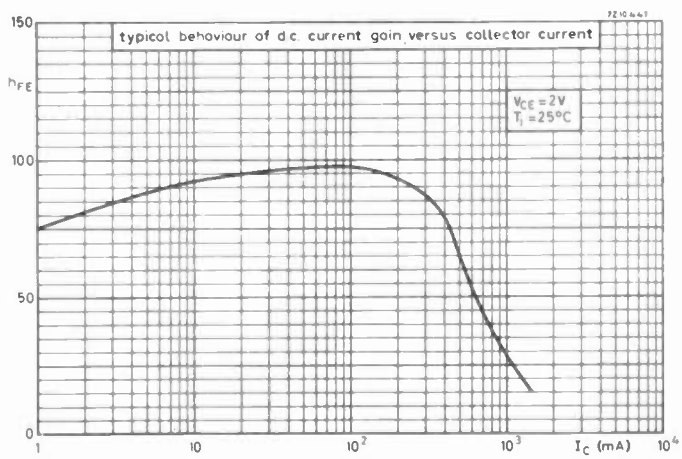
			BD135	BD137	BD139
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100 V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80 V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100 V
Collector-current (peak value)	I_{CM}	max.	1, 5	1, 5	1, 5 A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8 W
Junction temperature	T_j	max.	150	150	150 °C
D.C. current gain I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40
		<	250	160	160
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		250 MHz	
Collector current (d.c.)	I_C	max.		1, 0	
Total power dissipation to t_{mb} = 70°C	P_{tot}	max.		8 W	
Thermal Resistance					
From junction to ambient in free air	$R_{th\ j\text{-}a}$		100 °C/W		
From junction to mounting base	$R_{th\ j\text{-}mb}$		10 °C/W		
Saturation voltage I_C = 500 mA; I_B = 50 mA	$V_{CE\ sat}$			0, 5 V	
D.C. current gain ratio of matched pairs BD135/BD136; BD137/BD138 BD139/BD140 I_C = 150 mA; V_{CE} = 2 V	h_{FE1}/h_{FE2}	typ.		1, 3	
		<		1, 6	
D.C. current gain			BD135	BD137	BD139
I_C = 5 mA; V_{CE} = 2 V	h_{FE}	>	25	25	25
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40
		<	250	160	160
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	>	25	25	25

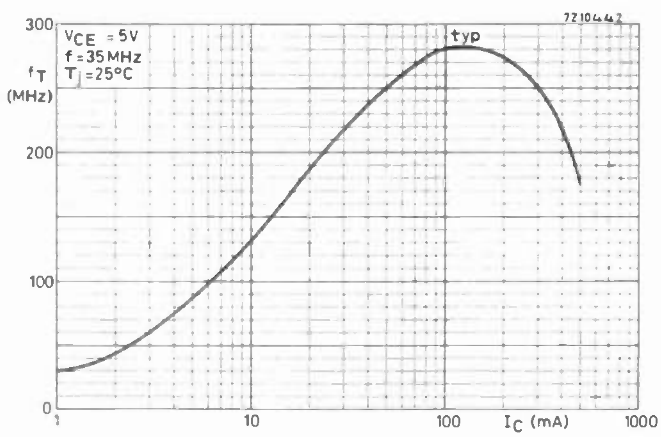
THE BD 135-139 SERIES ARE general purpose npn transistors recommended for driver stages in hi-fi amplifiers and TV receivers. They are housed in SOT-32 plastic cases. Their pnp complement is the BD 136-140.

Transistors BC635, 637 and 639 use the same chip as the BD135–139 series.

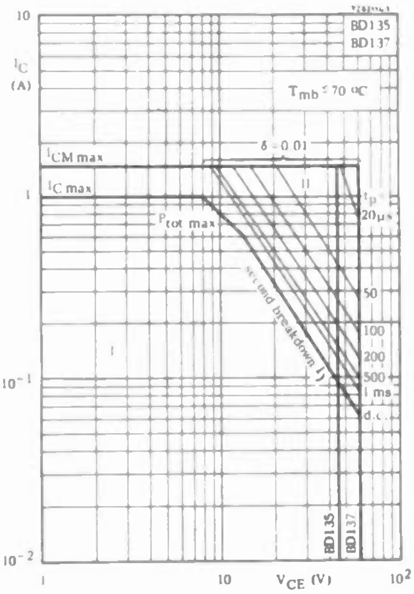
The devices are however mounted in a T092 plastic case. Power is limited to 1 watt – thermal resistance R_{th} j-a increases to 156°C/W.



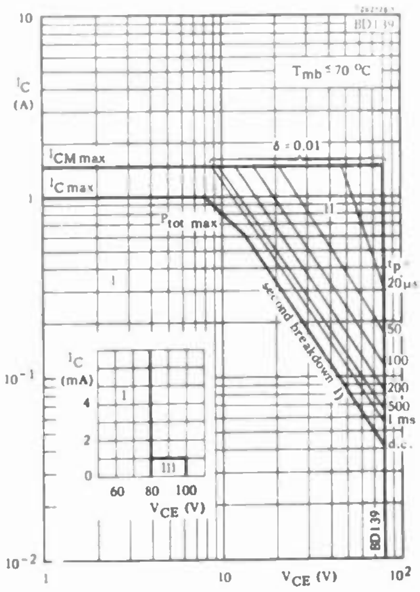




Maximum power dissipation related to case temperature.



Safe operating area for BD 135 & 137.

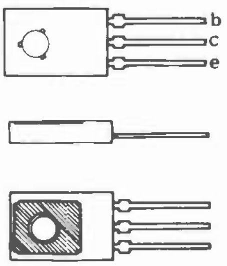


Safe operating area for BD 139.

WARNING — operation outside the areas shown for longer than the time specified can lead to transistor failure.

	Transistor Types			Connections
	BD135	BD137	BD139	1
Electrically similar (but see main text)	BD635	BD637	BD639	2

1



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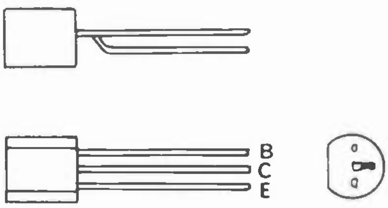

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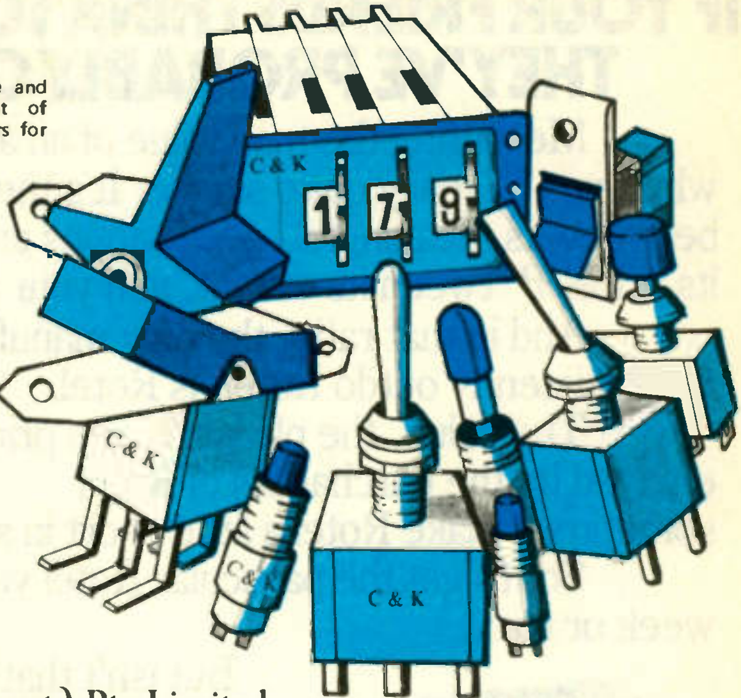

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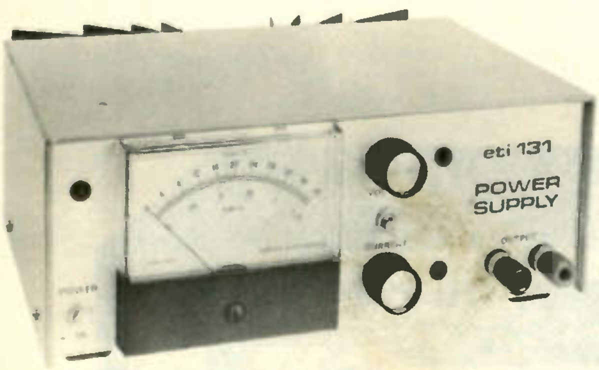
ETI 131 Power Supply



Build this superb 0-20 volt (or 40V) 0-2.5A (0-1.25A) general purpose power supply.

The ETI 131 power supply is the first kit to be made available from Nebula Electronics Pty Ltd.

The complete kit for the power supply includes all metalwork, rescaled meter, silk screened front panel and fibre-glass board screened with the component overlay.

Complete kit for ETI 131 power supply including all metalwork and rescaled meter.

$70.00 plus $5.00 P&P

*Built and fully tested**

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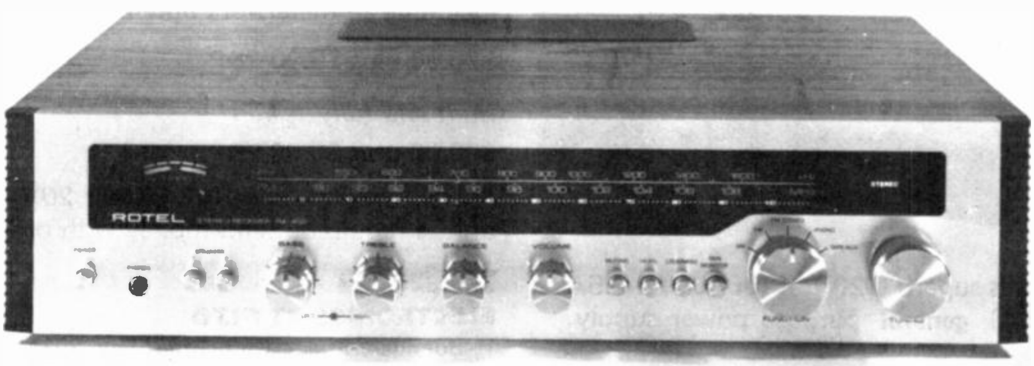
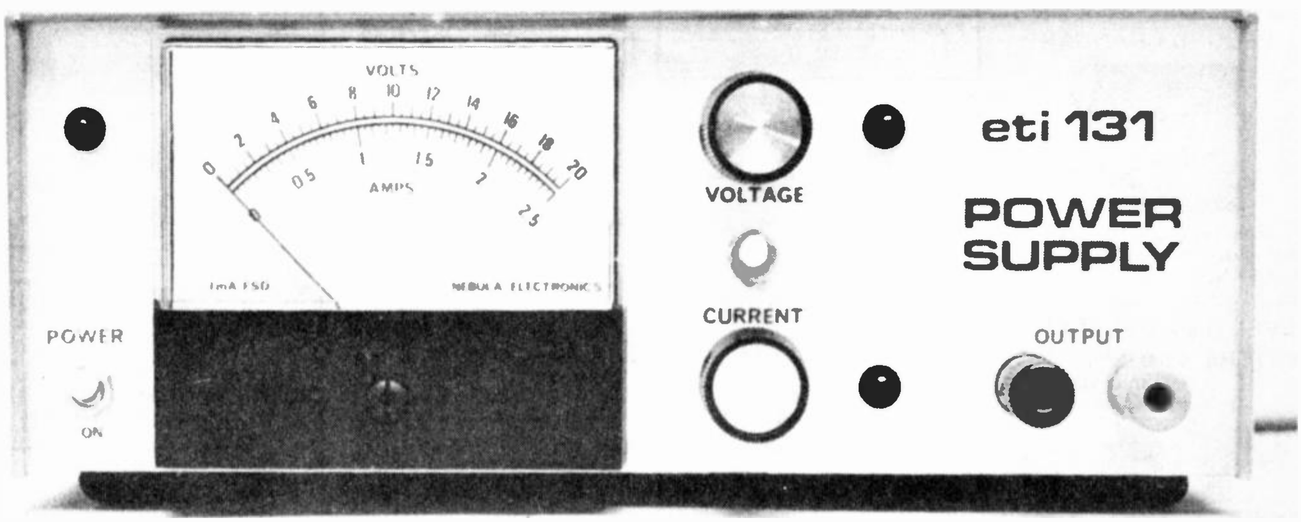


Rotel RX 402 FM/AM Receiver

General purpose power supply

This versatile general purpose supply produces up to 2.5 amps from zero to 20 volts – or up to 1.25 amps from zero to 40 volts. Current limiting is adjustable over the entire range for either output option.



SPECIFICATION – ETI 131

20 VOLT VERSION	
VOLTAGE	
Output	0–20 volts
Regulation	< 20 mV (0–2.5A)
Ripple and noise	< 1 mV at 2.5A
CURRENT	
Output	0–2.5A (up to 18 V) 0–2.0A (up to 20 V)
Limit	0–2.5A
Regulation	< 10 mA (0–20 V)
40 VOLT VERSION	
VOLTAGE	
Output	0–40 V
Regulation	< 20 mV (0–1.25A)
Ripple and noise	< 1.5 mV at 1.25A
CURRENT	
Output	0–1.25A
Limit	0–1.25A
Regulation	< 10 mA (0–40 V)

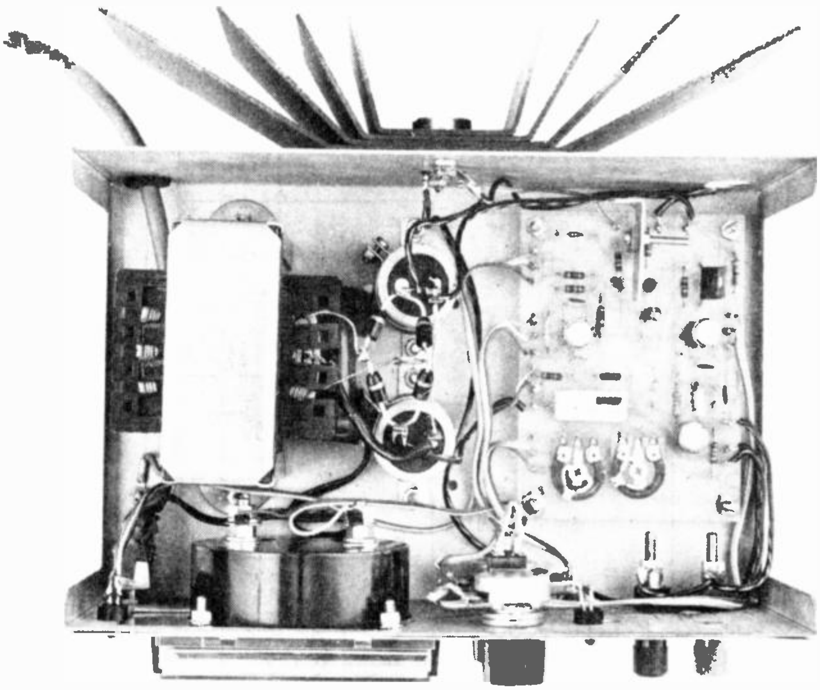
In both versions LEDs indicate voltage or current modes and the meter is switchable to read voltage or current.

AN IDEAL POWER SOURCE should supply a voltage which is adjustable over a wide range, and which remains at the set voltage regardless of line voltage or load variations. The supply should also be undamaged by a short circuit across its output and be capable of limiting the load current so that devices are not destroyed by fault conditions.

Two such supplies have previously been described in ETI. The first was a simple supply providing 0 to 15 volts at up to 750 mA. The second was a dual tracking supply providing ± 20 volts at up to one ampere. Both these supplies have been extremely popular, especially the simple one, and are still being built by many people. However there have been many requests for a supply having a greater output current capability than either of these previous designs could provide.

This project describes a supply that will provide 2.5 amperes at up to 18 volts (up to 2C volts at lower currents).

Alternately a few simple changes can make the supply provide up to 40 volts at 1.25 amperes. The supply voltage is settable between zero and the maximum available, and current limiting is also adjustable over the full range. The mode of operation of the supply is indicated by two LEDs. The one beside the voltage control knob indicates when the unit is in normal voltage-regulation mode and the one beside the current limit control indicates when the unit is in current-limit mode. In addition a large meter indicates the current or voltage output as selected by a switch.



Inside view of the completed 40 volt power supply. Note how the heatsink is mounted to the rear of the unit.

DESIGN FEATURES.

During our initial design stages we looked at various types of regulator and the advantages and disadvantages of each in order to choose the one which would give the best cost-effective performance. The respective methods and their characteristics may be summarized as follows.

The shunt regulator. This design is suitable mainly for low-power supplies — up to 10 to 15 watts. It has good regulation and is inherently short-circuit proof but dissipates the full amount of power it is capable of handling under no-load conditions.

The series regulator. This regulator is suitable for medium-power supplies up to about 50 watts. It can and is used for higher power supplies, but heat dissipation can be a problem especially at very high current with low output voltages. Regulation is good, there is little output noise and the cost is relatively low.

SCR regulator. Suitable for medium to high power applications, this regulator has low power dissipation, but the output ripple and response time are not as good as those of a series regulator.

SCR preregulator and series regulator. The best characteristics of the SCR and series regulators are combined with this type of supply which is used for medium to high-power applications. An SCR pre-regulator is used to obtain a roughly regulated supply about five volts higher than required, followed by a suitable series regulator. This minimizes power loss in the series regulator. It is however more expensive to build.

Switching regulator. Also used for medium to high-power applications, this method gives reasonable regulation and low power dissipation in the regulator but is expensive to build and has a high frequency ripple on the output.

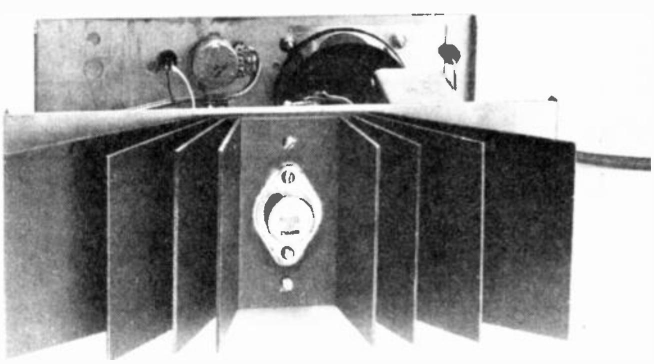
Switched-mode power supply.

The most efficient method of all, this regulator rectifies the mains to run an inverter at 20 kHz or more. To reduce or increase the voltage an inexpensive ferrite transformer is used, the output of which is rectified and filtered to obtain the desired supply. Line regulation is good but it has the disadvantage that it cannot easily be used as a variable supply as it is only adjustable over a very small range.

OUR OWN DESIGN

Our original design concept was for a supply of up to 20 volts at 5 to 10 amps output. However, in the light of the types of regulator available, and the costs, it was decided to limit the current to about 2.5 amps. This allowed us to use a series regulator — the most cost-effective design. Good regulation was required, together with variable-current limit, and it was also specified that the supply would be useable down to virtually zero volts. To obtain the last requirement a negative supply rail or a comparator that will operate with its inputs at zero volts is required.

Rather than use a negative supply



Rear view of the heatsink showing how it and the transistor are mounted.

General purpose power supply

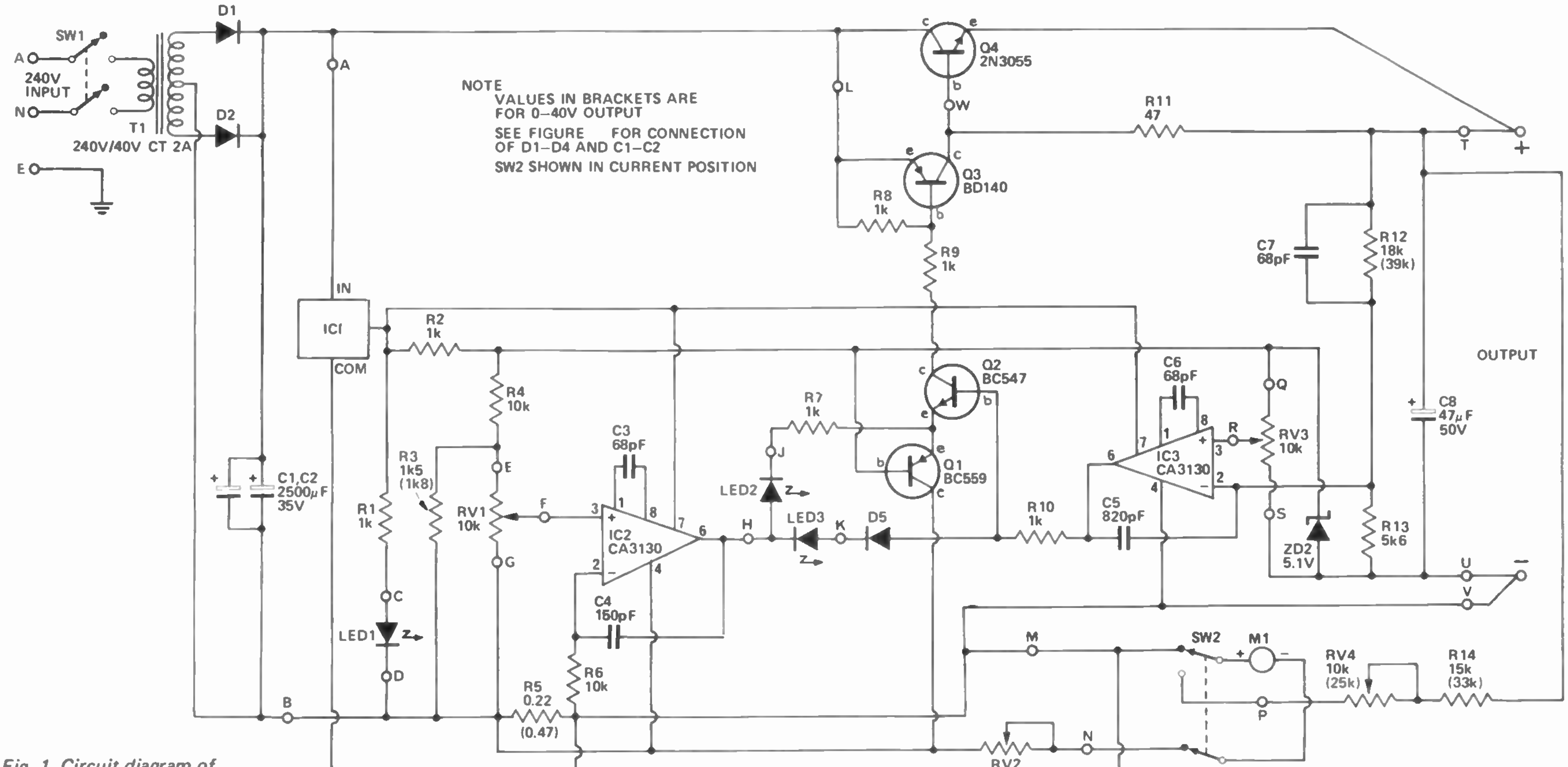


Fig. 1. Circuit diagram of the complete power supply 20 volt 2.5 ampere version.

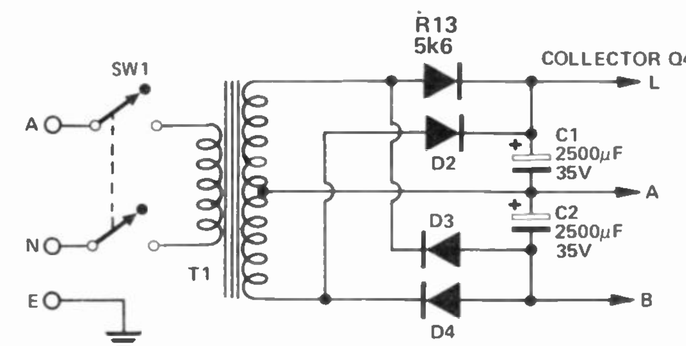


Fig. 2. Alternative rectifier and filter capacitor connections required for 40 volt, 1.25 ampere version.

HOW IT WORKS – ETI 131.

The 240 volt mains is reduced to 40 Vac by the transformer and, depending on which supply is being built, rectified to either 25 or 50 Vdc. This voltage is only nominal as the actual voltage will vary between 29 volts (58 volts) on no-load to 21 volts (42 volts) at full load. The same filter capacitors are used in either case. They are connected in parallel for the 25 volt version (5000 μF) and in series for the 50 volt version (1250μF). In the 50 volt version the centre tap of the transformer is connected to the centre tap of the capacitors thus ensuring correct voltage sharing between the capacitors. This arrangement also provides a 25 volt supply for the regulator IC.

The voltage regulator is basically a series type where the impedance of the series transistor is controlled in such a way that the voltage across the load is maintained constant at the preset value. The transistor Q4 dissipates a lot of power especially at low output voltages and high current and is therefore mounted on the heatsink on the rear of the unit. Transistor Q3 adds current gain to Q4, the combination acting as a high-power, high-gain, PNP transistor.

The 25 volts is reduced to 12 volts by the integrated-circuit regulator IC1. This voltage is used as the supply voltage for the CA3130 ICs and is further reduced to 5.1 volts by zener diode ZD1 for use as the reference voltage. The voltage regulation is performed by IC3 which compares the voltage as selected by RV3 (0 to 5.1 volts) with the output voltage as divided by R14 and R15. The divider gives a division of 4.2 (0 to 21 volts) or eight (0 to 40 volts). However at the high end the available voltage is limited by the fact that the regulator loses control at high current as the voltage across the filter capacitor approaches the output voltage and some 100 Hz ripple will also be present. The output of IC3 controls transistor Q2 which in turn controls the output transistor such that the output voltage remains constant regardless of line and load variations. The 5.1 volt reference is supplied to the emitter of Q2 via Q1. This transistor is in effect a buffer stage to prevent the 5.1 volt line from being loaded.

Current control is performed by IC2 which compares the voltage selected by RV1 (0 to 0.55 volts) with the voltage generated across R7 by the load current. If say 0.25 volts is set on RV1 and the current drawn from the supply is low, the output of IC2 will be near 12 volts.

This causes LED 2 to be illuminated as the emitter of Q1 is at 5.7 volts. This LED therefore indicates that the supply is operating in the voltage-regulator mode. If however the current drawn is increased such that the voltage across R7 is just above 0.25 volts (in our example) the output of IC2 will fall. When the output of IC2 falls below about 4 volts Q2 starts to turn off via LED 3 and D5.

The effect of this is to reduce the output voltage so that the voltage across R7 cannot rise further. When this happens the voltage comparator IC3 tries to correct for the condition and its output rises to 12 volts. IC2 then takes more current to compensate and this current causes LED 3 to light, indicating that the supply is operating in the current-limit mode.

To ensure accurate regulation the voltage sensing leads are taken to the output terminals separately from those carrying the load current.

The meter has a one milliamp movement and measures the output voltage (directly across the output terminals) or current (by measuring the voltage across R7) as selected by the front panel switch SW2.

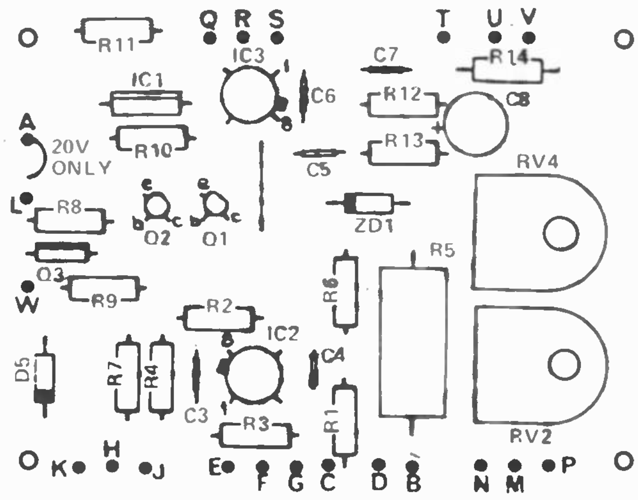
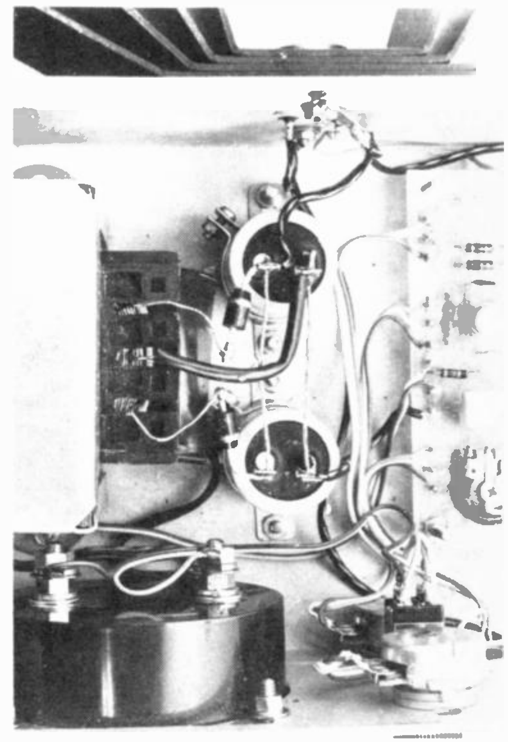
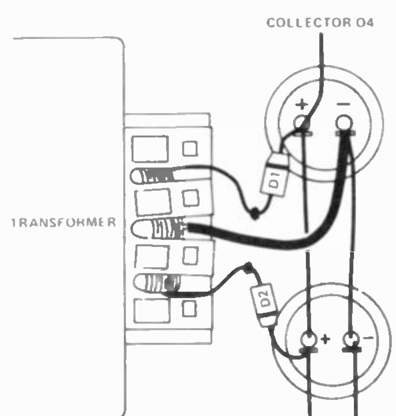


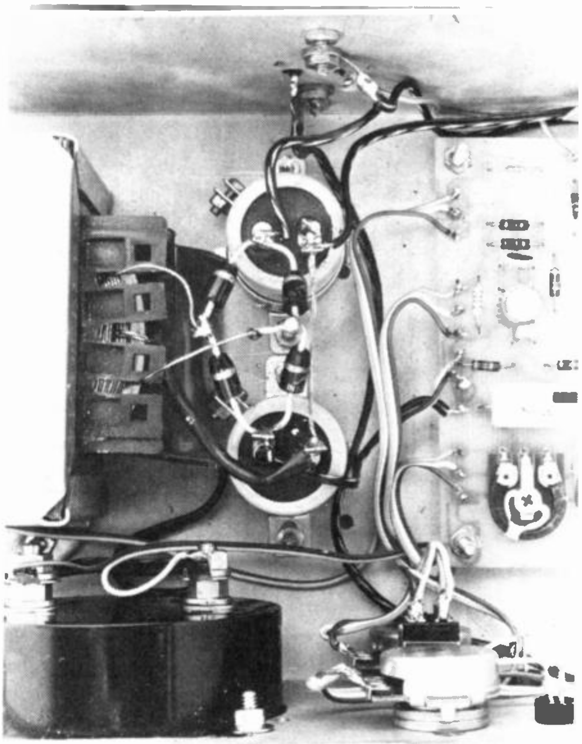
Fig. 3. Component overlay for the printed-circuit board assembly.

Fig. 4. How the supply is wired for the 20 volt 2.5 ampere version.





General purpose power supply



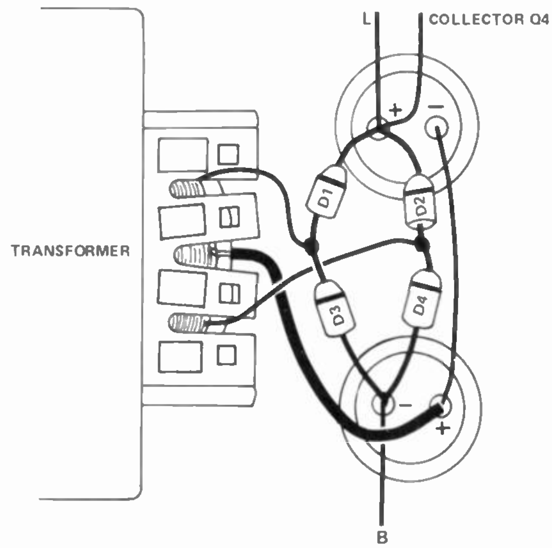


Fig. 5. How the supply is wired for the 40 volt 1.25 ampere version.

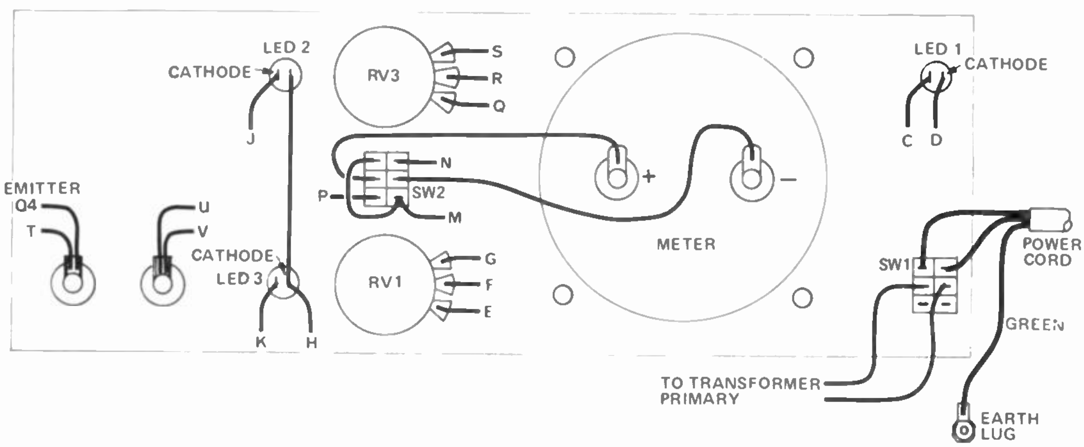


Fig. 6. Front panel wiring diagram.

rail we chose to use a CA3130 IC operational amplifier as the comparator. The CA3130 requires a single supply (maximum of 15 volts) and, initially, we used a resistor and 12 volt zener to derive a 12 volt supply. The reference voltage was then derived from this zener supply by another resistor and a 5 volt zener. It was felt that this would have given sufficient regulation for the reference voltage but in practice the output from the rectifier was found to vary from 21 to 29 volts and some of the ripple and voltage change that occurred across the 12 volt zener, as a consequence, was reflected into the 5 volt zener reference. For this reason the 12 volt zener was replaced by an IC regulator which cured the problem.

With all series regulators the series-output transistor by the nature of the design, must dissipate a lot of power especially at low output voltage and high current. For this reason an adequate heatsink is an essential part of the design. Commercial heatsinks are very expensive and sometimes difficult to mount. We therefore designed our own heatsink which was not only cheaper but worked better than the commercial version we had been considering — being easier to mount. However at full load the heatsink still runs hot as does the transformer, and under high-current low-voltage conditions the transistor may even be too hot to touch. This is quite normal as the transistor under these conditions is still operating within its specified temperature range.

With any highly regulated supply, stability can be a problem. For this reason in the voltage-regulation mode of operation, capacitors C5 and C7 are incorporated to reduce the loop gain at high frequencies and thus prevent the supply from oscillating. The value of C5 has been chosen for best compromise between stability and response time. If the value of C5 is too low the speed of response is greater — but there is a higher chance of instability. If too high the response time is unduly increased.

In the current-limit mode the same function is performed by C4 and the same remarks apply as for the voltage case.

As the supply is capable of fairly high current output there is inevitably some voltage drop across the wiring to the output terminals. This is overcome by sensing the voltage at the output terminals via a separate pair of leads.

Whilst the supply was primarily designed for 20 volts at 2.5 amps it was suggested that the same supply could be used to supply 40 volts at 1.25 amps and that this would be of more value to some users. This may be done by changing the configuration of the rectifier and by changing a few components. Some thought was given to making the supply switchable but the extra complication and expense were such that it was not considered to be worthwhile. Thus you should simply decide which configuration suits your need and build the supply accordingly.

The maximum regulated voltage available is limited either by the input voltage to the regulator being too low (at over 18 volts and 2.5 amps) or by the ratio of R14/R15 and by the value of the reference voltage.

$$(\text{Output} = \frac{R14 + R15}{R15} \text{ V ref})$$

Due to the tolerance of ZD1 the full 20 volts (or 40 volts) may not be obtainable. If this is found to be the case R14 should be increased to the next preferred value.

Single turn potentiometers have been specified for the voltage and current controls because they are inexpensive. However if precise setability of voltage or current limit is required ten-turn potentiometers should be used instead.

CONSTRUCTION

The recommended printed-circuit board layout should be used as construction is thereby greatly simplified. Printed-circuit board pins should also be used for the 20 wire connections to the board. These should be installed first. The rest of the components may now be assembled onto the board making sure that the polarities of diodes, transistors, ICs and electrolytics are correct. The BD140 (Q3) should be mounted such that the side with the metal surface faces towards IC1. A small heatsink should be bolted onto the transistor as shown in the photograph.

If the metalwork as described is used the following assembly order should be used.

a) Mate the front panel to the front of the chassis and secure them together by installing the meter.

b) Fit the output terminals, potentiometers and meter switch on to the front panel.

c) The cathodes of the LEDs (that we used) were marked by a notch in the body which could not be seen when the LEDs were mounted onto the front panel. If this is the case with yours, cut the cathode leads a little shorter to identify them and then mount the LEDs into position.

d) Solder lengths of wire (about 180 mm long) to the 240 volt terminals of the transformer, insulate the terminals with tape and then mount the transformer into position in the chassis.

f) Install the power cord and the cord retaining clip, wire the power switch, insulate the terminals and then mount the switch onto the front panel.

g) Assemble the heatsink and screw it onto the rear of the chassis via two bolts — then mount the power transister using insulation washers and silicon grease.

h) Mount the assembled printed-circuit board to the chassis using 10 mm spacers.

i) Wire the transformer secondary, rectifier diodes and filter capacitors. The diode leads are stiff enough not to need any additional support.

j) The wiring between the board and the switches may now be made by connecting points with corresponding letters on the front panel diagram and component overlay diagrams.

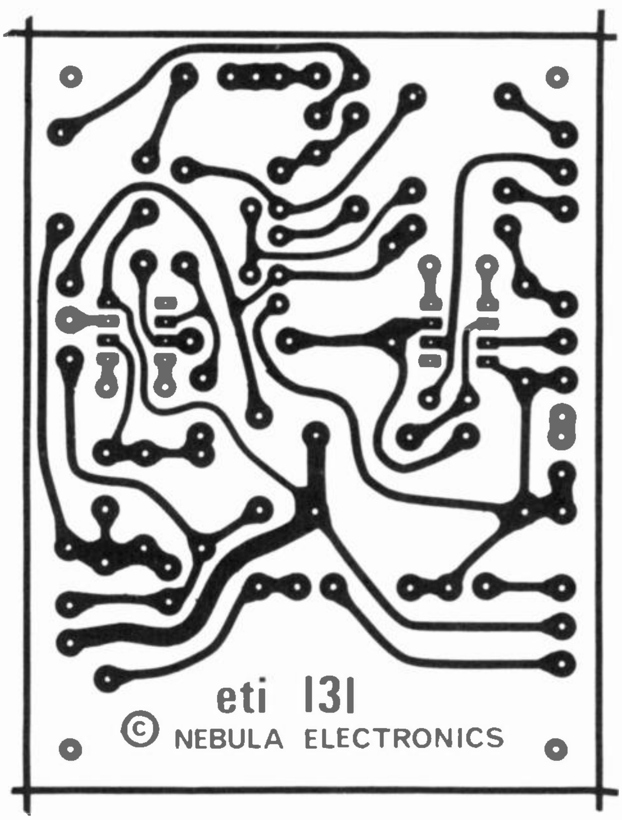


Fig. 7. Printed-circuit board layout for the power supply. Full size 100 x 75 mm.

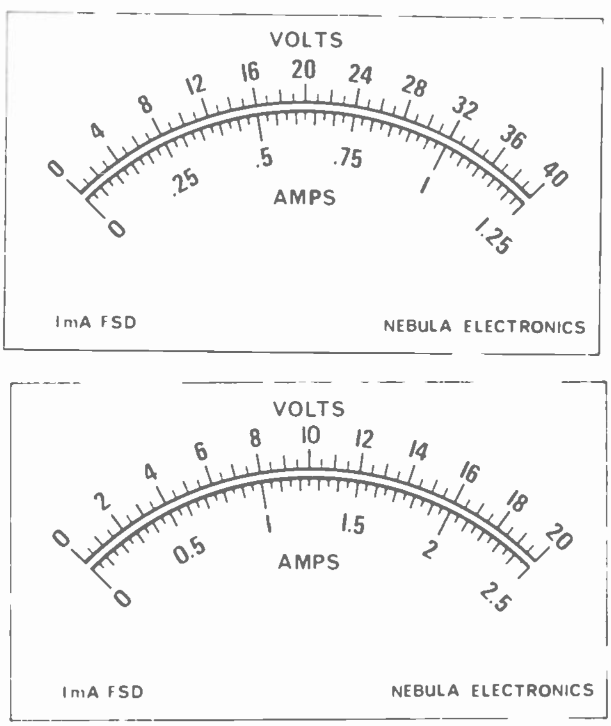


Fig. 8. Scales for the alternative meters for the unit shown full size.

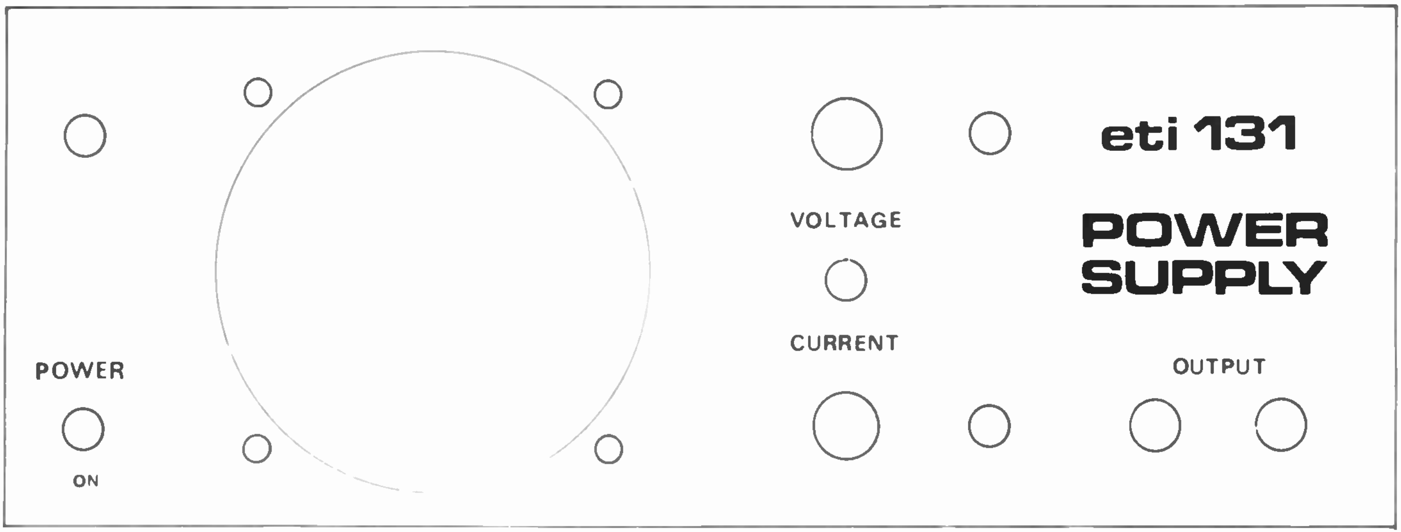


Fig. 9. Artwork for the front panel. Full size 224 x 82 mm.

The only setting up required is to calibrate the meter. Connect an accurate voltmeter to the output terminals and wind up the voltage control of the power supply until the external meter reads 15 volts (or 30 volts on the alternate arrangement). Switch the internal meter to read volts and adjust RV4 to obtain the same reading.

To set up the current reading first wind the supply voltage down to zero and connect an accurate ammeter across the output. Wind up the voltage control and observe that the current limit LED is on. Now adjust the current limit control so that the external meter indicates two amps (or one amp on the alternative unit). Now adjust RV2 so that the same reading is obtained on the internal meter when it is switched to the current position.

Complete kits of components for this project can be obtained from Nebula Electronics Pty Ltd, 4th Floor, 15 Boundary St, Rushcutters Bay — telephone 335850 — see advertisement on page 71 of this issue.

PARTS LIST — ETI 131A

Resistors

R1	—	1 k	½ W	5%
R2	—	1 k	"	"
R3	—	1 k5	"	"
R4	—	10 k	"	"
R5	—	0.22 ohm 5 W		
R6	—	10 k	½ W	5%
R7	—	1 k	"	"
R8	—	1 k	"	"
R9	—	1 k	"	"
R10	—	1 k	"	"
R11	—	47	"	"
R12	—	18 k	"	"
R13	—	5 k6	"	"
R14	—	15 k	"	"

Potentiometers

RV1	—	10 k lin rotary
RV2	—	1 k trim
RV3	—	10 k lin rotary
RV4	—	10 k trim

Capacitors

C1	—	2500 µF 35V electro
C2	—	2500 µF 35V electro
C3	—	68 pF ceramic
C4	—	150 pF "
C5	—	820 pF "
C6	—	68 pF "
C7	—	68 pF "
C8	—	47 µF 50V electro

Transistors

Q1	—	BC559
Q2	—	BC547
Q3	—	BD140
Q4	—	2N3055 (with insulation kit)

Diodes

D1,2	—	IN5404
D5	—	IN914

Other Semiconductors

ZD1	Zener Diode	5.1V 400 mW
LED 1,2	LED	5023 or similar
IC1	Integrated Circuit	LM341P-12
IC2,3	" "	CA3130

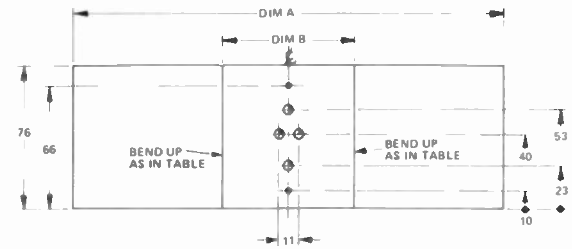
Miscellaneous

PC board ETI 131
Transformer 40V CT 2A A&R 5755
SW1,2 switch DPDT toggle
Meter 1 mA FSD scaled 0-20V, 0-2.5A
Chassis to Fig. 11
Cover to Fig. 13
Heatsink to Fig. 10
Front panel to Fig. 9
Two terminals
Power cord & clamp
Two knobs
Four 10 mm long spacers
20 PC board pins
Four rubber feet
nuts, bolts, washers etc.

PARTS LIST — ETI 131B

All parts for ETI 131A except

Change	R3	to	1 k8
	R5	to	0.47 ohm
	R12	to	39 k
	R14	to	33 k
	RV4	to	25 k



○ 2 HOLES 3.2mm DIA

◑ 4 HOLES 5mm DIA

MATERIAL 1.6mm ALUM BLACK ANODISED

ALL DIMENSIONS IN MILLIMETRES

	DIM A	DIM B	ANGLE
ITEM 1	110	40	75°
ITEM 2	130	50	60°
ITEM 3	170	60	45°
ITEM 4	230	70	30°

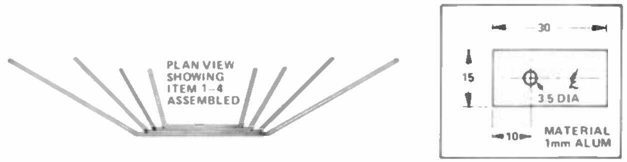


Fig. 10. Heatsink detail.

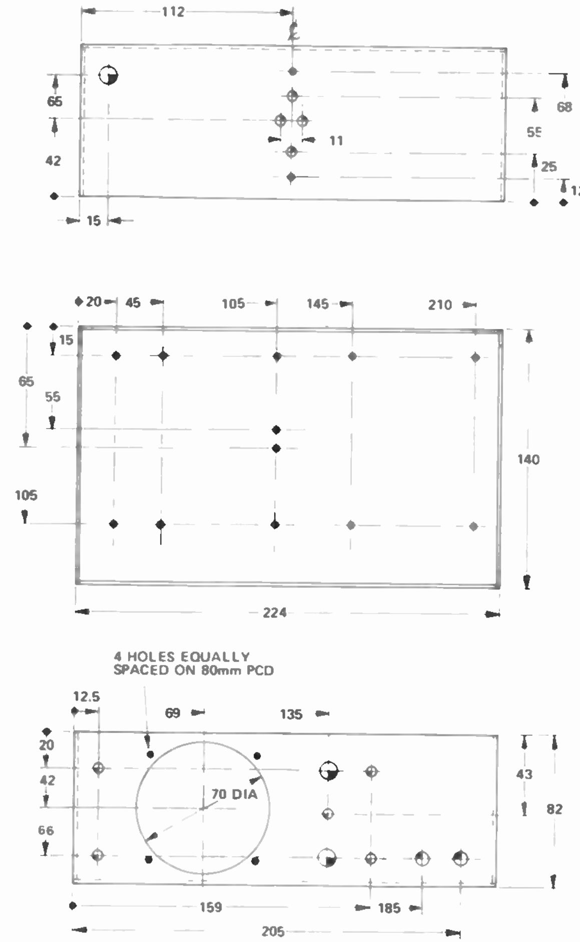


Fig. 11. Chassis metalwork.

○ 6 HOLES 3.2mm DIA

● 12 HOLES 4mm DIA

◑ 4 HOLES 5mm DIA

5 HOLES 6.4mm DIA

2 HOLES 8mm DIA

3 HOLES 10mm DIA

ALL DIMENSIONS IN MILLIMETRES

MATERIAL 1mm STEEL

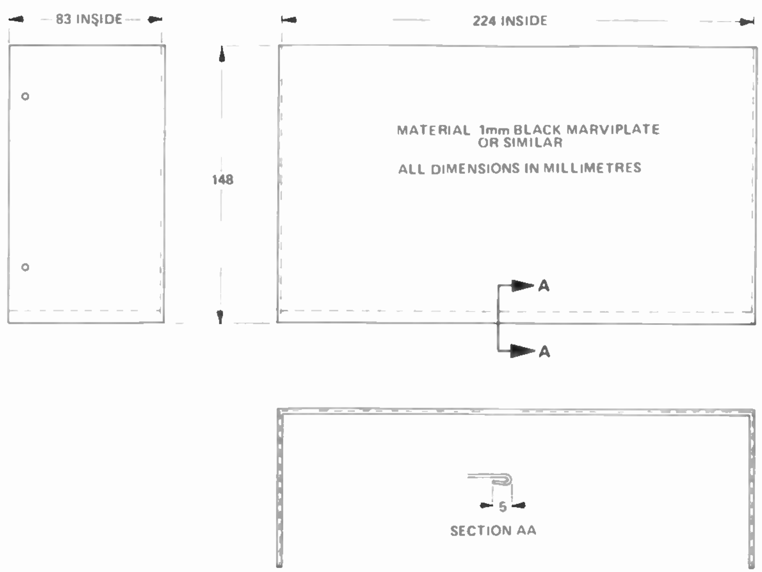


Fig. 13. Detail of metal cover.

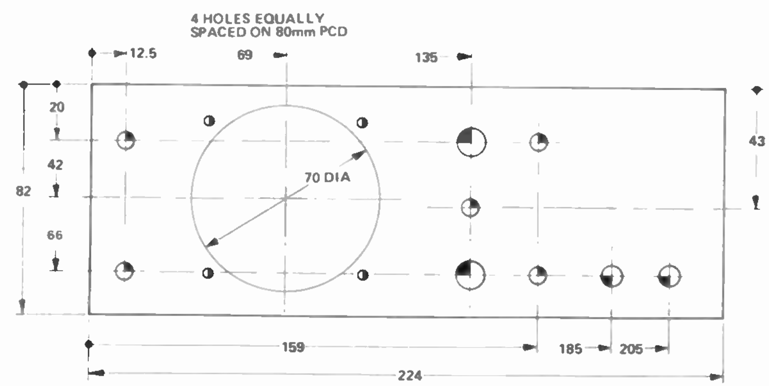


Fig. 12. Front panel drilling.

4 HOLES 4mm DIA

5 HOLES 6.4mm DIA

2 HOLES 8mm DIA

2 HOLES 10mm DIA

ALL DIMENSIONS IN MILLIMETRES

MATERIAL SATIN ANODISED ALUMINIUM SILK SCREENED.

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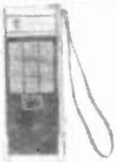

MODEL NC-310 DE LUXE 1 WATT 3 CHANNEL C.B. TRANSCEIVER

- WITH CALL SYSTEM
- EXTERNAL AERIAL CONNECTION

SPECIFICATIONS, NC-310

Transistors: 13
Channel Number: 3, 27.24 OMHz Citz. Band
Transmitter Frequency Tolerance: ±0.005%
RF Input Power: 1 Watt
Tone Call Frequency: 2000 Hz
Receiver type: Superheterodyne
Receiver Sensitivity: 0.7µV at 10 dB S/N
Selectivity: 45 dB at ±10 kHz
IF Frequency: 455 kHz
Audio Output: 500 mW to External Speaker Jack
Power Supply: 8 UM-3 (penlite battery)
Current Drain: Transmitter: 120-220mA
Receiver: 20-130mA.

$49.00 each or $95 a pair.
Post & pack $1.50 per unit.

MODEL C1000M MULTIMETER Compact, handy and versatile, the C1000M is the ideal low cost pocket meter, Mirror Scale. **Specifications:** 1,000 Ohm/Volc DC; 1,000 Ohm/Volt AC; DC volts — 10; 50; 250; 1,000; AC volts — 10; 50; 250; 1,000; DC amps — 1 mA; 100 mA; Ohms — 150 KΩ; Centre scale — 3 KΩ; Decibel — 10 dB to 22 dB; Dimensions — 3-1/2" x 2-3/8" x 1-1/8" 90 x 60 x 30 mm.

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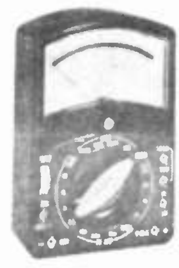

MODEL C-7077/P MULTIMETER. Specifications: 100,000 ohms/volt DC; 10,000 ohms/volt AC; DC volts — 5,5; 25; 50; 250; 500; 1,000. AC volts — 10; 50; 250; 500; 1,000. DC amps — 10µA; 2-5 mA; 25 mA; 500 mA. Ohms — 10 kΩ; 1 MΩ; 10 MΩ; 100 MΩ. Centre scale — 150Ω; 15 KΩ; 150 KΩ; 1-5 MΩ. Decibel — —20 to +22 dB. Dimensions — 151 x 102 x 48 mm Diode protected movement. Carrying case available Model C.

$27.95
P&P $1.50.

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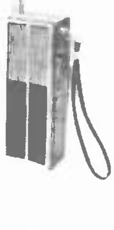
1. AM 535 to 1600 kHz, 2. Marine 1-5 to 4 MHz, 3 & 4. combined SW 4 to 12 MHz, 5. 30 to 50 MHz, 6. 88 to 108 MHz, 7, 8 & 9 combined VHF Aircraft 145 MHz-174 MHz Incorporating weather band.
Slider controls, Dial light, Fine tuning control, Flip-up Time Zone map, Telescope antennas complete with batteries

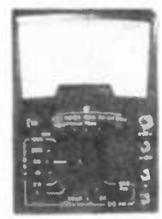
SPECIAL PRICE **$59** Post Pack $3.50



1 watt 2 channel transceiver with call system. 27.240 MHz. 12 transistor. PMG approved type.

SPECIFICATIONS: Transmitter — Crystal Controlled: 1 Watt input power to RF stage. Operating frequency — Any 2 channels in the 11-meter Citizens Band. Receiver — Crystal-controlled superheterodyne circuit with 455 Kc IF. Antenna — Built-in 60" telescopic whip antenna. Audio Output — 0.8 Watt maximum. Power supply required — 12 volts DC (Eight 1.5 volt DC battery cells). Loudspeaker — 2¼" PM type (built-in) function as microphone on transmit.

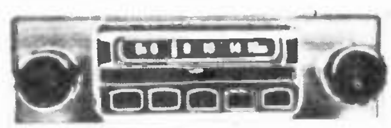
$45.50 each or $89 a pair.
Post & pack $1.50 each unit.



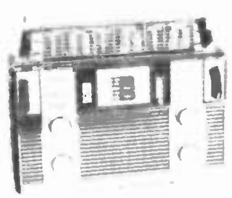
MODEL OL64 D/P MULTIMETER. Very ruggedly constructed this model is particularly suitable for workshops. It features special scales for measurement of capacitance and inductance. Diode protested movement: **Specifications:** 20,000 Ohm/Volt DC. 8,000 Ohm/Volt AC. DC volts — 0.25; 1; 2.5V; 10; 50; 250; 1,000; 5.000. AC volts — 10; 50; 250; 1,000. DC amps: 50µA; 1 mA; 50 mA; 500 mA; 10 A. Ohms — 4 KΩ; 400 KΩ; 4 MΩ; 40 MΩ. Centre scale — 40Ω; 4,000Ω; 40,000Ω; 400,000Ω. Decibel: —20 to +62 dB, Dimensions: 6" x 4-1/5" x 2"; 152 x 107 x 51 mm. Capacitance: 250 pF to 0.02 uF. Inductance — 0/5000H Carrying case available Model C.

$24.90 P&P $1.50.

8 transistor, push-button car radio. 12 volt neg or pos earth switching. With large 7 x 5 inch speaker and lock down aerial.



$39.95 P&P $2.50



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a truly portable communications receiver, based on the WADLEY LOOP principle, the same principle as applied in the DELTAHET and RACAL receivers. A truly crystal-controlled highly sensitive multiple-heterodyne portable receiver of exceptional stability with continuous, uninterrupted coverage from 500 kHz to 31MHz.
BARLOW-WADLEY XCR-30 features include: Selectable USB/LSB, CW & AM reception, frequency read-out 10kHz throughout the entire range, calibration accuracy within 5kHz, antenna resonator, tuning signal-strength meter, zero-set control, clarifier-vernier tuning, MHz & kHz tuning controls, telescopic antenna. Power source: 6 type D dry cells: provision for external DC power supply. Weight 9 lbs; size 11½ x 7½ x 4in.

$239 P&P $4.50

When not in use or for carrying, the top meter/megahertz scale flips down flush with the case and clear of the handle.

MODEL AS100 D/P MULTIMETER. This meter features double zener diode meter protection and 3½" full view easy to read 2 colour scale. It is fitted with polarity reversing switch and housed in a strong moulded case with carrying handle. **Specifications:** 100,000 ohm/volt DC. 10,000 ohm/volt AC. DC volts — 0.3; 12; 60; 120; 300; 600; 1,200. AC volts — 6; 30; 120; 300; 600; 1,200V. DC amps — 2 KΩ; 200 KΩ; 20 MΩ; 200 MΩ. Centre scale — 20Ω; 2,000Ω; 20,000Ω; 200,000Ω; 20 MΩ Decibel — —20 to +57 dB. Dimensions — 7-3/5" x 5-2/5" x 2-3/5" 193 x 137 x 66 mm. Carrying case available model I.

$37.50
P&P $1.50.

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Latest military design multi-band radio, 30 transistors and diodes. With exclusive (LED) light emitting diode tuning indicator for positive station selection.
Battery and electric covers all popular AM and FM bands.

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STEREO TODAY. QUADRAPHONY TOMORROW.

BANG & OLUFSEN BEOSYSTEM 3400

Bang & Olufsen's Beosystem 3400

Bang & Olufsen have designed the new Beosystem 3400 so that you can enjoy stereophonic sound today, and quadraphonic sound whenever you're ready for it. Connect two speakers and you have a remarkable stereo system – add two more and you have an oustanding quadraphonic music system.

So, when you're ready to change from stereo to quadraphonic sound, no complicated or costly conversions are necessary.

Why a quadraphonic system when all your records are stereo?

Some of your records are possibly mono, because you couldn't get them in stereo. But you wanted them purely because of the music or artist. In the future, finding stereo records may be as difficult as finding mono today, because more and more recordings are being produced in the quadraphonic mode.

The Beosystem 3400 allows you to take advantage of the multi-dimensional reality of quadraphonic sound now and at the same time continue to enjoy your mono and stereo records.

What makes the Beosystem 3400 outstanding?

First, a combined high-fidelity FM tuner with four output amplifiers, so that you can have two sets of stereo speakers in separate rooms, or full quadraphony in one room.

The amplifier power output is 2 x 30 watts R.M.S. for stereo and 4 x 20 watts R.M.S. for four channel. And thanks to advanced electronic design with the use of "split supply" coupled Darlington transistors at the output stages, distortion is minimal. There are terminals for four loudspeakers, a two or four channel record player, a two or four channel tape recorder and a set of two or four channel headphones.

The stereo/4 channel record player is an example of totally new construction. You can select all operations by lightly touching a rectangular control panel – the rest is done automatically.

The pick-up cartridge has a titanium framed Shibata-cut diamond. This special cartridge can provide every kind of sound reproduction – mono, stereo and 4 channel – both SQ matrix and CD-4 discrete.

The new Uni-Phase loudspeakers

From Bang & Olufsen's most recently announced range of Uni-Phase loudspeakers, a pair of S45s with a power handling capacity of 45 watts R.M.S. All the units in the cabinet operate in the same phase, even in the crossover range, so that the sound from all units reaches the ear simultaneously.

Thus the new B & O Uni-Phase loudspeakers produce sound more accurately and with more reality than most commercial speakers on the market to date. The Uni-Phase S45s also take up much less space than conventional pressure chamber speakers.

With the exception of two extra speakers (which you need not buy right away), Beosystem 3400 costs no more than a comparable stereo system.

BANG & OLUFSEN

B&O 1925 1975 50 with respect for the true sound

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BO729

Booster amplifier for 2 metre band

Most mobile two metre transceivers are limited to about ten watts output. This RF power amplifier designed by Roger Harrison VK2ZTB and Phil Wait VK2ZZQ, boosts output to 45 watts.

ONE OF THE MOST POPULAR amateur activities these days is mobile operation using the FM nets between 146 MHz and 148 MHz on the two-metre band. The use of FM, particularly for mobile operation, has a number of advantages. It reduces the effects of impulse noise interference, mostly generated by the ignition system of cars and provides clear, largely noise-free communications. Fixed, commonly-agreed channels are used, making tuning of receivers and transmitters unnecessary. However, the effectiveness of a mobile transceiver is affected by terrain, large buildings and other structures. These both reflect and absorb signals causing the commonly experienced 'mobile flutter' which is noticeable on all but the strongest of signals. The terrain and the necessity of having a relatively small antenna system with little or no gain limits the range one can achieve.

Most of these problems have been largely overcome by the installation of open-access repeaters which receive a transmission on one channel and re-transmit (hence, repeat) it on another channel. These repeaters are located in a high well-sited area so as to obtain wide coverage of a desired area.

The range of any mobile installation, and likewise the coverage of repeaters, is largely limited by the mobile's transmitter output power. Most mobile transceivers in use, such as those made by Icom, Yaesu, Trio etc, and many base station transceivers, produce about 10 watts power output. The sensitivity of the receivers in most of these commercially produced transceivers leaves little to be desired, and, as a consequence, output power and receiver sensitivity are not 'matched'. That is to say, one can often hear a higher power station, or a repeater, for a much greater distance than they can copy your transmitter. Not what you'd call an ideal situation.

The way to remedy this state of affairs is to add an RF power amplifier after the transmitter to boost the power output to a more suitable level. One thus gains more range and more 'solid' communications with less mobile flutter. More power for base station or home-station use is also an advantage. The normal ground-wave coverage is increased.

The next question is: 'What is a suitable power level'? This is largely determined by two things: the power supply and the pocket. Obviously, for a mobile installation, the power supply is a twelve volt battery. It is possible to run powers of 100 watts or more (witness the number of FT101's in mobile installations) but that sort of power really requires alteration of the alternator-regulator system in the car to cope with the increased battery drain. Running 150 watts DC input mobile on two metres is certainly possible, but that will have to be the subject of another article.

When considering the pocket, or how much a suitable power amplifier would cost, a good rule of thumb is 'less than a dollar per watt'. Thus, one needs to consider a single transistor. This must

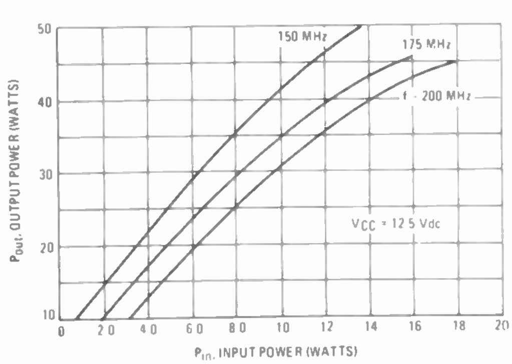


Fig. 1. Power output Vs power input for 2N6084.

fo = 175 MHz, Vcc = 12.5 VOLTS			
P_{IN} WATTS	P_{OUT} WATTS	INPUT OHMS	OUTPUT OHMS
4	21.7	0.8 – j 1.1	2.2 – j 0.3
8	37.1	0.8 – j 1.3	1.7 – j 0.5
10	40	0.8 – j 1.45	1.65 – j 0.4
12	46.5	0.8 – j 1.6	1.6 – j 0.3

Fig. 1(b). Input and output impedances vs power for 2N6084.

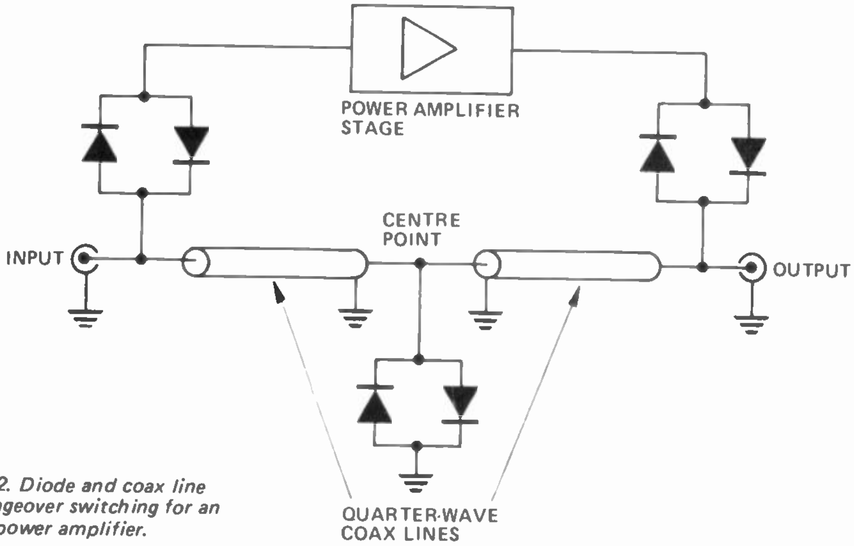
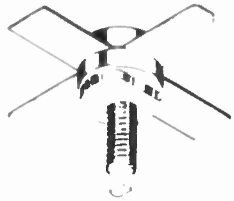


Fig. 2. Diode and coax line changeover switching for an RF power amplifier.



Physical construction of 2N6084

have adequate gain and be able to accept an input power in the range of 8 to 12 watts. There are a number of suitable transistors that commence at this level and will produce output powers in the range of 25 to 50 watts or more from a power supply rail of 12 V. Those transistors producing output powers over 50 watts from the 10 to 12 watt level become more expensive on a dollar-per-watt basis than those transistors producing output powers below 50 watts. The higher power transistors require a substantially larger heatsink also — increasing size and cost considerations. As most of the popularly used commercial transceivers — and many homebrew ones, are quite small physically, the size of the power amplifier is also a consideration.

Apart from cost, *availability* of suitable transistors and other components is a necessary consideration. The 2N6084 transistor fits all our requirements very well. The data sheet on this transistor indicates a power output of between 37 watts and 46.5 watts at 175 MHz for a power input of between 8 watts and 12 watts at a supply voltage of 12.6 volts. The manufacturers claim that the transistor will withstand severe mismatch under operating conditions. A graph of power output versus power input (i.e: drive power) is given in Fig 1 — along with a table of typical performance and base input — collector output impedances.

Having chosen the device, an appropriate circuit, suitable for a kit or simple home construction was necessary. The current ARRL VHF Handbook describes a circuit that works very well, but has a number of drawbacks. Local availability of some of the components in particular. It was also felt that the design could be simplified with a consequent reduction in components and cost. Another drawback was the problem of an antenna changeover relay. To cope with this level of power and have adequate isolation between the transmitter output and receiver input contacts a coaxial changeover relay is necessary. These items are not on everybody's shelf and generally cost in excess of $20 over the counter. Very off-putting.

DIODE AND COAXIAL LINE SWITCHING

Quarter wave coaxial lines and diodes are now being successfully used for this purpose however — and several articles describing the technique have recently been published in amateur radio publications. The method is simple, cheap and very effective. The circuit is shown in Fig 2 and works as follows:

During the receive condition, all the diodes are non-conducting and thus present a high resistance to the signal coming from the antenna. Thus, no signal is dissipated in the amplifier input or output circuits. The two diodes from the centre point present a high impedance across the coax line and thus have no effect on incoming signals from the antenna. Thus the signals travel through the two quarter-wave coax lines to the antenna input of the receiver without loss. When the transmitter is operated, all diodes conduct. The diodes at the centre point of the two quarter-wave lines will conduct and since a quarter-wave line shorted at one end presents an open circuit at the other end, each quarter wave line will present a high

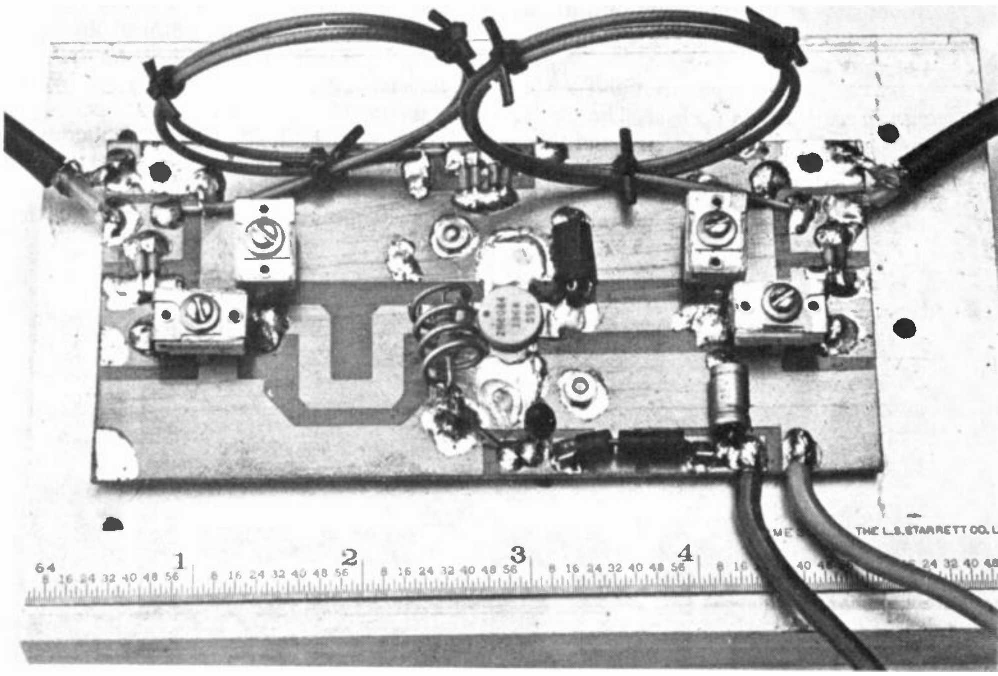


Fig. 4. The 45/W, two metre RF power amplifier. The 2N6084 transistor is visible in the centre of the p.c. board. The mica compression trimmers located on the right hand side are for tuning the input, those on the left for tuning the output. The printed inductances are readily visible. The two quarter wave coax lines are visible at the top. They may be coiled up as shown or conveniently arranged in some other way. Note that the components are soldered on the copper side of the printed circuit board.

Booster amplifier for 2 metre band

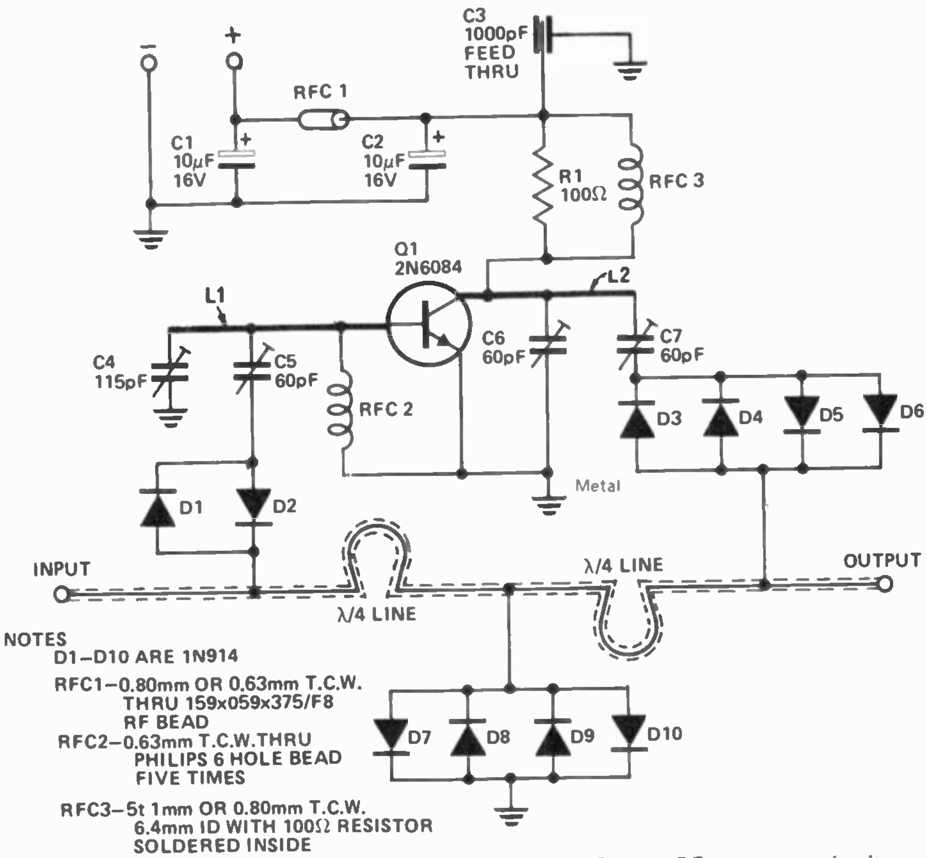


Fig. 3. 45 W 2 metre RF power amp circuit.

impedance at the input and output terminals respectively. The diodes between the input terminal and the power amplifier stage input will conduct and pass the driving power. The diodes between the power amplifier and the output terminal will likewise conduct, passing the output of the amplifier to the output terminal. The output power cannot return to the input as the two diodes from the centre point of the coax lines will conduct, shorting the quarter-wave line and presenting a high impedance at the output terminal. Happily, the impedance of the quarter-wave coax lines is immaterial and anything suitable may be used. However, their lengths must be an accurate quarter wavelength electrically taking into account the velocity factor of the cable. In developing this project, some trouble was experienced in this respect – so make sure you have the right length.

It appears that the velocity factor of ordinary, run-of-the-mill, garden variety RG58/U coax, obtainable from most suppliers varies considerably in its velocity factor, even over relatively short lengths. You can use this type of coax but a lot of pruning and tuning will be required. If a cable manufactured to tighter tolerances in velocity factor is used, this problem disappears. It is suggested that cables such as RG59B/U (or C/U) or RG223/U, which are nominally 5 mm diameter be used. Alternatively, a 2.5 mm diameter cable such as RG174/U may be used. All these cables have a velocity factor of 0.665 and have been found to be consistent in practice. They must, however, be accurately cut to the lengths specified, as detailed later.

Some trouble was also experienced with a commonly available 2.5 mm diameter cable of unknown type number, so be wary.

THE POWER AMPLIFIER CIRCUIT

The circuit is illustrated in Fig 3. Inductances L1 and L2 are actually rectangular, 5.5 mm wide strips, on the printed circuit board. They are not microstripline sections which would, require a double-sided printed circuit board), single-sided p.c. board is used in this project.

Tuning capacitors, C4,C5,C6,C7 are all mica compression trimmers mounted on a ceramic base and are readily seen in Fig 4 (page 87).

The dc return for the transistor base circuit is via an RF choke, RFC2, visible just to the right of the transistor in Fig 4. This consists of a number of turns of tinned or enamelled copper wire passed through the holes of a six-hole ferrite bead. This makes a low resistance, high inductance RF choke. Some published circuits specify the use of a low value resistor, or two resistors in parallel, in place of an RF choke in this part of the circuit. However, this is not recommended as the available power output is considerably reduced.

The transistor collector is shunt fed from the supply via RFC3. This is simply five turns of tinned or enamelled copper wire of a suitable heavy gauge, anything between 16 B & S and 22 B & S is adequate, with a low value resistor mounted inside to dampen it and lower the Q. A resistor value between 47 ohms

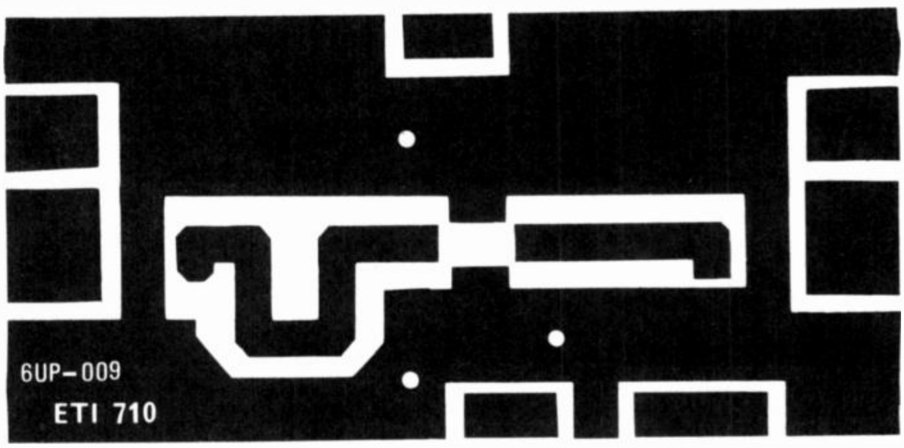


Fig. 5. Printed circuit board layout, copper side.

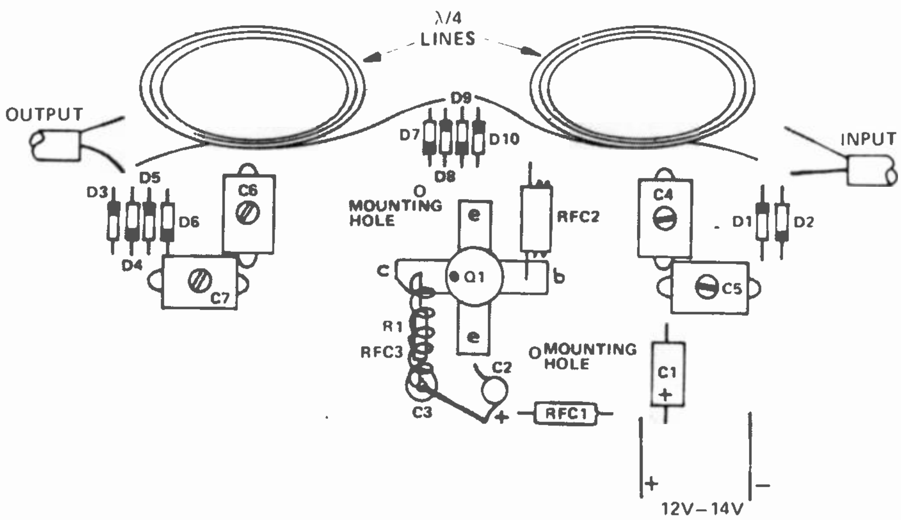


Fig. 6. Component layout.

and 180 ohms is quite satisfactory. The supply end of RFC3 is decoupled for RF by a 1000 pF feedthrough capacitor used as a standoff and tie point.

As the low frequency gain of the 2N6084 is quite high, the supply is also decoupled by several large value electrolytic capacitors, C1 and C2. The latter is a 10uF/35 V tantalum. The supply input is decoupled by C1 and RFC1. C1 is a 10 uF electrolytic. RFC1 is a 9.5 mm long F8 material ferrite bead, 4 mm in diameter, slipped over a 22 mm length of tinned copper wire. The gauge of wire is largely immaterial. Anything between 18 B & S and 22 B & S is quite satisfactory.

The diode switching requires a total of ten diodes. These may be 1N914 (1N4148) or 1N916 types, although these were found to be only barely adequate for the job. They do get quite hot to the touch after only a few minutes operation. More suitable types would be the Philips type BAX13, or even better still — BAV10. These latter ones are recommended. Despite the heating problem, no failures have been experienced with 1N914 diodes. However, if you have a predeliction for holding long 'overs', then use the recommended types for added safety. Absolute minimum lead length possible must be used when soldering them into position.

The input and output tuned circuits, consisting of L1-C4-C5 and L2-C6-C7 respectively, are designed to match the transistor base input and collector output impedances, at the required input and output power levels, to about 50 ohms. C5-C4 and C7-C6 form capacitive dividers. From the table included with Fig 1, it is obvious that the transistor impedances vary with power level. Thus the amplifier should be tuned up at the power level at which it is intended to be used. There is sufficient range in the tuning capacitors to accommodate a range of input power levels.

The 2N6084 is encased in an MT-72 stripline package, having two emitter leads. The collector lead has one corner removed — see the illustration of the package in Fig 3. The collector lead is also marked by a dot on the header as can be seen in Fig 4 & 6. The threaded stud is electrically isolated from the transistor leads. This sort of package construction reduces lead inductance and allows the stud to be bolted directly in contact with a heatsink for maximum heat transfer. The 2N6084 is manufactured by both Motorola and Solid State Scientific (SSS).

HEATSINK REQUIREMENTS

A heatsink is required to dissipate at least 45 watts of heat with a low temperature rise. As operation is of an intermittent nature, with relatively long intervals between on periods, heatsinks requirements can be relaxed somewhat. A 150 mm length of 100 mm wide heatsink having fins on one side only (fins about 25 mm deep) as can be seen in Fig 4, was found to be quite adequate. A diecast box having dimensions somewhat larger than the pc board could be used but its heat-sinking properties would be barely adequate and amplifier on times would have to be kept short. A proper heat-sink is recommended. The heatsink illustrated was obtained un-anodised. A black anodised heatsink would certainly do a better job. However, it is good practice to sand off the anodising in the immediate vicinity of the transistor stud, where it contacts the heatsinks.

POWER OUTPUT INDICATION

It is handy to be able to monitor power output, or at least have some indication of RF output. Some published RF power amplifier designs have included a stripline directional coupler (SWR indicator) on the pc board. This idea was rejected for a number of reasons. If you want to measure SWR it is best done at the antenna, not at the transmitter. All the best texts will tell you this. As an output indicating device it needs to be properly calibrated if you wish to read output power — a measurement normally carried out at rare intervals. It is also wasteful of space, and increases the cost of the project. A simple half-wave diode detector, capacitively coupled to the output connection with a very low value capacitor and a suitable meter is quite adequate. The meter may be remotely mounted.

CONSTRUCTION

The amplifier is constructed on a single-sided printed circuit board, 120 mm long by 58 mm wide, the board layout being given in Fig. 5. The component layout is illustrated in Fig. 6, and one can get a good idea of the component layout also from Fig. 4. Note that all the components are mounted on the *copper side* of the board, contrary to common practice adopted with most other circuits constructed on pc board.

If you have facilities for making your own pc board, construction should commence by first making the board. Although the board is of very simple design, it should preferably be made by one of the etching processes. Do not attempt to make the pc board by cutting away the unrequired copper. This usually results in: (a) board that looks grotty and, (b) a project that either does not work at all or does not work satisfactorily.

Boards should soon be available from suppliers if you wish to purchase one.

Commence by drilling the transistor mounting hole in the pc board using a 9.5 mm (3/8") drill. File it out slightly with a small round file so that the transistor header is a loose fit through the board. Next drill the two mounting holes, which are positioned diagonally opposite each other either side of the transistor, and the 1000 pF feedthrough capacitor mounting hole. Use a 3.2 mm (1/8") diameter drill. A clearance hole of about 4.5 mm to 5 mm diameter (3/16") will need to be drilled in the heatsink beneath the position of this capacitor.

Booster amplifier for 2 metre band

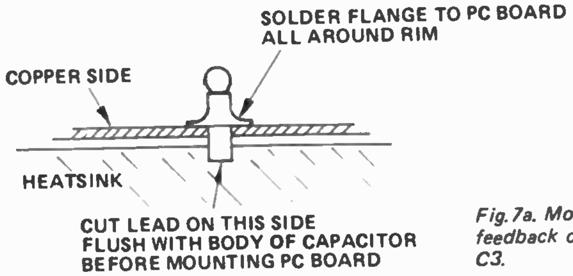


Fig. 7a. Mounting feedback capacitor C3.

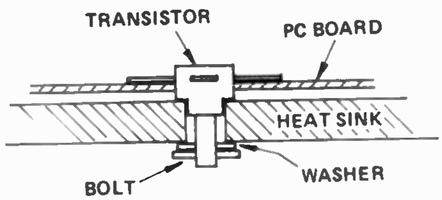


Fig. 7b. How the 2N6084 is mounted.

Now place the pc board centrally over the heatsink to be used and mark the positions of the transistor mounting hole, the feedthrough capacitor clearance hole, and the two mounting holes. Drill the heatsink using a 4.5 mm drill (3/16") as this is a good clearance size for the American 4-40 threaded stud on the 2N6084. Then drill clearance holes in the heatsink for the mounting bolts and the feedthrough capacitor.

Once the pc board and heatsink have been drilled and the hole positions checked to see that everything fits correctly without strain, the pc board may be wired.

Commence by mounting the mica compression trimmers, C4, C5, C6, C7. Refer to the layout in Fig. 6. The trimmer capacitors are constructed with large lugs, formed of the capacitor plates, that project more or less straight down from the ceramic body of the component. Carefully bend the end of each lug out at right angles before soldering the capacitor in place. Use a hot soldering iron with a large tip and solder rapidly, making sure that the solder is adequately melted to ensure proper wetting of the joint. It is advantageous to lightly tin the lugs before soldering. A temperature-controlled iron, such as the Weller, with an appropriate tip, is recommended.

Next slip a 22 mm or 25 mm length of 20 or 22 gauge B & S tinned copper wire through the Neosid type 159 x 059 x 375/F8 RF bead, making RFC1, and solder it into place as shown in Fig. 6. Now mount C1, C2 and C3. Cut the lead of the feedthrough capacitor (C3) flush with the body of the component on the back (heatsink) side of the board, as shown in Fig. 7.

When mounting C1 and C2 ensure that the proper polarity is observed. If C2 is connected in reverse it goes up in flames when the power is applied. It may damage C1 as well.

Mount all the switching diodes using an absolute minimum of lead length. Check that they are correctly oriented.

Before mounting the 2N6084, cut the base and collector leads to about 6 mm (¼") length. This should be done with care so as not to damage the rather soft leads. A pair of sharp, ordinary household scissors is a good tool for the job. On the premise that what people don't know won't hurt them, turn your back when you do this little job or else do it at some suitable hour in the dead of night so that the prime user/owner of the scissors doesn't see what you are doing. It avoids complications such as black eyes and minor stab wounds. Reasoned arguments such as the softness of the metal tend to go unheeded.

Straighten the leads carefully if necessary, so that they run straight out from the transistor header without any kinks. Place the transistor on the board and see that the leads sit flush on the board right up to the transistor header. Orient the transistor as shown in Fig 6. Carefully solder it into position, flowing the solder near to the 2N6084 case. Use a hot iron and ensure that proper wetting of the joints occurs.

Next wind RFC2 and RFC3. RFC2 requires a length of 22 gauge B & S tinned copper wire about 100 mm long. Thread it through the six-hole Philips ferrite bead five times. Solder it into position from the base of the transistor to the ground plane as shown in Fig 6. Keep the leads short. RFC3 requires a 100 mm length of 18 or 20 gauge B & S tinned copper (enamelled copper wire is also suitable). Wind five turns around the shank of a 6 mm (¼") diameter drill or other suitable former and then slip it off. Cut the leads to a suitable length, 5 mm to 7 mm is adequate, and then stretch the coil to a length of about 12 mm. Solder one end to the collector of the 2N6084 and the other end to the top terminal of the feedthrough capacitor, C3. Solder a short link of hookup wire from this terminal to the rectangular pad nearest C3, see Fig 7.

The pc. board may now be mounted into position on the heatsink. Apply a little silicone grease or heatconducting compound such as Bevaloid GS-13 to the transistor stud where it contacts the heatsink. Bolt the transistor down first. Carefully orient the mounting holes beforehand. Now slip a suitable-sized nut or fibre washer under the pc board mounting holes. Either should be a close fit between the pc board and the heatsink so that no upward or downward strain is placed on the transistor leads. Any upward strain may cause the cap to pop off — an inconvenience rather than a disaster, as it can be glued back on with a quick-setting glue such as 'Bondza' or 'Super 5000' without any apparent ill effect. Extreme care must be exercised

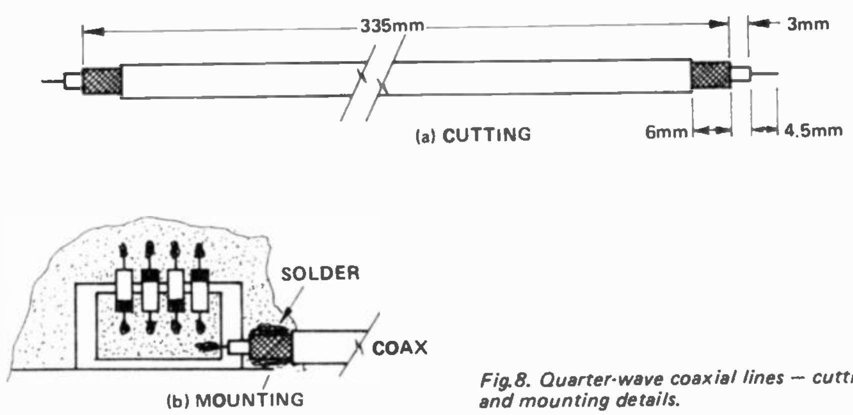


Fig.8. Quarter-wave coaxial lines — cutting and mounting details.

in doing this though. Not a recommended procedure, but possible. Any downward strain can cause the transistor leads to 'tear' at the header. This sort of damage is very difficult to repair.

The quarter-wave coax lines may now be installed. Cut two lengths to the dimensions shown in Fig 8. Solder the lines into position as illustrated, being careful not to damage the centre conductor or insulation. Use a hot iron and solder quickly. The braid at each end is best tinned beforehand. Alternatively, wrap it with a length of light gauge (say 22 B & S) tinned copper wire and tin the lot before attaching the line to the p.c. board.

The coax lines may be coiled and tied up as shown in Fig 4 or they may be wrapped conveniently in any position around the inside of any cabinet or case the amplifier may be mounted inside.

Finally, the input and output connections can be made via short lengths of coax to convenient coax sockets. As individual constructors will have different requirements in this regard, it is best left as an individual decision. Sockets that are compatible with the existing installation are best used.

The power supply leads will need to be rated to carry currents up to six amps. Any connectors will need to be adequately rated to carry these currents. As the amplifier is completely stable with no drive, and does not draw any current, it is not necessary to switch the 12 volt supply rail, except perhaps as a precaution, and this may be routed via a complete installation supply switch.

TUNE UP

Tune up is quite simple. You will need a dummy load of adequate rating and either an in-line power meter of reasonable accuracy or some power output indicating device. A power supply that can deliver up to six amps at 14 volts (maximum) is necessary. An ammeter that can read up to at least six amps would be handy also.

After carefully checking the construction, apply a supply voltage of between 12 and 14 volts. Check that no current is drawn by the amplifier.

With the dummy load connected and the driving transceiver or transmitter, apply a drive of between 5 W and 12 W, preferably the lower power. Tune the input trimmers for a peak in the output power indication. Do not hold the drive on too long with the amplifier in this condition. Next, apply drive again and tune the two output trimmers for a maximum in output indication.

Now, with the maximum drive power to be used, touch up all the trimmers for maximum power output.

Maximum collector dissipation should be kept under 80 watts. Also see that the maximum continuous collector current of six amps is not exceeded.

PERFORMANCE

At a supply voltage of close to 13 volts and a drive level of between 7 to 8 watts, a power output of 42 watts was obtained from the prototype. This is a gain of around 7 dB. The manufacturers of the 2N6084 specify a minimum gain of 4.5 dB at 175 MHz. However, one could expect a somewhat higher minimum gain at 146 MHz. An efficiency in excess of 55% is readily obtainable. ●

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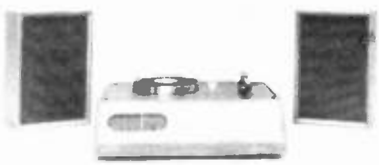

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Tone arm damping

Dramatically improve your stereo sound for less than $5.00! **by James Brinton**

A PROPERLY DAMPED tone arm and cartridge, compared with an otherwise identical combination, has many advantages. These include better tracking of warped records, cleaner reproduction of low-frequency information, greater immunity to shock and vibration, reduced high-frequency playback distortion, and — particularly with some of today's very-high-compliance phono cartridges — a dramatically solidified stereo image. In addition, because damping reduces or nearly eliminates the subsonic resonances characteristic of most arm-cartridge combinations, the once irksome task of matching an arm to a cartridge becomes simpler.

Damping appears under several labels. Pivot damping and viscous damping generally mean the same thing. There also is a related approach called "counterweight decoupling," which is far more common than viscous damping.

Early examples of damped arms are the 1960-vintage Weathers and ESL models; the Weathers unit (now reincarnated by Win Laboratories) was viscous damped while the ESL used a decoupled counterweight.

Today, a list of damped tone arms includes British designs like the Decca, the KMAL, and the Audio and Design arms — all with viscous damping in one form or another. Arms with decoupled counterweights are widely available today on record changers and single-play units (Dual and Lenco, for example, have applied the idea with considerable success), and separate arms with this form of damping include the SME, the Audio-Technica, and the Connoisseur.

This is far from a complete list, since damping isn't one of those characteristics raved about in advertisements. Even if the engineering department realizes its value, the fact that damping is part of a design often gets lost somewhere in sales and advertising. Thus, a feature that might help sell a tone arm can become a well-kept secret!

There is, to the sales-oriented executive or retailer, a rationale for ignoring viscous damping. It can be difficult to manage in shipment; perhaps worse, the inexpert audiophile might mistake the "feel" of an arm with viscous damping for that of one with high mass or friction, with the possible result being a lost sale.

HOW ARM DAMPING WORKS

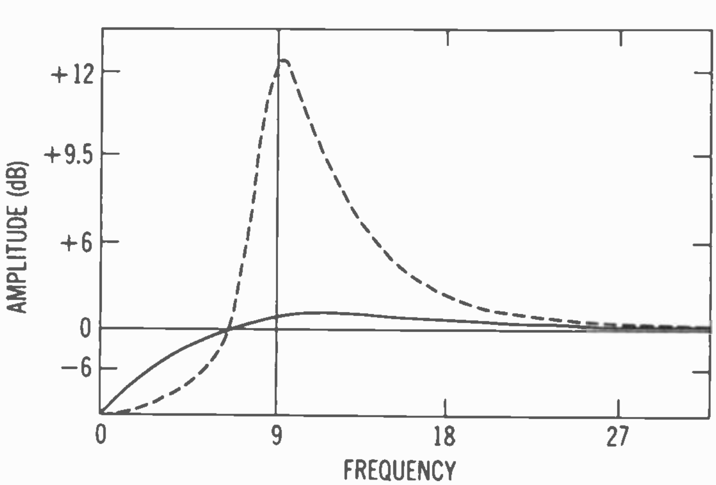
Because counterweight decoupling is easier to manage in the factory, during shipment, and in the store, it is employed more often than viscous damping. It usually consists of a flexible coupling between the counterweight and the body of a tone arm — perhaps a sleeve or rod or doughnut of rubber of plastic. This allows the arm and the counterweight to vibrate independently to some extent. In practice, with a simple decoupled counterweight, an arm-cartridge combination will have two lower-amplitude resonant peaks instead of the single higher-amplitude peak that would have appeared without decoupling. So decoupling ameliorates, but does not fully eliminate, the problem of subsonic resonances.

Harder to implement, and less convenient for maker and retailer, viscous damping can do a much more thorough job of solving the resonance problem. In its simplest form, viscous damping, or pivot damping, consists of a drop or two of very thick fluid — heavy petroleum or one of the ubiquitous silicones perhaps — placed in the tone arm's bearings. The fluid serves two purposes: First, it reduces whatever friction there is in the pivot; and second, it drastically reduces the effect of sudden or large movements on the motion of the arm. But the smaller, slower movements necessary for accurate tracking even of warped records are not interfered with. This selectivity is pivot damping's most desirable feature. Shock, vibration, and resonances and damped out quickly; the desirable arm movements actually become smoother and less encumbered by friction.

Thus, viscous damping has the same relationship to the vibrations and movements of your tone arm that shock absorbers do to those of your automobile.

Anything mechanical vibrates. Obviously, if the tone arm vibrates while you are playing a record, the vibration is going to be coupled to the stylus cantilever of the phono cartridge. Think of the stylus tip as analogous to a wheel on an automobile and the semi-elastic cantilever suspension as an automobile spring. Shock can be transmitted both from the road to the auto body and from the body to the wheel via the spring.

Any stylus cantilever motion not due to groove modulations is — or becomes — distortion in the cartridge's output. The cartridge, after all, can't be expected to tell the difference between motion caused by the groove and that caused by the movements of the arm alone. Now while it is just about impossible to keep a mechanical system like an arm and cartridge assembly from vibrating, viscous damping can be used not only to keep the level of the vibration low, but also to make the arm-cartridge system stop vibrating sooner than it ordinarily



Theoretical curves compare bass resonance in a damped arm (solid line) with that of same arm minus damping (dashed). Actual values will of course depend on mass and compliance values.

would have. With today's very-low-friction arms, this is important.

When an arm-cartridge combination is "excited" into vibration by acoustical feedback, a warp, or a shock, it continues to move up and down for from side to side about its pivots at its resonant frequency – say, anywhere from about 15 Hz down, depending on the cartridge used, the mass of the arm, and other factors. The length of time it will continue bouncing will be inversely related to pivot friction. With current low-friction designs, a single shock can engender movements that might take minutes to die away naturally. Something else is needed, like a shock absorber, to stop the bounce quickly. Viscous damping does the job. Because it does, the cartridge will convert far less of the arm's movement into unwanted electrical output. And that means less distortion.

SOME PRACTICAL TESTS

How important is this? After all, you can't hear "sounds" below 20 Hz. True, but you can hear their effects – and enjoy their absence.

Recently the USA's Boston Audio Society, with the guidance and encouragement of Dr. S. L. Phoenix of Cornell University's Department of Mechanical Engineering, has been experimenting with viscous damping. The results have been exciting. Usually damping was added to existing tone arms, since it is a rare audiophile who has enough know-how to build his own arm. This was a sometimes sticky job (see the box for do-it-yourselfers), but the payoffs often were dramatic.

Some members of the group had experienced difficulties using the ADC XLM cartridge, for example. The cartridge got rave reviews and turned into something of an audio cult symbol. But its users had found that in some arms it could bottom out on warps, mistrack, or otherwise disappoint. With the tone arm damped, however, the XLM sailed unperturbed over warps and traced grooves with less distortion than ever.

Similarly, some members had complained that the Shure V-15 Type III (which also has plenty of admirers so appreciative as to represent something of a cult) produced "a somewhat vague stereo image." Directionality and placement of instruments weren't as sharp as with some other cartridges, they had felt. But when it was mounted in a damped tone arm, the Shure gave what its users now felt was near-pinpoint localization.

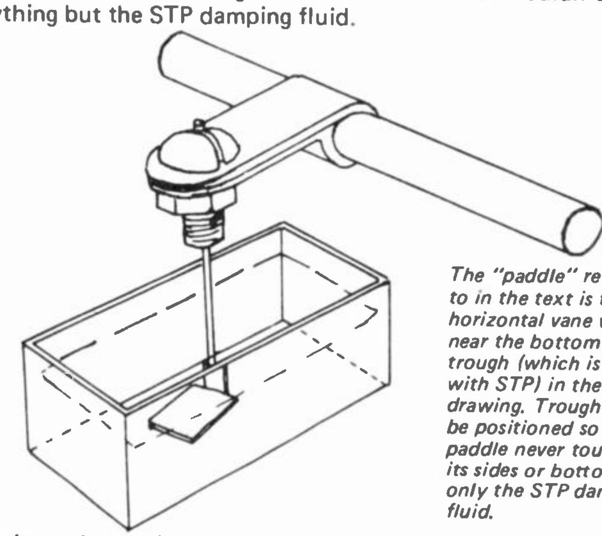
DO-IT-YOURSELF TONE-ARM DAMPING

If you are the adventurous sort – and handy – you can duplicate the experiments mentioned in the body of this article. They involve little investment in either time or money and can pay large dividends in improved phono reproduction.

Although several approaches were tried, the easiest to manage is the one described here. Not only is it simple to apply, but it also allows the user to vary the amount of damping and thus approach the optimum amount for his arm and cartridge. It was developed by Robert Graham of the MIT-Lincoln Laboratory.

The parts required are a nylon clamp, a nylon nut and bolt some stiff brass wire, and a small amount of brass sheet stock. Lighter metal could be used and would, in fact, be preferable. Also necessary is a small trough – say, 25 mm in both depth and width and about 60 mm long – capable of holding about half a cup of STP motor-oil additive. (Obtainable from most garages.)

The figure shows how these elements go together to form a tone-arm "damper". Note that the amount of damping can be varied by pushing the clamp closer to, or farther away from, the arm's pivots. In practice, the distance of the damping paddle from the pivots will be decided by the space between the turntable and the arm's vertical shaft; the paddle must move freely with the arm so it tracks to the inner grooves of a record – it shouldn't touch anything but the STP damping fluid.



The "paddle" referred to in the text is the horizontal vane visible near the bottom of the trough (which is filled with STP) in the drawing. Trough must be positioned so that paddle never touches its sides or bottom – only the STP damping fluid.

Horizontal damping appears to be a bit less critical than vertical damping, so begin your experiments by epoxying a paddle at right angles to the wire and making it about ½ inch square. Attach the damping assembly to your arm and – carefully – pour the STP in the trough, covering the paddle. Leave room below the lip of the trough so that the fluid won't lap over when you move the arm. (This is the messy part of homemade damping; but if you don't spill, you won't have to clean up. STP, is astonishingly 'sticky'. Try to avoid touching it – it's safe enough but very hard to wash off).

Now check for improved tracking of warped discs; with near optimum damping, no movement of the stylus cantilever should be visible. The stylus cantilever and the cartridge body should appear to move as a unit. Increase or decrease the paddle area until you achieve this condition. If you have a set of test records, you might go further and optimize the paddle area for best low-frequency tracking or square-wave response.

Chances are that you will slightly over- or under-damp your arm, but your approximation will be close enough. After obtaining the correct amount of horizontal damping, add a vertical paddle and experiment with it until there is as little side-to-side cantilever movement as possible when playing warped or off-centre records.

If all this seems a little bit *ad hoc*, bear in mind that it will give good results cheaply. But be warned: The experiment may convert you to an avid arm-damping enthusiast (as, obviously, it did me). – J.B.

TONE ARM DAMPING

There were other experiences with other cartridges. Some experimenters reported cleaner, tighter bass reproduction. Some appeared to suffer less preamplifier overload in critical pickup-input combinations. A few reported no striking difference in performance, but almost all of these either had outdated tone arms with high mass or friction, or were using low-compliance phono cartridges.

The most demanding audiophiles — those with the most advanced arms and most compliant cartridges — noticed the most improvement. Could it be that the better the record-playing equipment, the greater the need for damping?

There was another side to these admittedly informal tests. Some of the group used good cartridges in marginal arms, added damping, and noticed improved performance. Does this make damping a cure for so-so tone-arm design? No, but it might indicate that the movement of the past few years toward ever lower masses and friction may have reached a point of diminishing returns: Some resistance to arm motion may be desirable.

But why did things sound different? The group still is trying to answer this to its satisfaction, but there are some pretty fair guesses.

There are no absolutely flat records; arms and cartridges are continually being forced into resonance by nearly invisible warps. Higher-quality arms and cartridges, especially, respond readily to them. And there is no such thing as perfect acoustic isolation for any record player. Again the result is resonant vibration, this time triggered by shock, room vibration, and acoustic feedback.

Just getting these resonance products out of the cartridge's output should have cleaned up the sound, and seemingly did. After all, there was now less subsonic material and consequently less audible intermodulation between the resonances, their harmonics, and the music.

This freedom from subsonics may be especially important to owners of some super-preamps with response reaching almost to dc. Unless they are removed by damping, or filtered out electronically, signals due to arm-cartridge resonances not only could enter the preamp at levels several times as high as midrange musical signals, but also could be boosted by as much as 60 dB by RIAA equalization that (incorrectly) continues its rising bass characteristic into the subsonic region. Some of the better preamps offer a switchable subsonic filter as a preventive for the severe overloading that resonance-rumble interaction can cause in phono preamp stages — even those that have plenty of headroom at higher frequencies. (A subsonic filter project was published in Electronics Today, October 1974.)

There are other, less obvious payoffs, some still being explored, such as damping's effect on tracking-force variations. Among the advantages that may emerge is reduced record wear due to the suppression of instantaneous tracking-force extremes.

Like other electromagnetic transducers, a magnetic phono cartridge has a region of best performance — its so-called linear region — within which it accurately transforms the movements of its stylus cantilever into an electronic equivalent of the groove modulations. Tracking forces are specified not only to assure decent groove tracing, but also to place the stylus cantilever in about the centre of its linear range of motion (that is, of vertical flexing) with respect to the cartridge body. But tracking force is a static specification, and record playing is a dynamic situation; when a rising warp is encountered the effective tracking force will be increased as the arm is forced upward and/or the cantilever spring flexed toward the cartridge body. As the record surface descends, the effect is reversed. Thus begins the so-called pogo-stick effect that, particularly in an undamped arm, can cause continuing variations in instantaneous tracking force and even make the stylus hop out of the groove altogether.

Incorrect tracking force, whether it is too low or too high, momentarily moves the cantilever out of its optimum location. Either way, tracing suffers. There may be repeated, even if momentary, losses of contact with either or both groove walls and repeated instants at which tracking force exceeds the bearing strength of the groove walls. And the angular flexing of the cantilever will produce what is aptly known as "warp wow" — a change in relative stylus-groove velocity and hence a waver in the music's pitch. With damping, this sort of abuse seems to be greatly reduced because the stylus more consistently is in good contact with the groove walls and its cantilever less often is deflected outside its optimum range of movement.

One listener felt that, simply because the stylus no longer was being subjected to as much unwanted movement at resonant frequencies, the effect was as if someone had stopped fiddling with his system's volume and balance controls. It was, to him, similar to switching from a turntable with flutter to one without — only the difference was not in pitch, but in space. The feeling of "uncertainty" was gone.

Another reason for apparently cleaner sound may be that, because of improved tracing, there is less of the high-frequency "chatter" usually caused by the stylus rattling about in the groove. Although mostly above 20 kHz, this chatter could be indirectly responsible for some audible distortion.

On the basis of these experiments then, the desirable properties of arm damping seem amply confirmed. But, like most techniques, it can be abused. Too much damping, for example, can make a tone arm respond arthritically to warps and shocks and (though it might make for a nearly nonresonant arm-cartridge combination) reintroduces excessive cantilever flexing and hence some tracking problems. It's a question of finding optimum values.

In practice, the buyer of a damped tone arm needn't worry about overdamping. The arm designers have taken the problem into account and generally will have picked an amount of damping that will fill the needs of a wide variety of cartridges. The arm may overdamp or underdamp slightly without causing problems, while still obtaining nearly all of damping's advantages.

If there's no viscous-damped arm available for your particular needs, you can compromise by selecting one of the many good designs using counterweight decoupling. But bear in mind that, while decoupling lessens resonance difficulties, it may not be as complete a solution as viscous damping.

This article has been adapted from material originally published in the July 1975 issue of the US magazine 'High Fidelity'. It is reproduced here by permission of the publishers — ABC Leisure Magazines.

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537, 3 INCH, 5 MHz OSCILLOSCOPE
Band width: DC-5 MHz
Sensitivity: > 10 mV/DIV
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$54
$77
$34.50
KEW SNAP 5, 6 SNAP-ON AC VOLT-OHM SWIVEL CASE AMMETERS
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5B, Amps: 10/50
5C, Amps: 30/150
5D, Amps: 60/300
Volts: 150/300/600
Size: 115 x 60 x 40 mm
6B, Amps: 10/50
6C, Amps: 30/150
6D, Amps: 60/300
Volts: 150/300/600
OHMS: 0/300
Size: 190 x 65 x 40 mm
KEW SNAP 8, 9 ROTARY SCALE SNAP-ON AC VOLT-OHM AMMETERS
8-Amps: 6/15/40/100/300
Volts: 150/300/600
OHMS: 0/2000
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Amps: DC, 0-50uA/1/10/100 mA/10A
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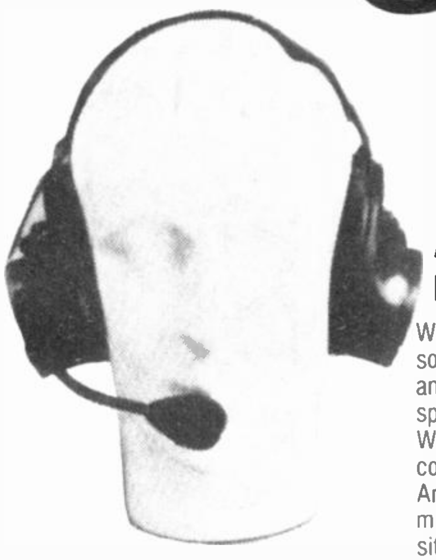

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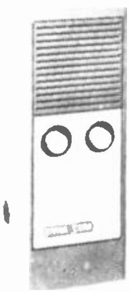

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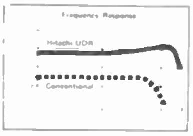

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OVER THE PAST FIVE YEARS, WE have seen the cassette recorder advance from its former lowly position in the high fidelity field to become truly comparable with reel-to-reel equipment whose position it now threatens and which it could ultimately usurp.

One cassette recorder has basically outshone the rest and may currently be regarded as the uncrowned champion. This is the Nakamichi 1000 Tri-Tracer 3-Head Cassette Recorder. Choosing the best cassette recording tape is more difficult — the contenders are many and their relative merits far more difficult to assess.

Over the past two years, we have evaluated literally dozens of different types of cassette tapes. Of these many have offered real improvements but have had limitations of one form or another. These tapes have included special formulations of chromium, cobalt, gamma-ferric oxide, multi-layered formulations, magnetically polarised (during the coating process), magnetically oriented formulations, and, last but not least, more finely ground particles with various forms of controlled particle dispersion.

Whilst it is true to say that most of these tapes had some particular merits none has been perfect. The Nakamichi Research Company, during the first two years of sales of their Model 1000 machine, recommended a chromium formulation which offered unquestionably good frequency response together with the possible option of a specially formulated gamma-ferric oxide tape, which, whilst not quite as good as the chromium dioxide tape, nonetheless offered a particularly good response.

Now however, for what are apparently good technical reasons, Nakamichi have standardised their latest machine on a new formulation tape from TDK. This formulation, called Super Avilyn, is a combination of cobalt and ferric oxide together with binders, but is not a cobalt-doped or cobalt-energised tape of the type currently being manufactured and marketed in the U.S.A. The end result is a basic particle with an extremely high coercivity, typically four times as high as that provided by regular gamma-ferric oxide particles, and 50% higher than that provided by cobalt-doped ferric oxide formulations.

TDK claim that this is a far more stable formulation offering a number of further advantages including higher stability, higher sensitivity and better uniformity, together with a better tolerance to varying bias settings than previous products that they have produced. It would appear that this tape formulation also causes less head wear than ferrichrome tapes or standard chromium dioxide tapes and, as such, is a preferable tape for use on the Nakamichi 1000.

Nakamichi have recently introduced a number of improvements to their machines which make them even better and more flexible than before. These improvements have resulted in Nakamichi standardising on a bias setting based on the Super Avilyn tape with the tape selection switch set for CrO_2 tapes. Our task was to find out why Nakamichi made this change and what has been achieved by it.

We had previously conducted an exhaustive evaluation on twelve other tapes, using the same procedures and instrumentation (Hi-Fi Review June 1975) and decided to use these tests as a yardstick for evaluating the Super Avilyn tape. Our procedure was simple and straightforward: firstly, to measure the frequency linearity as a record-to-replay response at levels of O dB, −10 dB and −20 dB, the O dB level being that indicated by the inbuilt recording level/meter whilst the −10 dB and −20 dB levels were accurately determined by an external

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	TDK SUPER AVILYN		BEST OTHER
Frequency Response:			
0 dB	24 Hz to 11 kHz		24 Hz to 9 kHz
−10 dB	24 Hz to 19 kHz		24 Hz to 15 kHz
−20 dB	24 Hz to >20 kHz		24 Hz to 20 kHz
Total Harmonic Distortion	100 Hz	1 kHz	6.3 kHz Not Tested
0 dB	.95%	1.69%	2.84% —
−6 dB	.34%	.35%	1.52% —
Bulk Erased Noise:	Dolby "In"		Dolby "In"
100 Hz	−70 dB		−70 dB
1 kHz	−80 dB		−77 dB
6.3 kHz	−78 dB		-76 dB
Saturation Level (for 0.1 dB compression):			
100 Hz	+5 dB		Not tested
1 kHz	+4 dB		+2 dB
6.3 kHz	−5 dB		Not tested.
Dynamic Range:			
100 Hz	75 dB		—
1 kHz	84 dB		79 dB
6.3 kHz	73 dB		—

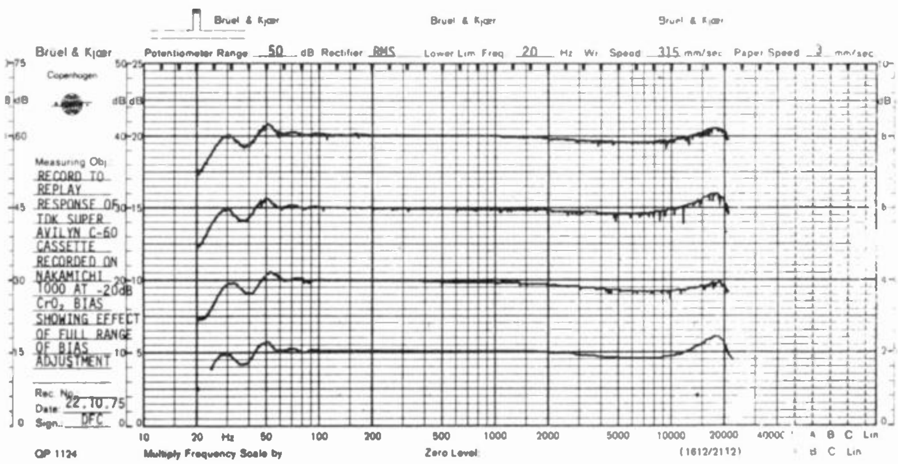
attenuator. The level recordings were automatically produced for each level without any special adjustment of the machine, apart from the normal azimuth alignment using the tri-tracer system.

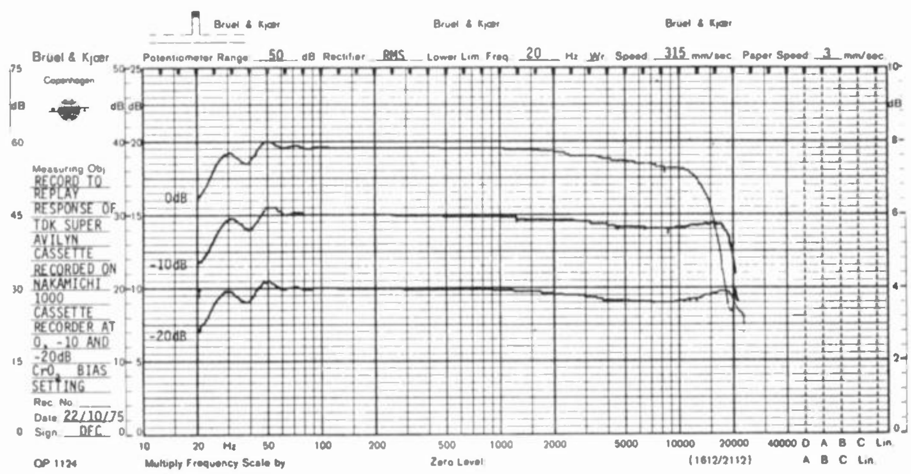
The frequency response at 0 dB, measured performance extending to beyond 11 kHz, was better than any other we have seen, indicating the tape's capacity to accept high levels without saturation. This capacity was further exemplified by the response at −10 dB extending to about 19 kHz, a response which would normally be expected only at a level of −20 dB. The response at −20 dB to beyond 20 kHz is most certainly equal to or slightly better than any other tape we have evaluated.

Our next series of tests involved the determination of the noise spectrum existing on the tape after bulk erasure. A one-third octave band frequency analyser was used to measure the noise threshold of the erased tape across the audible frequency spectrum when replayed in the normal mode, then with Dolby noise reduction, and finally with Dolby noise reduction and dynamic noise limiting together. The results achieved here were not in themselves astounding, but the measured level of noise compared with our previous measurements showed that the Super Avilyn tape has a threshold at least two decibels lower in the 1 kHz region than any tape previously measured. The figure here was −80 dB (compared with the normal 0 dB recording level), a particularly good performance.

To determine the upper limit of the tape's dynamic range, we recorded three signals at frequencies of 100 Hz, 1000 Hz and 6.3 kHz, at levels which were raised in one decibel steps from −5 dB to +5 dB. The playback response was then recorded graphically on our level recorder and was used to determine the upper level of the dynamic range. Obviously, as the recording level approaches the tape saturation point, the 1 dB steps become compressed and depart from what is true record-to-replay linearity. We set as our criteria limit the point at which an increase in input level of 1 dB resulted in an output step of 0.9 dB − that is, 0.1 dB compression. This was a far more rigorous test than we had previously applied in tests on other tapes. Even so, it showed that the Super Avilyn tape has a dynamic range of 75 dB at 100 Hz, of 84 dB at 1 kHz, and 76 dB at 6.3 kHz − really excellent figures.

Our next investigation was aimed at determining longterm variation in stability and dropout performance respectively, at 100 Hz, 1 kHz and 10 kHz. At 100 Hz, both in terms of





longterm and short-term variation, the results were as linear as one could hope for, and certainly better than anything we had previously seen. At 1 kHz, the dropout performance was very slightly higher than the best we had previously seen, but still exemplary. At 10 kHz the performance was still extremely good with the maximum excursions (typically) being 1 dB and the statistical mean being 0.3 dB − i.e. inaudible. The longterm variation for a full tape was also recorded (at 400 Hz) and this was remarkably flat, showing no significant variation in the mean recording level; most certainly the stablest longterm linearity response that we had seen from any cassette tape to date.

Our next test was an unusual one. We decided to take the Nakamichi 1000 and alter the bias to four different settings to see to what extent we could improve the frequency response at the −20 dB level by small variations in the bias adjustment. By altering the standard bias to alternative settings, we found that we would vary the frequency linearity at the top end of the frequency scale to produce responses ranging from level through to a peak of approximately 2 dB at 18 kHz. The level response was that set by the factory. We found however that the Nakamichi factory setting was already optimal for the Super Avilyn tape.

Listening tests proved that Super Avilyn tape sounds as good as its measured performance indicates. Background noise is substantially lower than other tapes and the dynamic range is unquestionably better. Frequency response is excellent, and the relatively non-critical bias requirements are a step in the right direction.

Providing you have a cassette recorder capable of exploiting the very high performance of which this tape is capable then it is really worth using − Super Avilyn tape looks in fact as being one of the most important advances in tape formulations in the mid-seventies. ●

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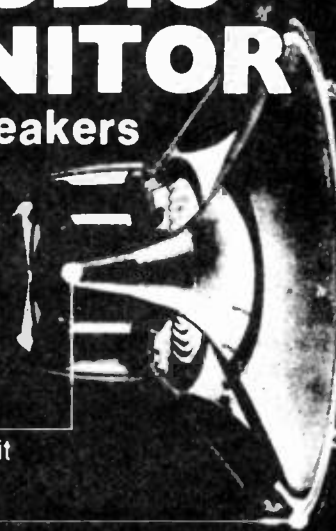

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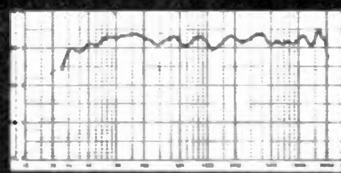

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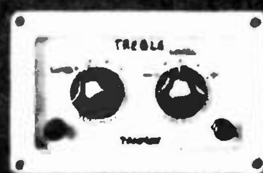

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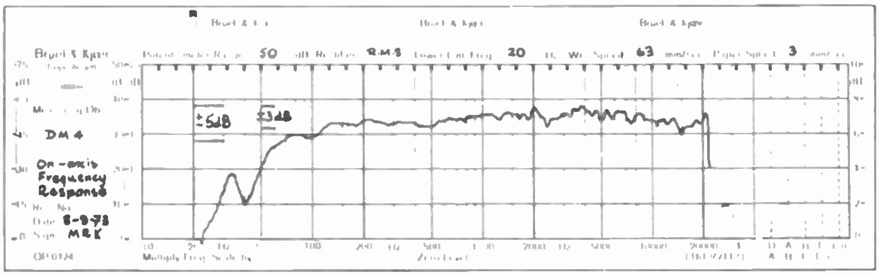

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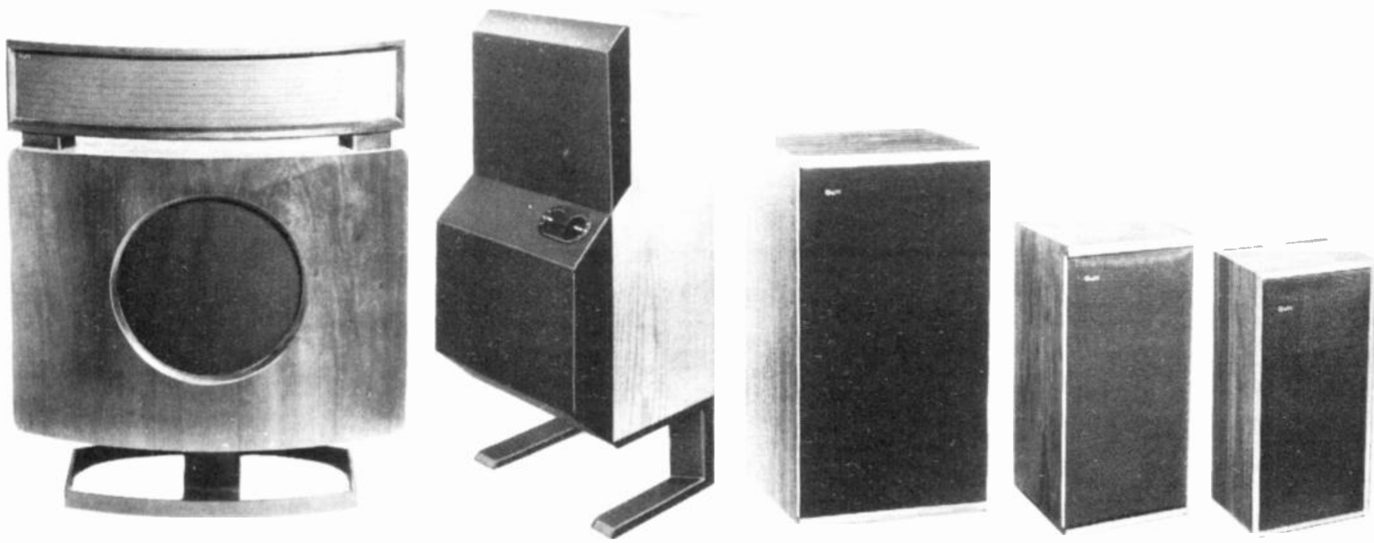

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ELECTRONICS —it's easy! PART 29

More about digital instrumentation.

VERY FEW VARIABLES to be measured by electronic means provide a digital signal directly: this is because the real-world is predominantly analogue by nature. Consequently, most so-called digital measurement systems involve a number of stages to make the signal compatible with the digital circuits of a system.

The most straight-forward 'digital' measurement method (at least at present), is to employ a suitable analogue sensor that provides a voltage (or current) output, related to the variable being measured. This signal then feeds an A/D converter to obtain a digital equivalent.

The low cost of digital calculation circuitry now enables linearization of sensor processes at moderate cost. Figure 1 gives an example of the digital linearization used in a thermocouple thermometer unit.

By referring to Fig. 2 we see that the linearization process, in the dual-slope digital voltmeter section of the system, is achieved by changing the ramp slope at a number of points. To do this a rate multiplier is used to multiply the clock frequency by a variable number, N/256, where N may be any number between 1 and 256. By this means 256 different ramp slopes may be generated. The slope in use is tracked by a segment counter which, in turn, causes a read-only-memory (ROM) to set up the correct digital-readout code.

Some sensing principles lend themselves to a more direct digital signal approach. For example, in the Moire-fringe displacement sensor, a grid of fine lines (called a grating) formed on glass is attached to the moving (or fixed) member of the machine whose movement is to be monitored. This is shown in Fig. 3. The other member carries a small index grating set to produce Moire-fringes which move as the two grids pass relative to each other. Movement of these fringes is monitored by photocells which provide a number of electronic pulses proportional to the magnitude of the displacement. These pulses can be counted directly with a reversible direction counter, thus allowing both directions of movement to be followed. Such a unit is known in the

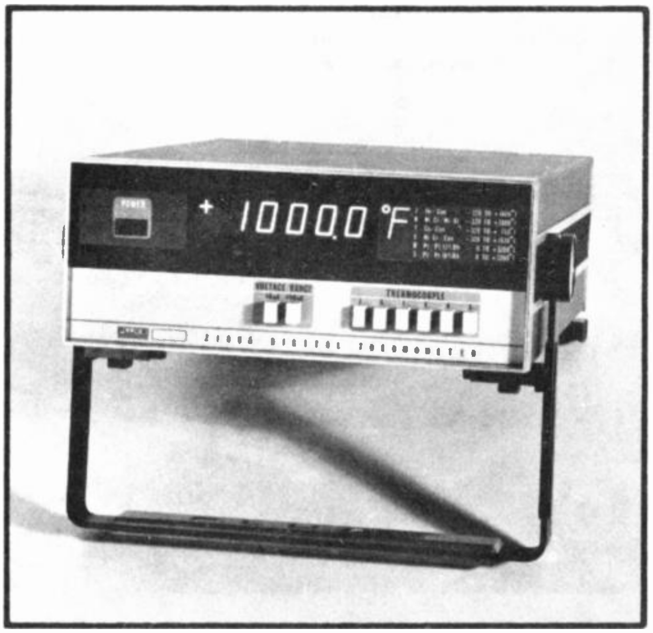
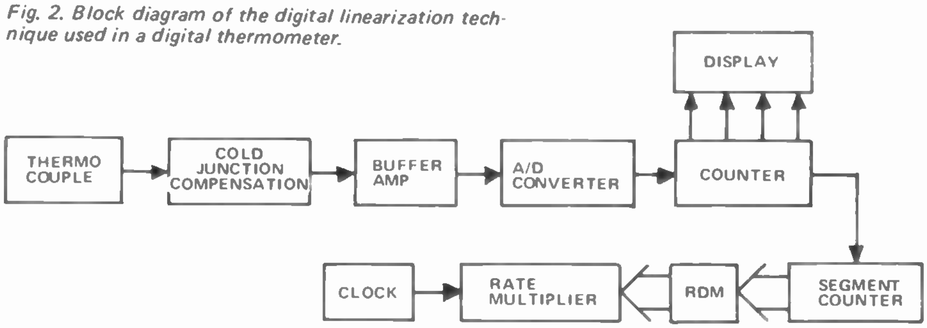


Fig. 1. This Fluke 2100 series digital thermometer incorporates digital linearization. It is suitable for use with any one of six common thermocouples.

Fig. 2. Block diagram of the digital linearization technique used in a digital thermometer.



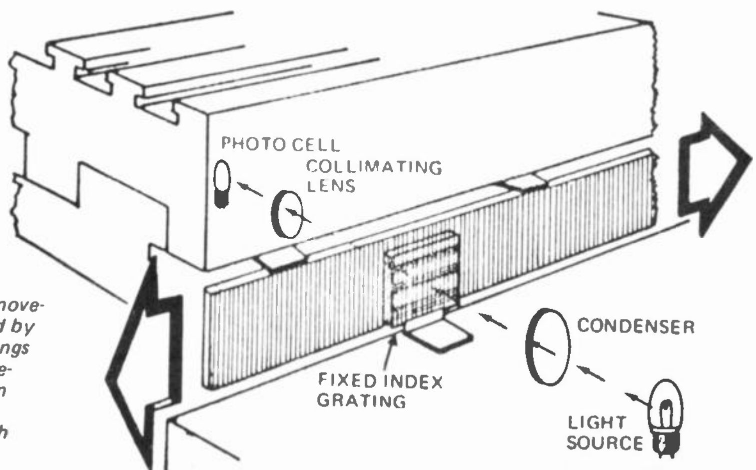


Fig. 3. Accurate measurement of movement is performed by using optical gratings to produce "moire-fringes" which can be counted as the gratings move with respect to each other.

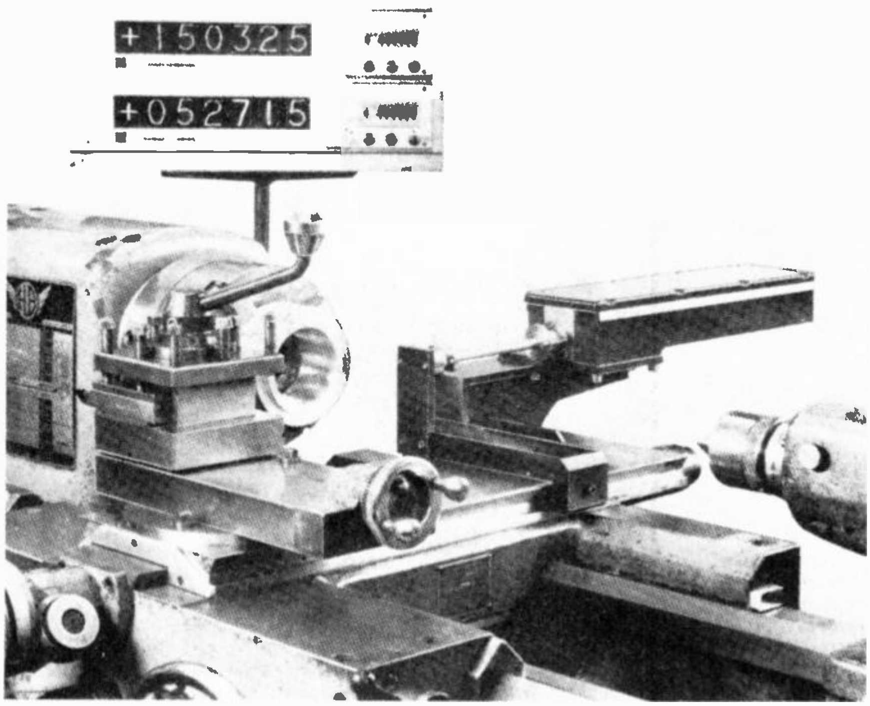


Fig. 4. This lathe is fitted with a digital readout of displacement. The self-contained Heidenhain linear sensor is to be seen high at the back of the cross slide.

metal working industry as digital readout (DRO) — a typical system is shown in Fig. 4. A somewhat similar length measuring system is the laser interferometer — this also provides fringes that can be counted to provide a measure of absolute displacement. Clearly in such cases the digital instrument must not lose or gain stray counts or else the wrong value is indicated. Such systems are called incrementals.

There is an alternative method which uses digitally encoded discs similar to those shown in Fig. 5. This is an absolute method which is not subject to pulse loss or gain, or to power failure errors which occur in the previous system if not fitted with a special non-volatile memory. The discs of such a system are read optically as though they were registers or other forms of digital store, each position having a different digital code as read across a radial line.

In some forms of digital pulse transducer it is the rate of pulse production that represents the variable, not the absolute number of pulses. An example of this sensor is the turbine flow meter used to measure liquid or gas flow. Figure 6 shows such a flowmeter where a small turbine rotates inside a pipe at a speed related to the flow rate. Rotation may be converted into pulses using optical, magnetic, capacitive or, in earlier designs, mechanical sensing. This form of sensor provides a variable frequency output which can be converted by a counter/timer system into a direct readout of flow rate.

Digital transducers are somewhat similar. They provide a signal which varies in frequency as the variable being measured changes. The sensor of such a transducer is made such that it alters a parameter of a frequency generating circuit. For example the quartz-crystal thermometer shown in Fig. 7 operates in this manner. In this unit temperature causes the resonant frequency of a crystal, mounted in the end of the probe, to change in a predictable fashion.

It is interesting to note that many natural physiological sensors operate on the pulse-rate system — neurons (the digital nerve sensors on the end of the nervous system) trigger with pulse repetition rates that rise in accordance with the intensity of the actuating signal (heat, cold etc).

Considerable effort has been expended — especially in the Eastern European countries in the late 60's — to produce reliable low-cost industrial sensors that provide a digital form of output. These have not, however, been accepted to the extent hoped. The current low-cost of extremely powerful digital circuits, however, is likely soon to produce a trend toward sensing devices having digital output.

Fig. 5. The absolute digital code disc acts as a store of the angular value of displacement. It is interrogated as though it were a register whose value is read optically across a radial line.

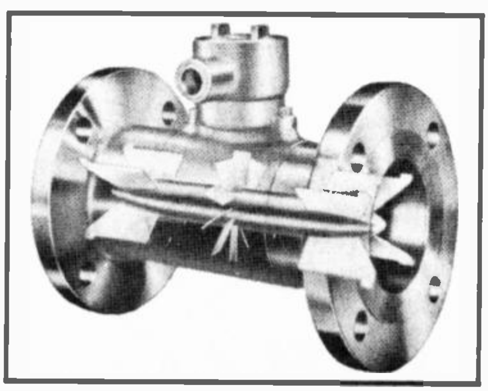


Fig. 6. Turbine flow meters like this one provide an output in the form of a pulse train with a pulse repetition rate proportional to flow rate.

ANALYSERS

Analysis is the general process used to break down an unknown by methods which separate and distinguish basic elements of seemingly complex arrangements, the elements so derived being satisfactorily understood basic quantities.

Synthesis is the alternative approach wherein a system is built up from known elements to produce the complex case.

Analysis may be regarded as being

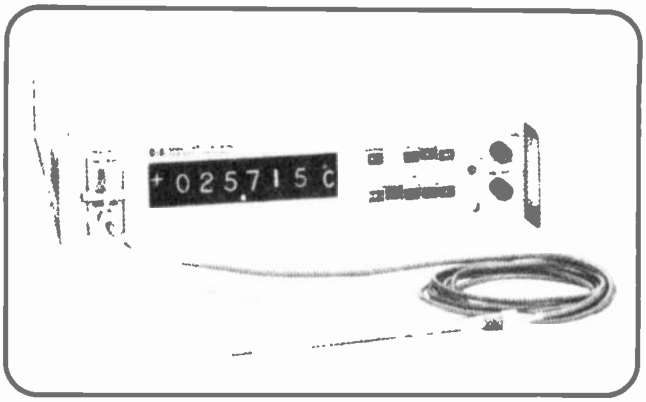


Fig. 7. Quartz-crystal thermometer from Hewlett Packard.

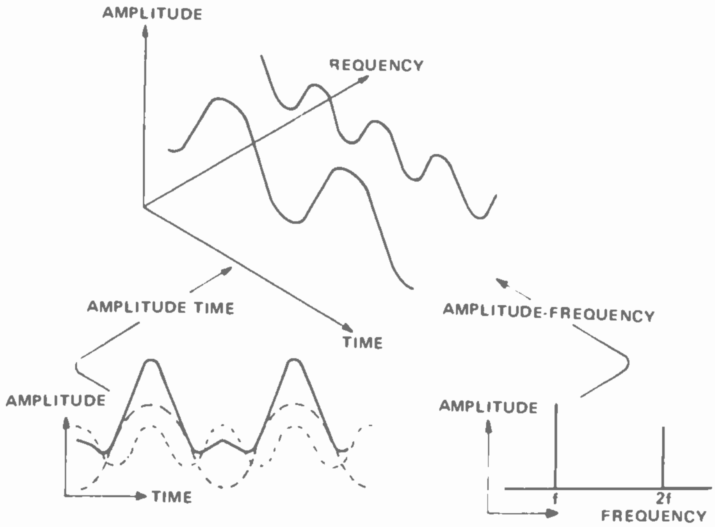
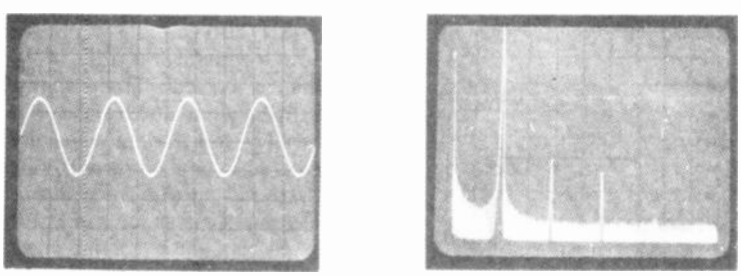
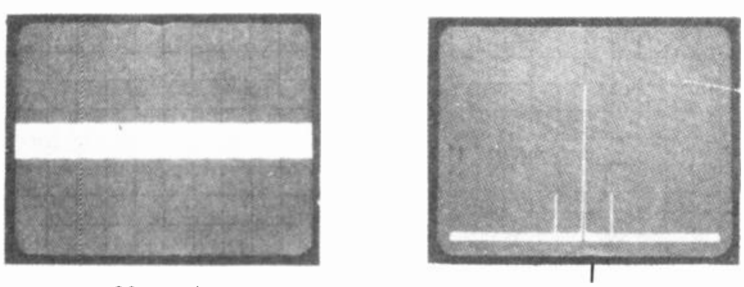


Fig. 8. Second harmonic distortion is not always easily seen on an amplitude versus time display. In the amplitude versus frequency display the second harmonic distortion and its amplitude are clearly seen.



2 µsec/div 0 1 MHz

Fig. 9. Frequency domain displays are often better than the time-domain method as these HP displays illustrate: (a) In the time domain (left) the signal looks pure but the spectrum analyser shows that it has significant distortion.



20 msec/div 15 MHz 200 kHz/div

Fig. 9b. A 2% amplitude modulation is barely discernible on time domain plot (left). The frequency domain plot clearly shows the frequencies present and their amplitude.

required when the behaviour of an existing system needs to be *studied.* Synthesis is used when a system is to be *devised.* There are of course many instances when both approaches are used to yield a solution.

Various types of electronic analysers are used in electronics. We will look here at spectrum analysers, logic state analysers and pulse-height analysers as these types are commonly met in modern circuit work. Each of these operates on an existing electrical signal breaking it down into frequency content, logic-state content and height of pulses, respectively.

SPECTRUM ANALYSERS

Signals in the time-domain, that is those displayed as amplitude versus time graphs, can also be displayed in terms of their amplitude-versus-frequency and phase-versus-frequency characteristics. (This was discussed in Part 4 where an example wave-form — a square wave — was broken up into its harmonics). The relationship between time, amplitude and frequency are seen by studying the three forms (shown in Fig. 8) of a fundamental sinewave having a large degree of second harmonic added in. Signals displayed as amplitude (or phase) versus frequency are said to be in the frequency domain. This kind of plot shows the frequency spectra of the signal, hence the name spectrum analysers.

The role of spectrum analysers is to display the signal content in its frequency domain form. There exists many instances where this form of display is better than a time-domain representation. Typical examples are where a fundamental has distortion (Fig. 9a) or where low levels of modulation or noise exist (Fig. 9b). Neither of these conditions could be satisfactorily detected, let alone measured, by a time-domain test.

Basic spectrum analysers use analogue circuitry and therefore do not qualify properly for inclusion in a discussion on digital instruments. However, as we will see later, the current trend is to include digital techniques in such instruments. Advanced analysis equipments, for example, often use a built-in digital computer.

There are two alternative forms of spectrum display. First, the repetitive signal can be studied over an extended time period by scanning across the expected frequency-range with narrow band-pass filters. A speedier, but more expensive method, works in a real-time mode thus preserving the time-dependency between signals. These are known as swept-tuned and real-time spectrum analysers respectively.

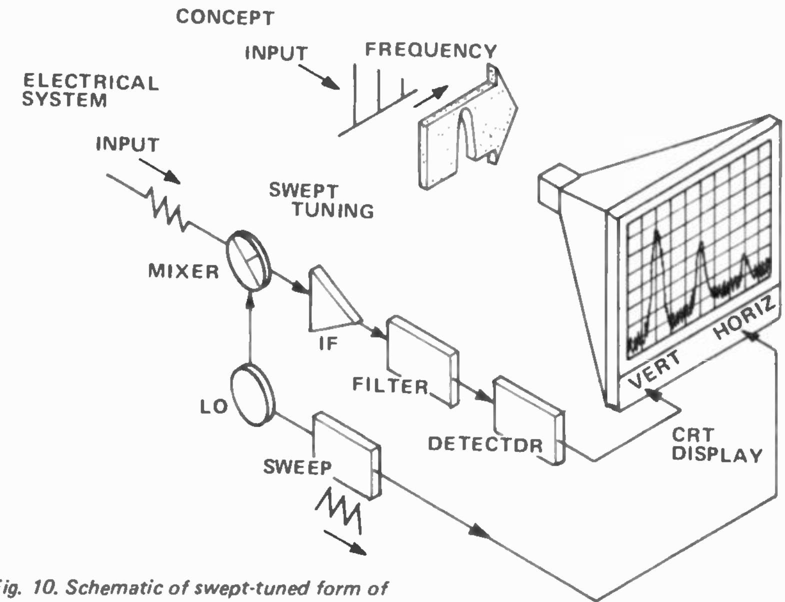


Fig. 10. Schematic of swept-tuned form of spectrum analyser.

Swept-tuned systems – Basically the task is to establish the amplitude (and sometimes phase) of the signal at each frequency in turn. Many practical difficulties exist because the absolutely narrow band filter does not exist and even if it did, it would take an enormous time to sweep it across the full bandwidth of the signal. Practical filters also have finite bandwidth and roll-offs. The bandwidth of the filter may also need to change if the requirement is for a filter bandwidth that is always a given proportion of the signal frequency as it sweeps the range.

Most difficulties are overcome by mixing the signal with a swept local oscillator and then detecting the output and using it to drive the Y plates of an oscilloscope. The sweep signal drives the X plates. Figure 10 depicts this arrangement.

Real-time systems – These use a stack of band-pass filters and detectors each connected to the signal simultaneously and with each having staggered centre frequencies. This is shown schematically in Fig. 11. The scan generator multiplexes the individual channels in order to produce a continuous spectrum on the oscilloscope screen.

It is clear that this method is much more expensive because many filters are needed. It does, however, enable a detailed analysis of once-only transient signals which could not be analysed with the swept-tuned arrangement of a spectrum analyser.

A range of spectrum analysers is available for the study of signals from 5 Hz to 50 GHz. Different instruments (or the use of different plug-ins with the same display unit) are needed because units typically cover only 4 to 5 decades, that is, say 5 Hz-50 kHz, 10 kHz-300 MHz and so on. The range is, however, ever widening. Wide range, however, is not always the virtue needed for spectral resolution is related to width of display screen.

Fourier Analysers – A third method of providing a frequency analysis is based on direct mathematical calculation using the Fourier transform technique to convert a time-domain signal into its frequency-domain equivalent. Such systems are extremely expensive compared with the above analysers, but provide a vastly greater capability.

They can also handle signals at the very-low-frequency end – dc to 100 kHz is typical. Their operation is quite different from the above in that the signal is fed as data values into the analyser unit via keyboard or paper tape from another computer or mass-storage system. It can also be fed in as an analogue signal from, for example, magnetic tape. The heart of the Fourier analyser is a microprogrammable computer system which can be set to compute using various programmes such as the so-called Fast-Fourier method of analysis. The same unit may also be able to carry out correlations between signals, plus many other processing techniques.

Digital circuitry in spectrum analysers – Digital circuits are being added by manufacturers to enhance the performance of analysers. Advantages claimed include operating ease and better placement of controls. Digital storage of the display signals can be used to enhance the display brightness and to allow a spectrum to be 'held' for comparison against a second spectrum obtained later. Digital

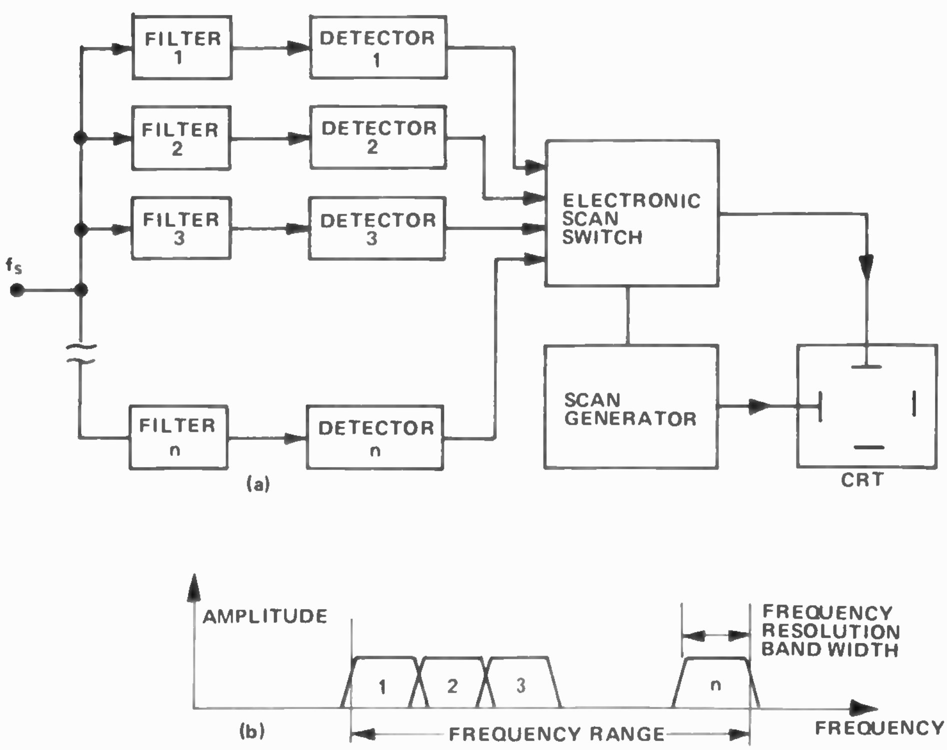


Fig. 11. Block diagram of real-time spectrum analyser based on stacked filters:
(a) schematic
(b) frequency response showing individual filter windows.

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SD7442	$3.40	5
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SD7492	$3.40	5
SD7493	$6.00	10
SD7495	$2.50	2
SD7496	$3.00	2
SD74107	$3.00	5
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RETAIL OUTLETS IN METROPOLITAN AND COUNTRY AREAS NOW BEING APPOINTED — ENQUIRIES WELCOME included; this reduces the noise thereby enhancing the signal/noise ratio on the display — as is illustrated in Fig. 12. Character generation (using digital methods) has been incorporated to display the relevant graph-axes factors — as shown in Fig. 12. The same unit also uses a photo-optical absolute-digital code disk to replace the mechanical switch usually used in a range control-knob.

Spectrum analysers are invaluable and are finding increasing use. Successful use is, however, a matter of experience and frequency-domain techniques are not dealt with as extensively as time-domain ones in training programmes. More details are available in the reading list — we can only provide the most elementary introduction here.

Logic-State Analysers — We check the operation of analogue circuits by measuring signal levels and frequency spectra at various points in the circuit. Digital circuits are different in that they contain the signal information in the form of multi-digit 'words' made up of two-state bits. To check operation, therefore, we must ascertain simultaneous logic-states at various points in the circuitry. The simplest analyser for this work is a probe which indicates logic hi or lo state at a selected point; coloured lights are used as indicators. A store function can be built-in to the probe to catch a short transition that would not otherwise be seen in the lamp display. It must also have connections suitable for PC board digital circuitry — see Fig. 13.

The single probe can be used to analyse the state of a circuit by moving from point to point in turn. To speed-up the analysing process a more extensive facility to use would be one that simultaneously shows the logic states of multiple points in the so-called Data-domain. The

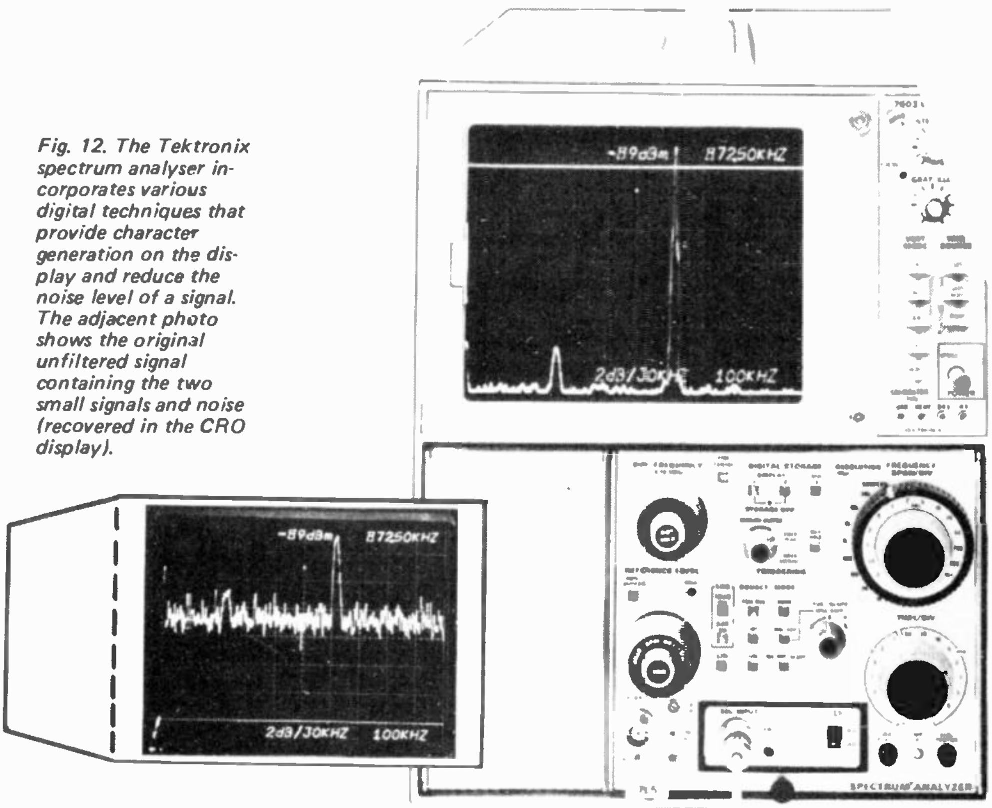


Fig. 12. The Tektronix spectrum analyser incorporates various digital techniques that provide character generation on the display and reduce the noise level of a signal. The adjacent photo shows the original unfiltered signal containing the two small signals and noise (recovered in the CRO display).

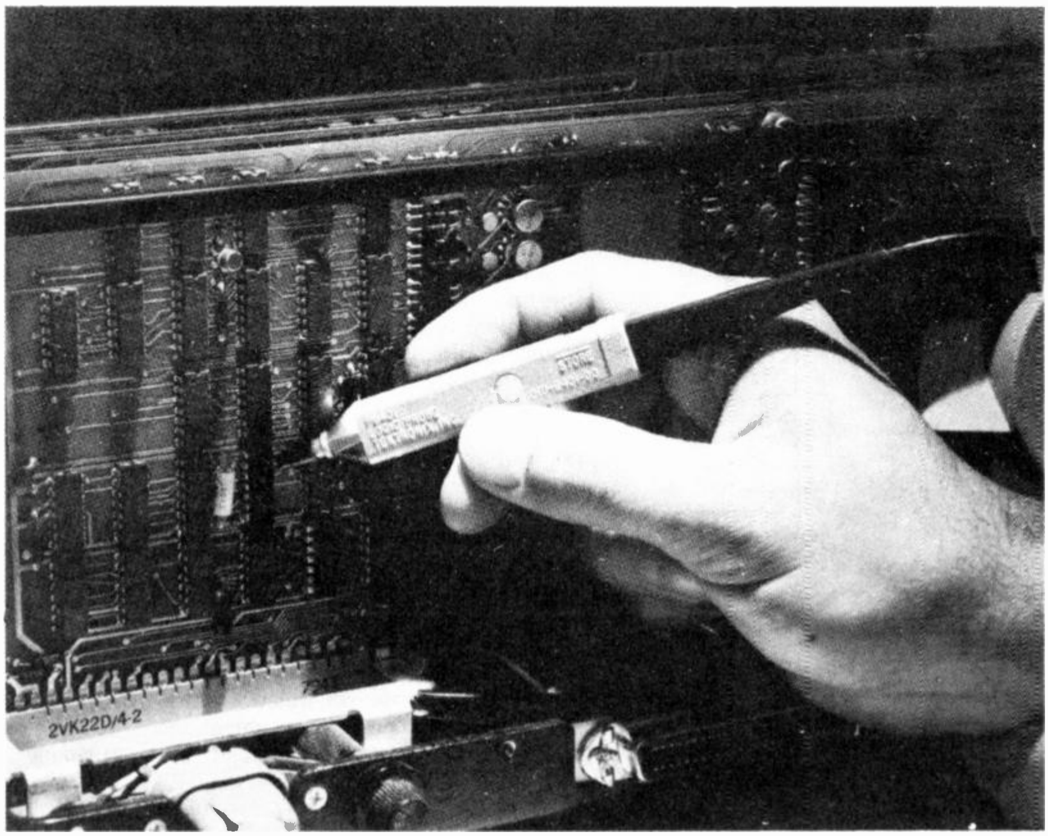


Fig. 13. Simple logic probe in action.

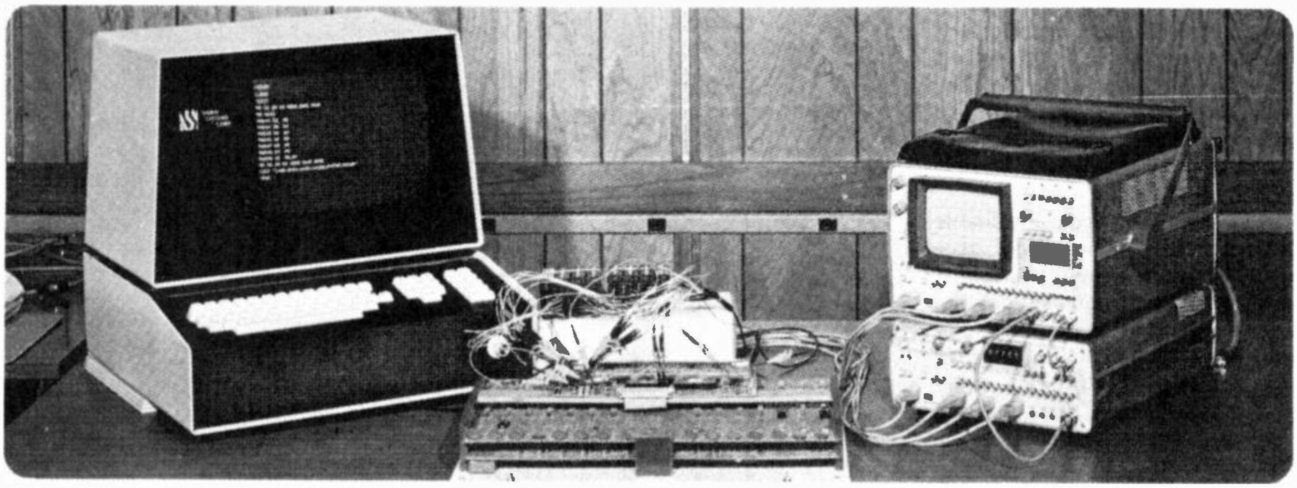


Fig. 14. Hewlett Packard logic-state analyser as set up to test a printed-circuit board card.

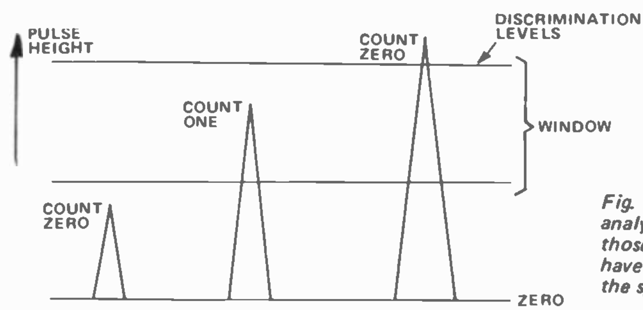


Fig. 15. Pulse-height analysers count only those pulses which have amplitudes within the specified window.

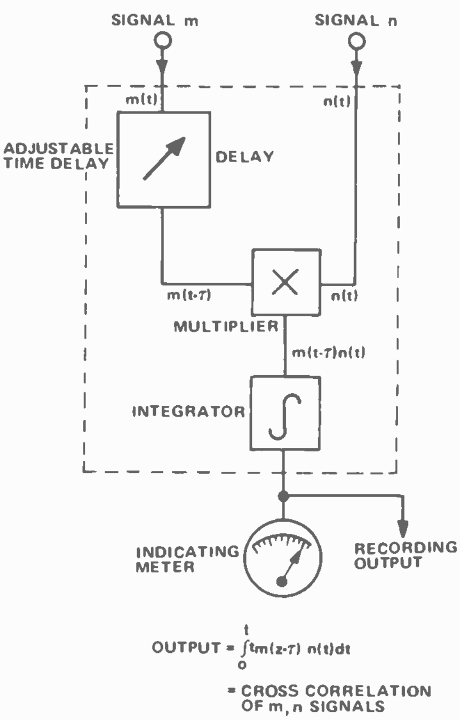


Fig. 16. Block diagram of the mathematical function performed by a correlator unit.

Hewlett-Packard system, for example (shown in Fig.14), displays over 500 points as a matrix of O's or 1's on a CRO screen. These instruments are used to debug, test or trouble-shoot complex digital circuits. Only large laboratories, however, would be able to justify the cost of such advanced logic analysers.

Pulse-height analysers (Discriminators) – Measurement processes involving ionising radiation and sometimes light-intensity levels rely on pulse counting, the pulses appear as rapid electrical currents produced from a photo-multiplier or ionisation detector. The relative amplitude of a pulse often distinguishes it from pulses from other sources. For example, different radio-active isotopes produce pulses of different energy, enabling an assay of radio-active mineral to be made by a study of occurence of pulses of different height. Photons arising from the various noise sources in photo-multipliers have different energy from those generated at the photo-cathode. This is a true detection process: noise can be reduced by discrimination of pulse heights.

Pulse height analysers use carefully selected trigger levels to accept only those pulses (for counting) that arise from the particular source of interest. Pulses above the trigger window, or below are rejected (not counted) as demonstrated in Fig. 15.

CORRELATORS

Correlation as a physical process can be visualized by considering two identical optical patterns formed on film transparencies. When the two are exactly overlaid, the maximum transmission of light occurs. At any other position the light transmission falls off to a minimum at greatest misalignment. The mathematical process modelling this is that whereby the two patterns (represented as formulae) are multiplied together and the multiplicand signal is averaged as depicted in Fig. 16. This process is repeated using a slightly different spatial (or timewise) phase-shift between signals each time the sums are performed The same idea of correlation applies for time-domain as well as space-domain signals. When two identical 'patterns' are compared in this way it is called auto-correlation. When two patterns that are not identical are compared it is cross-correlation. Correlation brings out any similarity as a peak in the correlator output when the greatest degree of correlation is achieved.

Early correlators used entirely analogue methods to carry out the signal processing. Today, correlators mainly use digital techniques in the manner shown schematically in Fig. 17. The two inputs are converted from analogue to digital form in the quantizers. One channel is progressively delayed by storage in a shift register. Multiplication and

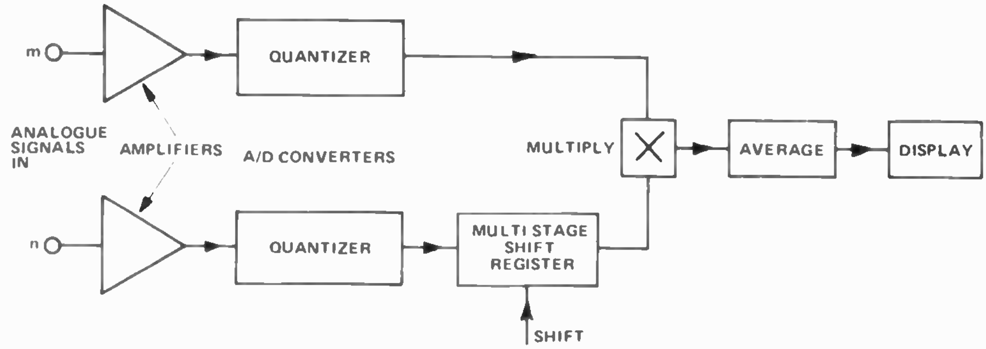


Fig. 17. The simplified block diagram of an auto correlator.

averaging are also achieved by digital methods.

Correlation finds use in the detection of periodic signals buried in noise; in establishing the degree of coherence between random signals; in establishing transmission time and source of transmission of a signal; in identifying the characteristics of a complex system (the input is perturbed with a noise-like signal which is cross-correlated with the output to give the transfer functions of the system). It is a particularly powerful tool and we should see more of its use if the cost of digital correlators continues to fall.

SYNTHESIZERS

These are a special kind of signal generator in that the signal output is formed by addition of a number of sources or by manipulation of a single, stable-reference frequency. A music synthesizer provides a whole range of musical sounds by combining many different tones into a single output. Although synthesizers work upon basic analogue signals the trend is to combine or modify the signals using digital control.

The advantages offered are (in the variable frequency generator kind of synthesizer) that a very stable reference oscillator has its frequency translated to (literally) billions of other values (the HP 8660 gives 10 kHz-2600 MHz) whilst retaining high stability. By pressing digital-key inputs, any chosen frequency value is generated. It is also possible to control the output via a programmable BCD digital input. Programming enables an enormous range of signals to be synthesized, a typical requirement being as part of an automatic test procedure. Figure 18 shows the philosophy of the HP 3330 series of automatic synthesizers with a typical programme card marked up for a frequency sweep routine.

Digitally-controlled power sources may be used to synthesize varying voltage (or current) levels over a test period at the commands of a mini computer in the same way as the above unit synthesizes frequencies.

Frequency and voltage synthesizers are often combined in the hybrid-computer (digital and analogue combined) in order to generate synthesized signals which are needed

a.

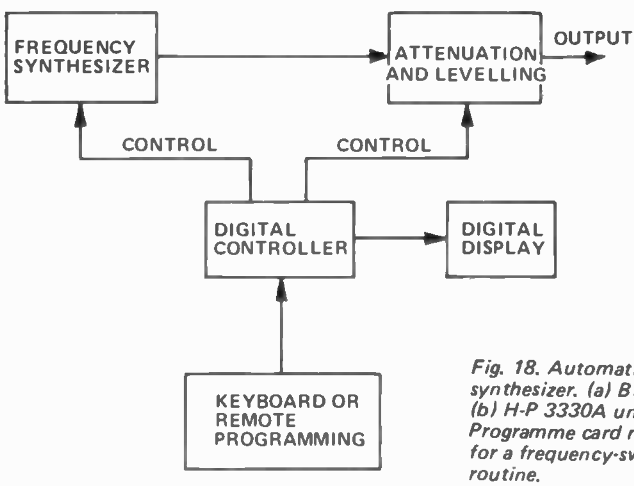
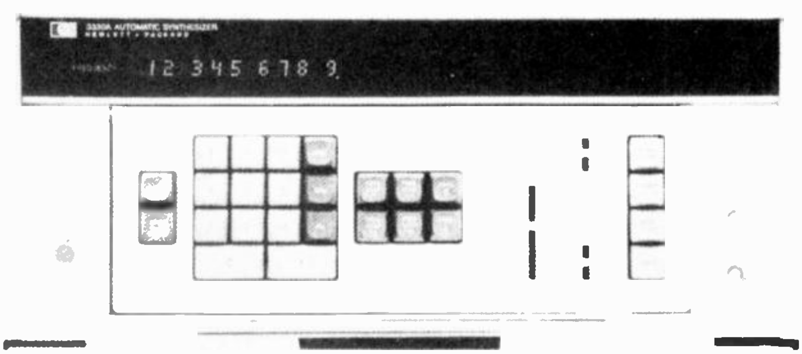
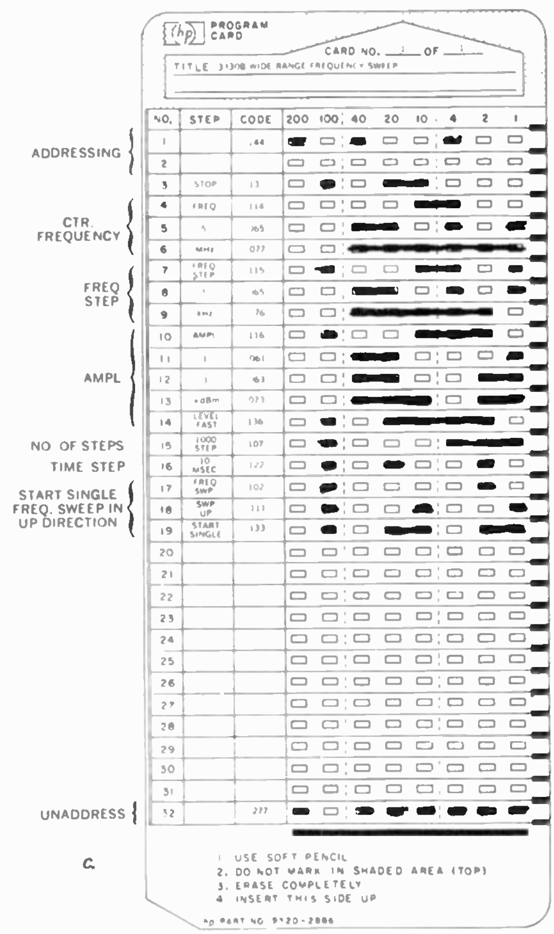


Fig. 18. Automatic frequency synthesizer. (a) Block diagram. (b) H-P 3330A unit. (c) Programme card marked up for a frequency-sweep routine.

b.





c.

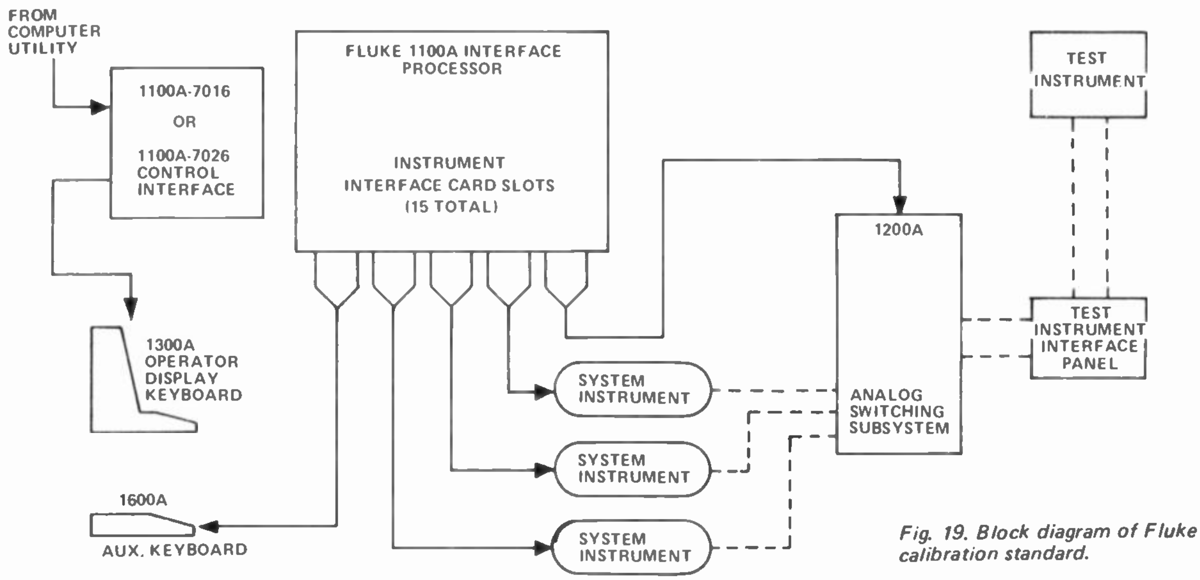


Fig. 19. Block diagram of Fluke calibration standard.

to derive a simulation of a complex system, such as a missile in flight.

COMPUTER CONTROLLED TEST SYSTEMS

With the enormous increase in complexity of routine complex processes (such as aircraft instrumentation and controls, refineries, automatic and large-volume manufacture of electronic systems) came the need to improve and speed-up the testing procedures needed to check out the thousands of different parameters involved. Computer controlled testing is far more reliable than human operator testing and is extremely fast. It can be economic even for the testing of small volume electronic equipment, especially where a large range of tests is involved.

The instrument or process to be tested is interfaced to the main test console which usually incorporates a wide range of facilities that are chosen with flexibility of operation in mind. Figure 19 shows an automatic system used to calibrate a test instrument. The test programme must be devised by a highly-trained professional designer, but once developed and programmed the testing can be performed by a less trained person.

It is not possible here to deal in depth with automatic testing as the range of requirements and equipment available are both great. The overall concept and scope of an automatic test system is shown in Fig. 20. Suffice to say very complicated automatic testing systems are in routine use in a wide variety of manufacturing and maintenance situation.

Further reading:

Digital Sensors — these are variously described in the many general books on sensors but rarely as digital concepts, specifically. Recent releases are:

"Transducers in measurement and control" — P.H. Sydenham, UNE Publishing Unit, Armidale, 1975 (Available ETI).

"Transducers in Industrial Measurement" — P.H. Mansfield, Butterworths, London, 1973.

"Analysers — detail is available in the data sheets and journals of companies such as Marconi Instruments, Hewlett-Packard, Tektronix, Honeywell, Spectral-Dynamics, Bruel and Kjaer and others.

"Counting Photons", ETI, November, 1974 and "Electronics in Medicine — Pt. 2" ETI, August, 1975, dealt with pulse-height analysis.

Hewlett-Packard offer a series of varied booklets on Spectrum Analysers, as well as video tapes. Application Note 150 provides basic understanding.

Synthesizers of the music kind are discussed in "Electronics in Music", F. C. Judd, Neville Spearman, London, 1972. A complete project of a music synthesizer was covered in articles in ETI beginning October, 1973. Part 1 contains reference to digital control of the synthesis process.

Manufacturers' data sheets are a source of reference to both laboratory synthesizers and programmable dc power supplies (which are also referred to as programmable power — DACs).

Auto Testing Systems have been described in a number of ETI articles. "Computer-interfaced instrumentation in the Development Laboratory", April 1972 discussed the potential. ●

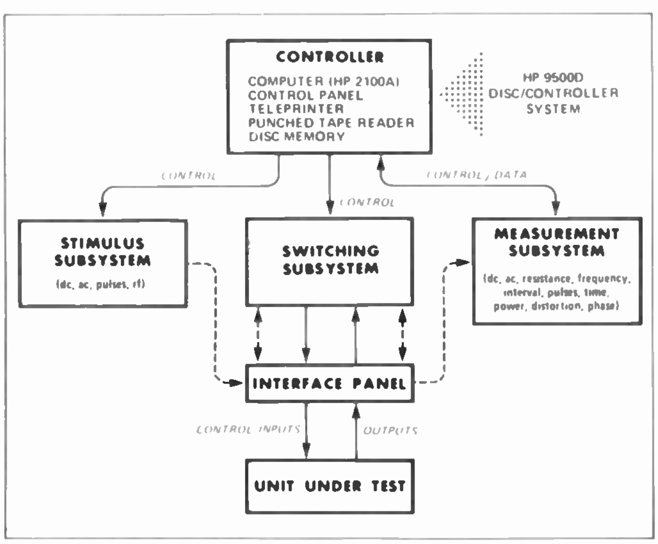


Fig. 20. Overall concept of HP9500 series of automatic test systems.

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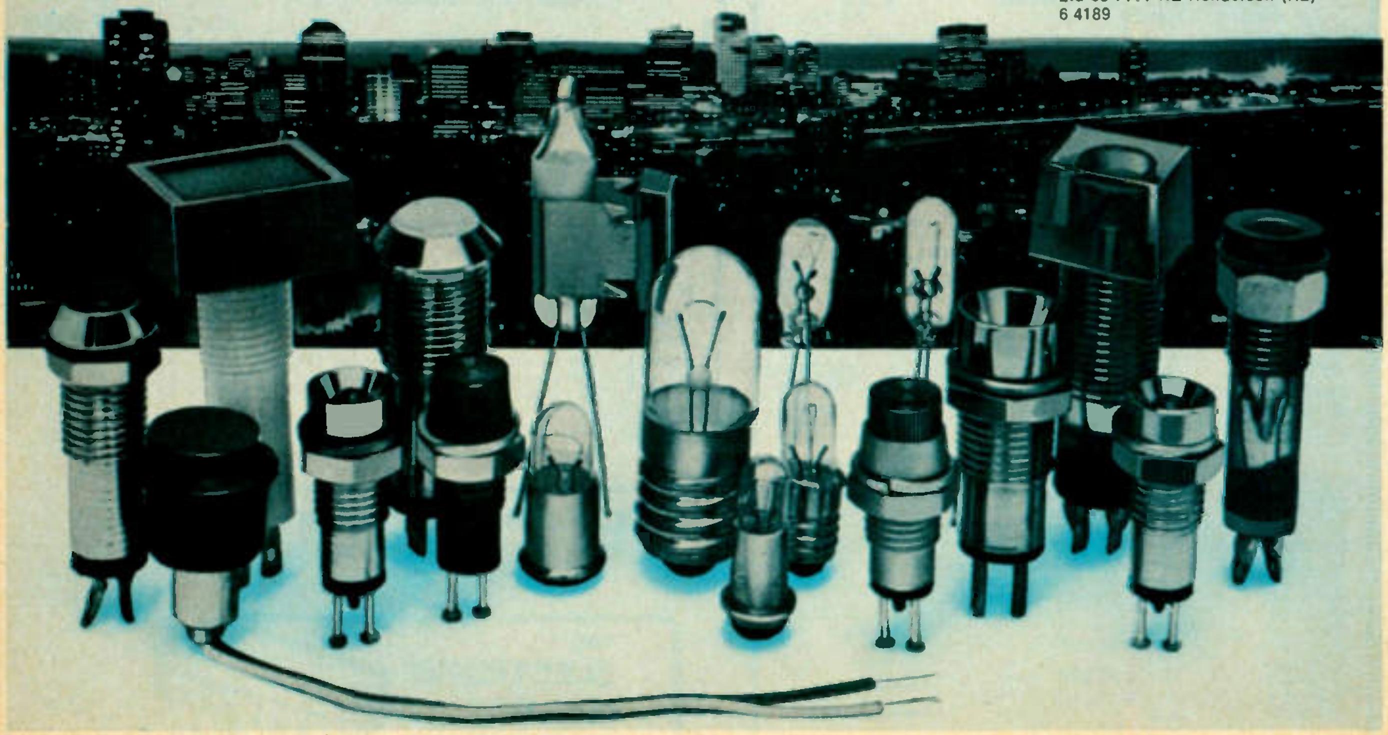

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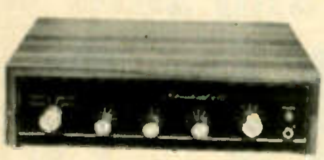

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Ideas for experimenters

As the name of this section implies, these pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory.

Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we produce constructional details.

Electronics Today is always seeking material for these pages. All published material is paid for — generally at a rate of $5 to $7 per item.

STORING CMOS IC'S

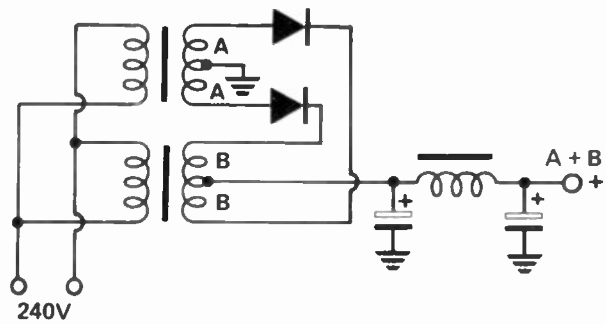
CMOS IC's can easily be damaged by constant handling. One method to overcome this problem is to wrap the I.C. in foil thereby ensuring that all the pins are shorted together. One disadvantage of this method however is that with several devices in the same drawer each one must be unwrapped to find out what it is. The method I have been using with complete success is to cut up a piece of polystyrene sheet, (a ceiling tile is quite satisfactory) to fit my component drawer, then wrapping it in aluminium foil.

The I.C's can then be pushed through the foil into the polystyrene Not only are all the pins shorted but the I.C's can be easily identified.

COMBINING TRANSFORMERS

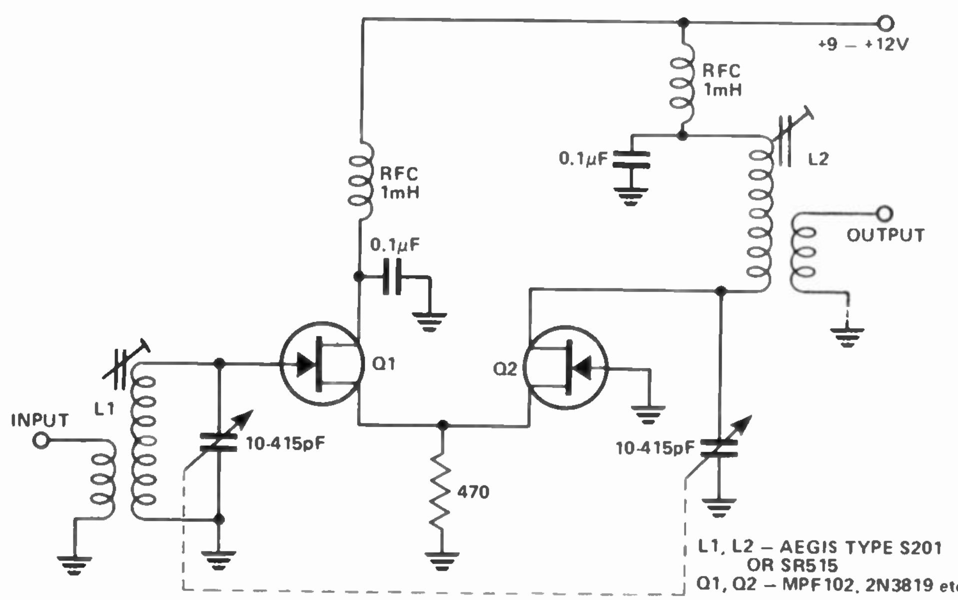
We all need power supplies from time to time . . . unless you work for Union Carbide!

Two unlike power transformers cannot usually be connected together, in series that is, to obtain a higher dc output voltage from a power supply as no centre tap is then available. And as bridge rectifiers are not always convenient in such cases the following circuit should be of interest.



The transformer on the positive side must have sufficient insulation breakdown voltage to handle the combined voltages. Current capacity of each should be sufficient for requirements. The rectifiers should have a peak inverse rating greater than the combined voltages. Transient protection is best placed across the primary side. The transformers must of course be correctly phased or the output will be reduced. Phasing is best accomplished in the primary circuits.

BROADCAST BAND PRESELECTOR



A preselector is very useful for broadcast band DX listening or for improving reception in country areas. It provides extra front-end selectivity as well as improving sensitivity. The circuit given here is simple to construct and performs very well. The coils L1 and L2 are locally available but other types made for broadcast band RF or antenna applications are suitable. L1 and L2 should be mounted no closer than 150 mm to each other to avoid RF feedback and possible instability although they are shielded.

Special Readers' Offer

CORVUS

Because of exceptionally high reader interest this offer originally made in our March issue is now extended to May 10th 1976.

Advanced Scientific Calculator

$99-50*

THE CORVUS 500 is an advanced scientific calculator similar in many ways to Hewlett-Packard's HP-45 and Texas Instruments' SR 51. This is understandable as Corvus was the calculator division of Mostek — the people who made the microprocessor chips for the HP 45 and HP 35 calculators.

A comparison of the three calculators is contained in Table 1 below. As can be seen the Corvus has quite remarkable capabilities for its (special offer) price. In addition the Corvus 500 is one of the most attractive and well styled units we have yet seen.

The Corvus 500 uses Reverse Polish notation and a four level stack to perform its calculations in either fixed point (number of decimal places displayed is selectable) or scientific display mode (10 digits plus two digit exponent).

In addition 12 digit floating operation is possible — which automatically changes to scientific notation if 12 digits overflow. Thus sin 20° is calculated as 0.342020143328!

The valid exponent range in scientific notation can extend from +199 to -200 whilst still obtaining a correct answer in the mantissa (leading figures of exponent not displayed). When exponent overflows the display flashes cyclically. The flashing warning may be deleted by pressing the clear flag once — whence calculations can be continued with the calculated number, or the x register may be completely cleared by pressing the clear key for a second time.

The Corvus 500 has flexible statistical functions. It is possible to sum two sets of data simultaneously (x and y registers). The sum and standard deviation of the x sum are called up by keyboard command, as well the number of x entries can be found in memory 7, the sum of x^2 in memory 8 and the sum of x in memory 9.

The percentage calculations offered are very useful. The two keys % and Δ% may be used to calculate percentage difference, percentage mark-up or discount and gross profit margin. The Reverse Polish mode of operation makes these calculations particularly straightforward.

CRITICISMS

The handbook supplied doesn't really do justice to the machine's capabilities. Like most of its kind it's almost adequate but has a few surprising omissions.

The machine's 62 functions are controlled by 30 keys. Because of this it is necessary to use the calculator fairly frequently to remember the various sequences. This criticism is of course applicable to other machines of this type.

Because the display reads out to 12 digits, transcendental and log functions take about three seconds to complete — it's a trade off between time and accuracy.

SUMMARY

The above criticisms relate to only minor drawbacks in a calculator which is flexible, extremely accurate and much less expensive than others with similar capability.

We thoroughly recommend this powerful advanced scientific calculator. It is excellent value for money.

COMPARISON OF ADVANCED SCIENTIFIC CALCULATORS

FEATURES	CORVUS 500	T.I.SR 51	HP 45
Type of Display	LED	LED	LED
Digits in Display	14	14	14
Fixed Decimal	to 9 places	to 8 places	to 9 places
Rechargeable	Yes	Yes	Yes
Type of Logic	RPN	Algebraic	RPN
No. Keys	30	40	35
+, −, X, ÷	Yes	Yes	Yes
Trig	Yes	Yes	Yes
Inverse Trig	Yes	Yes	Yes
Range of Trig	Full Circle	Full Circle	Full Circle
log x, LN x	Yes	Yes	Yes
e^x	Yes	Yes	Yes
10^x	Yes	Yes	Yes
Hyperbolic Functions	Yes	Yes	Yes
Degrees/Radians	Yes	Yes	Yes
Grads	No	No	Yes
Y^x	Yes	Yes	Yes
$x^n \sqrt{y}$	Yes	Yes	No
x^2 x $\frac{1}{x}$ nx	Yes	Yes	Yes
x!	Yes	Yes	Yes
x ex y	Yes	Yes	Yes
%, Δ %	Yes	Yes	Yes
Gross profit margin	Yes	No	No
Σ + Σ −	Yes	Yes	Yes
Mean/standard deviations	Yes	Yes	Yes
Variance	No	Yes	No
Random No. Gen	No	Yes	No
Linear Regression	No	Yes	No
Slope/Intercept	No	Yes	No

FEATURES	CORVUS 500	T.I.SR 51	HP 45
Vector Addition/ Subtraction	Yes	No	Yes
No. Memories	9	3	9
Memory Exchange	Yes	Yes	No
Permutations	No	No	
Scientific Notation	Yes	Yes	Yes
π	Yes	Yes	Yes
Change Sign	Yes	Yes	Yes
Stack Operation	Yes	No	Yes
Rotate Stack	Yes	No	Yes
Recall Last x	Yes	No	Yes
CONVERSIONS			
Degrees — Radians	Yes	Yes	No
Degrees — Grads	No	Yes	No
Polar — Rectangular	Yes	Yes	Yes
Deg/Min/Sec — Decimal	No	Yes	Yes
Litres — Gallons	Yes	Yes	Yes
Centigrade — Farenheit	Yes	Yes	No
Centimetre — Inches	Yes	Yes	Yes
Kilograms — Pounds	Yes	Yes	Yes
Mils — Microns	No	Yes	No
Feet — Metres	No	Yes	No
Yards — Metres	No	Yes	No
Miles — Kilometres	No	Yes	No
Miles — Nautical Niles	No	Yes	No
Acres — $Ft.^2$	No	Yes	No
Fluid Oz. — Litre	No	Yes	No
Fluid Oz. — CC	No	Yes	No
Ounces — Grams	No	Yes	No
Short Ton — Metric Ton	No	Yes	No
BTU — Calories	No	Yes	No
Voltage Ratio — dB	No	Yes	No

Data supplied by manufacturers of Corvus unit.

* plus $2.50 post and packing

CORVUS 500

"THE SCIENTIST/ENGINEER'S PROBLEM SOLVER"

WITH REVERSE POLISH NOTATION

. . this new entry to the scientific field offers the ultimate package—the efficiency and simplicity of Reverse Polish Notation, a powerful 4-register stack with nine memory registers, a 12-digit display for exacting accuracy, (scientific format of 10-digit mantissa, 2-digit exponent), total capability in scientific functions plus additional capabilities in statistics, conversions, and business

Clear
Clear display
Add, subtract, multiply, divide
Scientific display format
  10-digit mantissa,
  2-digit exponent
  floating decimal
Mode set to radians
Fix decimal point (0-9) in display
Sine
Cosine
Tangent
Hyperbolic sine
Hyperbolic cosine
Hyperbolic tangent
Memory store, 9 registers

Memory recall, 9 registers
Memory exchange, 9 registers
X ↔ Y exchange
Common log
Natural log
4-stack register
Rotate stack
Recall last X
Y to the X power
Reciprocal for all values, exponent range from −199 through +200
Pi
Change sign
Square root
Factorials

Summation plus (adds X and Y to memory for vector addition recalls sum of X and sum of Y)
Percentage
Percentage difference (Δ%)
Mean
Standard deviation
Centigrade to fahrenheit
Liters to gallons
Centimeters to inches
Kilograms to pounds
Degrees to radians
Set radian mode for trigonometric functions
Trigonometric rectangular to polar
Hyperbolic rectangular to polar

THESE FUNCTIONS ARE OBTAINABLE THROUGH THE INVERSE CALCULATION SEQUENCE:

Business display format, 12-digits floating decimal point
Arc sine
Arc cosine
Arc tangent
Arc hyperbolic sine
Arc hyperbolic cosine
Arc hyperbolic tangent
Xth root of Y

Gross profit margin percentage
Summation minus for vector subtraction
Anti log, natural (e^x), for all values from −230 through +230
Anti log, common (10^x), for all values from −99.9 through +99.9

Trigonometric polar to rectangular
Hyperbolic polar to rectangular
Set degree mode for trigonometric functions
X^2
Fahrenheit to centigrade
Gallons to liters
Inches to centimeters
Pounds to kilograms

OTHER FEATURES:

Display number (X) times 10 to ±100 power as 0 X-99
Display indicator for radian mode (decimal in right most LED)
Trig/Hyperbolic accuracy near angle 0 (and 90 degrees)
Anti-logarithm and logarithm accuracy near 0 and 1 respectively
Nickel-cadmium rechargeable batteries, AC adapter/charger, carrying case included. Six hours operation on full 12-hour charge

Corvus calculators are marketed in Australia by Unitrex Pty Ltd, 414 Collins St., Melbourne.

NOTES
The Corvus 500 is warranted for a period of 12 months from original purchase date — under normal use and service — against defective materials or workmanship. Defective parts will be repaired or replaced at Unitrex's option when the calculator is returned prepaid to Unitrex of Australia Pty Ltd., 414 Collins St, Melbourne, Vic 3000. The warranty is void if the calculator has been damaged by accident or misuse. Removal or alteration of serial number or repair by unauthorised personnel also voids warranty." The warranty contains the entire obligation of Unitrex of Australia Pty Ltd and no other warranties, expressed, implied or statutory are given — this warranty does not exclude limit restrict or modify any condition or warranty implied by the Trade Practices Act 1974, or other State laws or Acts . . .

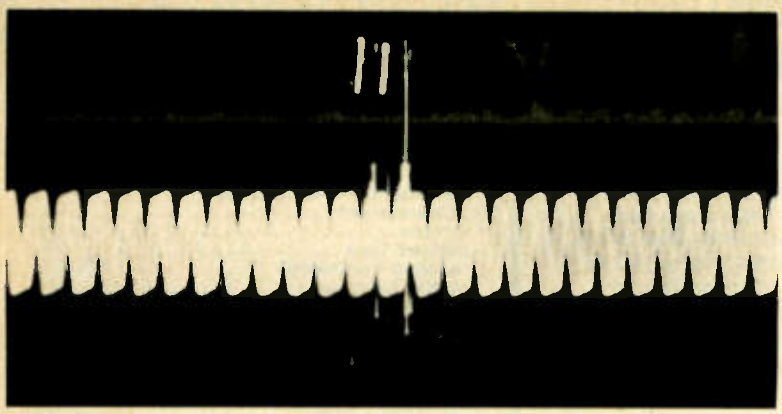
Price includes sales tax. Authorized purchasers may obtain units tax free ($86.32 + $2.50 post and packing) if a valid tax certificate is supplied.
The units can only be obtained as below. Electronics Today International cannot supply directly nor can undertake to demonstrate or discuss details of the units offered.
All units will be thoroughly inspected before despatch. The package should be carefully inspected before accepting delivery. Acceptance should be refused if the package is damaged.
Orders must be addressed exactly as per the coupon. Due to postal delays, readers should expect a delay of between three to four weeks between posting an order and obtaining delivery.
Finally — in the event of the unit not working — please return it directly to Unitrex, 414 Collins St, Melbourne, Vic 3000. NOT to ETI. This offer now closes on May 10th, 1976.

Corvus Offer

Name . . . .
Address . . . .

Please forward . . . . Corvus 500 Calculator/s. My cheque/postal note for . . . . is attached. Make cheque/postal note payable to Corvus Offer. Please forward $102 (i.e. $99.50 plus $2.50 postage and packing) per unit.

Send to Corvus Calculator Offer
c/- Electronics Today International
15, Boundary St., Rushcutters Bay, NSW 2011.

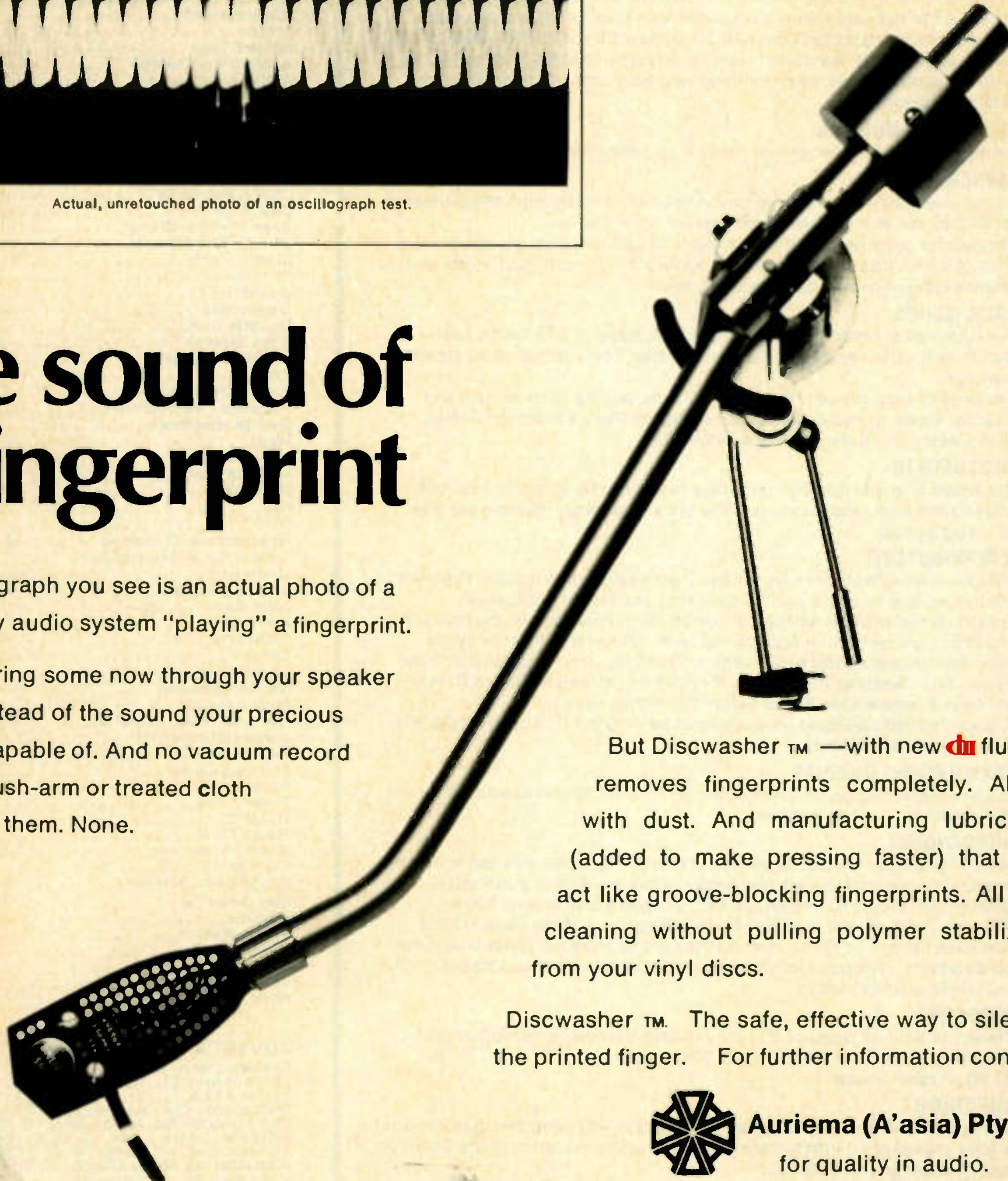


Actual, unretouched photo of an oscillograph test.

the sound of a fingerprint

The oscillograph you see is an actual photo of a high-quality audio system "playing" a fingerprint.

You're hearing some now through your speaker system. Instead of the sound your precious discs are capable of. And no vacuum record cleaner, brush-arm or treated cloth will remove them. None.



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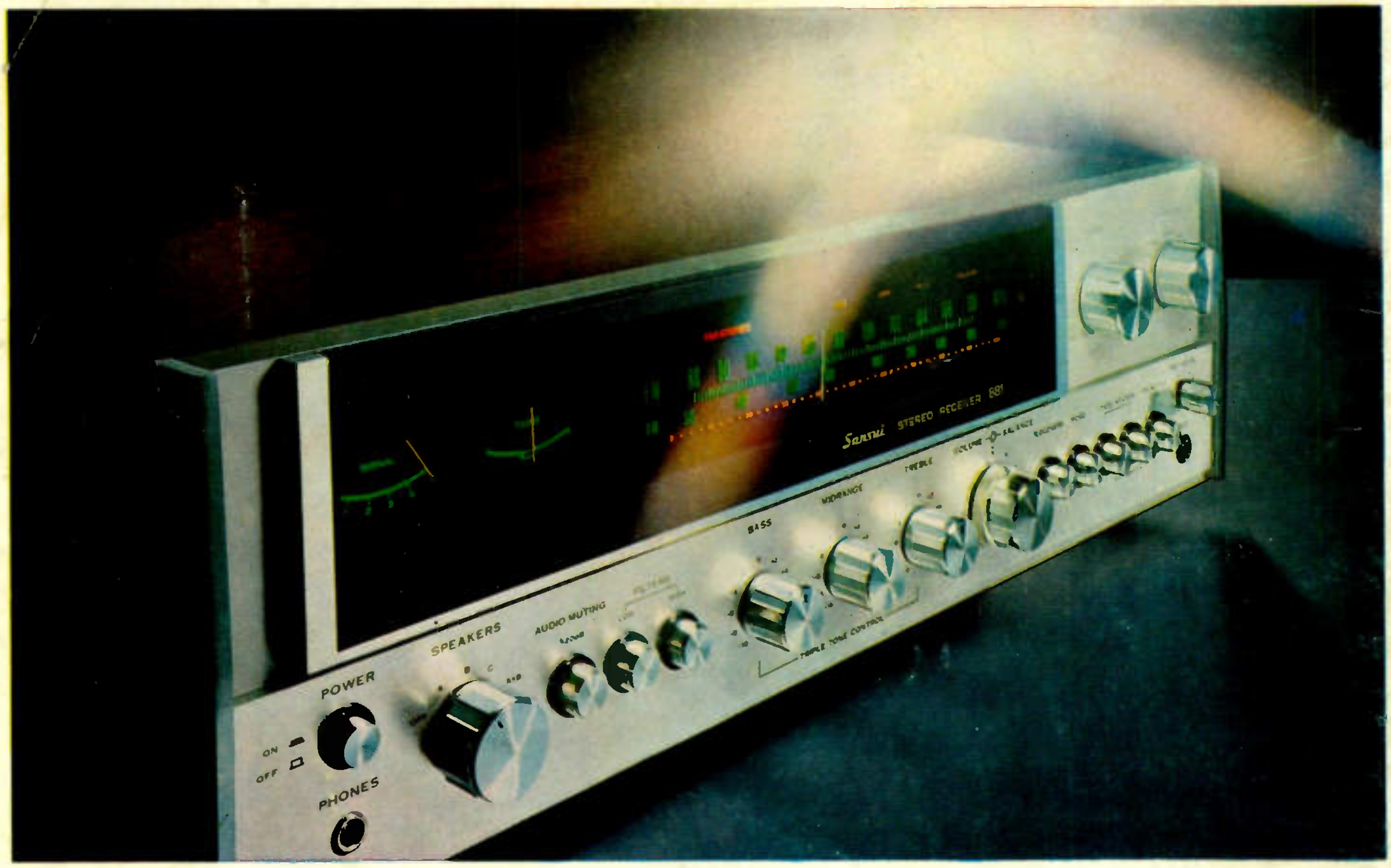

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