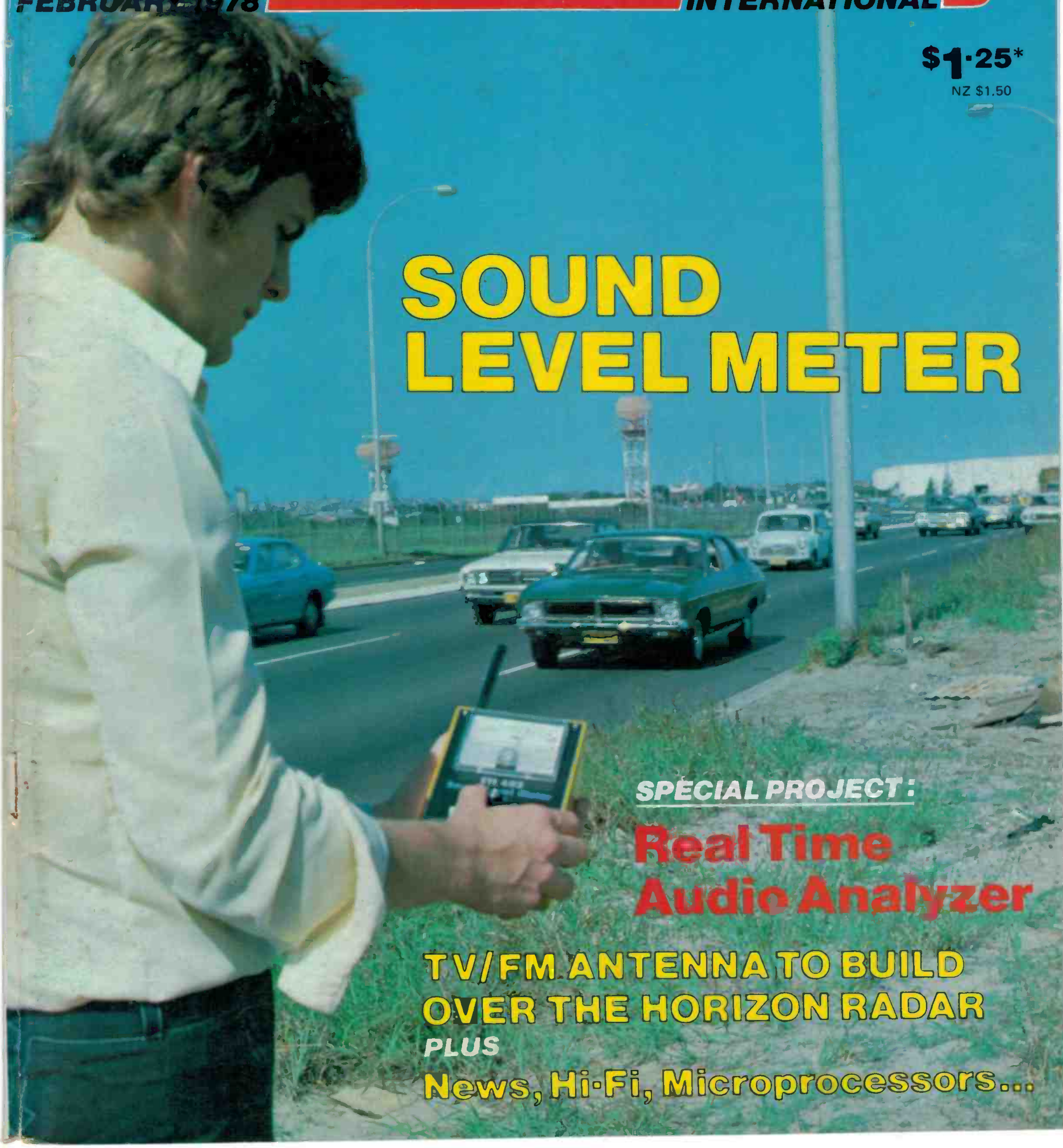
SPECIAL OFFER: TDK NECKLACE

electronics today INTERNATIONAL

FEBRUARY 1978

$1·25*
NZ $1.50



SOUND LEVEL METER

SPECIAL PROJECT:

Real Time Audio Analyzer

TV/FM ANTENNA TO BUILD

OVER THE HORIZON RADAR

PLUS

News, Hi-Fi, Microprocessors...

AUSTRALIAN OWNED AND PRODUCED

February 1978 Vol. 8 No. 2

electronics today INTERNATIONAL

Editorial: Les Bell

Publisher: Collyn Rivers

We regret that, due to space restrictions, we have had to postpone the final description of the 588 Theatrical Lighting Controller rack until the March issue. All specialised components used in this project should be available by that time.

Cover: We took the 483 Sound Level Meter out for various trials, including measuring traffic noise.

PROJECTS

FEATURES

NEWS & INFORMATION

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Registered for posting as a publication – Category B

News Digest

New BASIC Compiler

December 31, 1977, Los Angeles, California — Futuredata Computer Corporation has announced the availability of a Universal BASIC Compiler to run on 8080, 8085, 6800 and Z-80 microprocessors. In addition to being the first truly universal compiler, the Futuredata BASIC Compiler includes a high level debugger that allows program debugging without dealing directly with assembly language.

All standard BASIC statements are included plus string variables, array variables, bit functions, PEEK, POKE, INP and OUT functions. The user is also permitted to intermix assembly language instructions directly in the BASIC program. The Debugger allows the user to set and clear breakpoints with BASIC statement numbers and to display variables in memory using the BASIC variable name.

Futuredata BASIC has the option of outputting an assembly language source code of the compiled program to an editor file. Each BASIC statement becomes a comment in the assembly listing. The compiled assembly instructions follow the BASIC statement. This allows the user to optimize sections of the program by directly editing the assembly language after compilation.

The Futuredata Universal Compiler is especially well suited for developing programs for real-time process control and test equipment. The Compilers run in systems with at least 32K bytes of memory and are available for any of Futuredata's disk-based MICROSYSTEMS — the MICROSYSTEM/20 with dual 5" minifloppy disks, the MICROSYSTEM/30 with dual 8" floppy disks, or the MICROSYSTEM/32 with dual 8" double-sided, double-density floppy disk. Each MICROSYSTEM comes complete with an 8080, 8085, 6800 or Z-80 processor, a 960 character CRT-display, a 53-key ASCII keyboard, memory peripherals, full operating software and a full set of manuals.

Price: Universal BASIC Compilers — $300 each. Availability: stock to 30 days. Manufacturer: *Futuredata Computer Corporation, 11205 So. La Cienga Blvd., Los Angeles, CA 90045. Telephone: (213) 641-7700. Sales contact: R. Schaaf, Director of Marketing.*

Tektronix Digital Latch

As an extension of its logic analyzer the 16 channel DL 502 Digital Latch enhances the user's ability to make asynchronous measurements by latching pulses as narrow as 5 ns and amplitudes as small as 500 mV centered on a threshold set by the user.

The DL 502 plugs into any TM 500 Mainframe/Power Module. The digital latch is conveniently interfaced to the TEKTRONIX LA 501W Logic Analyzer with both housed in a TM 500 Mainframe. The DL 502 can also be used in a TM 500 Mainframe for convenient connection to the TEKTRONIX 7D01 Logic Analyzer in a configuration such as the popular TEKTRONIX 7603 Oscilloscope/7D01F Logic Analyzer/Display Formatter combination. The TEKTRONIX P6451 low capacitance data acquisition probes connect to the DL 502 which then interfaces to either the 7D01 or LA 501W Logic Analyzers. Further information from Tektronix Australia Pty. Ltd., 80 Waterloo Road, North Ryde, NSW 2113 (or local offices).

Due for a Fall

Amidst widespread concern following the re-entry of a Russian satellite over Canada, H.H. Sargent, chief forecaster for the US National Oceanographic and Atmospheric Administration (NOAA) has predicted that the days of the Skylab space station are also numbered — and are fewer than hitherto believed. Increased solar activity, as the sunspots increase, will cause ionisation and consequent expansion of the atmosphere thus increasing orbital drag at Skylab's altitude. Although many authorities are predicting sunspot numbers of 110 or less, H.H. Sargent's prediction is of a sunspot maximum number of 154, with peak activity during the first half of 1980.

432 MHz World Record Broken!

On the evening of 11th January, Les Jenkins VK3ZBJ and Wally VK6KZ (ex - VK6ZAA) shattered the existing world distance record for the 432 MHz amateur band.

Les, located at Frankston, near Melbourne, worked Wally who operated portable from a hill 26 miles to the west of Albany. Both stations used SSB, Les running 80 W PEP to a 44 element set of yagis (19.5 dB measured gain) and Wally ran 8 W PEP to an 8 element yagi.

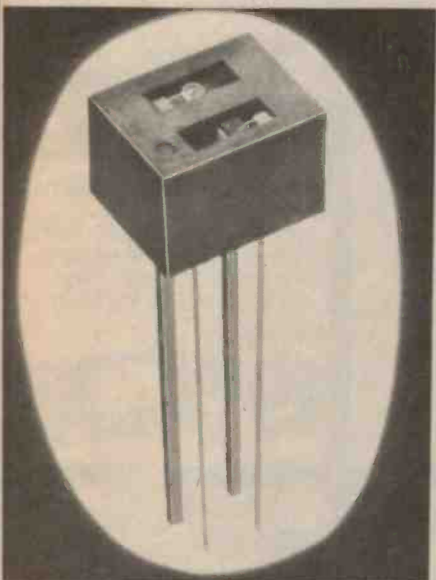
The distance covered is close to 1800 miles.

Reflective Object Sensors

Two new low cost reflective object sensors providing solid state reliability for non-contact sensing applications were announced by Optron, Inc., recently.

Both the new OPB 706 and OPB 707 reflective object sensors are ideally suited for such non-contact sensing applications as paper edge detection, tachometers, motor speed controls, eot/bot sensors, and proximity detection.

The devices combine a high efficiency solution grown gallium arsenide infrared LED with a silicon n-p-n phototransistor (OPB 706) or maximum sensitivity photodarlington (OPB 707) in a plastic package. The photosensor senses radiation from the LED only when a reflective object is within its field of view.



With LED current of 20 mA, the output of the OPB 706 is typically 750 μA when the device is positioned 0.050 inch from a 90% reflective surface. Under similar operating conditions, the output of the OPB 707 is typically 35 mA.

A built-in light barrier in both devices prevents response to radiation from the LED when there is not a reflective surface within the field of view of the sensor. With no reflective surface, the maximum sensor output due to cross-talk between the sensor and LED is 0.200 μA and 10 μA for the OPB 706 and OPB 707, respectively.

Technical data on the new OPB 706 and OPB 707 reflective object sensors is available on request to:

Namco Electronics,
239 Bay Street,
Brighton North 3186

Magnetic necklaces from TDK

Everyone even remotely involved with audio knows of TDK. They're the General Motors of the recording industry and respected worldwide for the integrity of their engineering.

Imagine our surprise then when we were told that TDK are marketing a magnetic necklace specifically intended to alleviate 'stiff shoulders and necks' – but when a company like TDK produce such a product they must be taken seriously.

TDK state that whilst it is generally believed that the cause of 'stiff shoulders' is mental and bodily stress, the exact reasons for the symptoms are not totally known. Nor is it understood how or why an applied constant magnetic field alleviates the symptoms.

There is nevertheless a great deal of evidence that the devices do work. They have for example been approved by the Japanese Ministry of Health and Welfare (approval number 51B-614). Prof. T. Yamamoto (Juntendo University, Tokyo) reports . . . with patients whose main complaint was stiffness in the shoulder, the necklaces were found to be significantly effective by 65-70 per cent (P 0.05).

Kyoichi Nakagawa (Director, Isuzu Hospital, Tokyo) states, 'Effectiveness of the magnetic necklace was found at the rate of 82.1 percent – 96.3 per cent on the probability level one percent to subjective symptoms. No disadvantageous side effect has been found . . . '

Akio Hirose (Medical Faculty, University of Tokyo) states . . . no detailed explanation of how it works is available . . . but as proved from our experiment magnetic necklaces are effective against 'stiffness' and we believe no side effects are caused (the experiment referred to involved blind sampling with 198 participants using TDK necklaces and 'dummy' necklaces having some minor magnetic field – Ed).

TDK's magnetic necklaces look just like normal jewellery. Nevertheless, the necklaces contain rare earth cobalt magnets originally developed for the NASA space project and having permanent life. They are about five times more powerful than ferrite magnets used in previous magneto-therapeutic devices. Field strength is a massive 1300 gauss but when worn the necklaces feel no different from a conventional piece of jewellery.

TDK magnetic necklaces are handled in Australia by the Caldor Corporation and that company has arranged to make the necklaces available to our readers at $49.95 including postage and packing. The offer is spelt out in greater detail on page 94 of this issue.

Thousands of people have used these necklaces and claimed they have experienced relief of 'stiffness' – however we must make it absolutely clear that there is no totally tangible scientific evidence to support or refute any claims or statements made although research is continuing worldwide. Therefore as no claims can currently be substantiated (and of course no claims are made by us or Caldor) – the ultimate decision and experience must be yours.

Nevertheless, the necklaces are made by TDK and that must mean something.

Hitachi Pull Out

Hitachi Ltd. is no longer selling CB radios in the US under its own name, but is continuing to supply to some US companies such as Radio Shack (Tandy) Sears and J.C. Penney. A spokesman for Hitachi said that their CB radio plant was being kept open not just to supply the US firms, but because the company was looking to Australia as a new market.

Meanwhile, RCA is 'carefully pruning' its CB product line while it studies the CB market to 'make our determination as to what our long-range posture in this business should be'.

Addendum

Somehow, the parts list of the 40W Stripline Broadband Amp got missed out last month. We reproduce it here, with apologies to frustrated readers.

Parts List – 40W Stripline Amp

Cin	680-1000p ceramic
C1, C4	47p metal-clad mica cap
C2, C3	100p metal-clad mica cap
C5, C8	two each 200p metal-clad mica caps
C6	200p metal-clad mica cap
C7	82p metal-clad mica cap
C9	150p metal-clad mica cap
C10	68p metal-clad pica cap
C11	33p metal-clad mica cap
C12	680-1000p button standoff cap
C13, 15, 17	1500p ceramic
C14, 16, 18	1µ 25 or 35 V DC tantalum
R1, R2, R3	15 ohm, ½W resistor
RFC1, 2, 3, 7, 10	printed inductors, on PC board
RFC4, 5, 6	4.7µH moulded RF choke
RFC8, 9	5 turns, 18 or 20 gauge tinned copper or enamel wire, 6mm i.d., 15mm long
SL1–9	50 ohm *stripline*
Q1	CTC B3–12
Q2	CTC B12–12
Q3	CTC B40–12

Low-light TV Camera

A new television camera which sees in the dark could well revolutionise security surveillance techniques and bring new opportunities to engineers, scientists and naturalists. It is the RCA Type TC 1040H closed circuit ISIT (intensified silicon intensified target) camera. AWA Rediffusion, jointly owned by Amalgamated Wireless (Australasia) Limited and Rediffusion of Great Britain, are exclusive agents in Australia for RCA closed circuit TV products.

The camera "turns night into day" in conditions where artificial light is not permitted or does not exist. The RCA ISIT camera tube ensures that bright highlights on the scene will not cause excessive blooming which results in useful picture information being obscured.

With the four billion to one automatic light range when using an fl. 4 auto-iris lens, full 24-hour operation is possible from starlight to full sunlight, scene illuminations being 2.7 by 10^{-5} foot candles for a usable picture. A single C/mos chip generates CCIR sync with phased locked loop synchronising the camera to power line zero crossing. Crystal control is optional. Mechanically, the camera is designed about sturdy die-cast and extruded metal structures making the entire case a heatsink, resulting in cooler operation and full shielding. Printed circuit boards are modular and plug in for convenience. The camera can be supplied in a weatherproof housing if required.

The camera has great possibilities for security work at night. It will also enable naturalists, zoologists and others to study wildlife in natural surroundings during darkness.

Fluke 8020A Update

In our review of the Fluke 8020A digital multimeter (ETI Dec. '77, p.81), we stated that the device was designed to reject 60Hz mains ripple. Elmeasco have informed us that all instruments they supply are designed for 50Hz rejection (they use a different crystal).

ETI/Unitrex Calculator Contest

Congratulations (and a Unitrex calculator) go to Mr. & Mrs. C. Mesnage of Elizabeth South, South Australia, who managed to get the two mobs of sheep in the December contest past each other in only 23 moves (and draw some delightful sketches on the envelope as well). The complete solution is too long to reproduce here; besides, the fun lies in working it out for yourself.

And now, with thanks to I. Rossow, of Bundamba, Qld., here is the February problem:

A rope is hanging over a pulley with a weight at one end and on the other end is a monkey the same weight as the weight.

The weight of the rope is 4 oz per foot; the age of the monkey and that of the monkey's mother combined is four years and the weight of the monkey is as many pounds as the monkey's mother is years old.

The monkey's mother is twice as old as the monkey was when the monkey's mother was half as old as the monkey will be when the monkey is three times as old as the monkey's mother was when the monkey's mother was three times as old as the monkey.

The weight of the weight and the weight of the rope is a half as much again as the difference between the weight of the weight and the weight of the weight and the weight of the monkey.

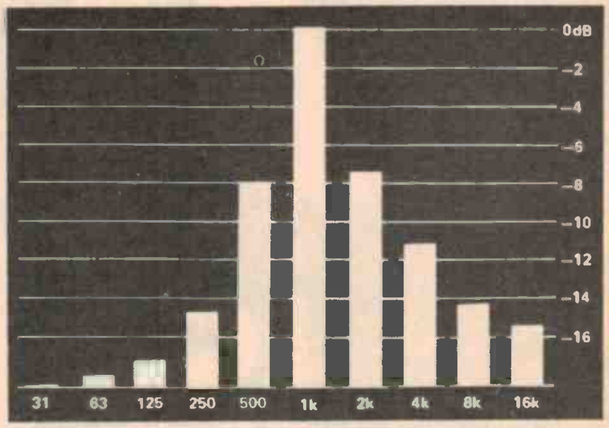
What is the length of the rope?

Seal an empty envelope, write your answer on the back of it, with your name and address, and send it to: Unitrex Calculator Contest (February), ETI Magazine, 15 Boundary Street, Rushcutters Bay, NSW 2011. The closing date is the 17th March.

Erratum

In the December issue, the digital frequency meter prices in the advertisement for J.R. Components (p. 119) were given incorrectly. In kit form, the prices are: for 20MHz version, $82.00; for 200MHz version, $89.50. For assembled and tested units, the prices are: for 20MHz version, $122.00; for 200MHz version, $129.50. We apologise for any inconvenience this error may have caused.

Audio Spectrum Analyser



Equalise systems for room acoustics accurately using this neat piece of 'test' gear.

AUDIO SPECTRUM ANALYSERS can be a valuable tool used in the setting up of a room acoustically with a graphic equalizer such as the ETI 485; to monitor programme material or just as a gimmick to please yourself and friends.

When setting up rooms pink noise is pumped into the room using an amplifier. A microphone is then used to monitor the sound and its output is the input to the analyser. Now by adjusting the graphic equalizer a flat response can (hopefully) be obtained.

Design Features

Spectrum analysis can be done by two main methods. The first is to have a tuneable filter which is swept across the band of interest. The output of the filter, when displayed on an oscilloscope, will be a frequency/amplitude graph of the input. While this gives a well-formatted and accurate display it is not "real time" in that if an event occurs at one frequency while the filter is sweeping elsewhere it will not be recorded. For this reason this method is used normally where the spectral content is constant and the sweep is only over a small percentage of total frequency (such as the output of a radio transmitter).

For real time analysis the frequency spectrum is broken into bands using bandpass filters and the output of each rectified. The output from these rectifiers can be displayed on a CRO as in this project or by columns of LEDs or similar methods. The number of bands and the dynamic range required determine the filters used. In this project where only about 20dB is required a single LC network is sufficient. Another unit we have built (not for a project) uses a 6 pole high pass filter followed by a 6 pole low pass one. This gives a flat response (∓ 1dB) over ∓ ½ octave and is 36dB down 1 octave away. However, it uses 6 op amps and 2% capacitors and resistors in each filter!

If there are sufficient requests for it we will publish a LED version of this unit.

SPECIFICATION — ETI 487

No. of bands	10
Frequencies	31, 63, 125, 250, 500, 1k, 2k, 4k, 8k, 16k
Filter characteristics	−12dB, one octave from nominal centre frequency
Display	CRO in XY mode
Input level	50mV − 10V
Input impedance	200k
Pink noise output	200mV
X output	±− 4V approx
Y output	0V to 10V

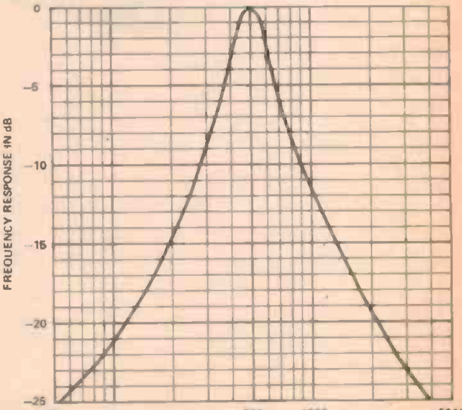
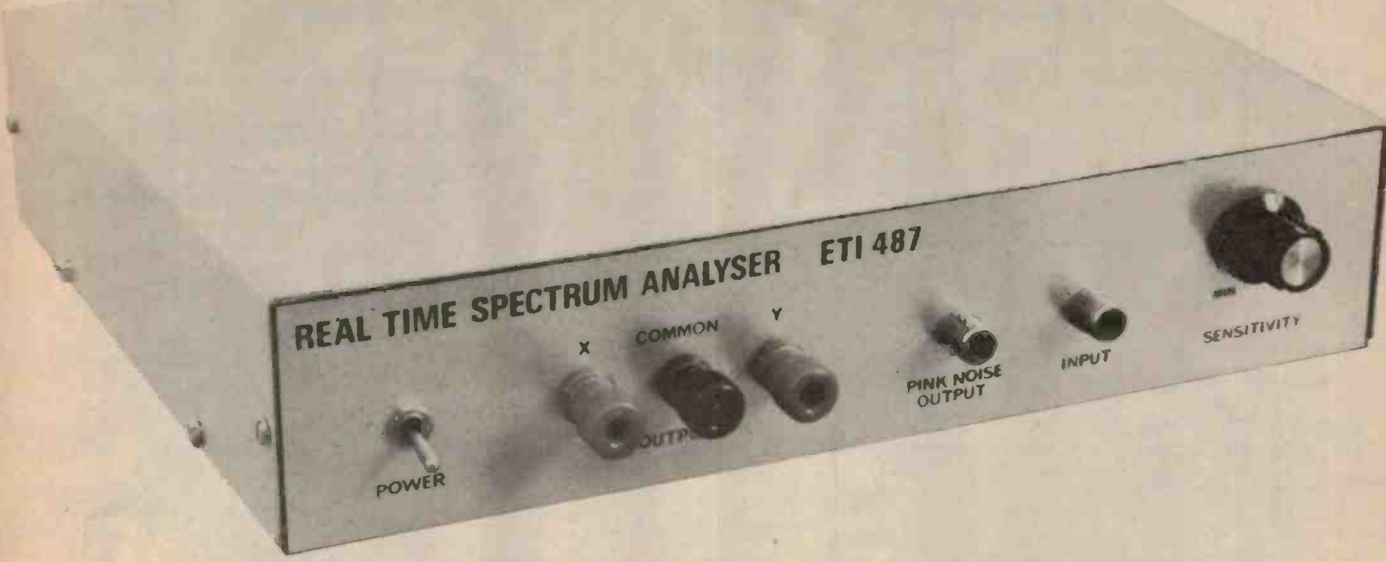


Fig. 1. The frequency response of the 500Hz filter. All other filters follow a similar curve.



HOW IT WORKS – ETI 487

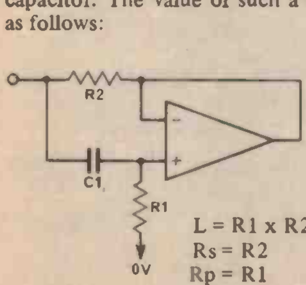
The unit can be broken into eight sections to help the explanation of how it works.

(a) Input amplifier
(b) Ten individual filters and rectifiers.
(c) Ten way analogue switch with decade counter.
(d) Staircase generator controlled by "c". (X output).
(e) Log converter.
(f) Ramp generator and comparator. (Y output)
(g) A pink noise generator.
(h) Power supply.

(a) The input amplifier has an input impedance of 220 k (set by R1) and a gain of 101 ((R3 + R2)/R2). The output of the amplifier drives all ten filters and Q1 and Q2 are used to buffer IC1 to give the drive capability required.

(b) The ten filter-rectifiers are identical except for component values and a bias resistor in the three lowest frequency filters, where tantalum capacitors are used in series. The filter is a parallel LC network which, with a series resistor, gives a band-pass filter.

As large valve inductors are expensive we have used an active one using an operational amplifier, two resistors and a capacitor. The value of such a network is as follows:



L = R1 x R2 x C1 H
Rs = R2
Rp = R1

The frequency response of the networks is given in fig. 1.

The rectifier is a half wave type where the gain is variable from about 4 to 12. A diode from the output back to pin 2 keeps the op-amp in the linear region on the negative half cycle allowing operation up to the 16kHz of the top filter.

(c) The analogue switches IC23/1 – IC25/2 are controlled by IC22. This is a decade counter with 10 decoded outputs, each of which is high only for one clock period. As the analogue switches need a high to switch them on, only one will be selected at any one time.

(d) The output of the decade counter also controls the staircase generator IC28 with the weighting networks R58 – R72 giving equal steps of about 0.9 volts. Resistor R89 provides a bias current and the output of IC28 starts at about +4 volts and steps down in 0.9V steps to about -4.2 volts when the output switches back to +4 volts. This is used to drive the X input of the CRO. To add some width to the vertical lines, IC29/1 and IC29/2 form an oscillator of about 300 kHz and after filtering by R90 and C69 is coupled into the input of IC28 by R91.

(e) The output of the analogue switch is fed to the diode-resistor network (D21 - D26, R73 - R77) which gives a simple log conversion. This method is simple, needs no adjustments and is adequate for the purpose. As there is some loss in this network IC26 is used to provide a gain of three to recover this loss.

(f) The ramp generator is formed by the constant current (12μA) source and capacitor C71. The capacitor can be discharged by IC25/4 and the current source is controlled by IC24/3. The voltage out of the log converter (IC26) can vary between zero and +10 volts and this is compared to the ramp voltage by IC30. The output of IC30 controls the oscillator formed by IC29/3 and IC29/4. When the ramp voltage exceeds the voltage from IC26 the output of IC30 goes high allowing the oscillator to start. This immediately discharges C71 and switches off the current source which causes the output of IC30 to go low again after only about 2μs. Diode D27 ensures however that the oscillator acts as a monostable giving an output of about 6μs to ensure the capacitor C71 is completely discharged. The output of IC29/4 also clocks IC22 which selects the next inut. If the input from IC26 is ever negative and C71 cannot be discharged to less than this voltage, IC29/3 and IC29/4 will oscillate continuously at about 100kHz clocking IC22 until it finds an input higher. This prevents possibility of lockup if the offset voltages of the op-amps all go the wrong way.

(g) White noise is generated by the zener action of Q3 which is reversed biased. It is amplified by Q4 to give 200 mV of white noise on its collector. White noise however has equal energy per unit bandwidth and what we need is pink noise which has equal energy per percentage bandwidth (i.e., equal energy per octave). To convert white to pink we need a filter at 3 db/octave. This is performed by IC27 with the RC networks providing the necessary curve.

(h) The power supply is a simple rectifier type with IC regulators to give stable supply voltages.

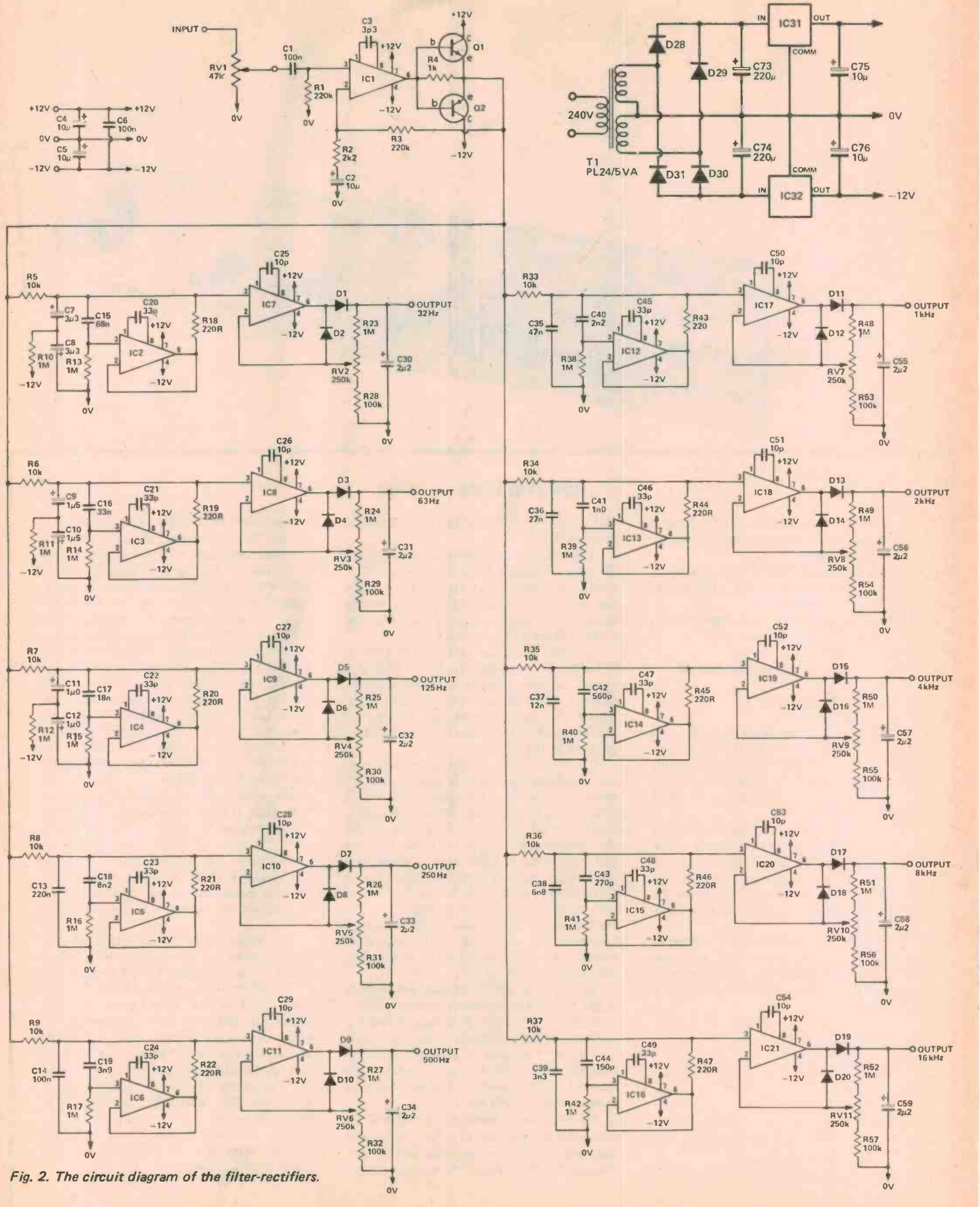


Fig. 2. The circuit diagram of the filter-rectifiers.

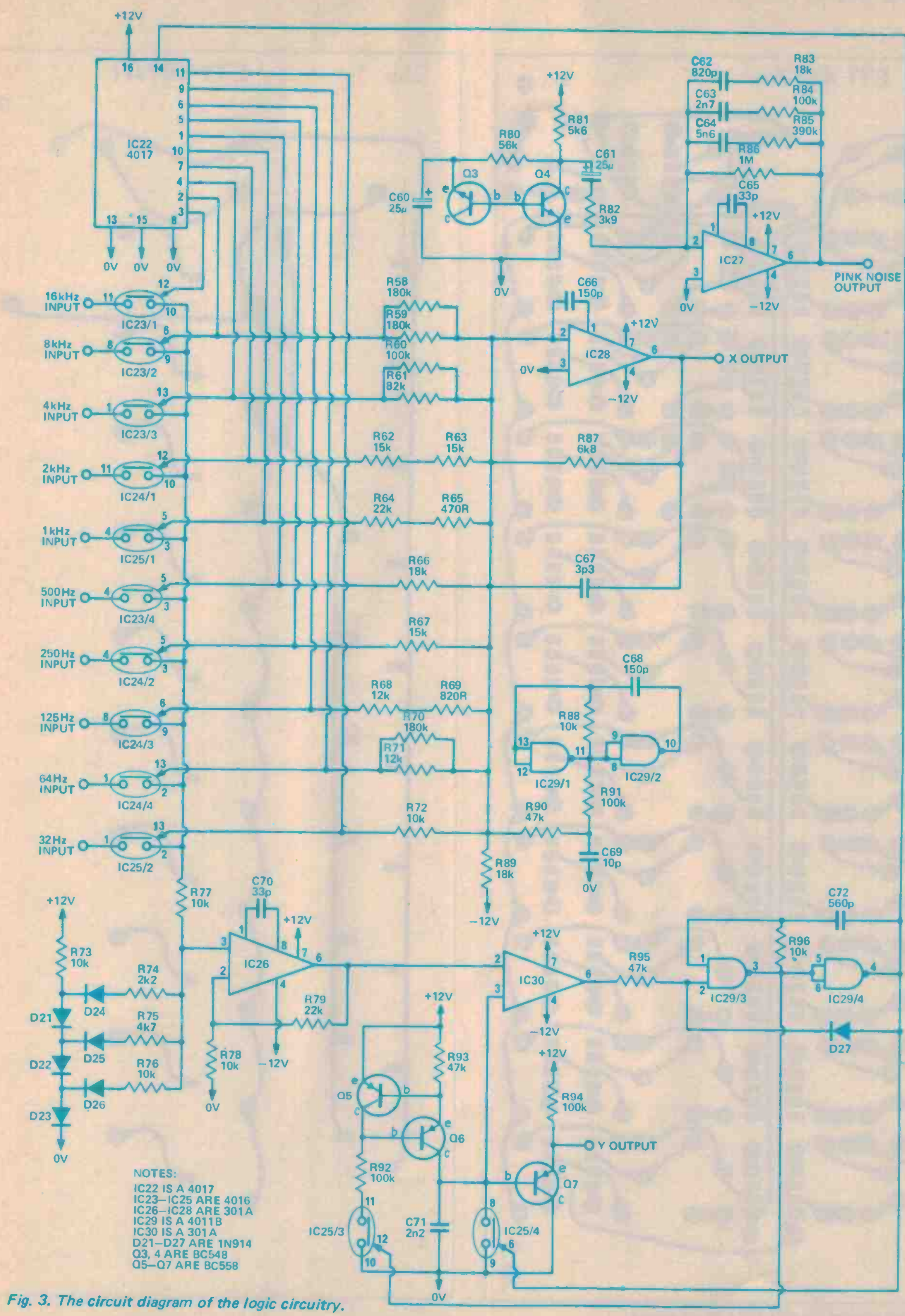
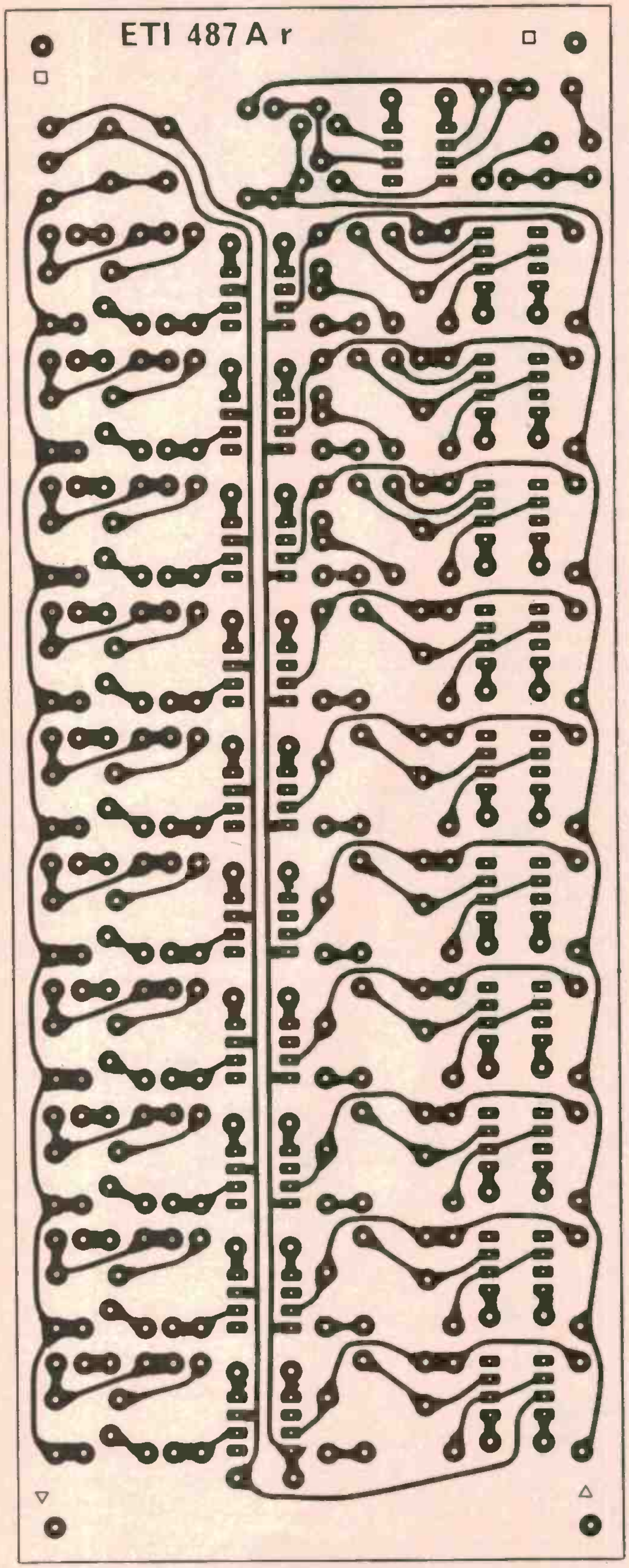


Fig. 3. The circuit diagram of the logic circuitry.

Description continued on page 88.



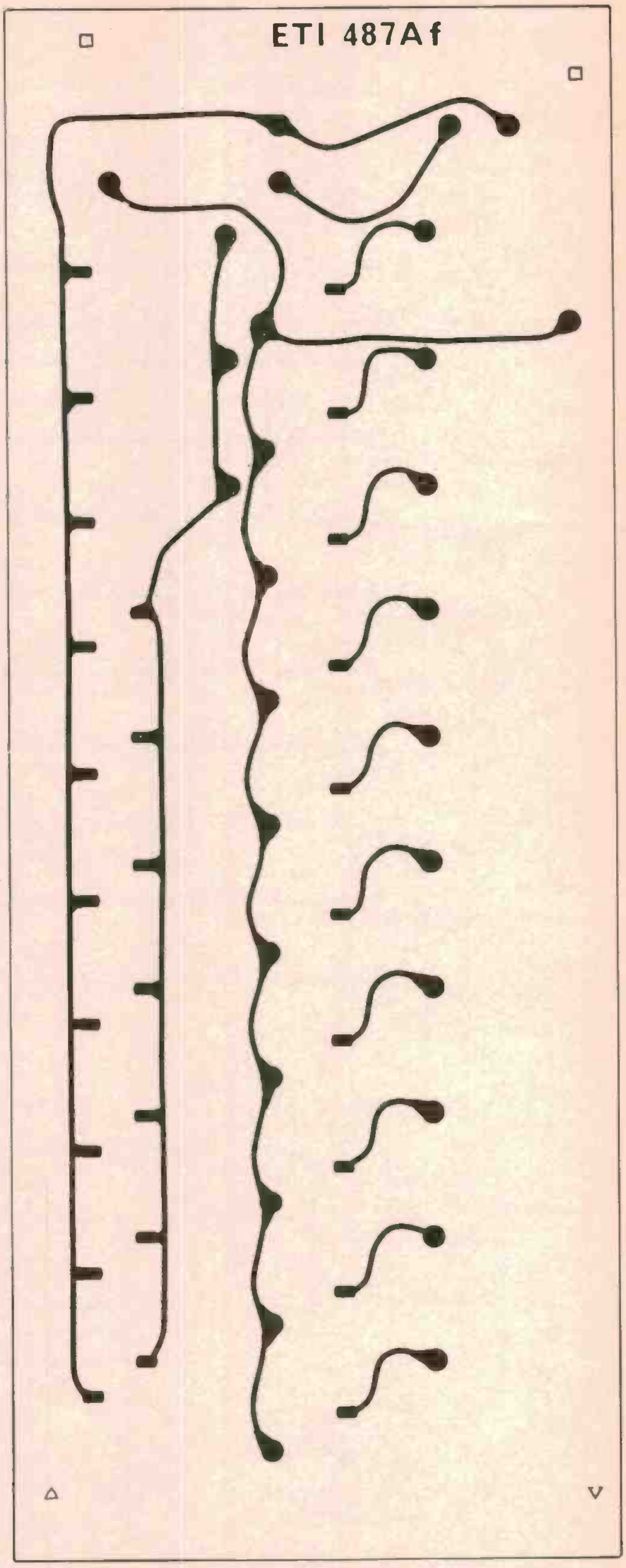


Fig. 4. Both sides of the ETI 487A board shown full size. See page 90 for details on making negatives from this page.


AUTOMATIC CrO2 TAPE SELECTOR
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Compact Cassette
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DOLBY
Printed in Japan
SA-C90 TDK.
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REW
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Rehearsals have ended. This is the real thing. Early this year, Ampex professional quality cassettes and tapes will be available from selected retailers. Ampex — well worth waiting for.

Photographed at Alberts Studios — Sydney
Recording Engineer — Bruce Brown
ACT O1C

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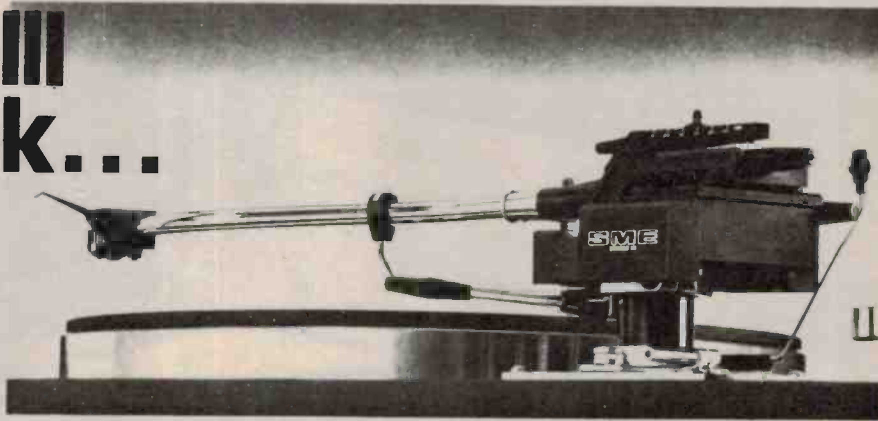
SOUND

SME Series III a close look...



by John Gardner

IN WHAT TO SOME WAS the 'golden age' of audio, when valves glowed merrily in crude-looking amplifiers, and sound emanated from an enormous loudspeaker in the corner of the room, there was a perfectionist who loved high fidelity. His search for the ultimate in audio led him naturally to focus critically on the currently available pickup arms. Nothing he saw pleased him and, being something of an engineer, he decided that he could make one far better than any that had so far been made. Thus it was that in 1959 a Sussex firm, Scale Model Engineering, produced a limited number of pickup arms for the pleasure of the managing director and a select group of his friends. After that the inevitable happened and in 1960 the first series of SME pickup arms appeared on the market. The Series II followed in 1962 and the Series II (Improved) in 1972.

Following the Rolls Royce tradition, SME have long proclaimed, proudly and unrepentantly, that theirs is 'the best pickup arm in the world'. This type of arrogant claim makes some reviewers and countless competitors all too eager to stick a spanner in the works: not an easy task in the early days because there was no rival to the Series II. When the Series II (Improved) first appeared the opposition had hardened and the SME, although still predominant in the pickup field, was hotly pursued by several aspiring champions.

Narrow Margin

Recently there has been a tendency in some quarters to 'write down' the SME in favour of other arms. This is not because the SME is any less good than it was, but because the margin between the leading makes is so narrow now as to be non-existant. An ideal time, in fact, to launch the Series III SME pickup arm.

Any resemblance between the Series III and its predecessors is, as they say, purely coincidental, but those of a conservative taste will be glad to know that production of the Series II will continue indefinitely. Seven years of development work went in to the new arm, during the course of which one version was abandoned as the cost of manufacture would have made it prohibitively expensive. Not that the Series III is cheap; at $318 in Australia, it is the tool of a perfectionist.

Gone is the J-shaped aluminium tube, gone is the elegant headshell and gone are the cylindrical counterweights. In their place, an S-shaped arm of titanium, a skeletal headshell of carbon fibre and a clever system of weights concealed in mouldings of glass-reinforced nylon. Retained are the pulley-and-weight bias compensator, the bed plate and the lateral bearing with adjustable pillar. The knife-edge fulcrum bearing is similar to that of the Series II but it is now angled with respect to the arm so that the cartridge moves in the same vertical plane as the bearing. On the J-shaped arm of the Series II, movement of the headshell vertically, appeared as a twisting motion at the knife edges, which some critics claimed was unsatisfactory. It would perhaps be more accurate to say that it was not perfect.

The New Design

Mounting details are exactly as for the previous arms and the Series III will fit any existing mounting board ready-drilled to receive an SME arm. The titanium 'carrying arm', as it is designated by SME, is very much smaller in diameter than any of their previous arms. SME say that titanium was chosen because it has the strength-to-weight ratio required, the tube being both light and rigid, with a nitrogen hardened skin and a soft fibrous core. Lightness is, of course, important as it minimises the effective mass of the arm; whilst rigidity is essential as the arm must not transmit mechanical vibrations. Other materials were tried for the arm, including carbon fibre, but it was found that for this application it was less suitable than titanium. The S-shape was adopted because it was convenient geometrically and it was felt that a straight arm could act as a torsion spring. Presumably a manufacturer who uses straight carbon fibre arms would counter the above argument but we cannot comment at present as we have not had an example for review.

The previous SME arm had the option of either a detachable or a fixed headshell. The detachable one is convenient and allows cartridges to be interchanged quickly but the coupling adds to the effective mass. The fixed head version is extremely awkward for changing cartridges but does have the advantage of lower mass. In the new arm we have the best of both worlds; the headshell itself is fixed but the entire carrying arm is a push fit into a socket close to the fulcrum. A connector in this position adds insignificantly to the effective mass. The logic of this arrangement is impeccable; slightly less acceptable is the $46 which a spare carrying arm costs. This should commend to us all the wisdom of selecting a cartridge that we like and sticking to it!

TECHNICS PRESENTS ITS CREDENTIALS.

Technics offer superb sound recording and reproduction in a range of front-loading hi-fi cassette decks—all packed with practical, purposeful features.

The RS 615 US credentials include super permalloy head, timer recording/playback facilities and the Dolby* NR system to reduce tape hiss to imperceptible levels. There are two large, easy-to-read VU meters, three-position tape selection and an electronically controlled DC motor which assures a high degree of stability in tape transport.

Models RS 630 US and RS 671 US have separate bias and equalization selectors assuring optimum recording quality with any type of cassette. Auto-stop mechanism, lockable pause button and the exclusive Technics HPF head are incorporated.

With a choice of three models, there's one that's compatible with your system . . . and pocket.

RS 615 US:—Wow and flutter: 0.10% (WRMS) ± 0.20% (DIN). **Frequency response:** CrO2 tape 30-16,000 Hz; normal tape 30—14,000 Hz. **Signal-to-noise ratio:** Dolby NR in 60dB (above 5 kHz); Dolby NR out 50dB (signal level 250 nWb/m). **Motor:** DC—electronic motor. **Heads:** 1—super permalloy head for rec./playback; 1—ferrite head for erasing. **Dimensions:** 41.0 cm (W) x 14.0 cm (H) x 30.5 cm (D). **Weight:** 6.3 kg.

RS 630 US:—Wow and flutter: 0.09% (WRMS) ± 0.20% (DIN). **Frequency response:** CrO2 tape 20-16,000 Hz; normal tape 20—14,000 Hz. **Signal-to-noise ratio:** Dolby NR in 60dB (above 5 kHz); Dolby NR out 50dB (signal level 250 nWb/m). **Motor:** Electronic speed control motor. **Heads:** 1—HPF head for rec./playback; 1—ferrite head for erasing. **Dimensions:** 41.0 cm (W) x 14.2 cm (H) x 32.1 cm (D). **Weight:** 7 kg.

RS 671 US:—Wow and flutter: 0.063% (WRMS) ± 0.15% (DIN). **Frequency response:** CrO2 tape 20—18,000 Hz; normal tape 20—16,000 Hz. **Signal-to-noise ratio:** Dolby NR in 62dB (at 10 kHz); Dolby NR out 52dB (signal level 250 nWb/m). **Motor:** 2—motor system; 1—electronic speed control motor for capstan drive; 1—DC motor for reel table drive. **Heads:** 1—HPF head for rec./playback; 1—ferrite head for erasing. **Dimensions:** 41.0 cm (W) x 14.0 cm (H) x 33 cm (D). **Weight:** 9.4 kg.

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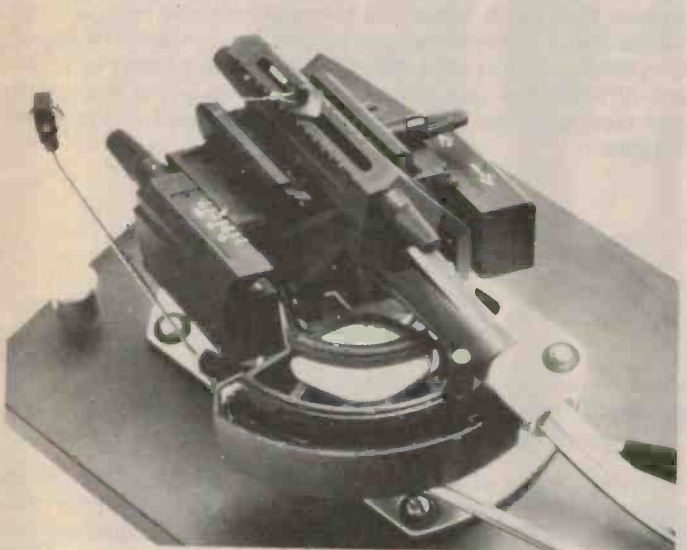
National Technics hi-fi

T77.4

SOUND SME Series III a close look...

The knife-edges, the arm socket and the counterweight framework are all of carbon fibre. The various adjustable weights are of metal encased in black glass-reinforced nylon. The few remaining links with previous designs, the bed plate, adjustable pillar, fulcrum, arm rest and lowering device are of solid metal and have the familiar camera finish.

Most of the counter-balancing is done by adjusting a number of fine-threaded screws with conical, milled heads forming a finger-and-thumb grip. Each screw draws a particular weight along a guide track to its required position. The main counter-balance comprises a weight box with a number of lead and plastic inserts of differing thicknesses. By choosing suitable combinations to pack the box all cartridge weights from 0.1 to 13 grams can be balanced. To achieve the lowest possible inertia, the weight box must always be packed with the heaviest weights close to the pivot. As supplied the box covers the range of cartridge weights from 6 to 10½ grams and so suits a high proportion of cartridges. An auxiliary pack of



two lead and three plastic spacers is provided, and a very clear diagram in the instruction book shows how the box should be re-packed if heavier or lighter cartridges are to be used.

Once the arm is at balance, the required tracking force is set by screwing a rider weight along a channel in the main weight assembly. The rider is marked with a clear numerical scale in ¼ gram steps from 0 to 1.5 grams. On the opposite side of the weight box there is another rider but this one does not have an adjustment screw: instead it can be slid to and fro, and it carries two calibrations, '0' and '+1'. If it is pushed back to the '0' position the tracking force is as indicated by the scale referred to above. In the '+1' position the indicated tracking force is increased by 1 gram, giving a total range of adjustment of 0 to 2.5 grams.

The next adjustment is that of lateral balance, this being necessary because the pickup arm is not straight and the weight of the cartridge applies a twisting force to the arm, so unbalancing the knife edges. To offset this a further screw moves the entire weight box laterally to the left or to the right.

The lateral balance is not too critical and is carried out by using the thread of the bias weight to lift the arm slightly from its bearing, then any imbalance can be detected by eye and compensated appropriately.

Hitherto the fine positioning of the main pillar on the bed plate was done by loosening a pair of hexagonal clamp nuts and sliding the column to and fro until the headshell and cartridge align symmetrically. Then the assembly was slid to and fro until the headshell and cartridge aligned symmetrically with the grid on the protractor provided. The same principle is still employed but there are now no clamping nuts: instead there is a type of rack-and-pinion system. The outer slot on the bed-plate has a series of serrations along its length and what was the clamp bolt is sprocketed to engage with the serrations. The head of the bolt is round but with inset flats for a special thin spanner which is supplied. A small movement of the spanner then drives the pillar along the bed plate. This particular adjustment can be done more easily than it can be described, and the rack-and-pinion system is more elegant and more simple than the previous arrangement.

There is also the benefit that the inner clamp nut is no longer required and this has allowed a further worthwhile design improvement to be made. One problem with the Series II is that the outrigger arm for the bias pulley is secured by the nut. Whenever this is loosened to move the pillar along the bed-plate, the bias thread neatly tangles itself up or else must be unthreaded from the pulley: more of an irritating hindrance than a permanent annoyance. This small criticism is removed on the Series III by the simple expedient of fitting a small holder for the bias outrigger in the position previously occupied by the inner clamp nut. The holder can be moved by finger pressure to angle the outrigger as required, but there is sufficient friction to hold it in a given position.

On the top of the weight box there is a stud which may be moved, by an adjustment screw, along a slot in the moulding. The loop from the bias thread fits neatly over this stud and the slot along which the stud moves is graduated from 0 to 2.5 grams in ¼ gram divisions. Bias compensation is set, as expected by twiddling the screw until the stud lines up with the calibration corresponding to the playing weight.

Fluid Damping

Some months ago a fluid damping system (FD 200) was introduced as an accessory for Series II arms; this damper is supplied with the Series III arm. In a laboratory situation we have been using a pair of arms, one fitted with the FD 200 and one without it. The arms are fitted with matched cartridges and fed to a common replay system. From the tests we have done we have no doubt that the damping system gives an audible improvement in quality. This manifests itself as greater clarity and smoothness of bass response. Fitting of the FD200 to the Series III is optional but strongly recommended. by the manufacturer. If a high compliance cartridge with good tracking properties is used, the benefit of fitting the damper may be less immediately obvious than if a medium to low compliance cartridge is used. However it will be found that in addition to improving the sound quality, the damper also gives considerable protection against external shock or mechanical vibration, and for this reason alone it is worth fitting. Our experience indicates that the damper will be essential for all moving coil cartridges.

For those not familiar with the FD 200, it is basically a crescent-shaped tank filled with a viscous silicone fluid and fitted close to the pickup lowering device. A small paddle is clamped to the pickup arm so that the blade is immersed in the fluid. The idea is that the fluid and paddle inhibit any sudden unwanted movement of the arm, either vertically or laterally, whilst not impeding its slow progress across the record. Thus neither warps nor heavy footed children prevent the stylus from following the groove to the best of its ability.

Setting up the arm is not difficult but it does require a degree of common sense and some manual aptitude. There are now gold plated phono sockets on the base of the column instead of a multi-way socket. It is essential that the flying earth lead on the output cable is connected as instructed. The cable itself has gold plated phono plugs at each end, which gives improved electrical contact. Stereo or CD 4 cartridges may be used but for CD 4 operation a small capacitor must be removed from each phono plug, at the amplifier end of the cable.

The trickiest single part of the assembly is the fitting and filling of the damping device and the securing of the paddle to the arm. Balancing, bias compensation and tracking weight adjustments are more elaborate than any other arm we know but if the manual is followed for a time or two there should be no problem. Incidentally, the manual, as we have come to expect, is a model of clarity with twenty-three pages of text and over sixty diagrams and photographs.

During the evaluation period no difficulties were experienced in everyday usage. Once the cartridge was fitted to the headshell and the arm was plugged in and balanced, there was nothing else to do but sit down and enjoy the music. Several different cartridges were used, the main one being the Shure V.15/III. One disappointment was that the dimensions of the new headshell, having been cut to a minimum, made fitting of the AKG P8ES cartridge very tricky. The AKG has the mounting lugs set forward which means that the body of the cartridge and the terminal pins set well back in the headshell, leaving barely sufficient clearance for the connector tags. We did succeed in fitting the cartridge but not without some risk of damage to the fine connector leads or the terminal pins. No other cartridge we tried gave this problem and it seems a shame that such a superb cartridge cannot be fitted more easily.

Impressions

Only an inexperienced reviewer would endeavour to find any obvious difference in sound quality between the Series II and the Series III pickup arms. Any improvement on excellence will inevitably be slight and therefore difficult to detect. In the end we decided to use the Series III alone for some time and then to re-fit the Series II and see whether we had any impressions worth reporting. A large number of familiar records was played during this experiment and many of them gave no distinct impression. A few we definitely preferred played with the Series III, but in no case did we find a preference in favour of the Series II with any of the records sampled. Obviously there is nothing conclusive about this test but it does give an indication of the kind of margin we are dealing with. Where there was an impression of improvement, it was of more detailed bass and a more overall transparency of sound.

The effective mass of the Series III is 5.05 grams which with a high compliance cartridge gives a theoretical low frequency resonance at 11 or 12Hz: this falls in the 'safe' area below the lowest wanted frequency and well above the highest warp frequency. A low frequency test record designed for locating resonances showed the low frequency resonance to be negligible. Lateral and horizontal bearing friction was so low as to defy measurement with the relatively crude gauges which are available for this purpose.

Whether the Series III at almost twice the price of the Series II is good value for money, is an impossible question. The fluid damper is included in the price of the new arm, which does reduce the differential a little. However, we suspect that this is one of the few reviews where price will not be the major influence on the potential purchaser. The law of diminishing returns says that the Series II is a better buy: the law of perfection says that the Series III is a better engineered and more universal arm. For many people that will settle the argument.

SME Series III Pickup Arm
Price $318
Distributor: Audio Engineers, 342 Kent Street, Sydney 2000

SOUND BRIEFS

Vereker In Australia Julian Vereker, of Naim Audio, the British amplifier manufacturer, paid a short visit to Australia recently. Full report in the near future.

Technics Class A+ We're still awaiting a review sample of this powerful new amplifier, although an explanation of the operation of its output stages leaves us in doubt as to whether the device tends toward Class A or Class B. But of course, what we're most interested in is its audible performance.

Laser record players The big news at the recent Tokyo audio show was a laser record playing system developed by a consortium of major Japanese manufacturers. Similar to proposed designs already developed in Europe and elsewhere, the system apparently works well but poses the question of how long it will be before purely electronic sources will become available.

Entre enters We announced recently the introduction of the Entre moving coil cartridge, and have now heard a sample playing via a Lentek head preamp. Results? Excellent, with first class tracking and a very smooth, clean sound.

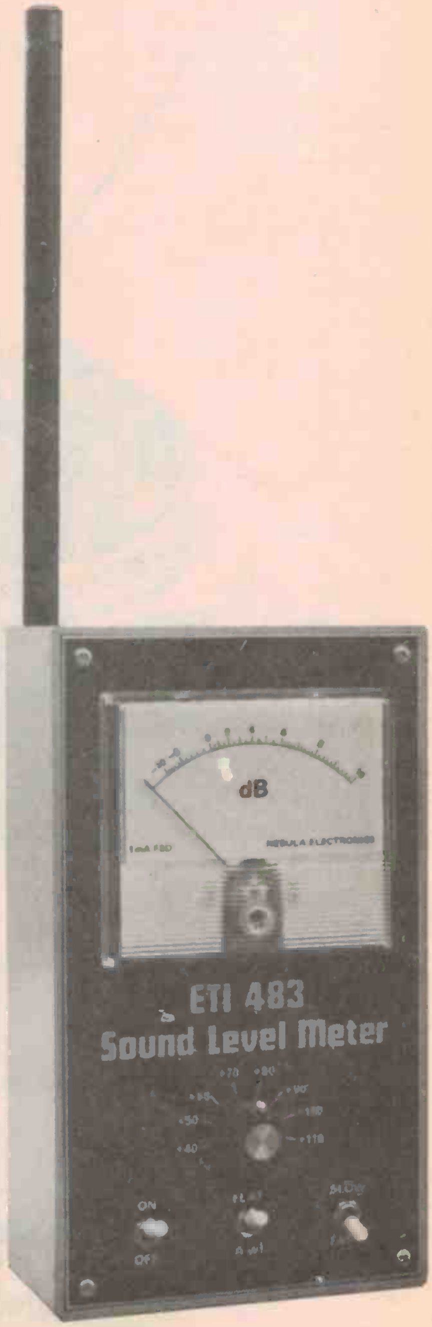
New P77 Garrott Brothers, the Weinz parabolic stylus people, have revised the damping of their excellent P77 cartridge. We're awaiting a sample and should be able to report on the effectiveness of the modification in the next issue.

New arm from ADC A new arm, similar in appearance to the Infinity Black Widow, has been introduced by ADC/BSR. Performance with the new ZLM cartridge seemed excellent to us when we heard the arm on a Linn-Sondek turntable.

HK receiver We've heard news of a new tuner amplifier from Harman-Kardon which is devoid of tone controls and other non-essential paraphernalia. Appearance is reported to be most attractive and claimed performance looks very interesting indeed.

Sound Level Meter

This sound level meter gives accurate results to allow noise levels to be monitored and controlled. An 'A' weight response is provided as well as the 'flat' mode.



THE PUBLIC TODAY is increasingly critical of excessive noise levels. Aircraft like the Concorde, for example, face opposition on grounds of noise levels while jet aircraft of around 1958 were just as noisy but then they were a great advance in science! Public awareness of noise has caused laws to be passed limiting the sound levels which can be produced without prosecution.

However, while it may be good to have a law to say the acoustic output of your party should not exceed 85 dB, how can you tell precisely what the actual level is! If the local constable is called the chances are he will not have a meter and will only be able to give his subjective assessment.

For this reason we have designed this project. It is not a super-duper do-all sound level meter but one which is economical yet gives meaningful results. The microphone used is relatively cheap (about $3.00), but is rugged and has a good frequency response. The microphone used in the B & K sound level meter is delicate and costs a small fortune !

There are many weighting networks used with sound level meters including ones which need a computer to calculate the results. We chose only the two most popular, the "A" weight and flat. The response of the "A" weight filter is given in Fig. 2.

SPECIFICATION – ETI 483

Sound level range	30dB to 120dB
Weighting networks	Flat or 'A' weight
Microphone	Electret
Power supply	9V dc @ 10mA

Calibration

This is a little difficult as a known reference is needed or another sound level meter to match it against. Initially however the "flat" attenuator potentiometer must be adjusted. To do this a 1kHz audio tone or sine wave signal across R1 is needed. Select "A" weight and an appropriate range and note the reading. Switch to "flat" and adjust RV1 to give the same reading.

Calibration is performed by RV2 and is adjusted with a known audio signal. If you cannot calibrate the meter Nebula Electronics Pty Ltd have offered to help. See page 30 for details.

Construction

Assemble the PC board according to the overlay in Fig. 4. The rotary switch can be either of the two popular sizes and can be mounted either with tinned copper wires or by drilling large (3mm) holes in the PC board, through which the leads of the switch can be passed and soldered directly to the tracks. Check when assembling that the wiper contact is in the correct position.

Assemble the front panel and leave the leads to the switches and meter long enough to be able to hinge it forward, as the PC board is mounted in the base of the box. The microphone insert is mounted on the end of a length of aluminium tube well away from the box. This is to help prevent reflections from the box affecting the readings. We attached the microphone using a length of heat shrink tubing over the aluminium tubing.

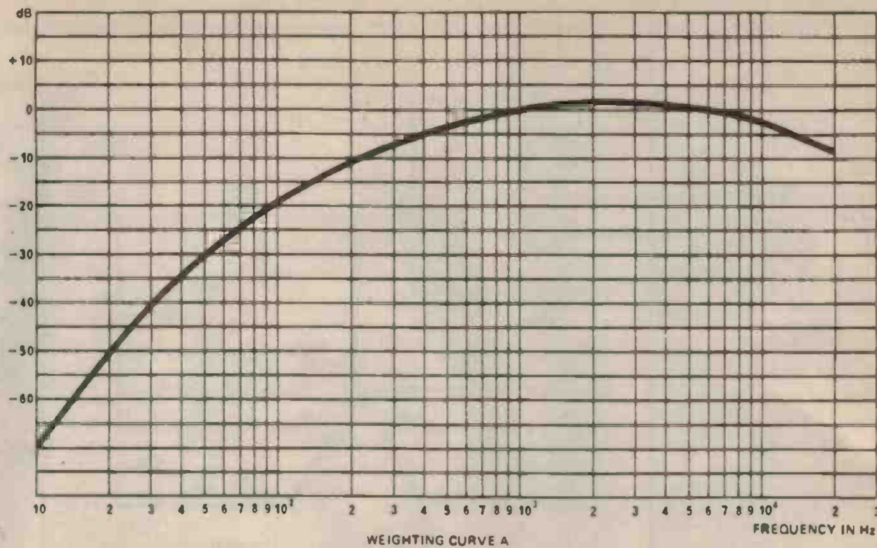


Fig. 2. The response of the 'A' weight filter.

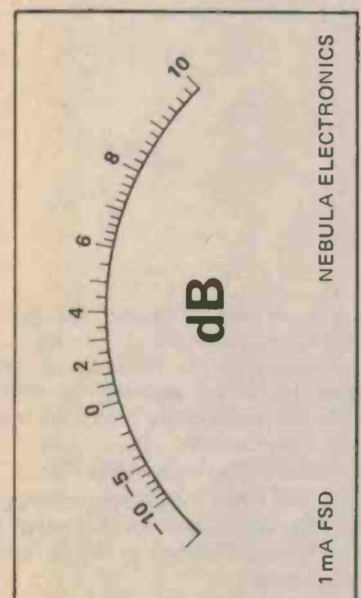
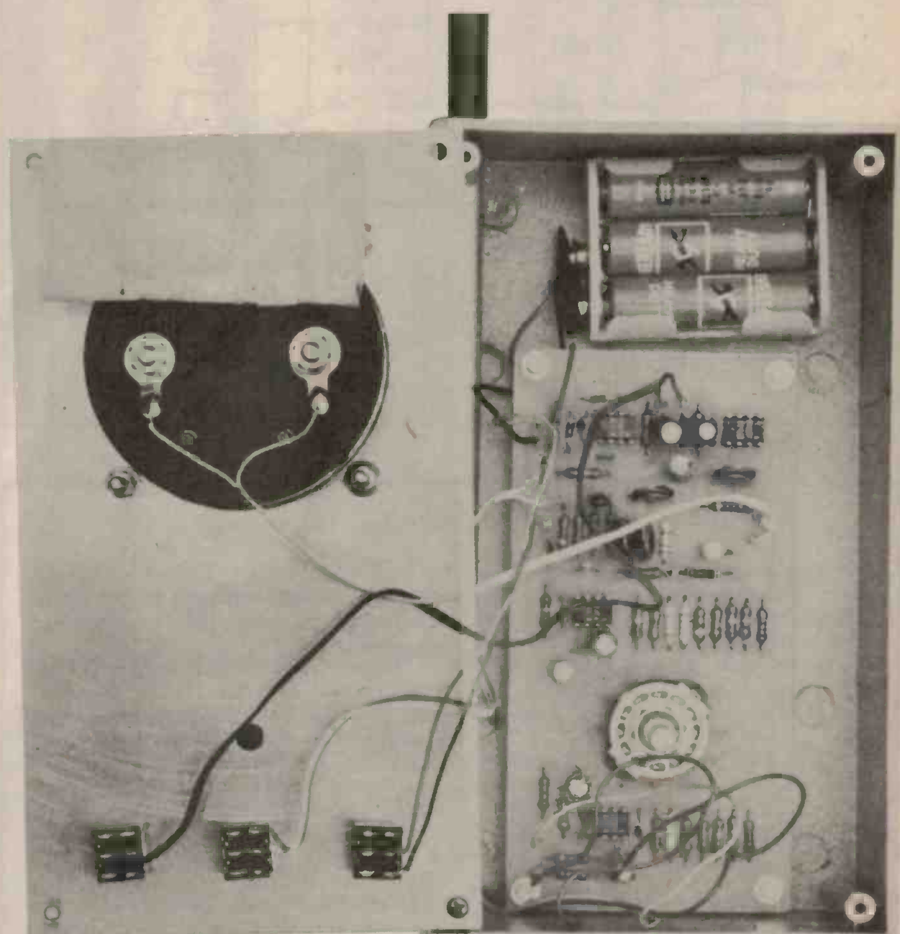


Fig. 1. The meter scale shown full size.



An internal view of the unit.

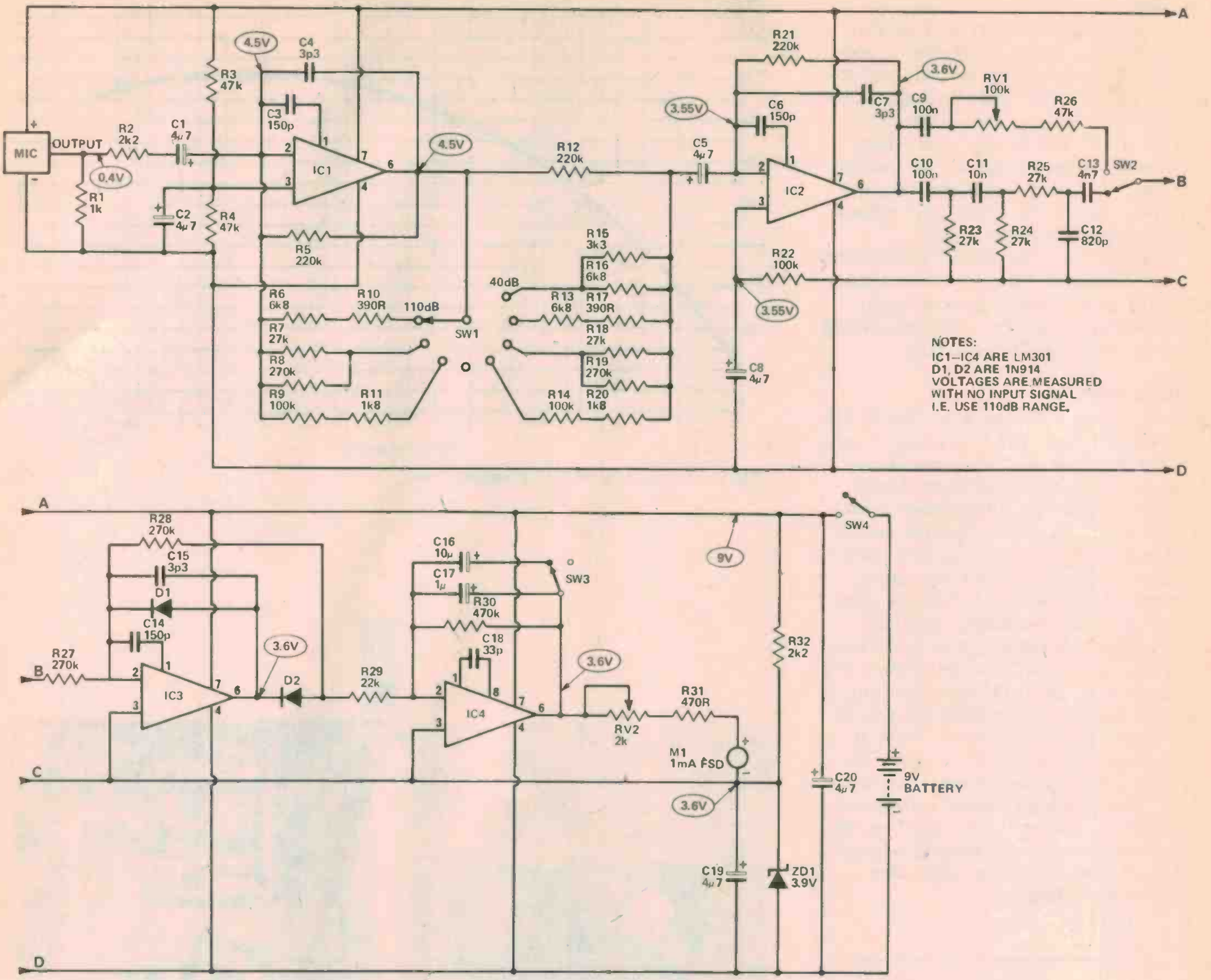


Fig. 3. The circuit diagram of the unit.

HOW IT WORKS – ETI 483

We have used an electret microphone insert which has the necessary FET preamp inside. As its output is a low level, especially in ambients around 40dB it is amplified by IC1 and IC2. The range switch SW1 is used to vary the gain of both ICs as shown below:

Range (dB)	Gain IC1 (dB)	Gain IC2 (dB)	Total Gain (dB)
+40	40	40	80
+50	40	30	70
+60	40	20	60
+70	40	10	50
+80	40	0	40
+90	30	0	30
+100	20	0	20
+110	10	0	10

The use of a switch as shown allows a single pole switch to control the gain of the two ICs while reducing the possibility of instability where gains of 80dB are involved.

The output of IC2 is filtered by the "A" weight network C10-C13, R23-R25 and R27. Switch SW2 selects either this "A" weighted output or the "flat" output via RV1, R25. The potentiometer RV1 is necessary to compensate for the loss of the filter network. Both networks should have the same loss at 1kHz.

IC3 is used to halfwave rectify the signal and IC4 integrates the signal to give the average level. Two values of integration capacitor are used to give the two response speeds.

The bias for the first IC is provided by R3 and R4 while the other three are biased by the voltage across ZD1. The meter is also biased to the zener voltage.

The printed circuit layout for this project is on page 90 of this issue.

Scotchcals of the front panel and rescaled meters are available for $3.00 and $11.50 respectively post paid from Nebula Electronics Pty. Ltd. 15 Boundary St. Rushcutters Bay 2011. Nebula also offer a calibration service (for meters which are working correctly except for calibration) at $5.00 plus $1.00 postage.

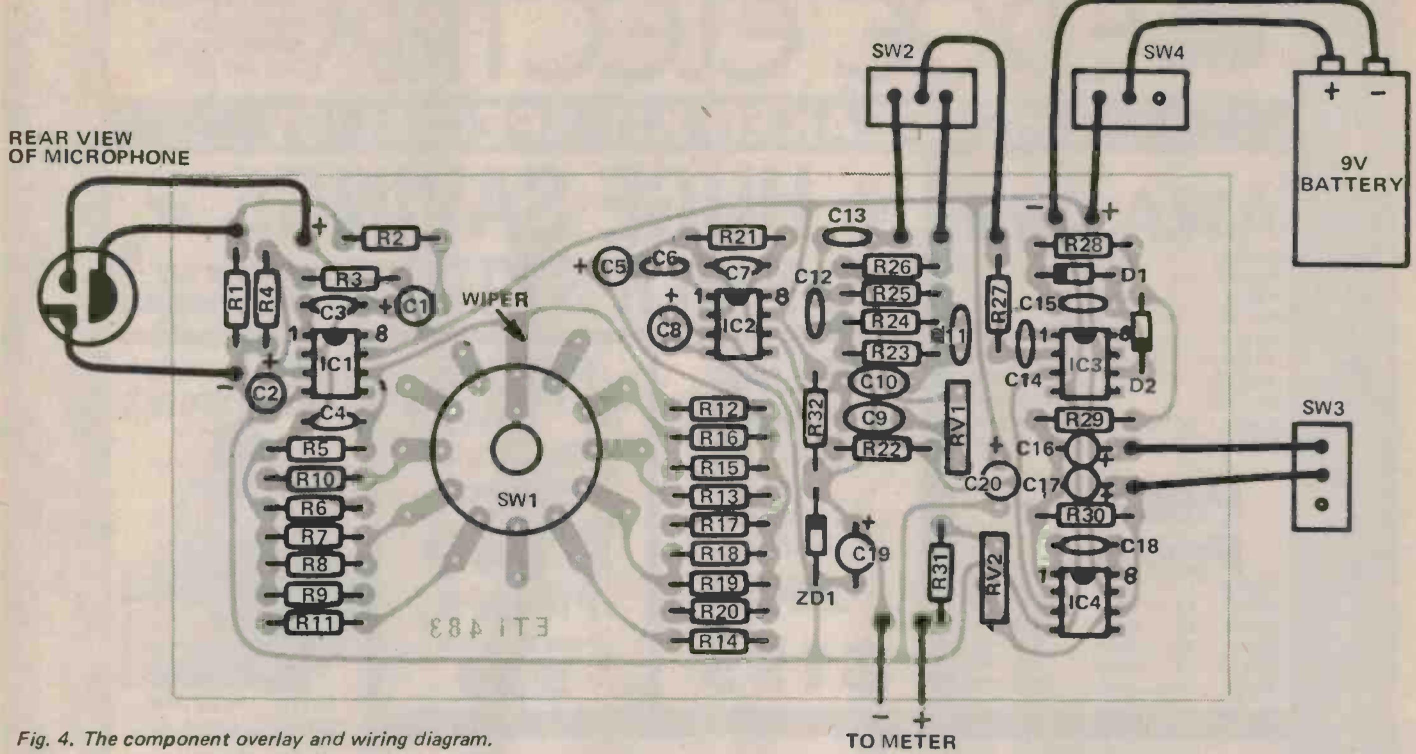


Fig. 4. The component overlay and wiring diagram.

PARTS LIST – ETI 483

Resistors	all ½W 5%
R1	1k
R2	2k2
R3,4	47k
R5	220k
R6	6k8
R7	27k
R8	270k
R9	100k
R10	390R
R11	1k8
R12	220k
R13	6k8
R14	100k
R15	3k3
R16	6k8
R17	390R
R18	27k
R19	270k
R20	1k8
R21	220k
R22	100k
R23–R25	27k
R26	47k
R27,28	270k
R29	22k
R30	470k
R31	470R
R32	2k2
Potentiometers	
RV1	100k trim
RV2	2k "

Capacitors	
C1,2	4μ7 16V electro
C3	150p ceramic
C4	3p3 "
C5	4μ7 16V electro
C6	150p ceramic
C7	3p3 "
C8	4μ7 16V electro
C9,10	100n polyester
C11	10n "
C12	820p ceramic
C13	4n7 polyester
C14	150p ceramic
C15	3p3 "
C16	10μ 16V electro
C17	1μ0 16V "
C18	33p ceramic
C19,20	4μ7 16V electro
Semiconductors	
IC1–IC4	LM301A
D1,2	1N914
ZD1	3.9V 300mW

Miscellaneous

PC board ETI 483
Microphone insert for RAPAR ECM1001
SW1 single pole 11 position rotary
SW2–SW4 SPDT toggles
1mA meter
Plastic case
6xAA size battery holder

The Decibel (db)

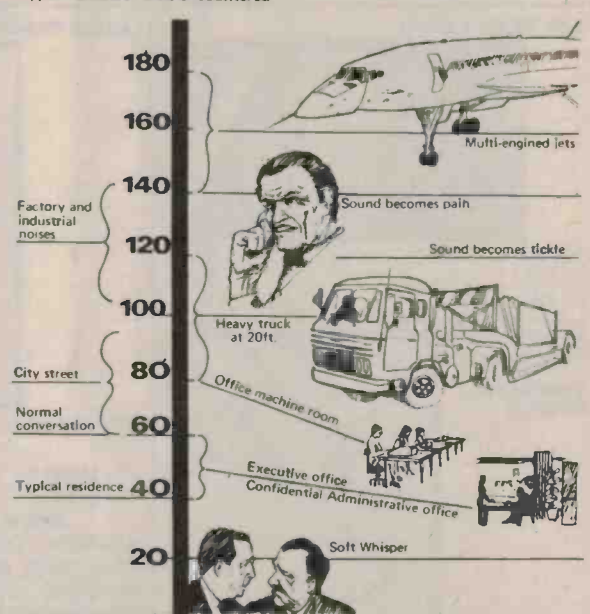
The ear can hear a sound power as low as 10^{-13} watt – this is a pressure of 0002 dynes per cm^2. The ear drum moves an amount approx. equal to the diameter of a molecule of nitrogen. When sound is uncomfortably loud, the hearer "feels" a tickle, then pain in the ear; a power level of 1 watt. approx.

Engineers take the logarithm of the power ratio and call it the DECIBEL (db).

The db level is given by – $db = 10 \log 10 \frac{Watts}{10^{-13}}$

The sound pressure level is $= 20 \log 10 \frac{P(dynes)}{.0002}$

Typical Decibel levels encountered



- *For a sound to be perceptibly louder or softer, it must be changed by 3 decibels.*
- *A noise twice as loud or ½ as loud is a change of 10 decibels.*
- *A reduction in noise of a few decibels in the low noise region (administrative office) is not significant. The same change at high sound levels (office machine room) is significant.*

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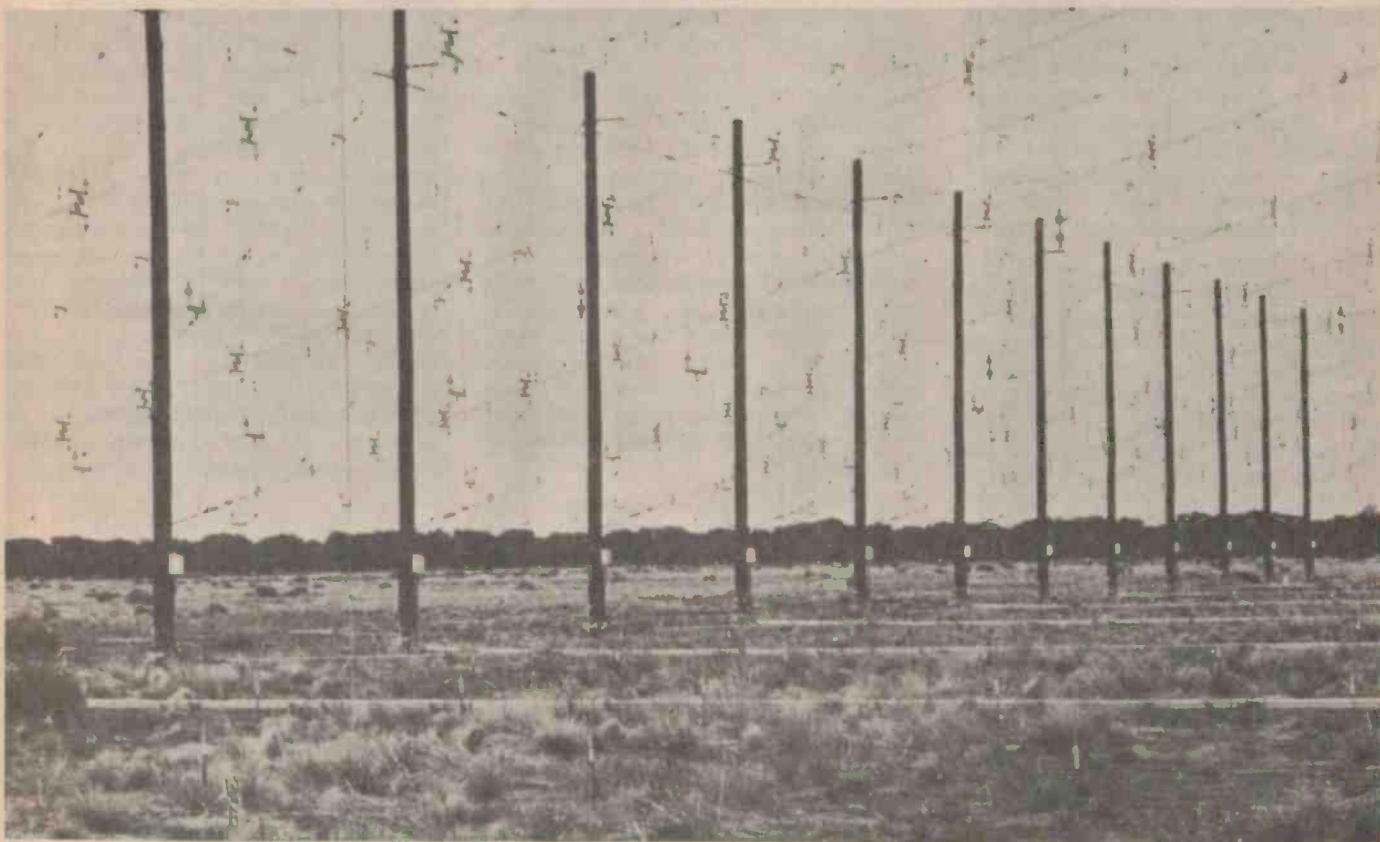
OTH-B Radar—In Defence of Australia...

'Only the United States and the Soviet Union have comparable systems.'



A paper by Dr. Desmond J. Ball, Strategic and Defence Studies Centre, Research School of Pacific Studies, Australian National University.

IN RECENT YEARS there has occurred a series of technological developments which appear to be making landbased national technical means of surveillance and early warning operating from one's own territory increasingly promising. One of the most significant of these is that of 'over-the-horizon' backscatter (OTH-B) radar. Australia is at the forefront in developing this technology — the Project Jindalee prototype system has been undergoing tests for over two years now, and has already achieved detection ranges against aircraft of more than 2,800 kilometres.[1] Only the United States and the Soviet Union have comparable systems.[2]

Jindalee is of enormous significance to the electronics community. For one thing, radio operators have recently been affected by the HF signals from the powerful transmitter — and, more especially, from overseas OTH transmitters, such as the new Soviet system. Second, private industrial organisations have benefitted from Jindalee contracts — $911,000 just from the exploratory stage of the project. Participation by Australian industry in the future is likely to amount to several millions of dollars. And, third, Jindalee is one of the most promising new developments from the point of view of the defence of Australia.

This paper briefly describes OTH-B and explains how it works, both in technical and operational terms; describes something of the history of OTH research in Australia; provides some cost-effectiveness comparisons with other surveillance and early warning systems; discusses some limitations of OTH-B systems; and, finally, discusses some of the more particular implications of the system for the defence of Australia.

High frequency radio waves (3 to 30 or even 40 MHz) have the interesting property of being able to propagate beyond the line of sight by reflection by the ionosphere — out to distances of several thousand kilometres. The

1 At a National Press Club luncheon on 30 September 1976, Dr. John Farrands, then the chief defence scientist, said that Jindalee would enable surveillance of aircraft or missiles over a range of 1000 kilometres. And although Dr. Farrands did not mention it in his speech, defence sources in Canberra said that the system had successfully tracked Qantas aircraft from Alice Springs to Singapore. See Canberra Times, 1 October 1976, p. 1, and 4 April 1977, p. 13.

2 The American OTH systems are regularly described in Congressional testimony and in the Secretary of Defense's Annual Defense Department Report to Congress.

Canada, Japan and the United Kingdom have participated in a number of co-operative OTH radar programmes with the United States.

A new Soviet OTH system began test transmissions in July 1977. Located near Kiev, the transmitters are extremely powerful — 20 or 40 MW or more. Radio operators from as far away as Australia have been affected by the transmissions. The signals have been affecting frequencies from 4 to about 27 MHz, or almost all of the HF band; they centre on 14.215 MHz. The signal bandwidth varies from 30 kHz to more than 300 kHz at some times. The pulsed signals have a repetition rate of 10 per second.

exploitation of this property has led to the development of three basic types of OTH radar systems. The first of these is a forward-scatter OTH system, designed to detect ICBM launches by the disturbance created in the ionosphere when it is penetrated by an ICBM with its engine plume. The United States operated an OTH-F system for this purpose until early 1975 – programme 440-L, with four transmitters in the Far East and five receiver sites and a correlation system in Europe. Programme 440-L was phased out because of the validation of the back-scatter principle, which freed the US from dependence upon overseas bases.

Two different forms of OTH-B systems have been developed, one to detect missile launches (the American system of which is designated programme 441-L and known as Cobra Mist), and the other for the detection and tracking of aircraft (programme 414-L) by means of energy reflected off the targets themselves, back, via the ionosphere, to receivers located with or near the transmitter. The currently planned American programme involves two OTH-B radars, one near Cutler, Maine (the prototype) looking north-east, and one in the State of Washington or Oregon looking northwest; the need for a third, south-looking radar is to be considered later.

The concept of an OTH radar that would operate on the backscatter principle dates back to at least the late 1940s. It was not proceeded with then because too little was known about the basic physics of the ionosphere and the complex signal processing needed was beyond current capabilities. In Australia, an experimental high frequency (HF) array was erected at Rockbank, Victoria, in 1961, and used for back-scatter experiments between September 1961 and February 1962. These proved successful, and a new array was constructed by the Australian Army for operational purposes. Extensive research was conducted during the 1960s, usually in conjunction with the US Air Force, 'involving the study of ionospheric propagation in relation to long range radio paths', much of which proved valuable from the point of view of the development of an OTH radar for operation in the southern hemisphere.[3] Actual investigation of OTH radar technology was begun by the Weapons Research Establishment in 1969, and in 1974 Australia signed an agreement with the United States to co-operate in the Jindalee project.

On April 11, 1974, the then Defence Minister, Mr. Barnard, announced that approval had been given to the Project Jindalee experimental OTH-B programme. The cost of the project between 1973-74 and 1977-78 was estimated at $3.4m. The radar equipment for the Project was assembled at the Weapons Research Establishment, Salisbury, and installed near Alice Springs during 1975-76. The transmitter site, consisting of a phased array antenna 185 metres long, several other masts to support communication and radar calibration antennas, power house, etc., is located in the Hart's Range about 160 km northeast of Alice Springs. The main receiving site, in the Mt. Everard area about 15 km north of Alice Springs, features a 600 m-long receiving array, calibration and communication aerials, and large earth mats providing stable ground planes; some 300 km of wire was used to make these mats. About six or seven technicians from WRE reside in Alice Springs, and these provide a 24 hour a day manning of both the transmitter and receiver sites.

Under Stage One of the project, the transmitting station at Hart's Range operates on a power output of some 50 kW, provided by five 10 kW sub-transmitters – 40 kW is utilised in the actual radar transmission, and 10 kW feeds into the 'ionospheric sounder' dedicated to monitoring the behaviour of the ionosphere. Sixteen further sub-transmitters are being installed under Stage Two. (Much of the equipment for this installation is from one of the decommissioned American OTH radar stations in Japan). The Hart's Range station should eventually operate on at least 1 MW. The basic operating frequency spectrum of the installation is expected to be 5 – 29.5 MHz. It will of course be at the higher end of the range at dawn, and the lower in the early afternoon, with considerable other variation due to other ionospheric and operational factors. It could at times go up to 60 MHz. On overseas experience, the operating frequency will centre around 14 MHz. The bandwidth will be quite wide, probably varying from about 30 kHz to more than 300 kHz at some times. The basic pulse repetition rate will depend to some extent on how the system is eventually optimised for the detection and tracking of high-Mach aircraft and relatively slow-moving ships. It should be somewhere from about 3 pulses per second to about 10/sec.

For early warning, an actual operating system would require two or three such 'Jindalee' installations. Given an angle coverage of 120° and a 60° redundancy over the direct north, two installations would provide survellance and early warning over 180°; if no redundancy was required, two installations would cover 240°, and three the full 360°.[4] An actual working system could be operational within five years from today.

Costs

It is not possible to be definitive with regard to the costs of an OTH-B system. Dr. John Farrands, the chief defence scientist, has said that the Jindalee Project will cost about $20m 'before we go to an actual working system'. This is much less than the $50m which the Americans have spent on the testing and validation of their OTH-B concepts.[5] Construction costs for the deployed operational system would add considerably to this. (The American OTH station at Orford Ness, UK, was reported to have cost £22m. The 1975 contract for the 414L station in Maine was for approximately $40m). It is unlikely that Australia could deploy a full working system of at least two

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3 The principal facilities here were those manned and operated by the US Air Force at Amberley, Qld, from 1965-1975, and Norfolk Is. in 1969-70.

Most of the relevant Defence research today is being undertaken at the RAAF Base at Pearce, W.A.

4 From the point of view of early warning of an air attack against Australia, duplicated coverage of the direct north is probably more important than full 360° coverage. It not only provides some redundancy, in the direction from which any threat is likely to come, of installations which are vulnerable to attack themselves as well as being subject to normal malfunctions; it also allows the application of the bistatic radar technique (which can be extended to the multistatic technique).

Bistatic radar systems, which involve the separation of the transmitter far away from the receiver(s), have come under intensive study in the US in the past year or so (the Sanctuary Project).

If some redundancy is accepted, a number of transmitters and receivers can be netted to provide look angles and precise tracking by triangulation, improving the target resolution of the system and hence increasing its utility for air defence.

Bistatic systems also have the advantage of allowing co-operative users to receive surveillance data without having to risk disclosure of their presence by radiating radar energy, an important advantage in some limited battle-field situations where the transmitter might be exempt (for technical or whatever reasons) from attack.

It is worthwhile recalling that the bistatic method was actually first considered in the 1950s in relation to OTH radar. See Joseph W. Chamberlain, *Physics of the Aurora and Airglow*, (Academic Press, New York, 1961), p. 220.

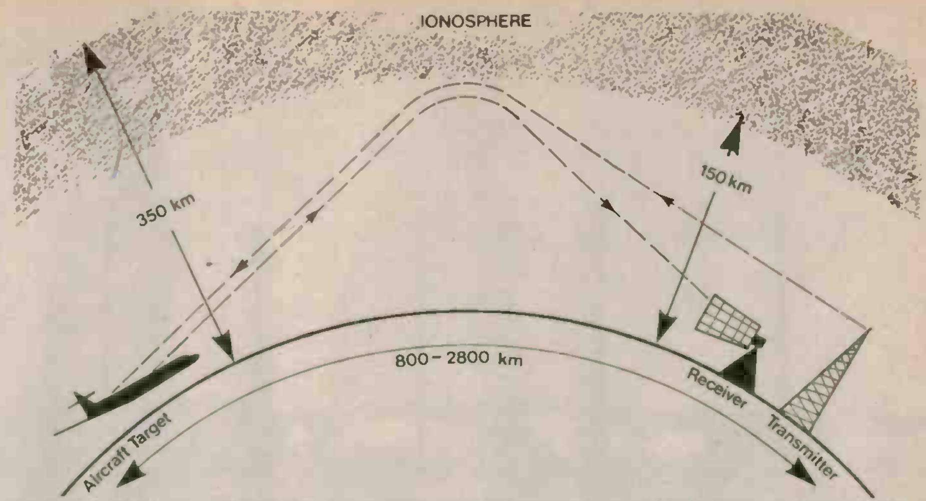
5 One reason why the Australian R & D cost should only be 40-50% of this is that, as Mr. Killen has said, 'costs have been kept down by borrowing special electronic equipment from the United States'. *Hansard, (H. of R.)*, 4 June 1976, p. 3115.

transmitter and receiver pairs for much less than $100m.

This does not compare altogether unfavourably with the costs of alternative surveillance and early warning systems. The two Hubcap radars, installed at Williamstown and Amberley in late 1968, cost about $6m each, while the five new aircraft surveillance radars recently installed at RAAF bases at Townsville, Amberley, Williamtown, Pearce and Darwin would have each cost only slightly less than this. These radars, however, are limited to line of sight detection — a few hundred kilometres for low flying aircraft or ships. Literally scores of these radars would be needed to provide the same radar coverage as one or two OTH-B radars.

Airborne early warning radars are even more costly. The unit flyaway cost of the cheapest of these aircraft, the Grumman E-2C Hawkeye, came out at $17.5m in the 1976 Israeli purchase, while in March 1976 the unit flyaway cost of the Boeing E-3A AWACS was given as $53.7m. The programme unit costs of these aircraft are about $30m and $104m respectively. Allowing for some down-time, some six to eight of these aircraft would be needed to provide full-time, all-weather coverage over a single battlefield area, and two or three such cohorts for a large-scale conflict. In any case, these aircraft are not really suited for strategic early warning, but really only for battlefield warning and control. Some longer-range early warning system is still necessary to allow these aircraft to get into the air in time to move out to meet the advancing threat.

Australia might also consider a satellite early warning system. The United States developed such a system for missile warning in the late 1960s, and recent testimony on the HALO and Teal Ruby programmes suggests that in five years or so spaceborne surveillance systems will also be able to detect tactical aircraft. These satellites would have to be in synchronous orbit to allow continuous coverage of the continent and the maritime and air approaches. The present American SLBM satellite early warning system relies on two satellites for such coverage, with at least one in reserve on the ground; these must be replaced approximately every five years. These satellites were estimated to cost $61.5m each in 1970, and the Australian price would have to include some reimbursement for R & D, launch costs, and the necessary ground support equipment, including a ground read-out station and sophisticated data processing facilities.



Over The Horizon — Backscatter radar relies upon the ability of the ionosphere to 'reflect' HF radio waves around the curve of the Earth's surface. Because the ionospheric layers vary in height and ability to reflect at different frequencies, complex processing by computer, in conjunction with continuous monitoring of the ionosphere, is required to derive meaningful information.

Limitations

OTH-B systems emerge quite favourably from these cost/coverage comparisons. This is not to say, however, that OTH radar does not have other limitations and inadequacies.

For one thing, although they can detect an incoming vehicle, OTH-B systems cannot identify its nationality or intent. Advances in signal processing techniques and powerful computers, together with inputs from some form of air traffic control data (such as electronic interception of air traffic communications) can alleviate this to a large extent. Indeed, as Mr. Barnard announced, one of the principal reasons for Jindalee's site location is 'the added attraction that Alice Springs was a check point on the routes of many international aircraft entering Australian airspace from the north, so that the radar had a ready source of aircraft of different characteristics for test purposes'. In any case, this is a problem for all long-range non-optical early warning systems, including all those alternative systems mentioned above.

Secondly, OTH systems could be vulnerable to enemy jamming of the receivers. However, although a relatively low-powered transmitter in the receiver's beam working at the right frequency would obliterate target returns, to do this operationally would be difficult. Because Jindalee is located so far inland, any jammer would have to be shipbased and relatively high-powered. The location of the receiver would also have to be known, which is not always the case, particularly with bistatic OTH-B systems. And the problems of tracking and imitating the radar frequency, shifting constantly over a quite wide frequency range, could be insoluble. Moreover, as General Gordon T. Gould, USAF, has testified in a discussion of the possibility of jamming OTH radar:

> 'When you start jamming something . . . you produce a form of warning itself. This is a way of alerting someone.'

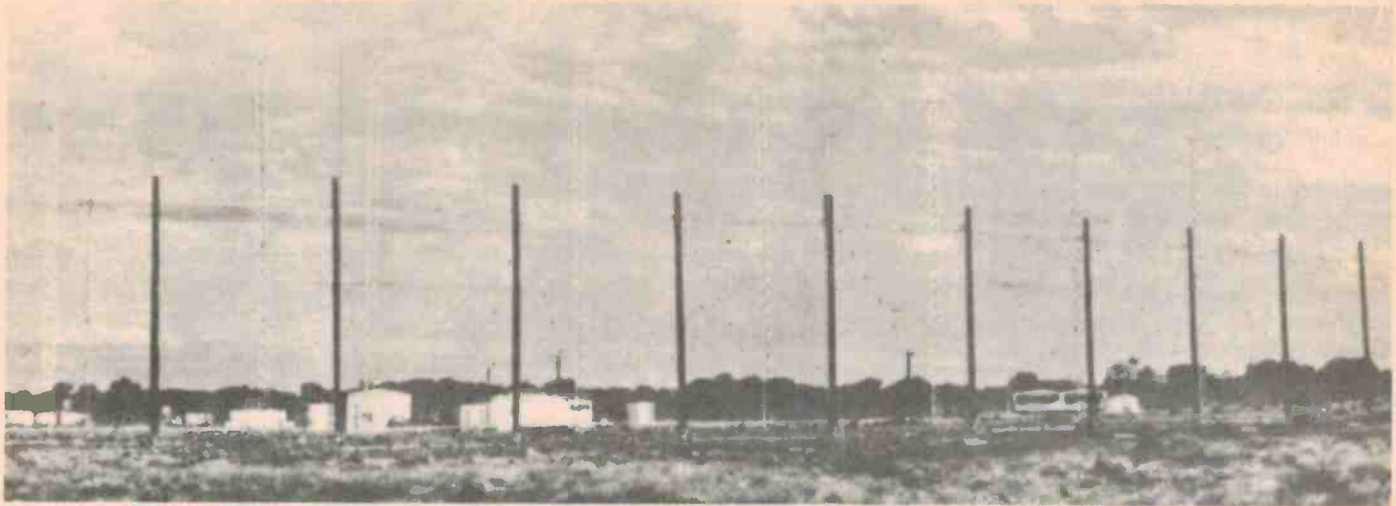
USAF OTH installations have electronic countermeasures (ECM) monitors to determine whether any interference is man-made, and no doubt these will be applied to the Australian system.

Third, the proper functioning of OTH radar depends upon good steady reflections from the ionosphere, which requires both good knowledge of the local ionosphere and an ability to rapidly tailor the frequency to the ionospheric weather. As Peter Laurie has written:

> 'Low frequencies are necessary at night to get reflection and high ones during the day to avoid excessive absorption. In practice, an OTH radar needs a secondary, vertical, sounding radar to test the ionospheric weather, together with an HF receiver to search the band for quiet channels. The best radar frequency is then calculated by a computer and the transmitters and receivers adjusted accordingly — which for installations as powerful and complicated as these are, is in itself quite a performance.'

Knowledge of the local ionosphere has improved immensely in Australia in the last few years, and techniques for monitoring solar activity now allow some prediction of ionospheric behaviour, and hence the adaption of frequencies to reduce the impact of solar induced phenomena.[6]

Fortunately, from Australia's point of view, auroral effects on the ionosphere are much more a concern in the northern hemisphere, with our *Aurora Australis* being comparatively less dramatic but also less serious; moreover, these effects are generally only significant at latitudes greater than 60°, which is a concern for northern



The Jindalee transmitting antenna.

hemisphere nations looking over the Arctic at each other, but not for a northward-facing Australian system.

In addition to the effects of natural phenomena on the ionosphere, attention must also be given to possible man-made disturbances – particularly by nuclear explosions in a possible general war. In 1962, the US conducted a number of high-altitude nuclear explosions to determine their effect on ionospheric propagation. The most spectacular of these was a 1-megaton bomb exploded more than 400 km above Johnston Is. In the Pacific on 9 July, which blacked out HF transmission between Australia and Hawaii and San Francisco for 20 minutes, and Japan and the US for 40 minutes.

Finally, the OTH radar installations, being large and fixed are vulnerable to destruction by direct physical attack, by both nuclear or conventional weapons. This is especially the case for the transmitters, which offer an extremely powerful signal (from 50-100 kw to 2 MW and even much higher) for radar-homing missiles (such as Shrike, Standard ARM, or long-range anti-radiation cruise missiles). This potential vulnerability is no greater than for many other early warning systems (such as the ground surveillance radars, the satellite ground stations or even the satellites themselves, and the airborne early warning system), but it may be necessary to divert elements of the Tactical Fighter Force (TFF) to the protection of these; this may involve the deployment of some of the force to, for example, Alice Springs. Of course, an attack on any of these systems represents unequivocal early warning.

Other more passive means of protection could also be adopted. For example, the vulnerability of OTH systems can be dramatically reduced by making the transmitters and receivers mobile. If the bistatic or (even better) multistatic techniques are adopted, whereby the transmitter is separated far away from the receiver(s), then there is no problem for the (assumedly concealed) receivers.

'It now seems that (OTH-B radars) also have a significant ability for tracking surface targets.'

The transmitters, however, are another matter. In the United States, both transmitting and receiving equipment was originally located on trailers, which were regularly moved about during the R & D phase of the development of the OTH-B system. Many of the roads in north and central Australia are capable of carrying the sorts of trailer which would be required to haul the OTH-B transmitter(s). The trucks used in 'beef trains' and ore haulage are capable of trailing 185-metre transmission antennae. Since the system may not be expected to operate while in transit, it can be constructed on a modular basis for rapid re-assembly at any one of a large number of pre-prepared sites.

The US Navy also has a shipborne OTH radar in advanced development; if this programme proves successful, Australia might consider the acquisition of such a system to be held in reserve for any future emergency. And, in the longer term, consideration should be given to satellite-borne transmitters.

Other Contributions

This discussion suggests the enormous value to Australia of an OTH-B system for the early warning mission. Three other contributions which OTH-B might make to Australian defence will be briefly discussed here.

The first is the contribution to continental air defence. In parallel with the development of the Jindalee Project, studies have been conducted by the Central Studies Establishment with the co-operation of the Navy and RAAF on the implications of Jindalee for this defence mission. OTH-B systems have detected targets out to about 3200 km, but the system has inadequacies from the point of view of air defence vectoring; although it can detect, the system has problems of location, especially at long ranges and when using relatively high frequencies, and its tracking capability is limited to distance and azimuth. The range resolution at this distance is about 1½–2 km for bandwidths of about 100 kHz, but is typically 20–40 km for the bandwidths at which OTH-B systems normally operate. The relative range accuracy is typically 2–4 km for a target location relative to a known location observed by the same radar, with absolute range accuracy 10–20 km assuming good real-time path assessments are made. The use of bistatic or multistatic techniques would improve these nominal performance characteristics.

Two means are available for using gross target data such as this for air

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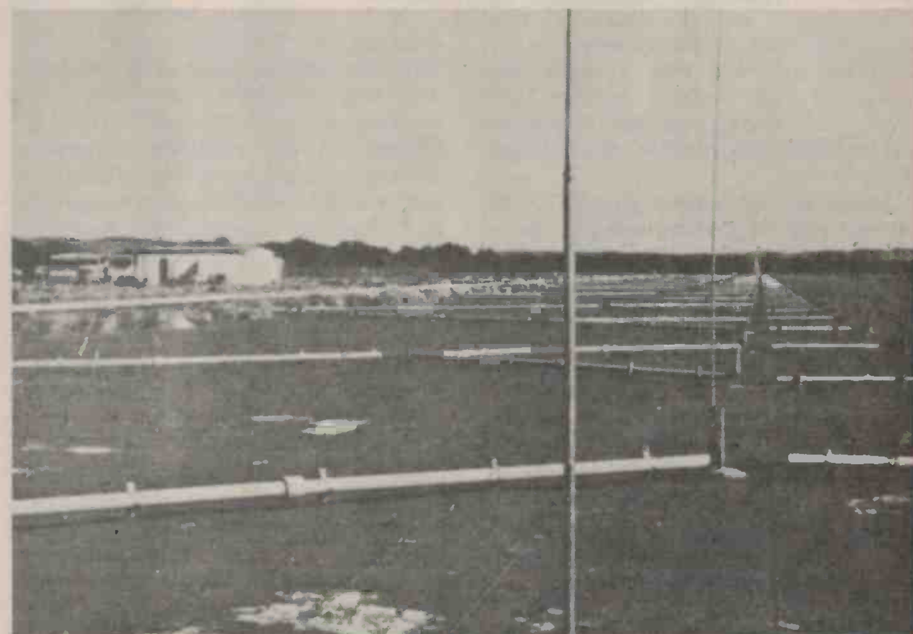
[6] The United States has developed a world-wide network of solar optical telescopes and solar radio telescopes for continuous monitoring of the sun, enabling it to detect, identify and assess the impact of any solar activity which would affect radio or radar use. Because it takes from 8-20 minutes to 72 hours for electromagnetic particles associated with solar flares to reach the earth, it is possible to adapt frequencies and other procedures to ensure continuous effective radar performance. See Hearings before a subcommittee of the House Committee on Appropriations, *Department of Defence Appropriations for 1977,* (Part 5), pp. 1441-1443.

defence purposes, depending on the capabilities of the interceptor aircraft's own radar system. The first involves the use of an airborne warning and control system in conjunction with the OTH-B radar, the approach being adopted by the US in its 414-L programme. Australia now has a requirement for such an airborne warning and control system in its Five-Year Rolling Programme; the aircraft under some consideration for procurement, the E-2C, can detect and track cruise missiles at 100 nautical mile ranges and large aircraft at 250 nm, and can spot small boats in high sea states. OTH-B radars would give airborne warning and control aircraft time to take to the air and move out to meet the advancing threat; interceptor aircraft with a good radius of action and a 'look down/shoot down capability' could then be vectored into actual intercept.

Given the relatively high costs of such airborne warning and control aircraft, however, consideration should be given to the operation of fighter aircraft in direct contact with the OTH-B receivers. Several of the TFF contender aircraft have radars which have a capability of directing long-range interception on the basis of OTH-B radar data simply by enveloping the area of irresolution given by the OTH-B station; these would include the Hughes AN/APG-63, the Hughes AN/AWG-9, the Marconi-Elliott system for the Tornado, the L.M. Ericsson PS-37A, and the new Hughes AN/APG-65. Interception probabilities would be increased if the fighters flew out in tandem.

The Jindalee Project is an important reason why Australia's new tactical fighter should have a large radar. Advocates of contender fighters with smaller radars (e.g. the F-16 and its 25 nm system) argue that large radars are unnecessary because most air combat takes place at visual or at least infra-red ranges — ignoring not only the enormous advantages in air combat of early target acquisition, but also denying the possibility of realising most of the air defence potential of the Jindalee system.

For the future, there are two possible techniques which, if successfully developed and applied, could greatly enhance the air defence potential of the system. One is the use of 'differential' systems. Because conventional OTH-B systems have a typical range resolution of 20—40 km and an absolute range accuracy of only 10—20 km, they have only limited capability in target location and tracking roles. However, it should be possible to construct a chain of relatively inexpensive forward monitoring stations some 100 km from the Australian coast which would enable this resolution to be reduced dramatically. The concept is essentially similar to that employed in the differential version of the Omega navigation system. Differential Omega involves the reception of Omega signals at fixed monitor receivers and the communication of lane resolution data to a central location where it is combined into an overall set of corrections and the 'differential fix' communicated to user systems. This technique improves the accuracy of the Omega system from that of about ±1-2 nautical miles in the case of normal hyperbolic Omega to about 200 metres. Improvements of a similar order should be feasible for a differential OTH-B system. Such a system would require some 30 forward monitor receiver stations describing an arc of some 12,000 km from (say) Lord Howe Island around through Papua New Guinea to islands off the south-west coast of Western Australia. In this system, the relative range accuracy would typically be 2-4 km. The continental air defence implications of this are quite profound, with the OTH radar correlation centre being able to control the direct vectoring of interceptor or maritime strike aircraft.


The Jindalee receiver antenna array.

Another possible technique has apparently enabled the United States to demonstrate a capacity not only to detect and track aircraft targets but also to identify them positively as well. According to *Flight International:*

> **'Tests have showed that — provided the frequencies used are such that the wavelength is longer than the largest dimension of the target, and that two or three different frequencies are used — examination of the amplitude, phase and polarisation of the reflected signal gives each target a recognisable signature. During trials with models it has proved possible to differentiate the MiG-19, MiG-21, F-104 and F-4.'**[7]

Again, the continental air defence implications are quite profound.

Surface Target

The second set of contributions which OTH-B systems can make to the defence of Australia lies in the area of naval applications. Recent developments indicate that much more consideration should be given to these applications. While OTH systems were originally developed for detecting and tracking airborne objects, it now seems that they also have a significant capability for tracking surface targets. Recent experiments by US Navy engineers, using an experimental OTH-B system in Virginia, have involved the successful tracking of ships in the Gulf of Mexico — a distance of about 2000 km. Australian Defence officials have been regularly informed of American progress with the naval application of OTH-B systems for at least the past three years. US intelligence sources reportedly believe that the Soviet OTH-B transmitter near Kiev is trying similar techniques.

Depending to some extent on the eventual site(s) selected for the system operational ranges against surface targets of out to about 2000 kilometres should provide excellent surveillance coverage of Australia's maritime approaches. Detection of surface targets is limited to relatively large and/or fast-moving vessels, but this is no real

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[7] See 'USSR Develops Anti-B-1 Radar?', *Flight International*, 8 January 1977, p. 50.

disadvantage from the point of view of early warning since any significant attack on Australia would include vessels in this category. Resolution of targets whose Doppler frequencies differ by 0.1 Hz or less is generally possible; at a transmission frequency of 20 MHz, 0.1 Hz corresponds to a difference in relative velocity of about 1.5 knots.

The US Office of Naval Research has also been investigating another interesting application of OTH radars. In May 1974 it was disclosed by Dr. Stephen J. Lukasik, Director of the Defense Advanced Research Projects Agency, that DARPA had been pursuing the detection of submarines and other ASW research through the application of OTH systems, but no details of this work were given. More recently, the US ONR has revealed that at least one aspect of this research involves the mapping of mid-ocean surface conditions and studying the detailed morphology of the surface.

The other contribution which OTH-B can make to Australian defence lies in the intelligence area. It is clear that a strategic policy of defence of Australia (as opposed to 'forward defence') requires an upgrading of our indigenous intelligence capabilities. The Army Signals Corps discovered with its Rockbank experiments in the 1960s that any type of OTH radar is potentially a means for eavesdropping on HF radio communication that might otherwise be too weak for ordinary receivers.[8]

Because of the great sensitivity, wide bandwidths and ability to cover such bandwidths over a wide frequency range, OTH-B receivers are admirably suited for gathering electronic intelligence. OTH radars must have an inherent capability for covering a wide range of the radio spectrum and for rapidly shifting from one frequency to another, in order to adjust to solar activity, day/night transitions and other changes in the ionospheric weather. This is especially significant because of the amount of military signals and communications which are transmitted on the HF band. General Gould alluded to this when he discussed the capabilities of OTH-B systems in 1971:

> **'It is clear from what we know that this system will have intelligence value . . .'**

he said.

For early warning, the OTH-B system can be used both as a radar and as an electronic intercept system. Since it is not necessary that the transmitter be continuously operating, transmission can be cut off every 30 minutes or so for a few minutes or even an hour, as with the new Soviet system; 'elint' can be gathered during the off-periods. It should be possible to develop programme for utilising the radar detection and electronic intercept capabilities of the system so that the early warning function is maximised. Alternatively, it may even be possible to modulate the frequencies so that the radar detection and the elint intercept capabilities can be operated simultaneously.

The operation of such a national technical system would reduce Australian dependence on US intelligence sources and make a genuine contribution to an independent Defence of Australia posture.

It is a common criticism of the Defence establishment that it has difficulty making positive or long-term decisions, and that, when made, its decisions often do not contribute to the defence of this continent. Australian defence science has come a long way with the Jindalee Project, in recognition of its enormous potential for Australia's defence posture. But Jindalee is still a research project, and to become fully operational would take perhaps five years following a decision to proceed. Giving the go-ahead for Jindalee to proceed to development as an operational system would be an excellent way for the Defence establishment to answer its critics.

'Airborne early warning radars are even more costly.'

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[8] The Mt. Everard receiver has already picked up signals from as far away as England on some occasions.

This eavesdropping function explains at least partly the presence of officers of the Defence Signals Division (DSD) in the Jindalee Project, although DSD expertise in long-range radio reception and knowledge of local ionospheric behaviour would undoubtedly merit its involvement in the project anyway.

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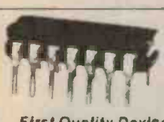

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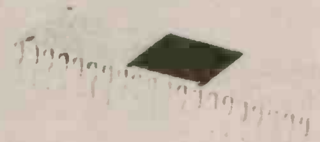

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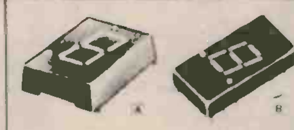

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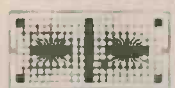

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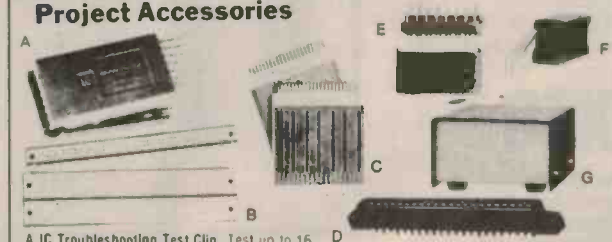

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1N4003	276-1102	2/.79
1N4004	276-1103	2/.89
~~1N4005~~	~~276-1104~~	~~2/.99~~
1N4735	276-561	2/1.29
1N4739	276-562	2/1.29
1N4742	276-563	2/1.29
~~1N4744~~	~~276-564~~	~~2/1.29~~
1N5401	276-1141	2/1.29
1N5402	276-1142	2/1.49
1N5403	276-1143	2/1.59
~~1N5404~~	~~276-1144~~	~~2/1.69~~
PTC205	276-1114	3/1.89

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Device	Rating	Cat. No.	Only
LASCR	200v 1.6A	276-1095	1.79
SCR	200V 6A	276-1067	1.99
SCR	400V 6A	276-1020	1.99
Triac	200V 6A	276-1001	1.79
Triac	400V 6A	276-1000	1.99
BR	50PIV 1.4A	276-1151	1.29
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BR	100V 4A	276-1171	1.99
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BR	400V 4A	276-1173	2.49
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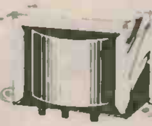

Cat. No.	Type	Volts	Current	Size	Each
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	LINE	150mV
Input Impedance	MIC	10K ohms
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	LINE	50K ohms
Maximum Input Level	MIC	45mV
	PHONO	140mV
	LINE	35V
Rated Output	AMP.	1V
	REC.	1V
Output Impedance	100 ohms	
Harmonic Distortion	At Rated Output	0.2%
	At 6V Output	0.3%
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	PHONO	−62 dB
	LINE	−65 dB
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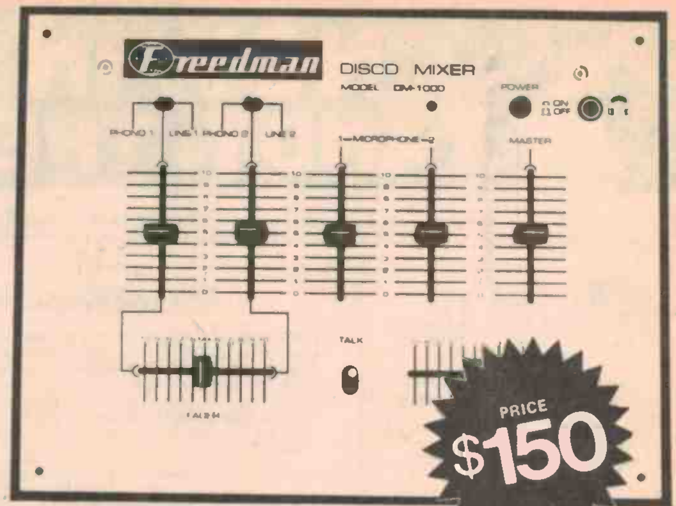

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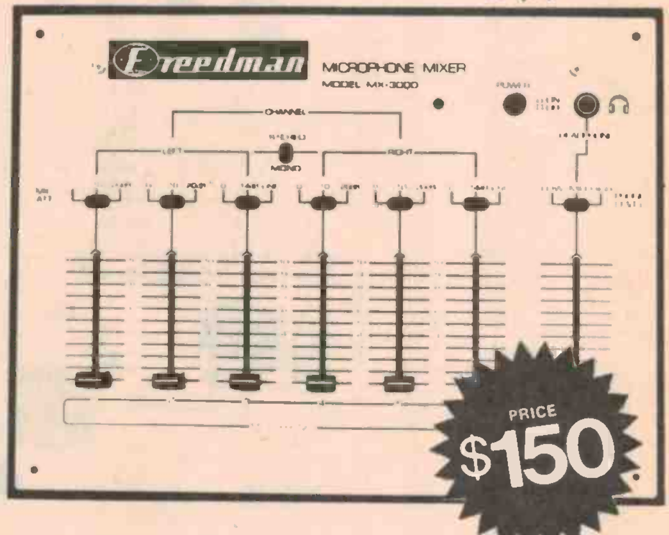
Maximum Input Level	MIC 500 mV (Att. 20 dB)
	250 mV (Att. 14 dB)
	160 mV (Att. 10 dB)
	50 mV (Att. 0 dB)
	Line 30 Volt



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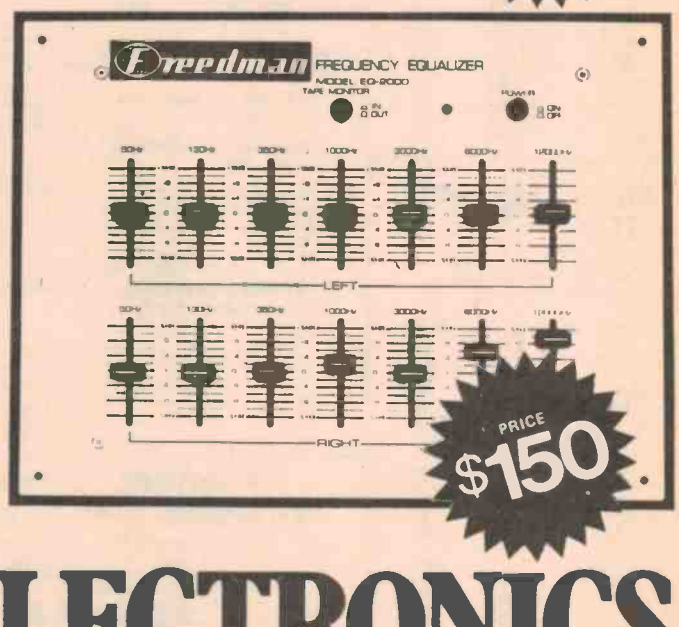
Tone Control Range	50, 130, 350, 1000, 3000, 6000 and 12000 Hz ± 12dB 7 Ranges
Inter Modulation Distortion	At 2 Volt output 0.05%
Harmonic Distortion	At 2 Volt output 0.05%
Hum & Noise	Shorted input −80 dB below 2 Volt output.
Output Level	Maximum 10 Volts



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Project 714

VHF LOG-PERIODIC ANTENNA

by Roger Harrison, VK2ZTB, who swears the prototype is still in use!

WITH THE AVAILABILITY of many imported transistor receivers that cover a variety of VHF bands, many people have discovered the delights of 'VHF Listening'. There are many interesting communications services using channels in the VHF region including taxis, aircraft, courier services — even weather satellites can be heard! From the small transistor 'portable' with auxiliary VHF coverage, many enthusiasts graduate to a more expensive 'general coverage' VHF receiver like the Eddystone 990R for example.

To receive the various transmissions that are spread over a wide range of frequencies, in various bands between 60 and 250 MHz, a wideband antenna is necessary. Most enthusiasts put up a simple dipole or perhaps several. Some make do with a TV antenna. Either system is a compromise. A 'discone' antenna is installed by some enthusiasts and while it is wideband with omnidirectional coverage, it has no gain.

Apart from the general VHF listening aspects, there are many 'TV DX' enthusiasts who seek out long distance reception of TV stations. During the summer months sporadic-E propagation via the ionosphere 'skips' distant TV transmissions many thousands of kilometres and Brisbane channel-O for example may be seen in Adelaide. Certain favourable weather conditions produce atmosphere 'ducts' which propagate VHF signals long distances. Radio amateurs often use TV DX as an indicator to amateur band DX 'openings'. A wideband antenna is worth its weight in QSL cards in these circumstances!

There are also many Hi-Fi enthusiasts using their TV antenna installation in a dual role: adding a splitter and connecting the TV and FM tuner. This situation is also very often a compromise. Many TV antennas, while having reasonable, if not adequate, response on most TV channels, do not have the required sensitivity or directivity over the 88 to 108 MHz FM broadcast band. They have demonstrably poor performance on stereo FM transmissions in many cases, particularly if one lives a fair distance from the transmitters, but not necessarily in a fringe area.

The difficulty in using a readily available TV antenna arises in the fact that it is generally a compromise. Those marketed for use in metropolitan areas are a compromise in several parameters. Response from channel 2 to channel 10, or channel 0 to channel 9, is required in capital cities — a frequency range spanning 60 to 222 MHz in the first case, and 45 to 215 MHz in the second.

A number of antennas are manufactured to respond to channels O or 2 (to cover the low frequency channels) and channels 6 to 11 in the upper range. That leaves a big hole in the middle. Others are cut to have a broad response around channel 2 and a 'peaked' response at three times that frequency, for use in strong signal areas.

The bandwidth response of these antennas on the lower frequency TV channels is often poor, although the effect may go largely unnoticed. When colour TV is installed and perhaps a splitter is added to allow connection of an FM tuner, the existing limitations of the installation become embarrassingly apparent.

Well, here's an antenna to solve all the multifareous problems for the various enthusiasts outlined above.

Log-Periodic Antenna

The antenna described is of the log-periodic type, so called for its physical design and wide frequency response. It has virtually constant gain and directivity pattern across the design frequency range. It uses a number of elements, arranged in this design as a series of dipoles. Only a small group (generally three or four) of these are 'working' on the chosen frequency or across a relatively narrow band within the design frequency range when the antenna is in use. A reflector element has been added to improve the front-to-back ratio, particularly on the lower frequencies.

Construction, although it appears complicated, is quite easy and inexpensive to boot! Most, if not all, the components can be purchased from hardware stores.

There are basically two models: one covering 60 to 250 MHz (TV channels 2 to 11 including the FM band), and the other covering 40 to 250 MHz (TV channels 0 to 11 including the FM band).

The overall construction of the 60 to 250 MHz model is illustrated in Figure 1. The 40 to 250 MHz model requires an additional three-elements of a larger size to accommodate the lower frequency range from 40 to 60 MHz. Construction of the additional elements is illustrated in Figure 6.

The model in Fig. 1 consists of ten dipole elements plus a parasitic reflector. A balun transformer with a 1:1 impedance ratio converts the approximately 70 to 80 ohms antenna feedpoint impedance from a balanced configuration to unbalanced, to suit a 75 ohm coaxial cable feedline.

Construction

Each of the dipole halves must be insulated so an insulated boom is required, along with some convenient method of mounting the dipole elements on it. There are two basic ways of achieving this — using a wooden boom and wooden element support brackets; or using a boom of ABS or PVC water pipe of a suitable diameter and conventional element to boom brackets.

VHF LOG-PERIODIC ANTENNA

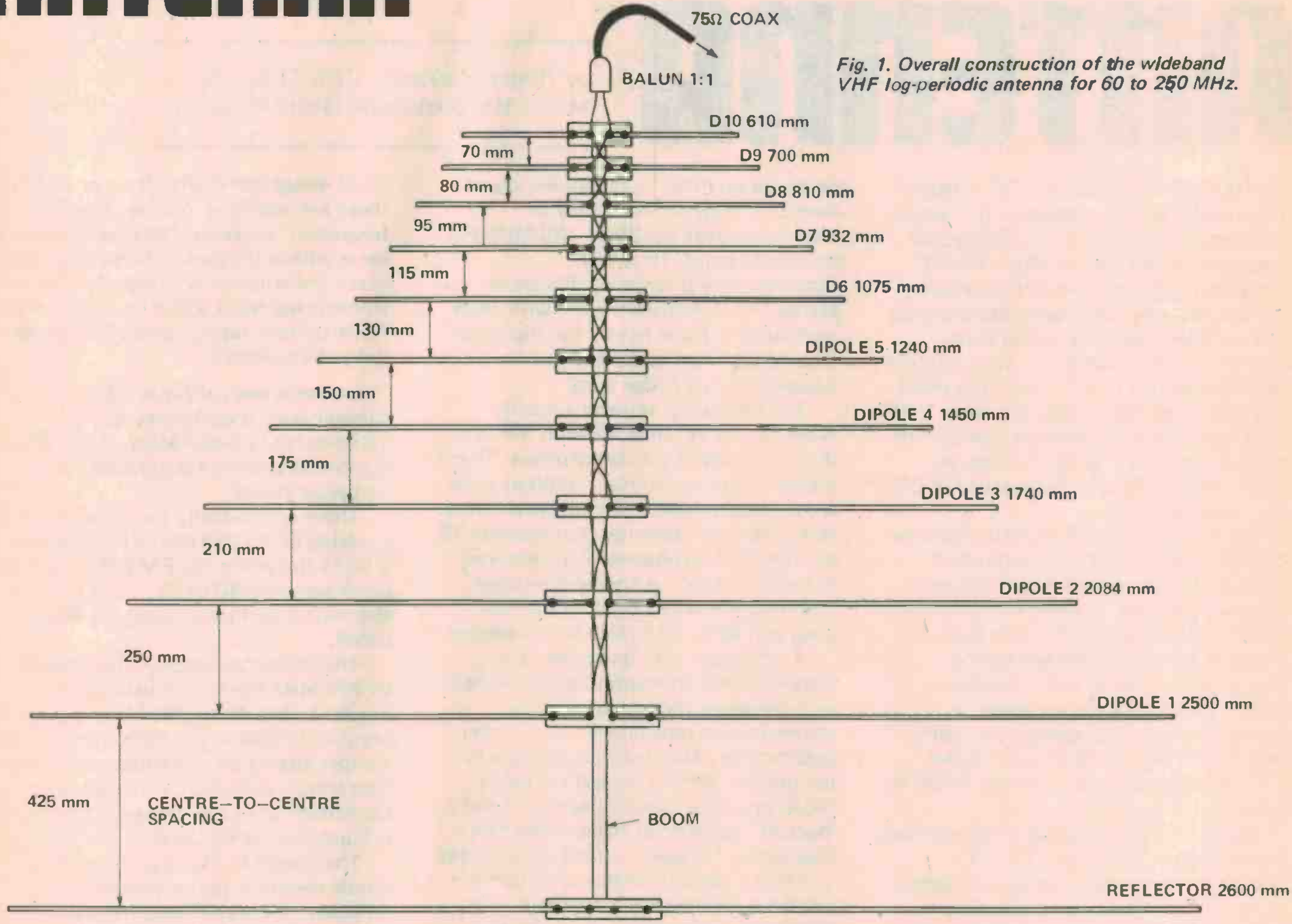


Fig. 1. Overall construction of the wideband VHF log-periodic antenna for 60 to 250 MHz.

Wooden Construction

The boom chosen for the model in Fig. 1 was ordinary rectangular-section 19 by 42 mm dressed size timber. Pine is cheapest, but is subject to warp. Western red cedar, or any close-grained, well-seasoned hardwood, free of warps and knots, would be a better choice. A length a little over 1.7 metres is necessary for the boom alone. A further 1.9 m length will be necessary to make the element to boom brackets.

The elements on the prototype were cut from nine, 1.83 m long (six foot) lengths of 10 mm (3/8") diameter aluminium tubing. This can be bought in many hardware stores, or from specialist aluminium suppliers (such as Alcan, Parramatta Aluminium Supplies, etc) for around 75 cents per length. Alternatively, the tubing can be bought in any of the standard length sizes, sufficient to make the required number of elements. The total length required is about 15.75 m, although around 700 to 800 mm must be added to this figure to account for wastage in offcuts. Thus, about 16.5 m will be needed altogether.

Each of the dipole halves is cut 5 mm shorter than required. The element lengths indicated on Fig. 1 are tip-to-tip measurements, and a 10 mm gap is allowed in the centre of inter-element feedline connection on each dipole. This is illustrated in Fig. 2.

If you are purchasing the aluminium tubing in 1.83 m lengths, they should be cut in the following way:—

TABLE

ELEMENTS	DIMENSION A
LOW REFLECTOR LOW DIPOLES 1, 2 & 3	400 mm
REFLECTOR (2600 mm) DIPOLES 1 & 2	250 mm
DIPOLES 3, 4, 5 & 6	200 mm
DIPOLES 7, 8, 9 & 10	140 mm

Firstly, the reflector will have to be made from two halves, necessitating a joint at the centre during final construction. All the elements should be cut and then stacked according to size before going on with the next stage of construction.

(a) From one length, cut exactly half the reflector, and half of dipole 7 (5 mm less than 466 mm, or 461 mm as explained). Repeat this with another length. You should end up with two pieces 1.30 m long, and two pieces 461 mm long. You then have the reflector and dipole 7 (or D7).

Align each bracket and element at right angles to the boom. A pilot hole should be drilled in the boom, to suit the 35 or 40 mm long screws, to avoid splitting the timber.

The spacings between each dipole, given in Figure 1, are centre-to-centre spacings of the elements.

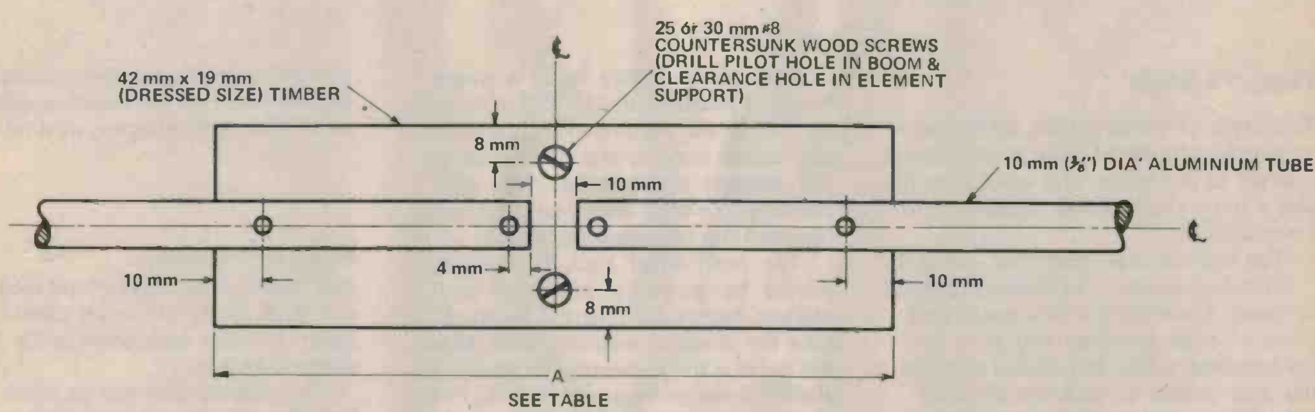


Fig. 2. Dipole boom bracket construction.

(b) From one length cut half D1 and half D6. Repeat this with another length.

(c) From one length cut half D2 and half D4. Repeat this with another length.

(d) Cut both halves of D3 from one length of tubing.

(e) Cut both halves of D5 and one half of D8 from one length.

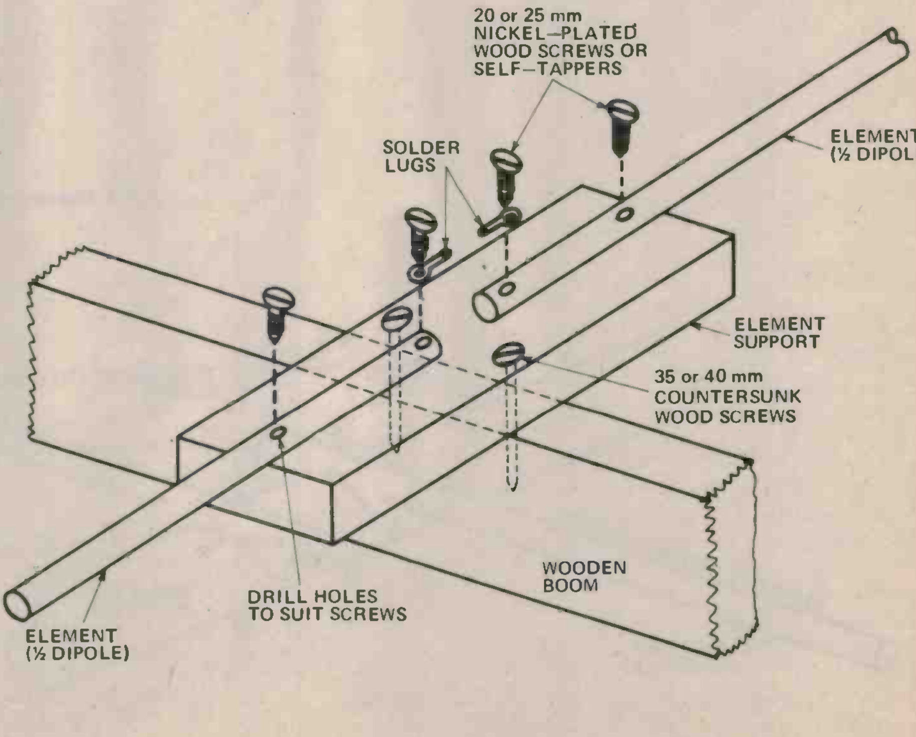
(f) Last of all cut one half of D8 plus both halves of D9 and D10 from one length of tubing.

The wooden element to boom brackets should be cut next. Dimensions are given in the table in Figure 2. Three, 250 mm lengths will be needed for the reflector and dipoles, 1 and 2. Four each of 200 mm and 140 mm lengths will be needed for the other elements. The first line in the table in Fig. 2 refers to the low frequency portion, described later.

Once these are cut and drilled, the element halves should be individually drilled according to Fig. 2, and then screwed to the brackets using 20 or 25 mm screws as in Fig. 3. Solder lugs are placed under the screws holding the centre ends of the dipole halves, as illustrated in the diagram. These provide for the feedline connections.

When the elements and brackets are all assembled, they can be mounted on the boom. Commencing with either dipole 10 or the reflector, mark the position of each bracket on the narrow side of the boom, one by one, and mount them.

Fig. 3. Element mounting using wood construction.



VHF LOG-PERIODIC ANTENNA

'Plumber's delight'

This style of construction, while more expensive than the wooden construction, is likely to last longer and will certainly give a more professional appearance if done carefully

The technique is illustrated in Fig. 4.

Standard element to boom brackets are used. These consist of a cad-plated piece of steel punched and bent to the required shape, and drilled through the 'top' centre to take the securing bolt. They are made to accept 10 mm diameter elements and fit 25 to 30 mm diameter booms. Each half of the elements is attached to an insulated boom consisting of a 1.7 m (approximately) length of ABS or PVC plastic pipe, often used these days for domestic plumbing. An offset between the dipole halves of about 15 or 20 mm is used.

The reflector may be in a single length if possible (not if 1.83 m lengths of tubing are purchased). Otherwise, two halves may be placed as close as the element to boom brackets will permit and a solid electrical joint made between the two securing bolts.

The position of each dipole half should be carefully measured and marked before drilling the boom to take the element securing bolts. Make the holes a little oversize so that the elements can be rotated a little to line them up for the sake of appearance.

Cut all the elements to size, more or less in the order given previously. However, with this form of construction, each dipole half will need to be longer by an amount equal to half the length of the element to boom clamps — about 25 mm.

Next drill all the dipole halves according to the requirements of the element to boom brackets, and assemble each element on the boom, commencing with either the reflector, or dipole 10.

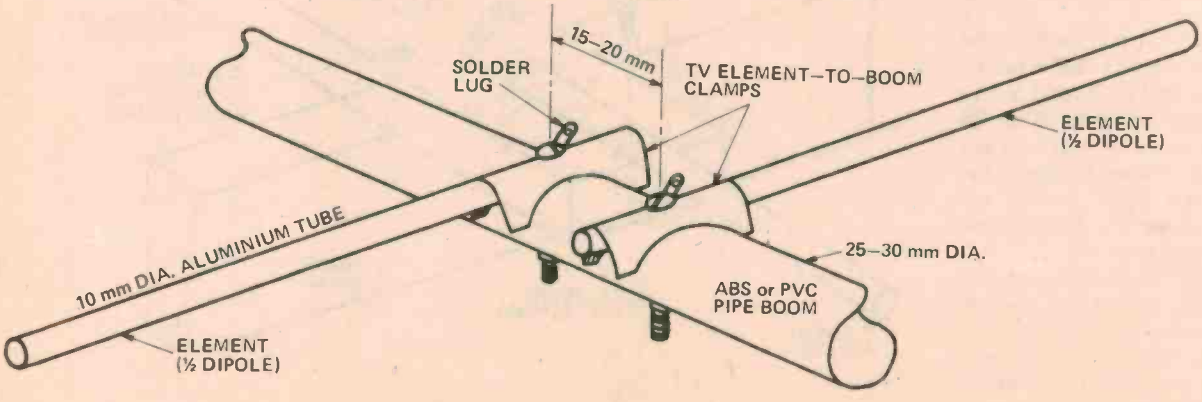
Feedline Connections

The feedline connections are illustrated in Fig. 5. Each individual dipole feedpoint is cross connected with the succeeding one.

The connections can be made with light-gauge hook-up wire, such as PVC covered 7/010, obtainable from most electronic component suppliers. Carefully solder each joint.

The balun transformer is mounted on the end of the boom, adjacent to, or beneath, dipole 10. Short connecting leads run from the balun input connections (balanced) to the feedline connection lugs of dipole 10.

Fig. 4. Element mounting for the 'plumber's delight' version.



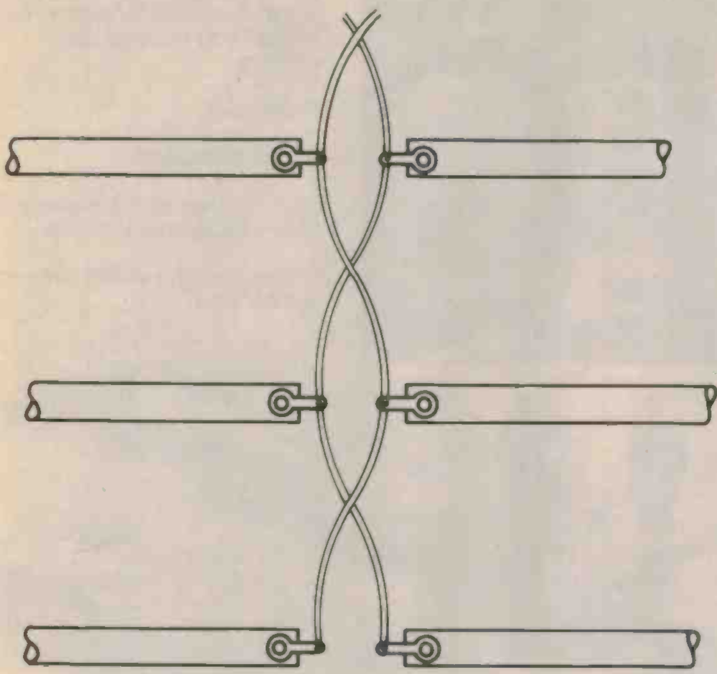
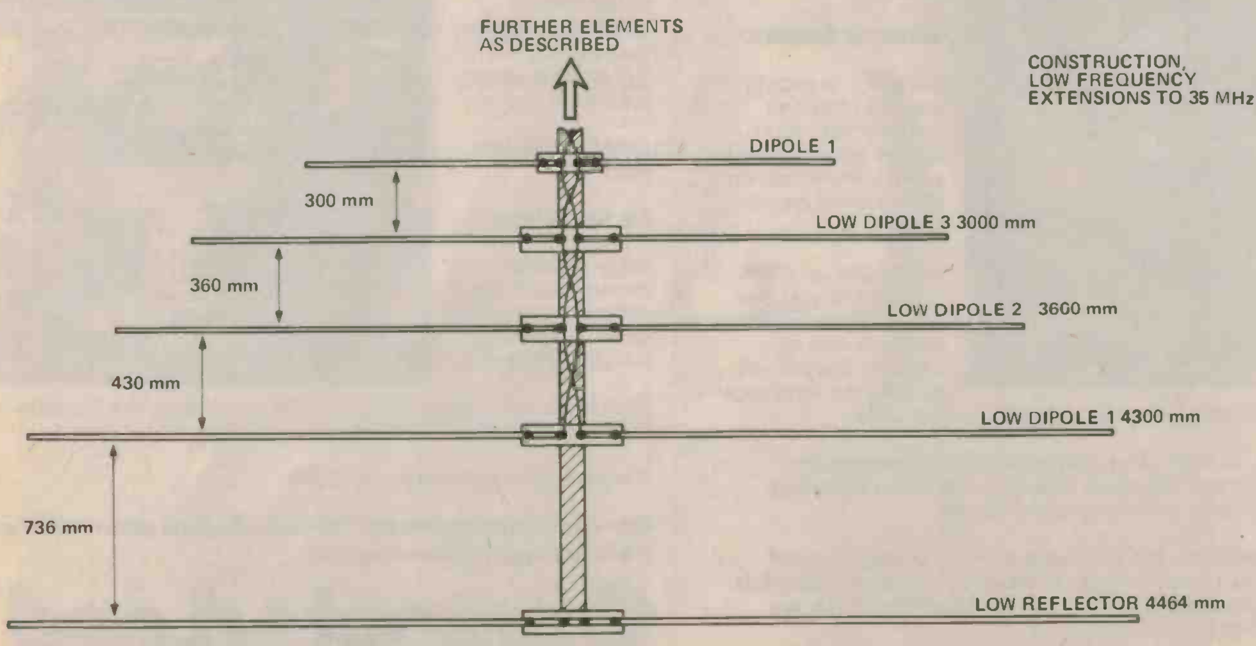


Fig. 5. Feedline connections between the elements.

Fig. 6. Construction of the low frequency extensions to 35 MHz.



Low Frequency Coverage

The 40 to 250 MHz model requires a longer boom, of larger cross-section, and has a total of fourteen elements. The dimensions of the extra three elements are given in Figure 6. They are mounted to the rear of dipole 1, and the original reflector is not used.

A boom 3.3 m long and about 25 mm by 50 mm dressed size cross-section is required to support the fourteen elements. The element to boom brackets can be made of 19 by 42 mm dressed size timber as before. A total length of 3.35 m (including cutting allowance) will be needed, as shown in the dimension in the table of Figure 2.

Plumbers delight construction can also be used for this model; construction is the same as described previously.

The longer low frequency elements in this model necessitate obtaining longer lengths of aluminium tubing, otherwise the shorter lengths will need pieces attached to the ends in order to make up the required lengths of the dipole halves. This can be done by slipping a 40 mm length of the next largest size tubing over the two pieces at the joint, and securing with small self-tapping screws. The feedline connections to the dipoles are as described previously.

Next month we shall continue with balun designs and further details on installation.

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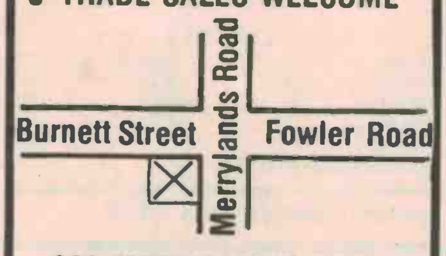

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VFETS FOR EVERYONE

In the first part of this article we examined the structure and features of a new type of semi-conductor, the vertical channel power metal oxide semi-conductor field effect transistor, Vertical MOSFET, or V-MOS recently introduced by Siliconix. This month we shall examine the actual use of V-MOS.

V-MOS POWER FETS like signal MOSFETS, may be used to perform many different functions. However, no matter what the circuit, certain conditions, common to all applications, must be provided. These are supply power, loading, drive signal, and establishment of appropriate operating points.

The electrical characteristics of the VMP1, VMP11, and VMP12, are shown in Fig. 1, and Fig. 2 shows them in graphic form. Since these are uni-directional devices, the source and drain are not interchangeable, and as they are n-channel devices conduction can occur only if the drain is positive with respect to the source, and high enough to ensure operation in the linear region — as with a vacuum tube, bi-polar transistor, or signal FET.

Like the vacuum tube, the absence of secondary breakdown allows full dissipation at any voltage supply up to maximum voltage and current ratings. Thus, where two different designs require the same dissipation but different voltage/load current, no derating is required. This is shown in the "safe operating area" curves. The only bi-polar transistor possessing this characteristic is the single-diffused type, which is also the least suitable for any application requiring wide bandwidth and/or high speed.

This characteristic also simplifies the establishment of suitable load-lines allowing greater safety margin in driving reactive loads where the load-line may be elliptical to the point of leaving the safe-operating area. Designers accustomed to using high voltage high dissipation devices to assure adequate safety margins at relatively low power levels need not therefore be too disconcerted at the 25 watt rating of these devices.

A 10 watt class A amplifier suitable for driving a tweeter in a bi-amped speaker system, for example, need not suffer excessive dissipation except perhaps with an electrostatic unit where such a power level would be inadequate anyway, unless it were operating at a very high cross-over frequency.

Output

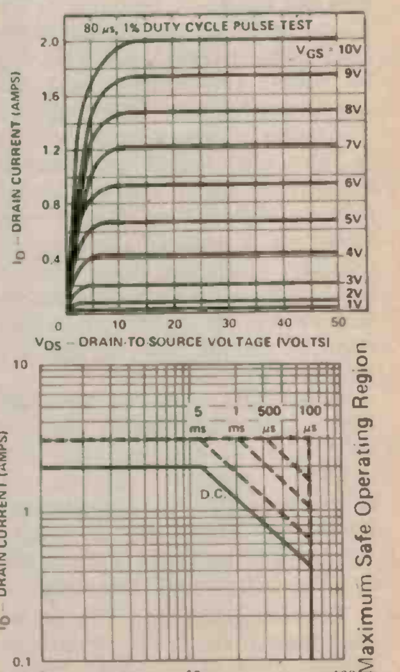
These devices may use any of the types of output circuits in general use with tubes and bi-polars, including transformer coupled (Fig. 12) where the benefits of the absence of charge carrier storage become apparent in the absence of severe ringing at the cross-over point, conventional series output such as in Fig. 3, which is a straightforward transformation from a bi-polar

Fig. 1 Electrical characteristics of the VMP devices (Siliconix).

		Characteristics		VMP 11 Min	VMP 11 Typ	VMP 11 Max	VMP 1 Min	VMP 1 Typ	VMP 1 Max	VMP 12 Min	VMP 12 Typ	VMP 12 Max	Unit	Test Conditions
1	STATIC	BV_{DSS}	Drain-Source Breakdown	35			60			90			V	V_{GS} = 0, I_D = 100 μA
2		$V_{GS(th)}$	Gate Threshold Voltage	0.8		2.0	0.8		2.0	0.8		2.0		V_{GS} = V_{DS}, I_D = 1 mA
3		I_{GSS}	Gate-Body Leakage			0.5			0.5			0.5	μA	V_{GS} = 15 V, V_{DS} = 0
4		$I_{D(off)}$	Drain Cutoff Current			0.5			0.5			0.5		V_{GS} = 0, V_{DS} = 24 V
5		$I_{D(on)}$	Drain ON Current*	1	2.0		1	2.0		1	2.0		A	V_{DS} = 24 V, V_{GS} = 10 V
6		$I_{D(on)}$	Drain ON Current*	0.5			0.5			0.3				V_{DS} = 24 V, V_{GS} = 5 V
7	SWITCH	$r_{DS(on)}$	Drain-Source ON Resistance*		2.0	2.5		3.0	3.5		3.7	4.5	Ω	V_{GS} = 5 V, I_D = 0.1 A
8					2.4	3.0		3.3	4.0		4.6	5.5		V_{GS} = 5 V, I_D = 0.3 A
9					1.2	1.5		1.9	2.5		2.6	3.2		V_{GS} = 10 V; I_D = 0.5 A
10					1.4	1.8		2.2	3.0		3.4	4.0		V_{GS} = 10 V, I_D = 1 A
11	DYNAMIC	g_m	Forward Transconductance*	200	270		200	270		170			mʊ	V_{DS} = 24 V; I_D = 0.5 A
12		C_{iss}	Input Capacitance		48			48			48		pF	V_{GS} = 0; V_{DS} = 24 V, f = 1 MHz
13		C_{rss}	Reverse Transfer Capacitance		7			7			7			
14		C_{oss}	Common Source Output Capacitance		33			33			33			
15		t_{ON}	Turn ON Time**		4	10		4	10		4	10	ns	See Switching Time Test Circuit
16		t_{OFF}	Turn OFF Time**		4	10		4	10		4	10		

*Pulse Test **Sample Test
Pulse Test Pulse Width = 80 μsec, Duty Cycle = 1%
VMC

Fig. 2 Typical VMP1 performance curves (Siliconix).



VFETS FOR EVERYONE

circuit (1), and single-ended output with current source, also transposed from an excellent bi-polar circuit (2) (Fig. 4).

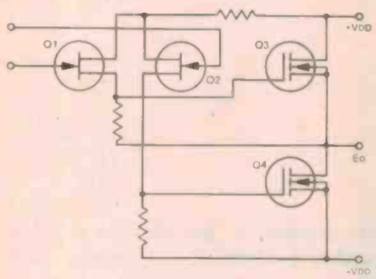


Fig. 3 Series output arrangement

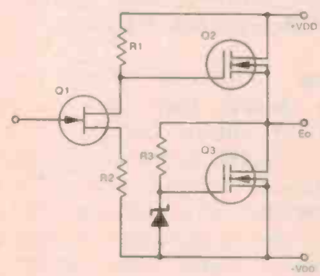


Fig. 4 Single ended output with current source.

Bias and Drive

These series of devices are n-channel, enhancement type MOSFETS, and may be biased and driven using methods appropriate to signal types and bi-polars. The drain is made positive with respect to the source and the gate enables conduction by being forward biased with respect to the source, that is to say it is biased in a positive direction. Unlike bi-polars, however, they are voltage, rather than current controlled, and circuit values are selected to provide the required voltage. Any current drawn is by the bias network itself.

Three bias methods are shown in Fig. 5. Figure 5a shows bias supplied from a fixed bias supply. It is the simplest possible method, allows extremely high input impedances since Rg may be almost any very high value desired, and its stability is limited only by the stability of the bias supply.

The design shown in Fig. 5b has the advantage of requiring no extra supply voltage since it is taken from Vdd. Disadvantages are low impedance and stability. Input impedance consists of the parallel combination of R1 and R2 (disregarding input capacitance of the MOSFET and the very low input leakage.) There are practical limits as to how high this combination can become; if for example, we have a 60 volt supply and require 6 volts bias, we might have some difficulty obtaining higher values than 9 megohms and one megohm for R1 and R2.

Higher values become more difficult to obtain, stability becomes less reliable, internal inductance and distributed capacitance become problems, and overcoming these difficulties usually costs money. In addition, if Vdd is subject to variation, then bias varies. In a class AB amplifier this could be quite serious, since Vdd varies considerably with output level; at high levels, Vdd can be expected to drop, causing a reduction in bias.

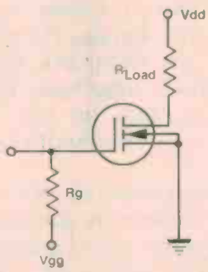


Fig. 5a. HI-Z separate bias supply.

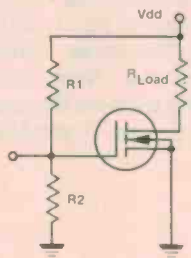


Fig. 5b. Moderate impedance supply.

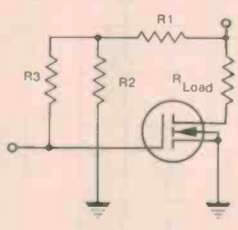


Fig. 5c. HI-Z common supply.

While this may reduce the danger of over-driving the device, it will be forced to operate in its non-linear region which may result in unacceptable performance characteristics unless taken into consideration in the overall circuit design (e.g. choice of feedback values). It does provide some degree of overload protection, and with correct choice of values can provide for class AB operation at low levels, shifting to class B at high levels. With these considerations in mind, and/or where moderate impedances are required, it offers a low cost, simple, and reasonably reliable method of establishing the operating point.

The method used in Fig. 5c is similar except that with the addition of R3 higher input impedances are possible. Its configuration is similar to a noiseless biasing system frequently used in low-level bi-polar amplifiers and integrated circuits (e.g. National LM381A) but its function is somewhat different. Resistors R1 and R2 form a voltage divider as in Fig. 5b, but their junction now forms a fixed bias source as in Fig. 5a. Resistor R3 can be quite high since no current flows. Meanwhile, since the parallel combination of R1 and R2 are effectively in series with R3 they can be reduced to more manageable values. Alternatively R2 can be replaced by Zener diode for stability comparable to Fig. 5a.

Input Protection

Unlike most signal MOSFETS, the gate of each of these devices, with the exception of the VMP4, is protected with an internal 15 volt, 10 mA zener diode. Most signal MOSFETS, as well as the VMP 4, are unprotected, or where extremely high impedances are not required, are protected by back to back zeners. I have no information as to why this different technique is used.
This different technique is used, but it is obvious that a negative signal swing on the gate will result in forward current through the zener. If the device is to be driven beyond cutoff, the driver must be capable of delivering current during its negative swing. Alternatively, a constant current source can be used, a series limiting resistor or a driver biased to the same class of operation as the V-MOS FET.

A constant current source (we'll examine an example of its use a little later) will limit current drive to the value of the constant current diode used; a series resistance will drop the drive voltage as the diode draws current. In both cases, diode current must be limited to 10 ma maximum. Higher currents will damage the protective zener diode.

In amplifier applications, a class A driver is commonly used. However, if a class B output is used, conduction only occurs during positive half-cycles. Therefore drive signal is not required during negative half-cycles. If a source or emitter follower driver stage is biased so as to pass no negative drive, the problem does not occur. However, great care must be exercised in the design of such a stage to ensure that drive does not disappear before the output device is cut off.

This is not too difficult with a class B or near class B stage; If the output device is operated at zero bias, then a small amount of bias on the driver will ensure conduction during slightly more than 180 degrees. Class AB operation is a little more tricky. If conduction is to occur for 270 degrees, for example, the driver should conduct for slightly more than this period.

Two types of drive circuits familiar to designers of bi-polar circuits are the Darlington and super beta, commonly used together to provide a quasi-complementary circuit. Both circuits are current amplifiers designed to provide a compound device with very high hfe and provide base current to the output device. However, similar circuits can be used with these devices to provide phase inversion in a series output stage.

Thermal considerations

As described earlier (Part 1) these devices exhibit a negative temperature coefficient with respect to current, so that as temperature rises, current is reduced, thus providing a self-inhibiting action which provides some protection against overload. However, this is not an unconditional effect Fig. 6 shows the relationship between RDS(on) and temperature (3), based on a worst case temperature coefficient of 0.7 per cent per degree C.

Suppose that the device when 'on' passes a current of 1 amp which causes it to heat up. The 'on' resistance increases (which is why current drops), increasing the voltage drop across the device and the device dissipation. Now, if adequate heat sinking is used there is no real problem but if it isn't, the 'on' resistance and junction temperature will rise to the point where extra charge carriers are generated, thus stabilizing

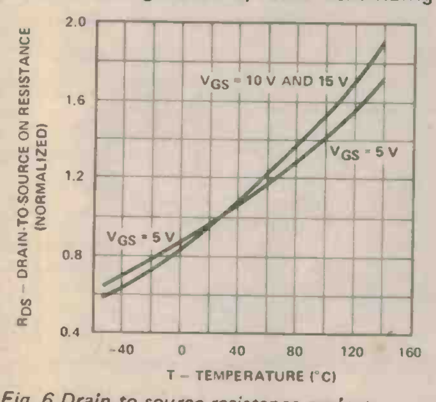


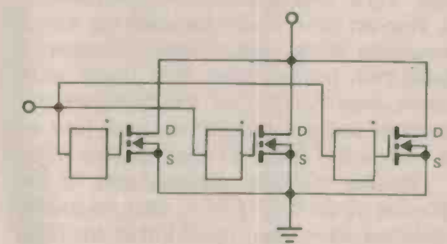
Fig. 6 Drain to source resistance against temperature (Siliconix).

RDS(on). That's great, except for the fact that this doesn't occur until the maximum safe junction temperature of 150 degrees has been exceeded.

You'll remember that we said earlier that the device was free of thermal runaway problems because of its negative temperature coefficient, but it isn't free of thermal destruction problems, and in any case, excessive temperatures will reduce output conductance. Heat-sinking requirements are, therefore, similar to those of bi-polars. The calculations of thermal operating conditions are beyond the scope of this article, but interested readers are referred to the Siliconix literature listed in the references, (4).

Extending the ratings

The current handling and therefore total dissipation capability may be increased by simply connecting several devices in parallel (Fig. 7). No ballast resistors are needed to ensure proper current sharing since if one device draws more current than another it simply gets a little warmer which causes it to draw less (assuming adequate heat sinking, of course). The only major precaution needed is to keep lead inductance in the gate and source connections to a minimum to prevent parasitic oscillations, unless the devices are driven from a low impedance source.



*TO PREVENT SPURIOUS OSCILLATIONS, A 500 Ω-1K Ω RESISTOR OR FERRITE BEAD (FOR HIGHER SPEED) SHOULD BE CONNECTED IN SERIES WITH EACH GATE.

Fig. 7 Basic circuit for parallel operation (Siliconix).

It may be advisable to insert what the British call "stoppers" — small resistors (100 to 1000 ohms) in series with each gate, wired directly to the socket, or ferrite beads mounted on the leads close to the socket terminals. An additional plus when paralleling several devices is that the gm is multiplied by the number of devices used. Mutual conductance gm is specified as the ratio of a large change in current to a small change in control voltage. If, for example, a change of 0.4 volts on the gate produces a change of 0.1 amp through one device, connecting two devices in parallel will give us an output swing of 0.2 amps, but it will still require only the original 0.4 volts gate swing. Since voltage gain A=gm x RL, if gm is increased, A is increased.

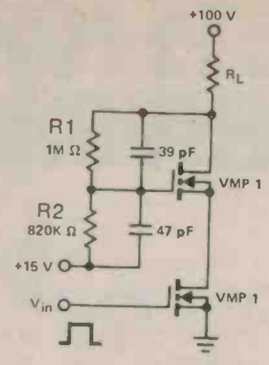


Fig. 8 Diagram for series operation (Siliconix).

In real use, of course, the internal resistance of two devices in parallel is less than of one, the optimum load is less, so in amplifier applications, the net amplification A is the same. But notice that the drive requirements have not changed. With bi-polars current would have to be supplied to each base, thus increasing the output requirements of the drivers. Indeed, with many high-power amplifiers using multiple output devices the drivers are also power devices.

We can also extend the voltage ratings by series operation of two or more devices Fig. 8 shows the technique. Resistors R1 and R2 bias Q2 'on', while C1 and C2 ensure fast switching. The input control signal is inserted between gate and source of Q1. Ordinarily the bottom of the divider chain is at ground potential for signal frequencies, so that circuit is really a cascade.

Maximum current and gm are the same for one device.

Some practical applications

An efficient light dimmer circuit as proposed by Siliconix is shown in Fig. 9. The 4011 acts as a pulse width modulated oscillator whose duty cycle is determined by the ratio of R1 to R2, with R2 adjusted to control the brightness of the W-90 bulb. Of special interest here is the fact that with its fast switching time, the VMP1 is especially suited to pulse width modulation at power levels and suggests it as being suitable for use in switching, or class D linear amplifiers.

A DC to DC converter is outlined in Fig. 10. The VMP1s form an oscillator with positive feedback provided by the additional coil in the gate circuits. In operation the upper V-MOSFET is biased 'on', and the lower V-MOSFET

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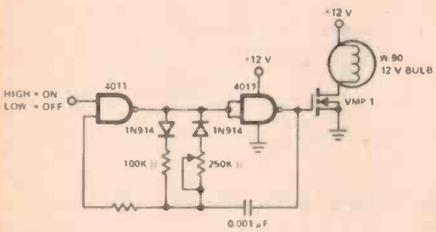


Fig. 9 Circuit of a high efficiency light dimmer (Siliconix).

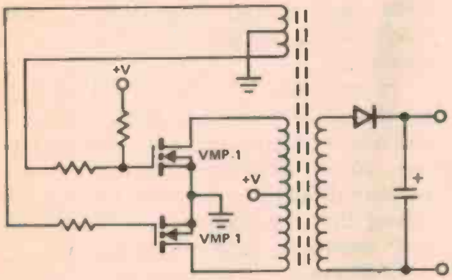


Fig. 10 A d.c. to d.c. converter (Siliconix).

is 'off'. When power is applied the upper device conducts causing current to flow from Vdd through the upper half of the transformer primary and the upper V-MOSFET to ground. The induced current flow through the feedback coil develops a voltage such as to shift the bias in the upper device 'off' (if the winding is connected with the correct polarity) and the lower device 'on'. This causes current flow from Vdd through the lower half of the transformer primary and the lower V-MOSFET to ground.

The secondary circuit consists of a single rectifier and filter. The resistor in the upper gate prevents shorting out gate bias, and the one in the lower gate keeps both sides balanced. In addition, each resistor limits current through the protective diodes. These are expensive devices for such an application, but the high reliability, the reduced rf radiation (due to reduced switching transients) and the circuit simplicity easily make up for the cost. The very high circuit impedance enables running frequency to be set by the self-resonance of the transformer.

Single-ended push-pull transformer coupled audio amplifiers are shown in Figs. 11 and 12. Both utilize the biasing system described in Fig. 5b. A load-line drawn on the output characteristic will show the optimum load to be 24 ohms. In Fig. 11 gate drive is supplied by a single junction FET, and voltage feedback is taken from the output transformer secondary and series fed to the source of the input device. Distortion is under 2% at full output (try to get that with a single ended tube or bi-polar) and could probably be reduced even further by adopting a source follower output stage.

A push-pull version of Fig. 11 is shown in Fig. 12 using a differential input to provide phase splitting, drive, and a feedback point. Although the transformer winding ratio implies the use of a low impedance loudspeaker, a step-up ratio could be used for direct coupling to an electrostatic speaker, a balanced transmission line (both with some modification of the feedback circuit) an unbalanced transmission line, or a 70 volt speaker distribution line.

Notice in both circuits, and in the biasing circuits of Fig. 5, that no source resistors have been used, either for local feedback or for bias setting. In tube and bi-polar circuits it's a useful technique, and with bi-polars can be used to stabilize bias and control thermal runaway by using the increased current flow to increase the voltage drop, thus reducing base-emitter voltage. However, if used with these devices, it will actually impair the self-limiting action of its negative temperature co-efficient. If temperature rises due to high current, current flow is reduced. This would reduce the voltage drop across a source resistor, lowering the source voltage and increasing the gate-to-source voltage, causing an increase in current flow. The circuit would work great while it lasted — which wouldn't be for long.

Record amp

Figure 13 shows a magnetic recording amplifier derived from a tube circuit. Its biggest advantage lies in its ability to provide equalization for head losses by incorporating the head within the feedback loop. Additional equalization is then required only for gap losses and tape self-demagnetization. Q1 acts as a driver for Q2, the output stage, which, with series resistor R9, provides a high impedance current source for the record head, as well as providing a mixing pad between audio and bias currents.

The record head's return path to ground is through R11. The inductance of the record head results in an impedance characteristic which rises with frequency. At frequencies at which the impedance of the head is low in comparison with R9 and R10 in series, load current is essentially constant. As frequency rises, however, head impedance becomes appreciable. With appropriate selection of R9 and R11, depending on head characteristics, the voltage across R11 decreases as the head impedance becomes significant. If feedback is taken across R11 it will decrease with rising frequency, causing an increase in gain, at a rate of 6dB/octave.

Feedback is applied across R3 via R10 and C8 (which supplies bass boost below 80 Hz) C5 and C6 provide additional high frequency boost for a total ultimate slope of 12 dB/octave. This circuit is so effective that no additional boost is needed at 15 ips, and only a small amount at 7.5 ips with high coercivity tape.

The biasing method used is that of Fig. 5c. The large amount of local current feedback provided by R2 and R3 results in a high output impedance

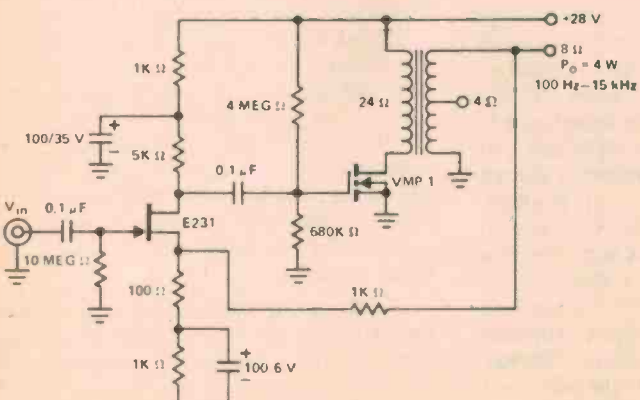


Fig 11 Simple single ended transformer coupled audio power amplifier (Siliconix).

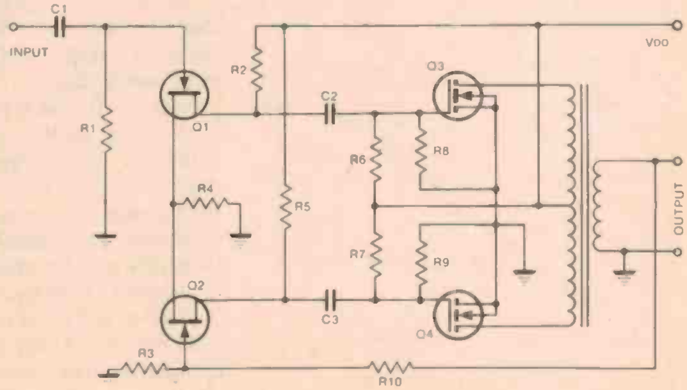


Fig. 12 Transformer coupled output.

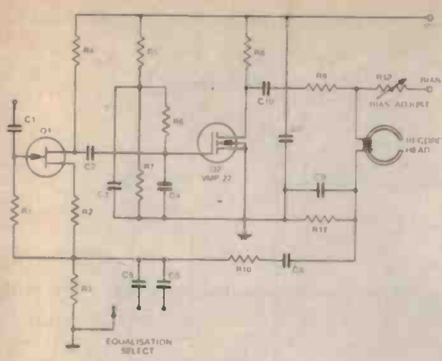


Fig. 13 Tape recording amplifier.

for Q1, so the biasing network is selected to provide high impedance with reasonable values. Capacitors C3, C4, C7 and C9 bypass bias signal to avoid overloading Q2, and to prevent attenuation of bias current.

Power amp

Figure 14 shows a high quality power amplifier designed by Siliconix Inc. (5) and described in their application notes. Output current capability is increased by using three VMP12's in parallel, providing for 6 amp current 75 watt dissipation and load optimized at 8 ohms. Q11-13 operate as a source follower, while Q8-10 form a quasi-source follower. This is accomplished by applying local feedback from drain to gate via R14, R15, and driving the gate by a modified current source. This consists of a cascade circuit with a constant current diode as the load.

For the benefit of those not familiar with these devices, a constant current diode is really a FET connected internally as shown in Fig. 15. Since current in a FET is controlled essentially by the gate-to-source voltage, changes in load or in applied drain-to-source voltage have negligible effect since gate-to-source voltage is held constant. This is a current analogue to the zener diode and is described in detail in Siliconix literature (6).

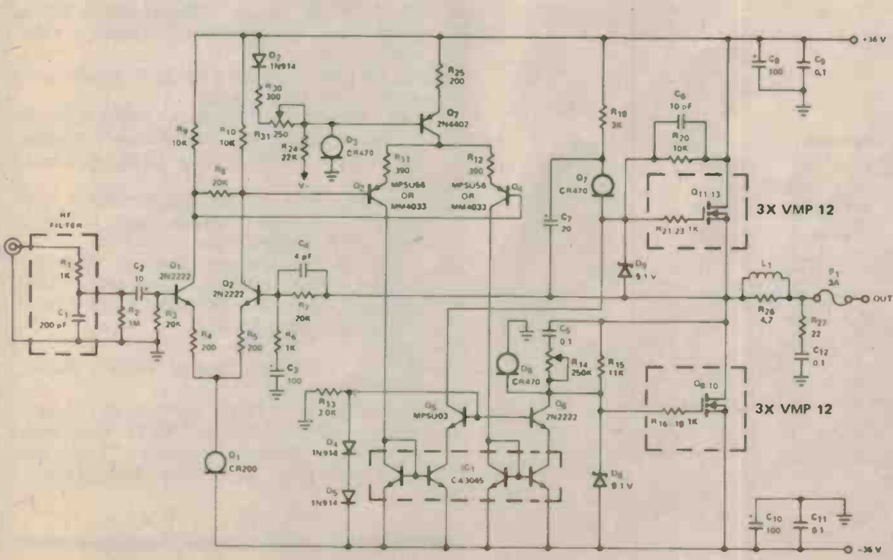
The design is push-pull from input to output, thanks to differential circuitry throughout, prior to the drivers. Open loop distortion is low, bandwidth wide, allowing satisfactory performance with only 22 dB of feedback. Lead compensation only is used (via C4), along with the liberal use of local feedback (R4, R5, R11, R12,). The result is very low transient IM and a slew rate of over 100 V/microsecond. THD is quite respectable even though the numbers might not impress the average audiophile accustomed to amplifiers with great specs and poor sound.

Incidentally, D8 and D9 illustrate an excellent method of providing output current limiting. In this case, 9.1 volt zener diodes limit drain current to slightly less than 2 amps. At first one might be tempted to depend on the built-in protection diodes to accomplish this, but it should be remembered that these devices are for protection against static discharge. Their zener voltage of 15 volts at 10 mA cannot possibly be used since the absolute maximum permissable drain current occurs at a gate-to-source voltage of 10 volts.

Commercial amps

A simplified version of Yamaha's B1 amplifier is shown in Fig. 16, (8). In this circuit a cascade drive system is used, but in a differential form with the constant current source in the common source circuit. This is an example of all FET design of excellent performance and received rave reviews in several publications including ETI. It's also inexpensive!

Fig. 14 A high quality 40W amplifier (Siliconix).



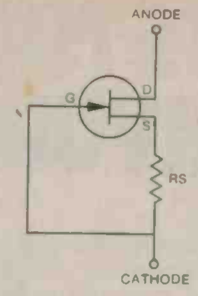


Fig. 15 A FET as a constant current diode.

The VHF linear amplifier in Fig. 17 will deliver 5 watts peak envelope with second and third order intermodulation at -30 dB from 144-146 MHz. It will also prove useful as a receiver pre-amp with a noise figure of 2.4 dB. V-MOSFETS show considerable promise in rf applications because of their linear transfer characteristic, the high gain capabilities even with Ft somewhat above 600 MHz, low noise and (in receiver front ends) very wide dynamic range. Although this article has dwelt on the VMP 1 family, there is also the VMP 4, designed specifically for rf applications and which is now available.

Finally, how about something elegant for its simplicity, such as the tapered current voltage limiting battery charger shown in Fig. 18. This is especially useful with Ni-Cad batteries which are intended for stand-by use and are permanently on charge, such as electronic clocks. Overnight shut-downs of a few hours are occasionally but irregularly experienced. You know what this can do to clocks. Especially alarm clocks which are supposed to make noises, turn on radios, start the coffee at a pre-set time in the morning so you can go to work. Battery operation is not too satisfactory if the readout is on continuously, and Ni-Cads should not be on permanent floating charge.

With this little device current is supplied to the battery via the VMP-1. Gate voltage is set at a value equal to the desired end-of-charge voltage. As the battery charges, its voltage increases, reducing gate-to-source voltage, thus reducing charging current. When the battery reaches full charge its voltage, and that of the source, equals gate voltage, and charge is terminated. If a load is placed across the battery it will draw current, and as the battery voltage drops slightly below gate voltage, charging at a trickle rate occurs — automatically.

VFETS FOR EVERYONE

Experimentation

The various applications shown are intended as suggestions for further experimentation. They are mainly designed to illustrate various characteristics of the device under consideration, and are not necessarily representative of commercial practice or of finished designs. In some cases this may be just as well! But we would be delighted to hear of any readers' experience with any of these or other circuits.

The author's feeling is that V-MOS constitutes a genuine breakthrough in semi-conductor technology, as important as the silicon transistor and the FET itself. We'll be seeing more of these devices, with higher ratings (a 10 amp 200 volt unit is already under development) and specialized characteristics. They are said already to be in use commercially as magnetic core drivers.

Digital enthusiasts may be somewhat impatient with the strong emphasis on audio applications in this piece but other literature has placed great emphasis on digital applications, with little attention paid to linear techniques beyond the 40 watt amplifier described here. The serious reader in all areas is referred to the references at the end.

Further literature may be obtained from Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. They have been most helpful in providing information for the preparation of this article.

Have fun.

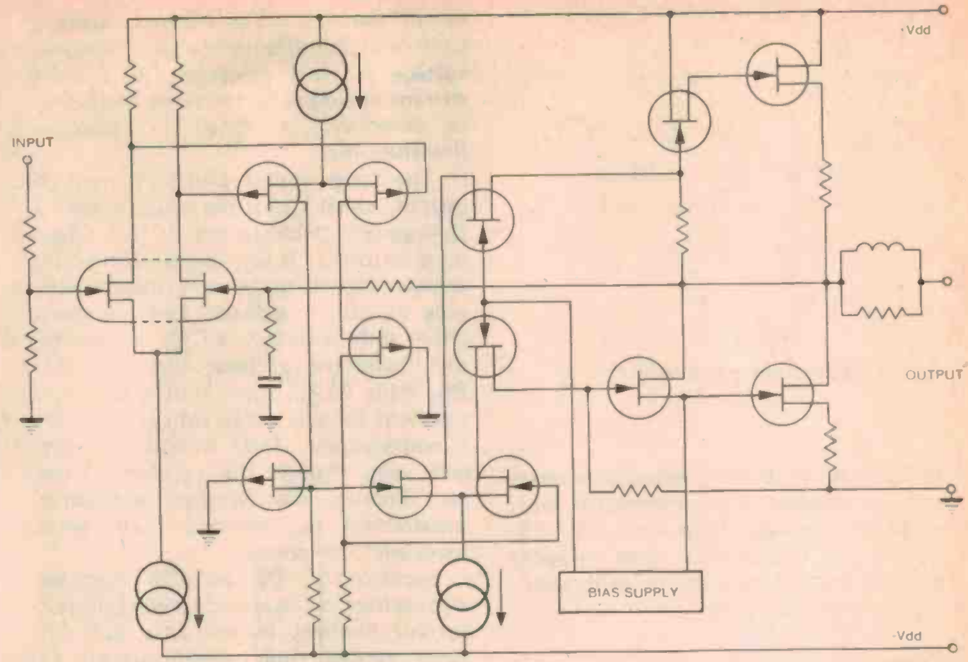


Fig. 16 Simplified Yamaha VFET amplifier diagram.

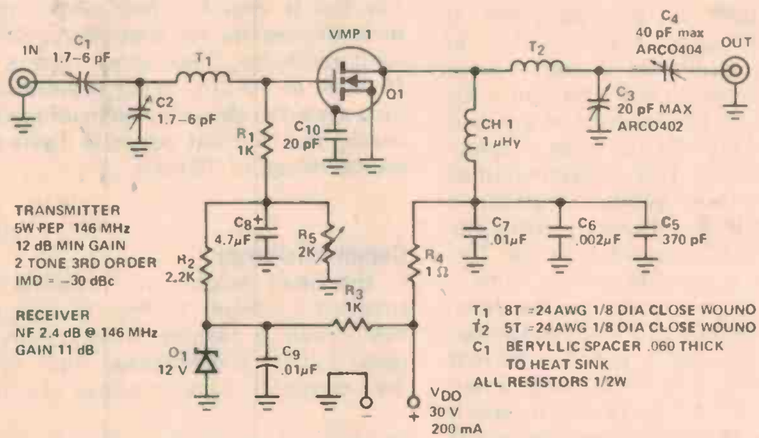


Fig. 17 144-146 MHz linear amplifier (Siliconix).

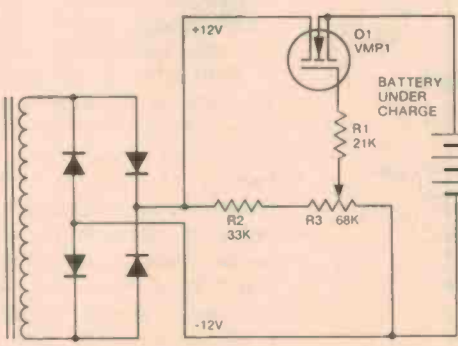


Fig. 18 Tapered current voltage limited battery charger.

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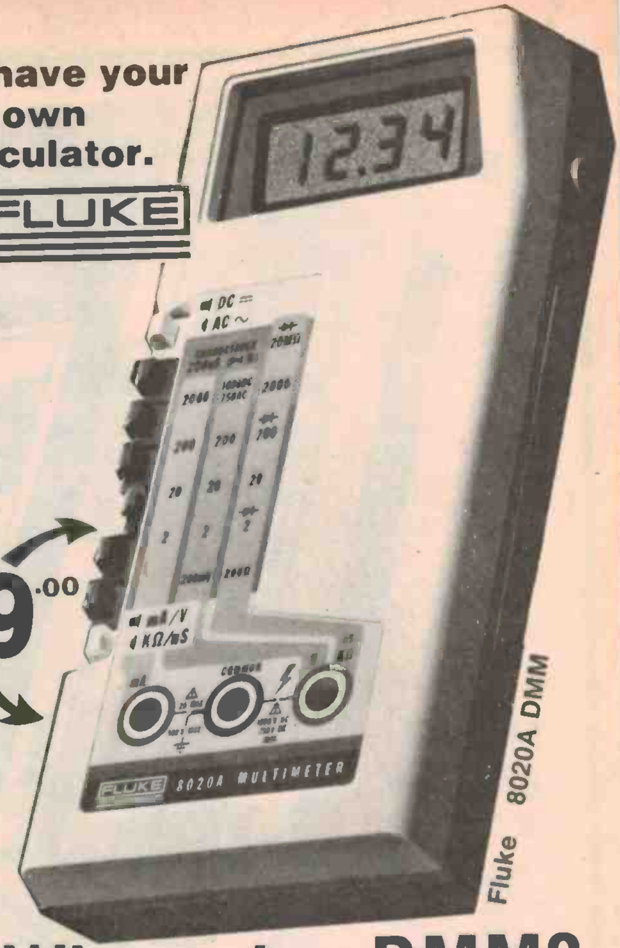

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UHF CB ANTENNAS

Roger Harrison explains what's what on 476 MHz mobile.

MANY CBERS HAVE been sitting on the sidelines waiting to see what happens with UHF, and as everything seems to be coming together now for UHF CB – here's an article on antennas for the UHF CB band. It was compiled with the assistance of Scalar Industries, one of Australia's foremost antenna manufacturers.

The introduction of the 476MHz CB band has opened up a whole new field in antenna technology to the CBer.

Although it is true that the same basic principles apply for 27MHz as well as UHF there are a number of critical differences when you get down to the practical situation.

That old phrase about "near enough is good enough" no longer applies when it comes to UHF antenna systems.

Physical construction and coax cable terminations become quite critical.

Even the mounting base becomes an intricate part of the whole antenna, contributing to, or detracting from, the overall efficiency of the system.

Mounting bases:

The antenna mounting bases used on 27 MHz are virtually unusable.

Their physical construction makes them become part of the antenna and the usual method of terminating the cable further compounds the problem.

Efficiency of these bases, while fine on 27MHz, is quite poor on 476 MHz because of these physical problems.

This can be best appreciated when you look at the length of antennas for the UHF band.

A full quarter-wave antenna is only 15cm long while the same type of antenna on 27 MHz is 277 cm long.

The amount of unshielded cable termination and the bolt to which the whip attaches, that passes through the antenna base, all become an appreciable part of the antenna itself.

The combined length of cable termination and whip bolt is typically between 4cm and 7cm on a 27 MHz antenna base!

If most or part of this is situated below the necessary groundplane area, or roof line of the vehicle to which it is fitted, then it can result in an appreciable loss. You might do just as well sticking a screwdriver in the transceiver antenna socket.

The availability of above-roof terminating bases overcomes the problems just outlined.

In these special bases the whole of the coaxial cable is terminated above the vehicle roof or groundplane line so that as much as possible of the available power from the transmitter is radiated by the antenna itself.

A typical UHF antenna mounting base is illustrated in Fig. 1.

These bases are used quite extensively in commercial grade mobile antennas for the 400 MHz to 500 MHz land mobile band, and are generally more easily assembled than conventional mounts.

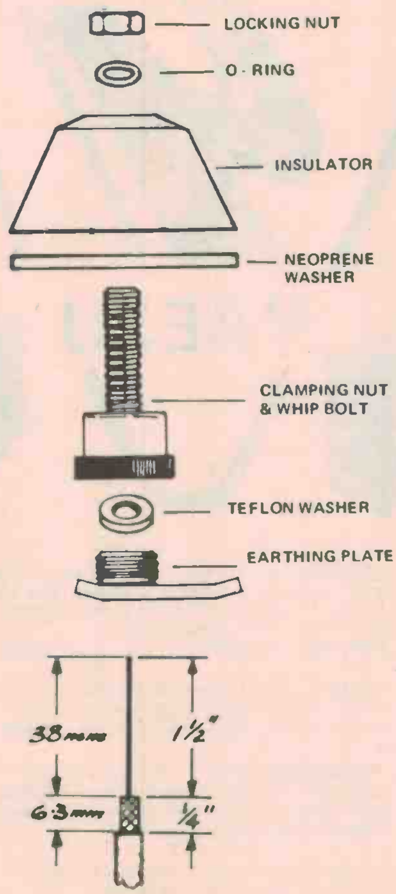

Figure 1. The Scalar antenna mounting base type OB, illustrated here in an exploded view, permits correct termination of the coax for proper operation of the UHF antenna.

Figure 2. This base antenna, model CB470 made by Scalar, has a genuine gain of 6dB over a half-wave dipole and provides an increase in the effective radiated power of four times omnidirectionally. Overall height is 2.44 metres.

And that's not to be sneezed at.

As you can see, such an antenna would be very useful in a base station installation for 476 MHz.

With a height of 2.44 metres, a 6 dB gain antenna is an eminently manageable size – and there are no SWR adjustments to make! The Scalar model CB470 base station antenna is of this type and is illustrated in Fig. 2.

The same thing can be done for mobile antennas, as the same principles apply.

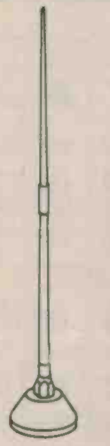

Figure 3. This mobile whip has a gain of 4.5dB and is only 534mm long. It is Scalar's model CB410 and mates with their type OB UHF base.

UHF base antennas:

BASE station antennas for the UHF band become quite sophisticated.

An antenna having a real gain of 6 dB over a half-wave antenna becomes a practical proposition.

It should be realised by most readers here that a 27 MHz base station antenna with a true gain of 6 dB would be 22 metres (72 ft) high!

Compare this to a 6 dB gain UHF antenna – it's only 2.44 metres (8 ft) high.

These types of 'gain' UHF antennas are comprised of 'collinear dipoles'.

They consist of a series of half-wave radiators stacked one on top of the other and all connected in phase.

This increases the effective radiated power.

A vertically polarized antenna of this type, having a gain of 6 dB, when used in conjunction with a 5 watt UHF CB transceiver would increase the effective radiated power to an equivalent of 20 watts omnidirectionally.

In other words, the set up would produce the same results as a 20 watt transceiver connected to a half-wave vertical antenna.

Figure 4. Scalar's dual band 27 MHz and 476 MHz mobile antenna, model CB420, allows operation on both the HF and UHF bands.

UHF mobile antennas:

'GAIN' mobile antennas are already available for the UHF band.

Two-element, vertical whip antennas are available that have considerable gain compared to a quarter-wave whip. One type has a gain of 3 dB which increases the effective radiated power by two, and another has a gain of 4.5 dB, increasing the effective radiated power by a factor of three. A 4.5 dB gain mobile antenna, the Scalar CB410, is illustrated in Figure 3.

The antenna 'gain' also works on reception so adding a gain antenna boosts performance both ways.

Dual-band antenna:

A RATHER unique antenna development, designed by Scalar Industries and peculiar to Australian CB requirements, is a dual-band-mobile antenna which can be used quite effectively for either 27 MHz or 476 MHz (it is illustrated in figure 4).

A diplexer, or combiner as it is more commonly referred to, will also be shortly available which will enable this antenna to be used simultaneously with a 27 MHz and 476 MHz transceiver, either in receive or transmit mode, without the need for switching.

You'll be able to hold dual-band duplex conversations while mobile!

Cable and connectors:

Coaxial cable for UHF CB transceiver installations will have to be carefully selected.

The old standard – RG58 can only be used in short runs, provided a good-quality brand is selected.

It is quite unusable in base station installations as the antenna coax run is usually around 15m to 30m.

A 30m length of even good quality RG58 coax will have a loss of about 10 dB! That is, only one tenth of your power will reach the end of the cable. The rest of it will be vainly trying to keep the coax warm!

As you need to deliver as much power to the antenna as you can get, a loss of this much is just no good.

However, manufacturers have been coming to the rescue for many years and some excellent quality coax cables are available that will do the job nicely.

They cost more than the RG58 you use on 27 MHz, but it's worth it.

Connectors too, can be a source of loss in a UHF installation.

That old PL259 is just too 'lossy' to use.

The problem is that, to the RF signal trying to get through a connector of that sort, it finds that it doesn't look like a connector! Even with 'good' connectors, a loss of around 0.2 dB is always allowed for each connector.

A commonly available connector that serves very well on UHF is the BNC connector.

These suit the smaller-diameter cables (5mm – 6.5mm) and are a push-on type of connector. They're relatively inexpensive these days.

For larger diameter cables, the type N connector is more commonly used.

These will handle cables up to 13mm in diameter used for long, low loss, runs in base station installations.

The Philips FM320 transceiver uses a Belling-Lee coax antenna socket, as used commonly with TV coax installations, and have proved adequate.

Shop around!

THE variety of UHF antennas available to the CBer will be quite broad, and careful consideration should be taken before jumping in and buying the first antenna you see.

Plenty of good advice will be available from Australian antenna manufacturers as to the most suitable type and proper installation of UHF antennas for the 476 MHz ultra high frequency CB band.

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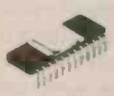

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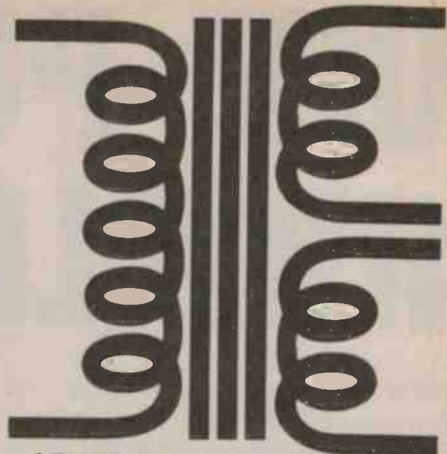

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part 3

140 W Microstrip 2 Meter Amplifier

With the introduction of larger VHF transistors it is now possible to construct relatively simple high power amplifiers. The circuit of Fig. 17 shows a 140 W output amplifier using two CTC BM 70-12 transistors. The transistors are used in parallel with separate input and output circuits of 25 Ω impedance, the two circuits combining to make a 12.5 Ω impedance point at C13 and C14.

Stabilization is accomplished by using collector to base feedback networks which have a low impedance to low frequencies applying large negative feedback to prevent oscillations.

Current sharing between the devices is improved by tying the devices together at a high impedance point (relative to the transistor impedance) along the line (12.5 ohms) and tying the bases and collectors together with 15 ohm resistors, R3 and R4.

Underwood metal clad mica capacitors are used throughout because of their low series inductance and high current capacity. They cannot be substituted. Elmenco trimmers are used for C13 and C14. These were not variable in the original design but were found necessary to optimise the matching at two metres.

Bias can be applied for linear operation using one of the bias circuits. described in November and 140 watts pep can be achieved before flat topping.

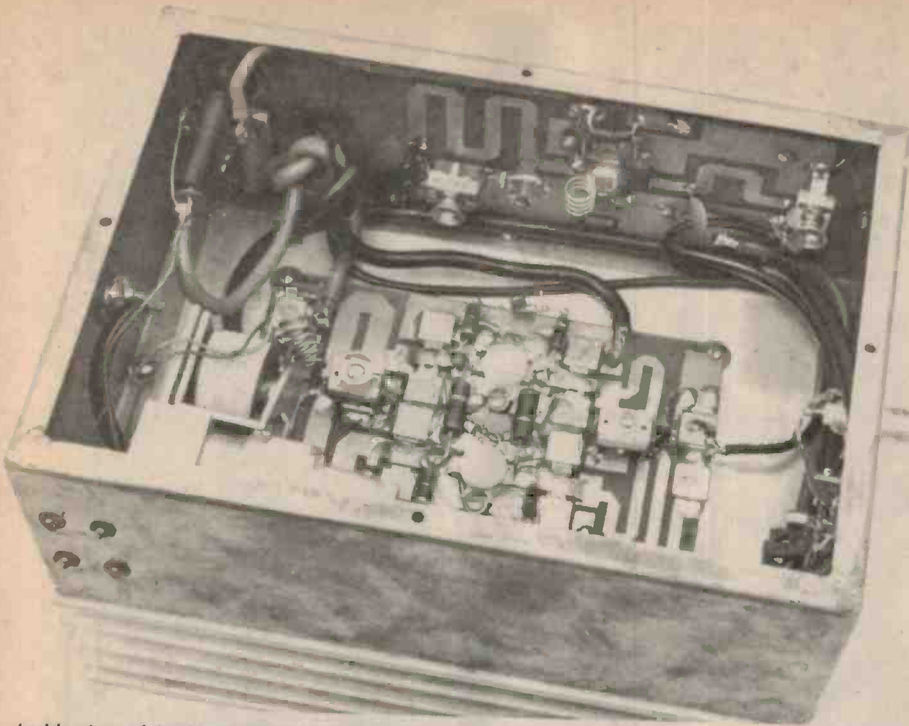
Overall view of the 10 W to 140 W amplifier used for 2 m mobile operation. Note size of the main heatsink — designed for continuous operation! Heatsink for the ETI 716 driver in the foreground. Mounted on the inside back panel is the changeover relay. The fuse holder proved inadequate for the job as around 25 amps is pulled from the car battery when you hit the button!

Construction

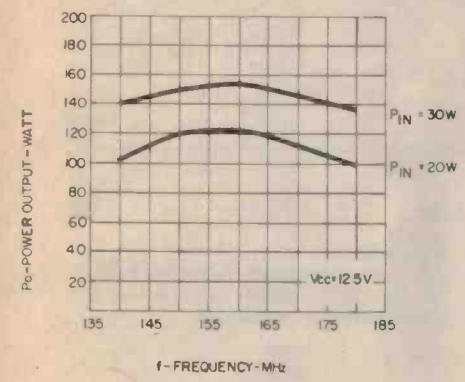
The pc board layout is shown on page 75. This layout will work for G-10 glass filled epoxy board with a thickness of .062" = 1.6mm. Other types of pc board can be used, however, microstrip line length and widths will have to be corrected! The pc board has copper foil on both sides. One side is etched to form the pattern and the other side is used as a ground plane.

The recommended assembly procedure follows:

1. Trim the board to size.
2. Punch or drill 10 tap holes for 6BA screws (no. 43 drill). Hole centres shown as small dots on the pc layout.
3. Use the pc board for a template and lay it on the heat sink. Drill 8 pilot holes into the heatsink using the previously drilled holes in pc board as guides. Drill one in each corner and one in each side of the device mounting hole. Drill out centre holes where the transistors mount.
4. Tap the 8 heatsink holes for 6BA screws.
5. Use a file to clear the mounting hole for the BM70-12 flange. Check transistor for flange dimension.
6. Use 10 mil copper shim stock to connect top side ground points to the ground plane (bottom side). Make one ground plane connection under each emitter lead. Two additional ground plane connections are made by folding the shim stock over the edge of the board to ground the case of C15 and C18.
7. Study photograph very carefully. first, mount the BM70-12 into position. Locate the shunt capacitors as shown in the photograph and spot solder the case to ground. Remove the BM70-12 and mount copper straps L1 and L2. Notice that these straps mount on top of the capacitor



Inside view of 10 W to 140 W broadband power amplifier used on 2 m band. Input on the right, output on the left. The ETI 716 drives the 140 W output broadband amplifier utilising two BM70-12's. By a fortunate accident, the ETI 716 pc board was made laterally reversed! Simplified cabling arrangements. The carrier-operated switching and bias circuits are located on a small board on the lower right.



leads and the base and emitter leads will mount on top of the straps. Solder all capacitors and straps carefully to avoid shorts. Mount the BM70-12 and solder its leads near the cap. Repeat Step 7 for Q2.

8. Mount remaining shunt capacitor and miscellaneous components as shown in photograph.

Performance

The power bandwidth is shown on the graph. The performance at 146 MHz was improved by making C13 and C14 variable.

Power output — 140 watts
Power input — 30 watts
Efficiency — 50%
Supply voltage — 12.5V
Supply current — 23 amps
Max supply voltage — 16.0V
Spurii — better than 60dB down

This amplifier is fully protected against infinite VSWR. In fact a 10 mm spark can be drawn from the output terminal to a key ring with the antenna removed. We did it and the amp still worked!

Using the ETI 716 and the 140 W Amp

How about 140 watts output mobile? The ETI 716 was mounted in the same case as the 140 W amp and used to drive it. See Fig. 18.

A coax relay was used on the output with diode switching on the input. The ¼λ coax line was used with the delay which shorted the unused contacts to earth on transmit, therefore shorting the end of a ¼λ line which reflects an open circuit at the amplifier input. The exact length of this line will have to be measured with an impedance meter or by cut and try method due to the effects of the coax fittings into the relay and the length of line inside the relay itself to the shorting contacts.

If a shorting type relay is not available, normally open contacts can be used with a ½λ line which again reflects an open circuit at the amplifier input. This line must also be measured in situ due to the effects of the relay.

Switching

A carrier operated relay circuit is included in Fig. 18. A small portion of the drive signal is tapped off via the 1pF capacitor, rectified and used to drive the BC109-179 pair which switches the coax relay. A delay is introduced if the 10µF capacitor is switched in giving fast-attack slow-delay switching for SSB use. This simple circuit is very effective and will operate on less than a watt input.

Heatsinks

Heatsink requirements for these amplifiers depend on the type of service. However maximum heatsink temperature should not be allowed to rise above 100°C from a 30°C ambient.

For the ETI 716 amplifier the recommended heatsink would be better than 2.3°C/watt rating — for the 140 watt amplifier better than 0.5°C/watt.

$$\text{H.S.} = \frac{\Delta T^0 C}{\text{power dissipated (watts)}}$$

Always use heat conducting compound between the transistor and the heatsink and be sure that the heatsink is *perfectly smooth and flat.*

Parts List

C1, C3	two each 68p or 69p metal-clad mica caps.
C2, C4	two each 200p metal-clad mica caps.
C5, C7	two each 100p metal-clad mica caps.
C6, C8	two each 68p metal-clad mica caps.
C9, C11	1500p redcap or hi-k ceramic
C10, C12	1µ 35V DC tantalum (metal-case type)
C13, C14	40p Elmenco mica compression trimmer in parallel with 25 to 47p metal clad mica cap. — or 115p Elmenco trimmer.
C15, C18	33p metal-clad mica caps.
C16, C17	300p metal-clad mica caps
R1, R2	15 ohm ½W resistors
R3, R4	15 ohm 1W resistors
RFC1	0.33µH moulded RFC.
RFC2, RFC3	0.15µH moulded RF chokes
RFC4	6 turns, 18g tinned or enamel wire, 6mm i.d., 15mm long.
L1, 2, 3, 4	copper strap, 5mm wide x 20mm long x 0.4mm thick (0.2 x 0.75 x 0.015 mil)
Q1, Q2	CTC BM70-12.

VHF POWER AMPLIFIERS

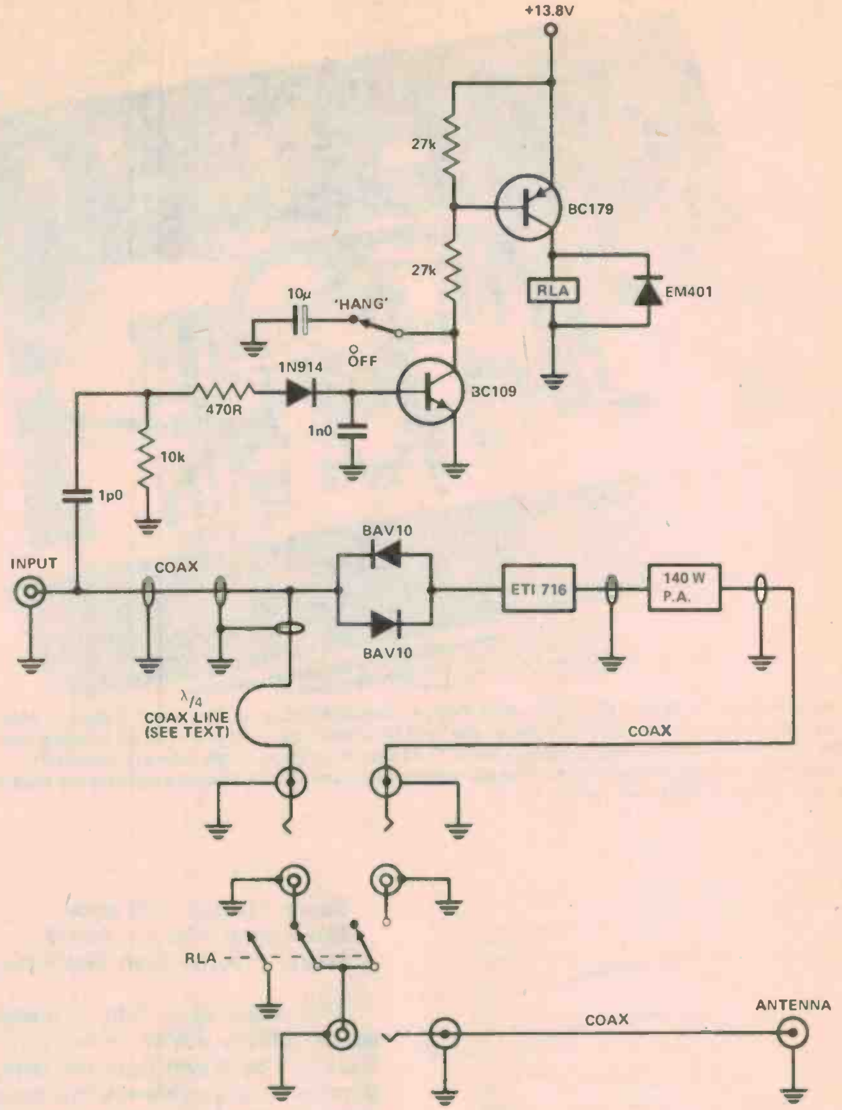


Figure 18.
The carrier-operated relay switching circuit for the 10W to 140W mobile power amplifier. Construction is non-critical.

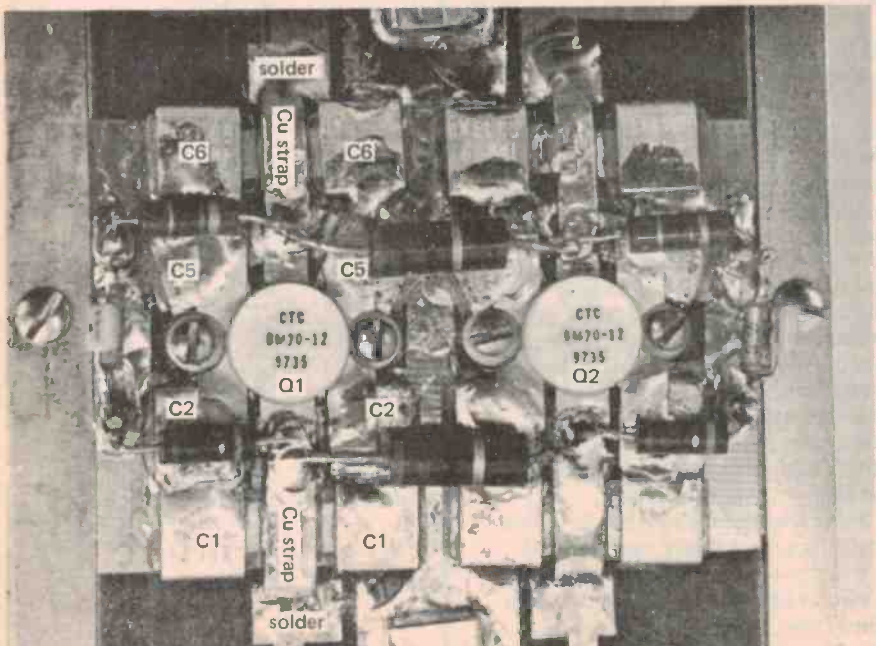
What Next?

The last 10 years or so have seen the introduction of commonly available RF power transistors to 150 W power output and others that operate to 3000 – 4000 MHz.

The next generation of devices are likely to be VMOS power FETS. Already available is a device which gives 20 watts output at 160 MHz, has a gain of 15dB, a drain impedance of around 60 ohms, is completely indestructable, can be used in a broadband circuit flat from 30 – 250 MHz and if that's not enough can be used for the front end transistor as well with a noise figure of 2.4dB!

Acknowledgements

The authors wish to thank Sydney University Department of Electrical Engineering for their help in providing much of the test equipment used. We would also like to thank Ian Little of Ampec Engineering for generously supplying us with the VHF power amp evaluation kits and copious amounts of data on the CTC range of transistors used in these projects.



Pix 6
Close view of portion of the 140W amplifier showing mounting of the transistors, metal-clad mica capacitors and small components.

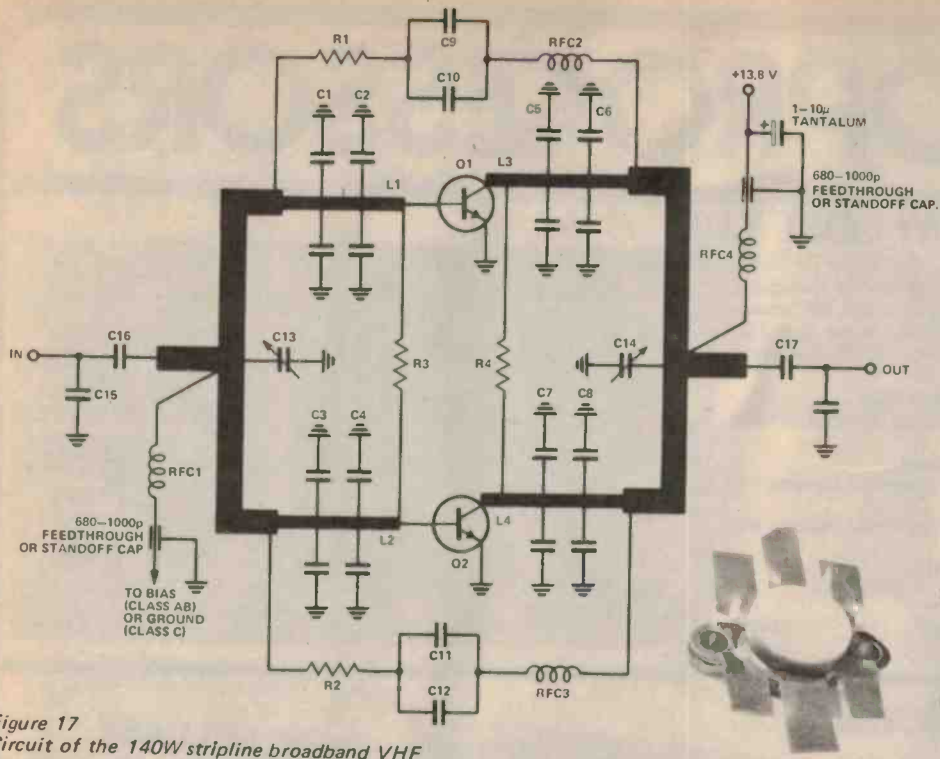


Figure 17
Circuit of the 140W stripline broadband VHF power amplifier. Two BM70-12's produce around 140W output from about 25W drive. Bandwidth extends from 140 to 180 MHz. Construction is illustrated in the photographs. The DC input power may be reduced by simply reducing drive power or the DC supply voltage.

THE BM70-12 PACKAGE

References

Not a definitive list, but certainly 'required reading'.

1. "Matching Network Designs with Computer Solutions", by Frank Davis; Motorola Applications Note AN-267.
2. "Practical VHF and UHF Coil-Winding Data", by Donald Kochen, K35VC; 'Ham Radio', April 1971, pp. 6–14.
3. "Solid State Two-Metre FM RF Power Amplifiers", by Arthur R. Hall, W4CGC; 'Ham Radio', April 1973.
4. "Mounting Stripline-Opposed-Emitter (SOE) Transistors", by Lou Danley; Motorola Applications Note AN-555.
5. "Transmitter Power Amplifier Design", by W.P. O'Reilly; Wireless World, September-October-November 1975 – January 1976.
6. "40 Watt, 12 Volt VHF Broadband Power Amplifier", by Robert Artigo, CTC Applications Note 2.1.8.4D.
7. "140 Watt, 12 Volt VHF Broadband Power Amplifier", by Robert Artigo, CTC Applications Note 2.1.8.4E.
8. "Microstrip Transmission Line", by James R. Fisk, WIHR; 'Ham Radio', January 1978, pp. 28-37.

ETI data sheet SN76477

THE SN76477 is a bipolar/I²L device that provides a noise source, VCO, low frequency oscillator, envelope generator, plus various mixing and control logic on a single 28 pin DIL package. By the connection of appropriate external components and application of logic level control signals a wide variety of complex sounds can be synthesized. The design of the SN76477 allows for maximum user flexibility and the device should prove useful in applications requiring audio feedback to an operator (home video games, toys, timers, alarms, etc.)

The block diagram in Fig. 1 shows the main circuit blocks, each of which is described in detail below.

SLF (Super Low Frequency Oscillator)

The SLF can be operated in the range 0.1-30 Hz, the specific frequency is determined by a control resistor connected to pin 20, and a capacitor connected to pin 21. The frequency being given by the following equation:

$$F_{SLF} = \frac{0.64}{R_{SLF} C_{SLF}} \text{Hz}$$

VCO (Voltage Controlled Oscillator)

The VCO provides an output whose frequency is dependent upon a voltage fed to its input, the higher the voltage the lower the frequency. The control voltage may be either the SLF output, or an external voltage applied to pin 16, the SLF output being selected when the voltage applied to pin 22 is a logic '1', and the external source when pin 22 is at logic '0'.

The "range" of the VCO is internally set at a ratio of 10:1. The minimum VCO frequency is determined by a control resistor connected to pin 18 and a capacitor to pin 17. This minimum frequency is given by the equation:

$$F_{MIN\ VCO} = \frac{0.64}{R_{VCO} C_{VCO}} \text{Hz}$$

The "pitch" of the VCO's output is changed by varying the duty cycle of the output. This is achieved by adjusting the ratio of the voltages at pins 16 and 19. The duty cycle is given by the following equation:

$$\text{VCO Duty Cycle} = 0.5 \left| \frac{\text{V pin 16}}{\text{V pin 19}} \right| \%$$

leaving pin 19 high produces an output with 50% duty cycle.

Noise Oscillator

The "noise oscillator" supplies random frequencies for the "noise generator". The noise oscillator requires a 43 k resistor to ground at pin 4. The "noise oscillator" controls the rate of the "noise generator". An external noise oscillator may be used to provide this control. The external source is applied to pin 3 and provides an automatic override of pin 4.

TABLE 1

MIXER SELECT C	MIXER SELECT B	MIXER SELECT A	MIXER OUTPUT
PIN 27	PIN 25	PIN 26	
0	0	0	VCO
0	0	1	SLF
0	1	0	NOISE
0	1	1	VCO/NOISE
1	0	0	SLF/NOISE
1	0	1	SLF/VCO/NOISE
1	1	0	SLF/VCO
1	1	1	INHIBIT

Noise Generator/Filter

The output of the "noise generator" feeds an internal noise filter. This "rounds off" the generator's output, reducing the HF content of the noise. The upper 3 dB point is given by

$$F_{UPPER} = \frac{1.28}{R_{NF} C_{NF}}$$

where R_{NF} and C_{NF} are external components connected to pins 5 and 6 respectively.

ABSOLUTE MAXIMUM RATINGS AT T_A = 25° C (Unless otherwise specified)

SUPPLY VOLTAGE, Vcc (1), PIN 15	6.0V
SUPPLY VOLTAGE, Vcc (2), PIN 14	12.0V
INPUT VOLTAGE APPLIED TO ANY DEVICE TERMINAL	6.0V
STORAGE TEMPERATURE	−65 C to +150 C
OPERATING TEMPERATURE RANGE	−55 C to +120 C
LEAD TEMPERATURE 1/16 INCH FROM CASE FOR 10 SECONDS	+260 C

RECOMMENDED OPERATING CONDITIONS

	MIN	TYP	MAX	UNITS
SUPPLY VOLTAGE, Vcc1, PIN 15	4.5	5.0	5.5	V
SUPPLY VOLTAGE, Vcc2, PIN 14	5.7		9.0	V
OPERATING FREE-AIR TEMPERATURE	0	25	70	C

OPERATING CHARACTERISTICS AT T_A=25° C AND Vcc1=5.0V

Mixer

The "mixer" logic selects one, or a combination, of the inputs from the SLF, VCO and noise generator. Selection is according to Table X.

System Enable Logic

The "system enable" input provides an enable/inhibit for the system output. The output is inhibited when the voltage at pin 9 is a logic '1', and enabled when logic '0'.

One Shot Logic

The "one shot" logic can be used to provide sounds of a short duration. The duration of the "one-shot" is given by the following equation

Fig. 2. Showing the various envelopes that the SN 76477 circuitry can produce.

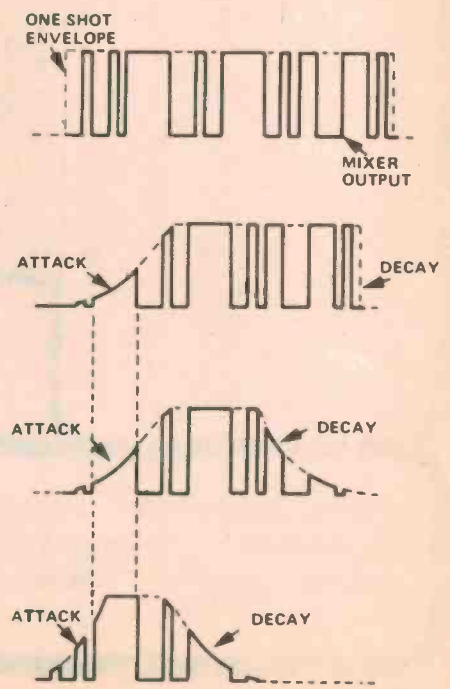
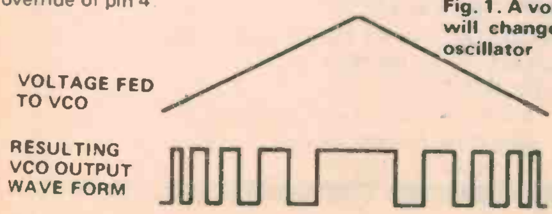


Fig. 1. A voltage fed to the input of the VCO will change the output frequency of this oscillator



SOUND EFFECTS GENERATOR

Fig. 3. Block diagram

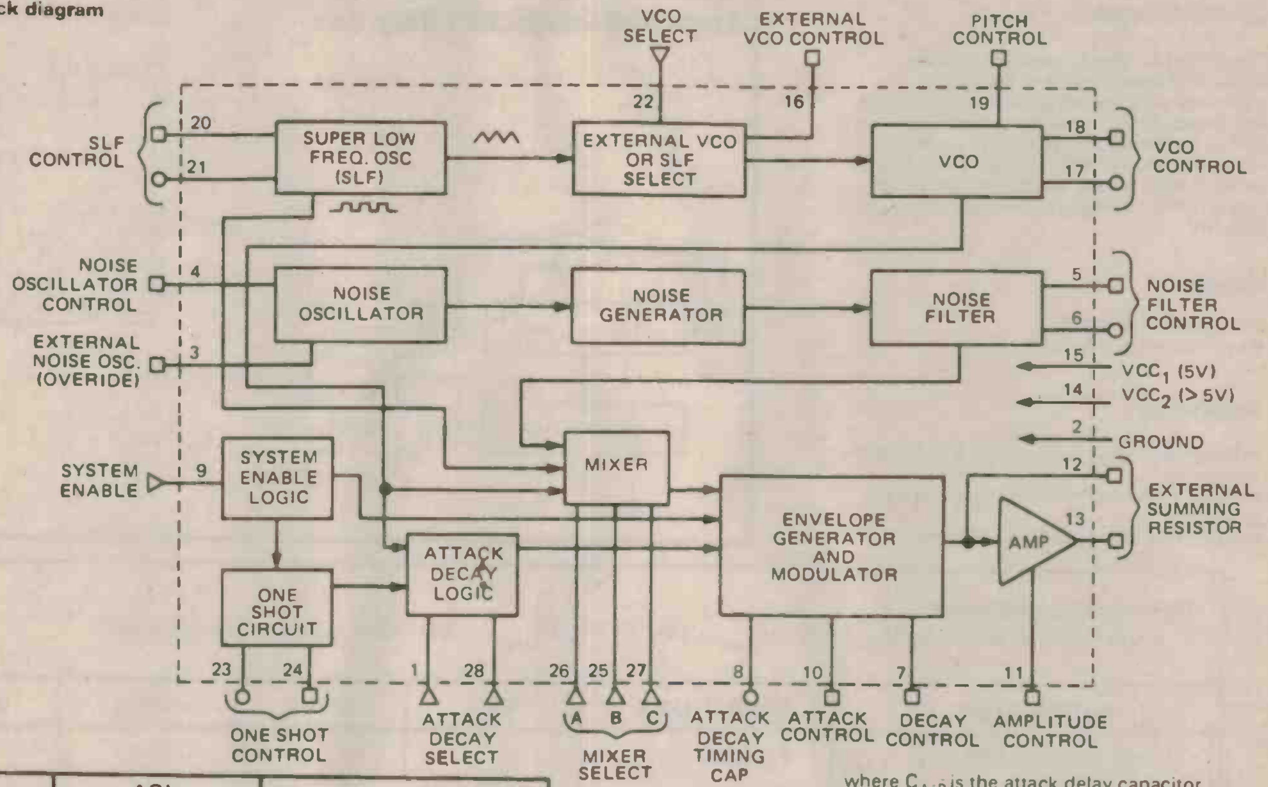


TABLE 2

AOL SELECT 1	AOL SELECT 2	OUTPUT
PIN 1	PIN 28	
0	0	VCO
0	1	MIXER ONLY
1	0	ONE–SHOT
1	1	VCO WITH FLIP–FLOP

$T_{OS} = 0.8\ R_{OS}\ C_{OS}$

where R_{OS} and C_{OS} are external components connected to pins 24 and 23 respectively. The maximum duration of the "one-shot" is about two seconds.

The "one-shot" logic is triggered by the trailing edge of the system enable logic control signal.

ADL (Attack/Decay Logic)

The ADL determines the envelope for the mixer's output. The envelope selected is determined by the ADL control inputs to pins 1 and 28, the output selected being shown in Table 2.

Envelope Generator and Modulator

The attack/delay characteristics of the output are determined by the components connected to pins 7, 8 and 10.

The attack and delay times are given by the following:

$T_{ATTACK} = R_A\ C_{A/D}$ secs

$T_{DELAY} = R_D\ C_{A/D}$ secs

where $C_{A/D}$ is the attack delay capacitor connected to pin 8, and R_A and R_D are resistors connected to pins 7 and 10.

Output Amplifier

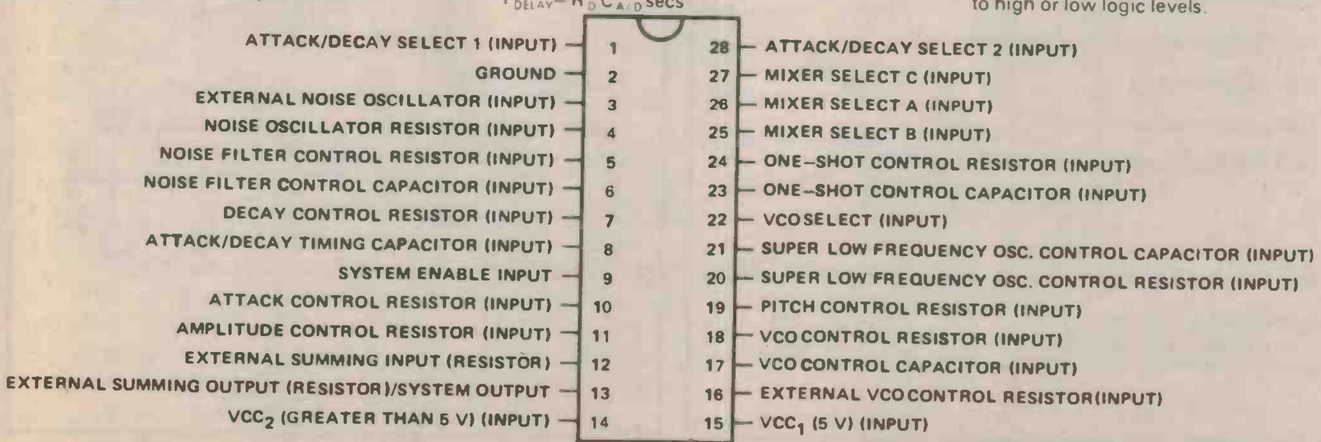
The output amplifier provides a low impedance output. The peak output voltage is determined by the following equation.

$$V_{OUT} = \frac{3.4\ R_S}{R_G}$$

where R_S is a summing resistor connected to pins 12 and 13 (set equal to 10 k) and R_G is a gain resistor connected to pin 11.

Notes:

1. Supplies greater than 5VO may be used, in which case they should be connected to pin 14 to allow the internal regulator to supply the internal circuit requirements.
2. For dedicated sound logic inputs (pins 1, 9, 22, 25, 26, 27 and 28) may be hard-wired to high or low logic levels.



ETI data sheet MM5837 NOISE SOURCE

General description

The MM5837 digital noise source is an MOS/MSI pseudo-random sequence generator, designed to produce a broadband white noise signal for audio applications. Unlike traditional semiconductor junction noise sources, the MM5837 provides very uniform noise quality and output amplitude. The circuit is packaged in an 8-lead Epoxy-B mini-DIP.

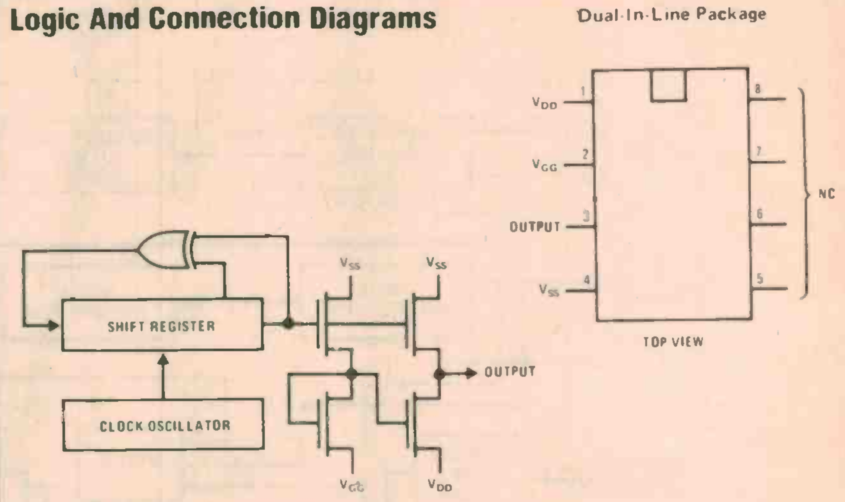
Features

- Uniform noise quality
- Uniform noise amplitude

Applications

- Electronic music rhythm instrument sound generators
- Music synthesizer white and pink noise generators
- Room acoustics testing/equalisation

Logic And Connection Diagrams



Electrical Characteristics
T_A within operating range, V_{SS} − 0V, V_{DD} − 14V ±1.0V, V_{GG} −27V ±2V, unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output (Loaded 20 kΩ to V_{SS} and 20 kΩ to V_{DD}	T_A 25°C				
Logical "1" Level		V_{SS} −1.5		V_{SS}	V
Logical "D" Level		V_{DD}		V_{DD}+1.5	V
Logical "0" Level	$V_{GG} - V_{DD}$	V_{DD}		V_{DD}+3.5	V
Supply Currents					
I_{DD}	No Output Load	3		8	mA
I_{GG}				7	mA

Absolute Maximum Ratings At Ta = 25° C (Unless Otherwise Specified)

Supply voltage, Vcc (1), pin 15 . . . . 6.0V

Supply voltage, Vcc (2), pin 14 . . . . 12.0V

Input voltage applied to any device terminal 6.0V

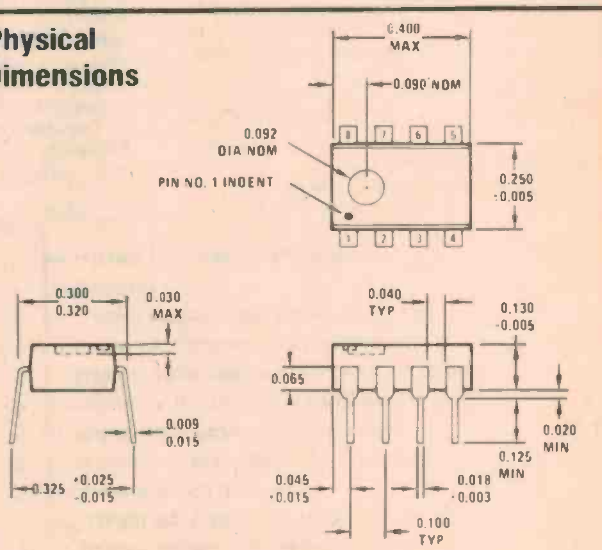
Storage temperature . . . . −65° C to +150° C

Operating temperature range . . . . −55° C to +120° C

Lead temperature inch from case for 10 seconds . . . . +260° C

Recommended operating conditions	MIN	TYP	MAX	UNITS
Supply voltage, Vcc_1, pin 15	4.5	5.0	5.5	V
Supply voltage, Vcc_2, pin 14	5.7		9.0	V
Operating free-air temperature	0	25	70	C

Physical Dimensions



Moulded Dual-In-Line Package (N)
Order Number MM5837N

PRINTOUT

ETI's COMPUTER SECTION

NEWS

S100 Standardisation

In the attempt to standardise and define the S100 'standard', Steve Edelman of Ithaca Audio, P.O. Box 91, Ithaca, N.Y. 14850, USA, is organizing a group to undertake the job. Anyone interested can contact Steve, and if you are at the Second West Coast Computer Faire (San Jose, California, March 3-5) there will be a meeting on this topic, chaired by Steve.

New IBM Micro

Now that IBM's 5100 desk-top computer is over two years old, the General Systems Division has come up with an upgraded version. The 5110 uses floppy disk drives rather than the tape cartridge, and is reportedly much faster than the old machine. Other enhancements include an improved display and extended I/O capabilities. Pricing starts at US$9,875.

Fairchild 9440

Fairchild has begun deliveries of a new 16-bit microprocessor, the 9440, which is the subject of a trade secret lawsuit filed by minicomputer maker Data General. The IIL 9440 is claimed to execute a minicomputer instruction set at TTL minicomputer speeds, and uses a 16-bit bus to carry both addresses and data. Although the 9440 executes the Data General Nova 1200 instruction set, Fairchild claim they are not out to replace 1200's, but instead go for applications like top-line smart terminals, telecommunications and personal computers. A basic kit, including software, will cost $750.

Hard Disks

Rumour has it that both IBM and Shugart are working on a new type of non-floppy disk with a capacity in excess of 10 Mbytes, compared to less than 1 Mbyte for standard floppies. Although the same size as a standard floppy, the disk is non-removable, and consequently more reliable.

Price Cut Round

Following a recent price cut move by Intel, who reduced SBC boards by up to 25%, Motorola has slashed prices on its memory boards, and Mostek has reduced the prices on its OEM-80 Z-80-based boards by up to 28%. At the same time, Zilog's second-source in Carrollton, Texas, introduced a new 16K byte RAM board, using 16K dynamic RAMs. The RAM-80A sells for US$364 in 100-up quantities.

IREECON '79

The Institution of Radio & Electronics Engineers, Australia, will be holding its next International Electronics Exhibition/Convention – IREECON – in Sydney between 27th and 31st August, 1979.

As has been the case in the past, it is anticipated that overseas and Australian engineers, scientists and technical personnel will be participating in discussions and lectures during the course of the Exhibition, which is to feature an extensive display of technical electronics equipment by leading world-wide and local manufacturers or distributors.

The Institution is pleased that enquiries regarding exhibition space at the 1979 Exhibition have already been received following the outstanding success of the 1977 Exhibition in Melbourne.

Next Month in ETI

We've got all kinds of good stuff lined up for your edification and delight – but one thing in particular stands out. Put together a microprocessor, some ROM, some logic and a loudspeaker and what have you got? Yes, you're on the right track . . . No, it's an electronic musical doorbell, actually! This little gizmo caused the biggest stir in the office since the talking calculator, and you can build it for around $40 – full constructional details in next month's ETI!

COMPUTER CLUB DIRECTORY

Sydney: Microcomputer Enthusiasts Group, P.O. Box 3, St. Leonards, 2065. Meets at WIA Hall, 14 Atchison St., St. Leonards on the 1st and 3rd Mondays of the month.

Melbourne: Microcomputer Club of Melbourne, meets at the Model Railways Hall, opposite Glen Iris Railway Station on the third Saturday of the month at 2 p.m.

Canberra: MICSIG, P.O. Box 118, Mawson, ACT 2607 or contact Peter Harris on 72 2237. Meets at Building 9 of CCAE, 2nd Tuesday of month at 7.30 p.m.

Newcastle: contact Peter Moylan, Dept. of Electrical Engineering, University of Newcastle, NSW 2308. (049) 68–5256 (work), (049) 52–3267 (home).

Brisbane: contact Norman Wilson, VK4NP, P.O. Box 81, Albion, Queensland, 4010. Tel. 262 1351.

New England: New England Computer Club, c/- Union, University of New England, Armidale, NSW 2351. (New club; not restricted to students)

Auckland: Auckland Computer Club, P.O. Box 27206, Auckland, N.Z.

Computer clubs are an excellent way of meeting people with the same interests and discovering the kind of problems they've encountered in getting systems 'on the air'. In addition, some clubs run hardware and software courses, and may own some equipment for the use of members. Try one – you'll like it!

If your club is not listed here, please drop us a line, and we'll list you. The same applies if you are interested in starting a club in your area. Also, if established clubs know their programme of forthcoming events, we can publicise them.

ONE ARMED MPU!

John Miller-Kirkpatrick shows how an MPU can do the work of a handful of CMOS.

THIS ARTICLE LOOKS at some of the uses of these new microprocessor (MPU) integrated circuits and associated components. "In one short article?", you may ask, but we don't mean to go into great programming details, etc, all we intend to do is to show how you could use an MPU in your next project.

Either accidentally or on purpose nearly every electronics constructor redesigns a circuit when he comes to building it. In order to show how to use an MPU in an otherwise TTL/CMOS project I have used as an example the Electronic One-Armed Bandit project and intend to discuss how this could have been built with an MPU. As this project contained about $25 worth of ICs while an MPU design would cost a lot more, a one-armed bandit with an MPU is not an economically feasible proposal. One could argue that MPU chips are going to get cheaper or that you could add enough features to the basic bandit to make it worth the extra money, but for the present let's ignore the cost and talk about the principles involved.

The block diagram of the original bandit is shown as Fig. 1; physically it was presented as four units — case, power supply, main logic PCB and display PCB. The display PCB contains a 3 digit counter, 3 decoders and 3 seven segment displays and also has 12 LED lamps which are used as "spinning wheel" indicators. The lamp's flash apparently randomly and then stop and indicate 3 sections of the 12 lamps — some of the combinations of the 3 lamps selected are winners and others are losers.

By referring to the block diagram you can see that three oscillators cause the 3 sets of 4 lamps to flash at different rates giving an extra feeling of randomness so that you do not feel too cheated when it has all of your money! Pulling the handle feeds the oscillator outputs to the 3 divide-by-ten counters. When the handle is released the oscillators and counters stop. The states of the stopped counters are now gated into a decoder which produces a set of outputs corresponding to first prize, second, third, fourth or hard-luck! The first four of these outputs cause a number to be loaded into a pre-settable counter which then proceeds to count down to zero whilst at the same time incrementing the payout counter. The payout counter is decremented at each pull of the handle and thus the final unit is a good representation of the real thing, even if it does not have random Hold and Double or Quits features.

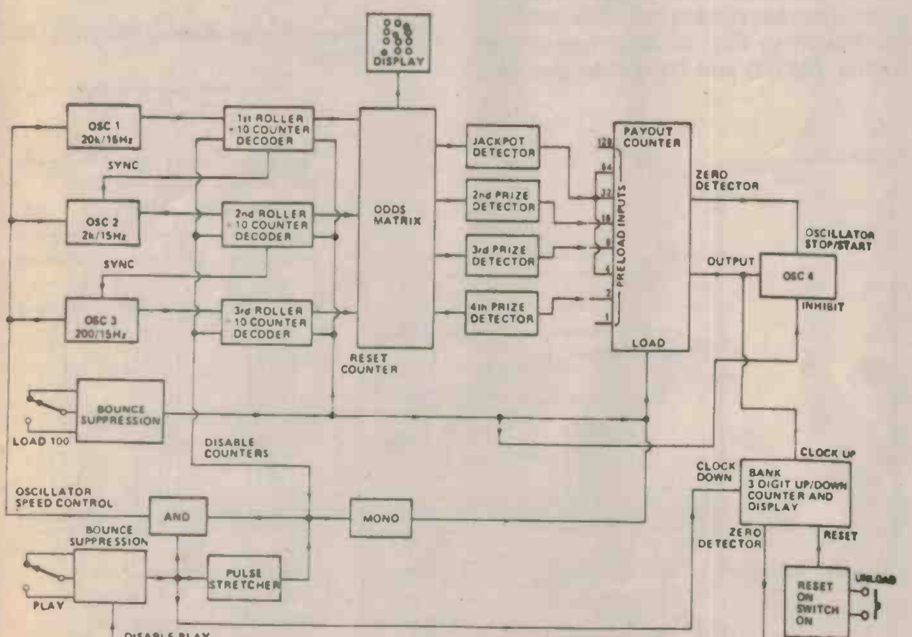


Fig. 1 Block diagram of 'One Arm Bandit' using conventional TTL/ CMOS logic.

Leave that and that but rip the rest out

Any builders of the original unit might be interested enough to do just that and so lets have a look at what we still need in the MPU version. The case would need little or no modification, any mods being the addition of more buttons, lamps, bells and whistles to extend the features of the basic unit. The power supply would need to be changed to give + 5V and −12V and or −20V depending on the devices used. MPUs do not require fancy power supplies with millivolt regulation) the 7805 5V rgegulator and a couple of zeners will suffice.

For the present we will leave the display PCB with its associated counters but it is not indispensable! We are thus left only with the main logic PCB which is exactly where our MPU wants to go.

A microprocessor chip can be thought of as several separate units in one chip. The first unit is a decoder similar to a BCD to seven segment or decimal decoder, the data fed to the decoder is an instruction. Thus an instruction might be decoded so as to cause a clear or an increment of a counter, alternatively it might gate a flip-flop and thus cause an output to change state. Simple MPUs such as SC/MP have about 50 different instructions, the 6800 has about 80, while a Z80 has 158. The range of instructions covers logical operations such as AND, OR and EXCLUSIVE-OR, counter incrementing/decrementing/loading/dumping or the transfer of data from one part of the chip to another in parallel or serial form. If you wanted to build an MPU you would need shift-registers, counters, decoders, latches and a decoder (ROM), all of these to be interconnected so that each can control/be controlled by any other.

ONE ARMED MPU!

The instructions which we feed into our decoder could be decoded as a transfer of data from a register to a latch which is in turn connected to the outside world. It is convenient to have only one set of information connections to the outside world and thus these connections have to serve as instruction input and as counter input/outputs, this set of lines to the outside is called a bi-directional data bus.

As we need to use this data bus for both instructions and data we need to store each separately internally, thus are born the expressions Instruction Register and Accumulator Register, really just a couple of 8 bit latches. SC/MP has an extension to the Accumulator and naturally enough this is called the Extension Register. It can swap its data with that in the Accumulator and has the additional function of being a shift-register with its serial input and output connected to the outside world. Thus our first instruction could cause the data on the data bus to be latched into the Accumulator, the second instruction swaps data with the Extension and the third and subsequent instructions clock the data in the Extension out to the MPU output pin at the same time as clocking the data on the serial input into the Extension. To build such a device with TTL would require about a dozen packages. With SC/MP it becomes a set of bit patterns input to the decoder.

The 8 bit wide instructions mentioned above have to be presented at the data bus in sequence as they are required. The address of the next data unit is supplied by the Address Bus which is normally 16 bits wide thus giving access to 65,536 sets of data. The address is held internally in a 16 bit parallel access counter which can exchange data with the Accumulator, Extension or Pointer Register. Thus, if we can change the value of the Address bus counter we can point the MPU back to a previous instruction address and thus cause it to enter a loop. The Address register is known as a Pointer register in SC/MP which has 4 such registers. PR-O is used for the next instruction address and the other 3 are used to access other addresses for data I/O. By loading a Pointer Register in a manner similar to that of loading the Extension we can either access any of our 65,536 addressable slots or we can cause the MPU to get its next instruction from any of the slots.

Accumulating data

The Accumulator is used for input/output, for the results of logical ANDS, OR, and EX-ORs and can also be used as the result and one of the operands in an ADD instruction.

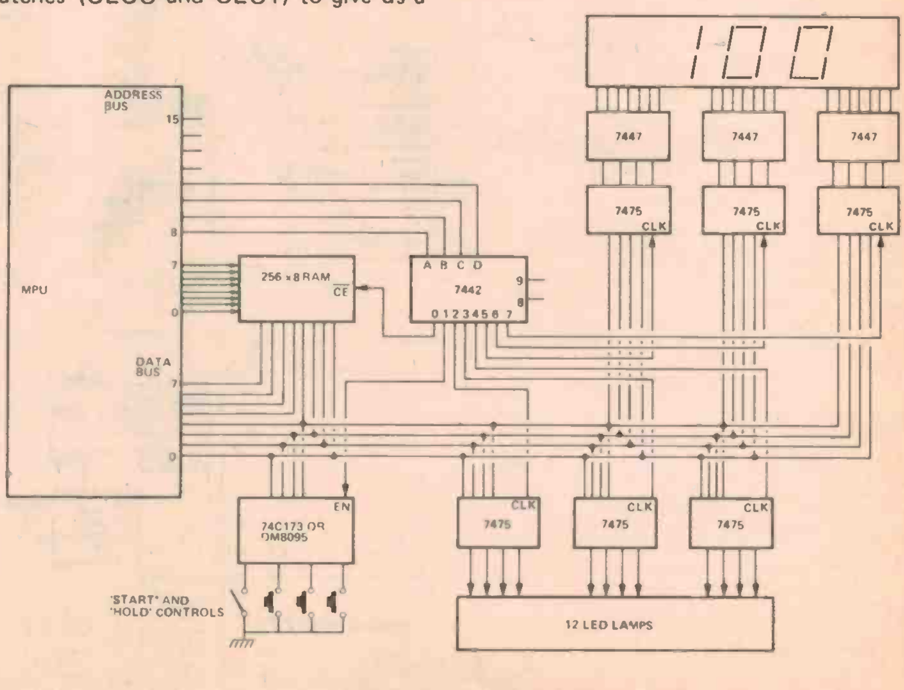
Data input/output can be accomplished through the serial I/O pins connected to the Extension Register or via the main data bus. It is usual to have some area of RAM connected to the data bus for storage of intermediate results, a couple of 2112 chips gives 256 pigeon holes each with 8 bits of data storage. The RAM is accessed by a Pointer Register which selects a) the RAM physical devices and then b) one of the 256 locations within that RAM. The 16 bit pattern for location zero (the first) in a RAM based as hex location OFOO would be OOOO 1111 OOOO OOOO, and it is easy to see how this bit pattern could be decoded with AND and NAND gates to give a single enable line signal (one 7420 and two 7421s?). Similarly, if we had a couple of 7475 latches we could decode a particular address (eg OEOO) and use the enable to clock the latches and thus store the data which had been output on the data bus at the same time. These 7475s are to be used for driving the LED lamps in our Bandit so that we need two sets of latches (OEOO and OEO1) to give us a maximum of 16 LED lamps (we need 12). We can use a similar latch but with WIRE-OR or TRI-STATE outputs (74173) to latch data into the MPU from a series of switches such as the start handle or possibly HOLD switches.

Simulation is the Answer

If you had lots of sheets of paper you could pretend to be an MPU pretending to be our bandit. Get someone else to operate you by pulling your left arm as the Start Handle and then start counting very fast until they release your arm. If you can manage it count three totals at a time and thus when your arm is released you can write down these three numbers on a scrap of paper. The MPU would do the same thing by sensing the changes in the data from our switch latch, adding to pseudo-counters in RAM locations (scraps of paper) and then stopping when the switch latch changes state again.

Now you look at your scraps of paper and decide whether the numbers correspond to any on a list of winning combinations which you have previously compiled. If the combination is a winning one then your list will have a 'Win amount' figure next to the winning combination, which is now credited to the players bank. If the player did not

Fig. 2 Block diagram showing 'Bandit' based on MPU chip.



win then one unit is taken from his bank. You are now ready to have your arm pulled again.

If we use the existing display PCB we have to add or subtract from the bank by pulsing the bank counters on that PCB. We could keep these counters internally and latch out the BCD data in a similar way to that with the LED lamps, via a couple of latches. These latches would then feed into the BCD to seven segment decoders and on to the displays. There is no reason at all why the BCD to seven segment conversion could not be done within the MPU and seven segment data output to the latches and then directly to the displays.

Hardware and Software

A simple definition used to be that Hardware hurts your foot if you kick it and you cannot kick software. Now that computers are not the giant metal monsters that they used to be this definition is no longer true but hardware is still the physical devices and software the program.

For our application we obviously need an MPU chip and as our application is very simple let's use a SC/MP MPU. We need somewhere to store our program and our pseudo-counters. For this we could use a 256 x 8 bit RAM (2 MM2112s). For a more permanent unit we would have to additionally use a PROM but we can use RAM in this example. We have to enter our program as a sequence of bit patterns into the RAM starting at address location 0001 as this is where SC/MP goes to find its first instruction after the reset button is pressed. A simple development system will allow programming of the RAM with simple toggle switches and the program can be checked out at a very slow speed or as single steps.

We also need a four bit input latch (74173) connected to the handle and HOLD switches and 3 four bit latches (74173 or 7475) for the LED lamp drivers. If you intend to replace the BANK counters with software pseudo-counters then another 3 four bit latches will be needed to latch out the BCD data for each digit. To make accessing of these latches easy we can ignore the top four bits of the address bus and use the next four bits as inputs to a 7442 1 of 10 decoder. This will now break up the addresses into 256 byte lumps, any access to 0000-00FF will enable the RAM, 0100-01FF the switch latch, 0200-020FF and LED latch, etc. A block diagram of this is shown as Fig. 2, and as you can see the outputs from the 7442 are used as follows:— Output 0 address locations 000-00FF used for main RAM (program & data).

Output 1 address location 0010 used for switch latch, Outputs 2, 3, 4 address locations 0200, 0300, 0400 used as LED lamp drivers. Outputs 5, 6, 7 address locations 0500, 0600, 0700 used as BCD output latches. With the exception of the RAM all of the other devices hung onto the data bus only use bits 0-3 of the data bus. the other bits being ignored.

Conclusions

The system we have started to design here is hopefully one of the simplest MPU circuits you have ever seen. Once you have grasped the idea of using one 8 bit data bus for most of your input/output you are well on the way to understanding MPUs. The very nice thing about MPUs is that for any given hardware configuration there are lots of software possibilities, for instance we have to have a four bit latch for the start switch so why not hang 3 HOLD buttons on it as well? By latching out seven segment data instead of BCD you could use any combination of the seven segments plus decimal point to display letters or patterns. By moving up to a 5 x 7 matrix display you could output even more patterns/letters. At an approximate guess the hardware shown in Fig 2 would cost about $45 compared to the $20 for the original (displays not included) but for the extra money you have a much more flexible system. MPU's are not cheap but for what they can do for you they are a bargain!

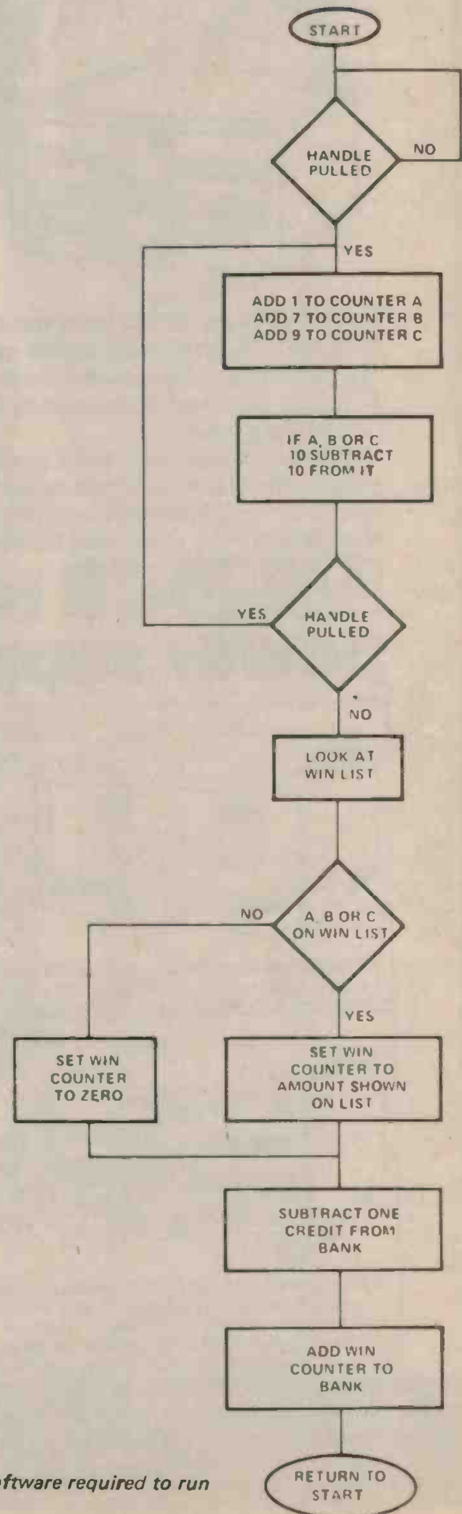


Fig. 3 Flow chart of software required to run the MPU 'Bandit'.

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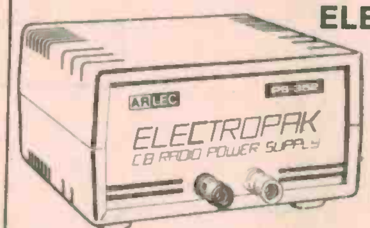

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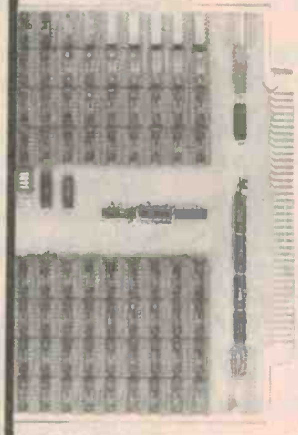

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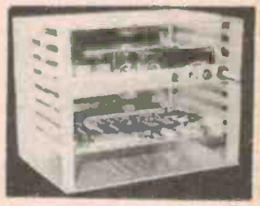

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74L0S05	.37	74LS47	1.30	74LS161	1.20
74LS08	.33	74LS74	0.55	74LS174	1.00
74LS09	.33	74LS75	0.70	74LS175	1.00
74LS10	.33	74LS85	1.58	74LS190	1.20
74LS11	.33	74LS86	0.60	74LS191	1.20
74LS13	.80	74LS90	1.20	74LS192	1.20
74LS14	1.40	74LS91	1.20	74LS193	1.20
74LS20	.33	74LS92	1.20	74LS367	.80
74LS30	.33	74LS93	1.20		

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SOLDER		DIL — TIN		WIRE WRAP GOLD	
8	.25	22	.35	24	1.40
14	.35	24	.45	14	.70
16	.28	28	.50	16	.70
18	.35	40	.90		

Continued from page 15.

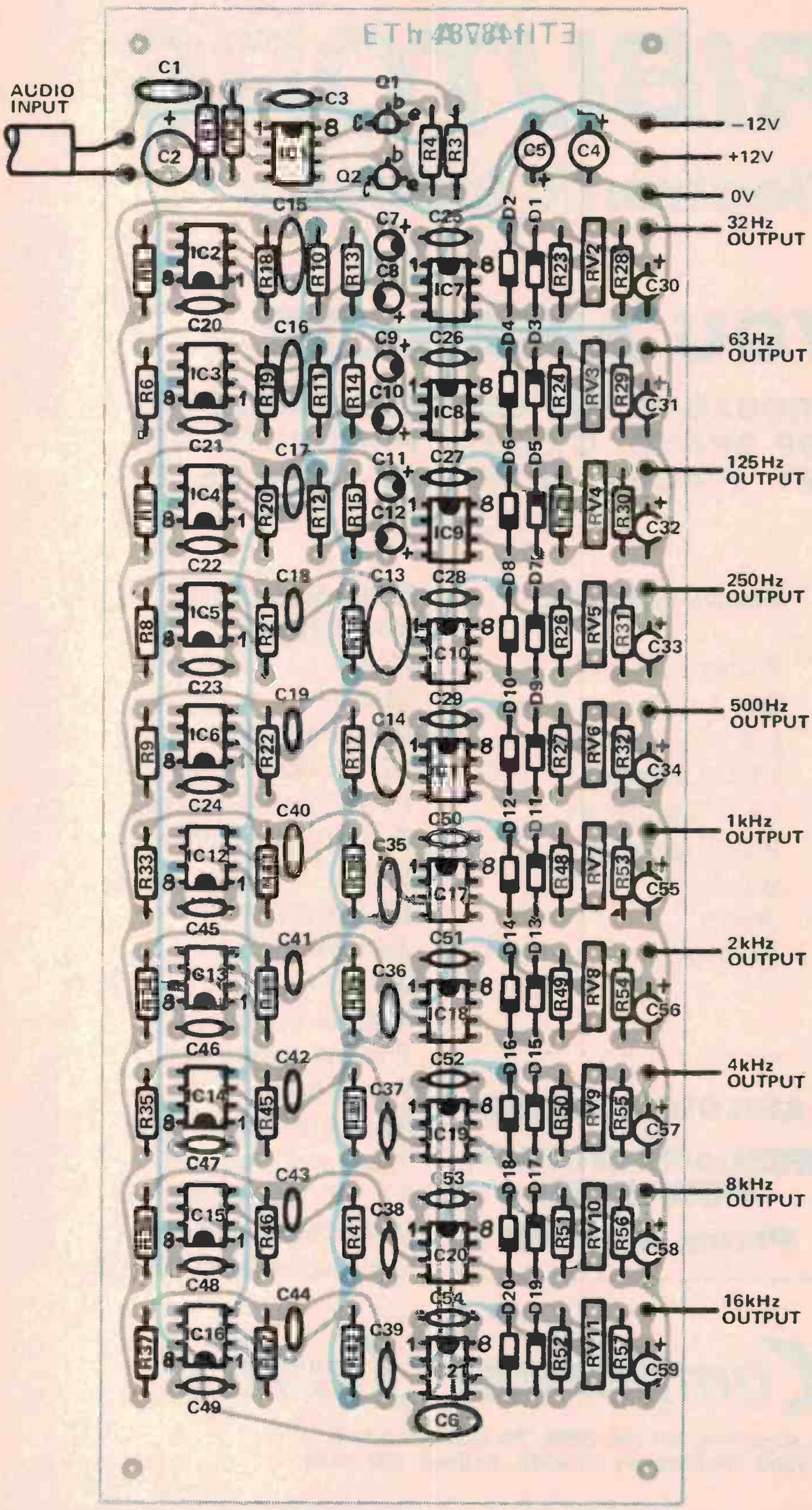


Fig. 5. The component overlay of the filter-rectifier board.

PARTS LIST – ETI 487

Resistors	all ½W 5%
R1	220k
R2	2k2
R3	220k
R4	1k
R5–R9	10k
R10–R17	1M
R18–R22	220R
R23–R27	1M
R28–R32	100k
R33–R37	10k
R38–R42	1M
R43–R47	220R
R48–R52	1M
R53–R57	100k
R58,59	180k
R60	100k
R61	82k
R62,63	15k
R64	22k
R65	470R
R66	18k
R67	15k
R68	12k
R69	820R
R70	180k
R71	12k
R72,73	10k
R74	2k2
R75	4k7
R76–R78	10k
R79	22k
R80	56k
R81	5k6
R82	3k9
R83	18k
R84	100k
R85	390k
R86	1M
R87	6k8
R88	10k
R89	18k
R90	47k
R91,92	100k
R93	47k
R94	100k
R95	47k
R96	10k
Potentiometers	
RV1	47k log rotary
RV2–RV11	250k trim
Capacitors	
C1	100n polyester
C2	10µ 25V electro
C3	3p3 ceramic
C4,5	10µ 25V electro
C6	100n polyester
C7,8	3µ3 16V tantalum
C9,10	1µ5 16V "
C11,12	1µ0 16V "

Construction

Due to the complexity of the unit it is recommended that PC boards are used. These boards are assembled as per the overlay diagrams. Watch the orientation of all the ICs, diodes, capacitors, etc., when installing them. Note that as the board is not a plated through type that the tracks on the top side of the board must also be soldered to the components. This prevents the use of sockets for the ICs but they are not really worth the cost for low priced ICs

Capacitors continued

C13	220n polyester
C14	100n "
C15	68n "
C16	33n "
C17	18n "
C18	8n2 "
C19	3n9 "
C20—C24	33p ceramic
C25—C29	10p "
C30—C34	2μ2 25 V electro
C35	47n polyester
C36	27n "
C37	12n "
C38	6n8 "
C39	3n3 "
C40	2n2 "
C41	1n0 "
C42	560p ceramic
C43	270p "
C44	150p "
C45—C49	33p "
C50—C54	10p "
C55—C59	2μ2 16 V electro
C60,61	25μ 16 V "
C62	820p ceramic
C63	2n7 polyester
C64	5n6 "
C65	33p ceramic
C66	150p "
C67	3p3 "
C68	150p "
C69	10p "
C70	33p "
C71	2n2 polyester
C72	560p ceramic
C73,74	220μ 25 V electro
C75,76	10μ 25 V "

Semiconductors

IC1—IC21	LM301A
IC22	4017 (CMOS)
IC23—IC25	4016 (CMOS)
IC26—IC28	LM301A
IC29	4011B (CMOS)
IC30	LM301A
IC31	7812
IC32	7912
Q1	BC548
Q2	BC558
Q3,4	BC548
Q5—Q7	BC558
D1—D27	1N914
D28—D31	1N4001

Miscellaneous

PC boards ETI 487A, 487B
Transformer PL24—5VA
Case to suit
3 core flex and plug
240V power switch
Input / output terminals to suit

as used.

With the board 487A be very careful as there is 240V on the board. It is recommended that the wires be terminated directly to the board, without PC board pins, and that the 240V tracks on the underside of the board be coated with epoxy to prevent contact.

We mounted the unit into a home-made box as we did not have a commercial one on hand to suit.

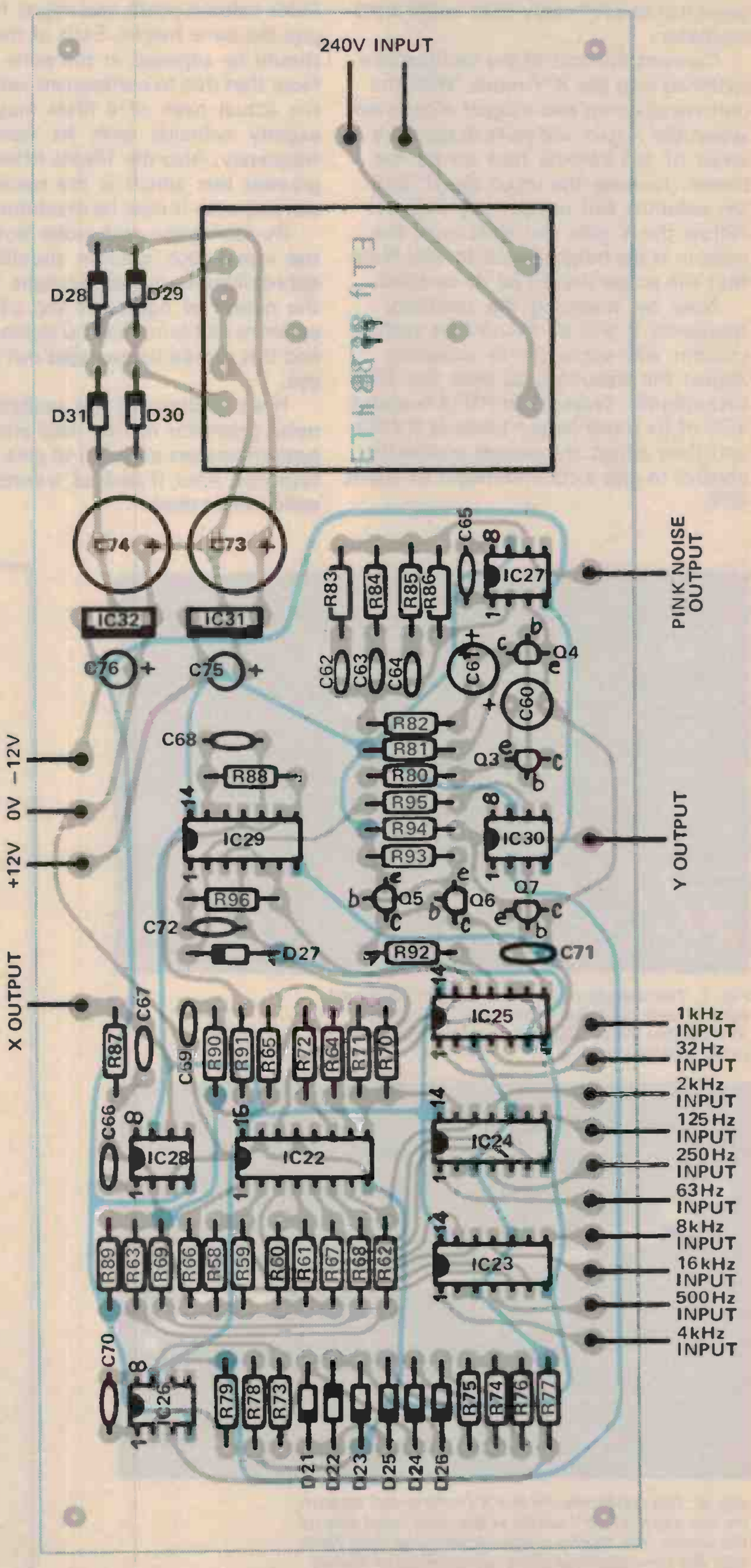


Fig. 6. The component overlay of the logic-power supply board.

Alignment

This can be done using the pink noise generator or preferably with a sine wave oscillator.

Connect the unit to the oscilloscope switched into the X Y mode. With the unit switched on and a signal connected, adjust the X gain and shift to obtain a series of ten vertical bars across the screen. Increase the input signal until the columns will not get any higher. Adjust the Y gain and shift until the column is the height of the screen. Note that the scope should be dc coupled.

Now by sweeping the oscillator frequency it will be found that each column will come up in sequence. Adjust the frequency to peak the 16 kHz column. Now adjust RV11 to about 75% of its travel (wiper towards RV10) and then adjust the overall sensitivity control to give a column height of about 80%.

Now using the same amplitude adjust the signal generator frequency until the 8kHz column peaks and adjust RV10 to give the same height. Each of the filters should be adjusted in the same way. Note that due to component variations the actual peak of a filter may not exactly coincide with its nominal frequency. Also the 16kHz filter has the greatest loss which is the reason for starting with it near its maximum gain.

By taking the pink noise output to the input each column should be approximately the same height. Due to the nature of noise the top of the columns will jump up and down a little and this should be averaged out by the eye.

If an oscillator is not available the noise generator can be used and the potentiometers adjusted to give an even response. Also, if desired, a vertical dB scale can be made.

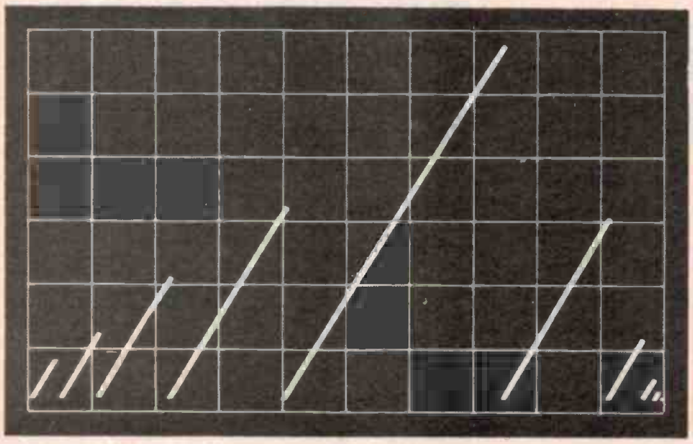


Fig. 7. The waveform on the Y output (vertical) with a 1kHz tone input. See page 12 for the X-Y display. Note that the time between cycles varies with the height.

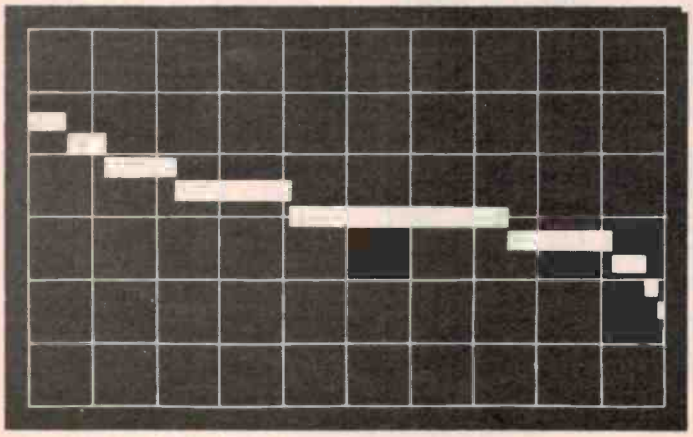


Fig. 8. The waveform on the X (horizontal) output. As this starts at +4 V which is the right hand side of the screen, the 16kHz output is sampled first. Note that the time between steps corresponds to that in fig. 7.

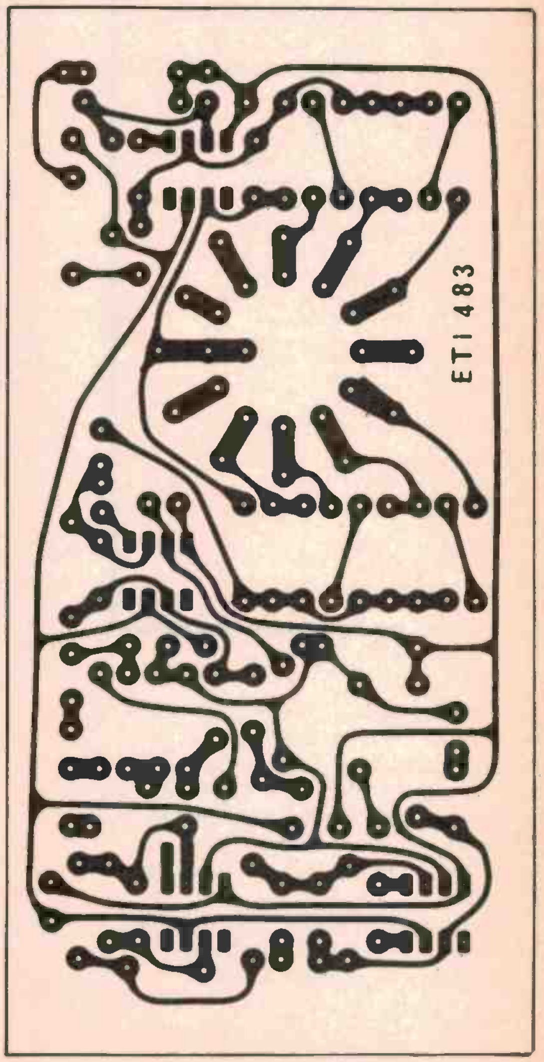
Making negatives

This method can be used to copy ETI artwork from October 1977 on only. The film used is Scotchal 8007 which is UV sensitive and can be used under normal subdued light.

Cut a piece of film a little larger than the pc board and expose it to UV light through the page of the magazine. The non emulsion side should be in contact with the page. This surface can be detected by picking it up by one corner and it will curl towards this surface. Exposures of about 20 minutes are normally necessary.

The film can now be developed by placing it emulsion side up on a table, pouring some Scotchal 8500 developer on the surface and rubbing it with a clean tissue.

The printed circuit layout of the sound level meter ETI 483 shown full size.



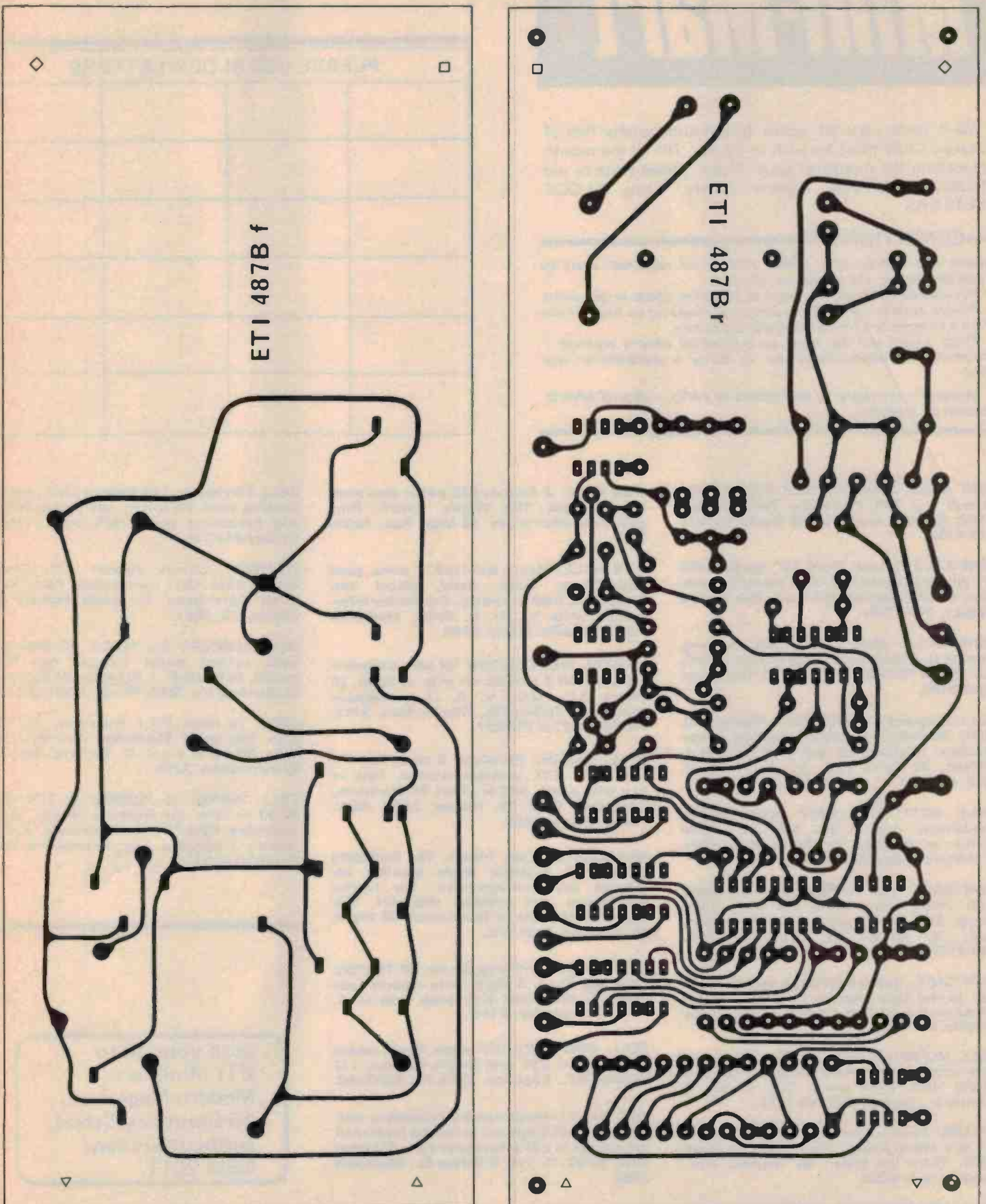


Fig. 9. Both sides of the ETI 487B board shown full size.

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FOR SALE: MK III Musicolor. Assembled with timber dress sleeve and triple 100w lamps. $70. Owner getting married – needs cash. 24 Malouf St., Canley Heights. 604-4137.

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SELL MC/MP Introkit plus SCMP10. Comes with comprehensive data manuals – switches hardly used. $100 o.n.o. D.K. Brown, 8 Whittle St., Gatton. (075) 62-1814.

ETI4600 Synthes. Set assembled and tested. P.C.B.'s. Wired Keybd, Reverb Unit, Patchbd. $800. Write Ian Miller, 35 Guilford Ave., Prospect, S.A. 5082.

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SELL master mind program for HP 19C/29C (specify); $2.28. 5 digits, auto random code generator etc. Need only press GSB O. S. Bliss, 7 Cooper Plc., 5110.

SELL. BWD model 300 scope. Needs repairs (transformer) $20 with circuit. C. Coen, 117 Sladden Rd., Engadine, 2233, Ph. 520-6498.

FOR SALE: comprehensive conversion instructions (with diagrams) to include horizontal bat control in ETI's November color TV-game offer. $2.50. D. Yee, 8 Bolton St., Beaumaris 3193.

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WANTED: Circuit diagram A.C. Cossar. Model 1035 Osc. Instructions. Palec Mod. ET4a Valve tester. R. Brazill, Howard St., Epsom, Vic, 3551.

OSCILLOSCOPE trio 1560A. 15 MHz dual trace current model includes two PC27 probes. $495 ONO. J. Kingston, 24 Carpenter St. Bendigo, Vic, 3550. Phone: (054) 42-1104.

SELL 74 issues E.T.I. from Oct. '71, $50. Also 105 issues Electronics Australia from June '68. $70 o.n.o. G. Brooker, Box 41, Broadmeadow, 2292.

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The new Weller power vacuum desoldering station for printed circuit board repair. Famous Weller closed loop temperature control protects sensitive components while soldering or desoldering. See-through solder collector is easy to clean or replace. Non-burnable cord sets afford safety and longer life. Low voltage tool inputs give added safety margins. High impact resistant tool handles and stainless steel barrels mean longer tool usage.

Also there's now cordless soldering from Weller – (see right). Soldering was never easier than with the Weller cordless kit, consisting of iron charger, solder, 4 different tips and a handy screwdriver.

Other products from The Cooper Group include Crescent, top quality electronic pliers; Lufkin, measuring equipment; Nicholson, precision files; Xcelite, professional hand tools and Wiss shears and scissors. Whatever your requirements, you can choose Cooper products with confidence.

The Cooper Group

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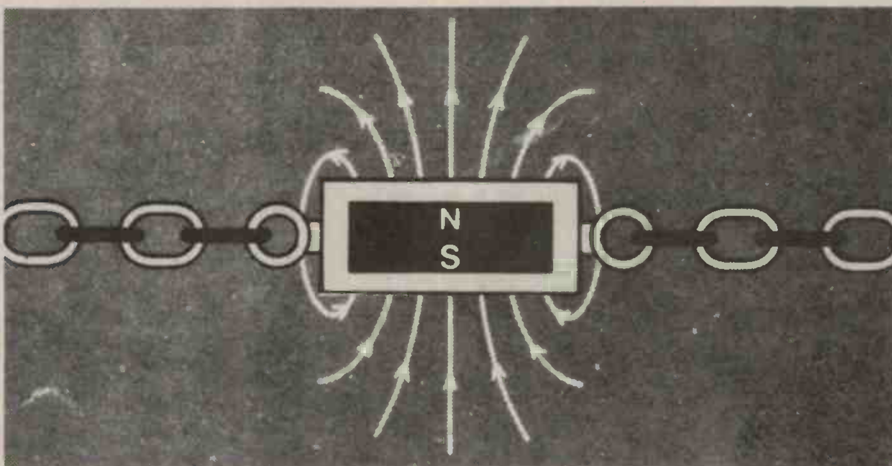
The Cooper Tool Group Limited,
P.O. Box 366, Nurigong Street, Albury NSW 2640, Australia. Telephone: 215511 Telex: 56995

COOPER INDUSTRIES

Necklace Offer!



VERY many people suffer from so-called 'stiff shoulders' or 'stiff necks'. It is generally believed that these unpleasant symptoms are caused by mental or bodily stress but the exact cause is not apparently really known.

The TDK Electronics Corporation have produced a magnetic necklace which they state has proven effective in relieving such symptoms for a very high proportion of sufferers.

The Japanese Government's Ministry of Health and Welfare has given its approval (NO. 51B-614) to this necklace and we have read four fully documented reports from independent authorities (such as the University of Tokyo's Medical Faculty) to support TDK's statements.

The necklaces are made in two basic forms. Gold-plated 430mm long and rhodium-plated 560mm long — these, TDK suggest, would suit men or women. respectively. Both are sold at the same price.

The necklaces contain extremely powerful rare earth cobalt magnets which were originally developed for the NASA space programme. The magnets are permanent. Necklaces are supplied complete with two connecting rings, one hook and one length of chain as spares.

TDK advise users to wear the necklace in direct contact with the skin. It should be worn continuously including whilst asleep, removing it only whilst taking a shower or bath.

Most people find it effective after two to three days.

The TDK magnetic necklace is handled in Australia by the Caldor Corporation and they have made arrangements for our readers to obtain either type at the same price — $49.95 including postage and packing.

Necklaces should be ordered via this magazine using the form (or replica thereof) published on this page.

Please make cheques payable to 'Necklace offer' and send c/- Electronics Today, 15 Boundary St, Rushcutters Bay, NSW, 2011.

Please allow at least three to four weeks for delivery — there really are mail delays — particularly of parcels!

Thousands of people have used these necklaces and claimed they have experienced relieve of 'stiffness'. Nevertheless we would like to make it absolutely clear that all papers published so far show that the devices vary in their effect from one person to another and that in some cases they have no effect at all. There is no totally tangible scientific evidence to support or refute any claims or statements made although research is continuing worldwide. Therefore as no claims can currently be substantiated (and of course no claims are made by us or Caldor) the ultimate decision and experience must be yours.

Nevertheless, the necklaces are made by TDK and that must mean something.

Manufactured by,

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TDK ELECTRONICS CO., LTD.

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The latest Lafayette 27 MHz trancievers whose versatility, reliability and performance are famous world wide with 100,000's in constant use. Lafayettes two-ways offer ruggedness and compact size making them ideal for use in industry, farm, sports and marine applications.

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or $2.00 per dozen

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SQUARE 25 mm SCALED 0-10. . . . . $3.10

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.1, .22, .33, .47, .68, 1, 1.5, 2.2, 3.3, 4.7 ALL 35 Volt .30

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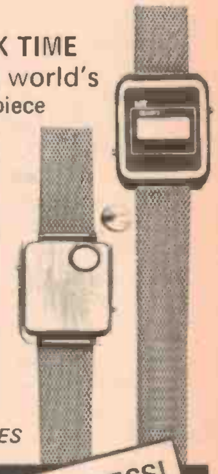
• NS4640 – Scientific/Engineering/Statistical calculator – 12 digit including 2 digit exponent. RPN logic. 3 separate addressable memories. Four level "rollable" stack. Fixed or floating decimal statistical functions. Metric conversions, percentage, square roots, etc. Rechargeable batteries. Supplied with charger. **PRICE: $33.00**

• NS – 201R, Full scientific, rechargeable batteries, charger and desktop stand. Billfold style. **PRICE: $26.85.**

• NS – 201R, Full scientific, rechargeable batteries, charger and desktop stand. Billfold style. **PRICE: $26.85.** • **NS100** – Ultraslim Pocket (7.5mm thin) Billfold style, **PRICE: $21.74.** • Other National Semiconductor models available. • **Elcon SC-44F**, Scientific – $32.50 (Recharg. battery & charger). • Plus 15% Sales Tax, if applicable – all calculators. • P & P. Int. $3.00. N.S.W. $2.00.

NEW! UNIK TIME BY EMONA– the world's thinnest digital timepiece



* 5 function, 4-digit quartz crystal accuracy Hour minute, second, month, date. * Super thin styling (6mm) with 4 elegantly styled faces. * Removable battery hatch for easy customer battery replacement. * Gold or silver toned case with lizard or mesh band options. * High contrast, easy to read liquid crystal display with command backlight. * Full year warranty with worldwide service.

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ALSO AVAILABLE: * Full range of National semiconductor watches (see E.T.I., Dec '77) * LED Electronic Digital Alarm clocks. * A range of Digital Clock Radios.

STOP PRESS! Now available full range of TEXAS calculators at competitive prices.

BULK Electronic Warehouse

NEW PRODUCTS FOR MICROPROCESSOR USERS

NUMERIC KEYBOARD KITS

Ideal for keyless entry systems, burglar alarms, micro processors etc. Keys 0 to 9, blue with white lettering and CLR key, red with white lettering. Giant key-top 18 x 18mm, long life (10-6 guaranteed operations), made in Germany by Rafi, PC mounting, very low profile. $5.90 Full Kit or 75c per key. 10 kits $5 ea 25 kits $4 ea.

DOLLAR STRETCHERS $1 PACS

- ☐ 99 2 PVC Transistor Tuning Gangs 20mm x 20mm, 200pf as in most radios.
- ☐ 1 20 Yds Hookup wire. Multi-stranded in assorted colours.
- ☐ 3 9 Phillps Asst. VDR's. For servicemen, experimenters, c.w. data.
- ☐ 8 200 Asst. Screws, Nuts.
- ☐ 129 60 Asst. Self-Tapping Screws.
- ☐ 130 120 Asst. Steel Washers.
- ☐ 131 120 Asst. High Grade Nuts.
- ☐ 132 100 Asst. Screws.
- ☐ 124 12 Pot. Nuts, Washers.
- ☐ 11 20Ft. Plastic Spaghetti Tubing in various colours.
- ☐ 17 10 Volume Controls Some with switch, ganged.
- ☐ 18 10 Preset pots. Tab mtg. TV types.
- ☐ 2 50Ft. Speaker Cable — colour coded.
- ☐ 170 4-14 Pin DIL Sockets — gold pins.
- ☐ 171 3-16 Pin DIL " " "
- ☐ 24 3-UM3X4 Battery Holders.
- ☐ 25 10 — No. 216 Battery clips.
- ☐ 27 3 Magnetic 8 ohm Earpieces — 3.5mm plugs.
- ☐ 29 15 Fuses 3AG 1¼" x ¼" Choose ½A, 1A, 2A, 3A, 5A, 10A.
- ☐ 39 5 Core 16G Solder — 60-40 multicore, 10Ft.
- ☐ 5 15Ft Twin Core Shielded Fig. 8 cable.
- ☐ 96 5—5K ohm Volume Controls. Miniature for trans. radios — c.w. knobs.
- ☐ 76 Mono crystal cartridge, Gen. purpose
- ☐ 87 3 3/8' x8" long round ferrite rods.
- ☐ 134 3 Suppressor Resistors — HT Lead.
- ☐ 110 3 Computer Boards, loaded with trans, diodes, res, caps, approx 150 asst. parts.
- ☐ 111 2 Car Cigarette Lighter Plugs Useful for all car accessories.
- ☐ 112 2 Neon Indicator Bezels — 250v. AC Red.
- ☐ 136 3 Asst. Neon Bezels 250VAC.
- ☐ 113 2-6V Indicator Bezels, Chromed, choose red, green, amber.
- ☐ 119 5-2 Pin Plug Sockets Sets. Polarised with covers.
- ☐ 120 8-3AG Plastic In-line Fuseholders.
- ☐ 123 10 ASST. Potentiometers. New, incl. preset, gang, switched etc.
- ☐ 14 25ft. Dial Cord — plus 5 springs.
- ☐ 26 Tuning Dial Kit. Incl. spindle, 3 pulleys, pointer, drum, cord, spring and instructions.
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- ☐ 133 2 RCA to RCA audio leads.
- ☐ 95 15 Radio Knob Assortment.
- ☐ 151 2 Push button switch, 6P2T ea.
- ☐ 30 2 Panel Fuseholders — std 3AG.
- ☐ 152 6 Mini-Slide Switches, 3P2T, PCB mtg.

JUMBO BAGS $3ea.

- ☐ 400 ¼W Asst. Resistors
- ☐ 500 ½W " "
- ☐ 300 1W " "
- ☐ 100 Asst. Semiconductors
- ☐ 100 Asst. Poly Caps 160—630V
- ☐ 150 Asst. various caps
- ☐ 60 Asst. Electrolytics
- ☐ 160 ASST. BULK PARTS Inc. res, caps, semis etc. We don't have time to sort out!

BONANZA JACKPOTS

For experimenters and constructors, a large assortment of new, high quality parts — samples, specials, end-of-line components incl. semiconductors.

JACKPOT No. 1
A 500gm (approx) Lucky-dip offer, all useable parts. Up to $25 worth for only $5.

JACKPOT No. 2
A 2Kgm (approx) assortment in a 315 x 270 x 160mm box includes relays, edge connectors, pots, switches, semis and many others too numerous to mention ONLY $10.

10W STEREO AMP

Sounds great, many features — bass/treble controls, 5 pin din rec/play & h'phone sockets, loudness, rumble and scratch switch ceramic cart, input, 35V 1.2A req, transformer, extra $4.00.

Few only Available ☐ **$19**

5" B & W SHARP TV TUBE

Brand new, sealed in manufacturers carton. Ideal for servicemen, amateurs, experimenters etc. Were selling at $11.95, now only $5.95; sorry no yokes avail.

DOLLAR STRETCHERS $1 PACS

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- ☐ 235 6 DPDT Mini Slide Switches
- ☐ 232 5 TO5 Black Finned Heatsinks
- ☐ 220 100 Asst. ½W RESISTORS. 5/, 10/ mixed carbon composition.
- ☐ 169 5-16 PIN DIL PLUGS. Gold Pins, suit 16 Pin IC Sockets
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- ☐ 167 10-IN914 Silicon Diodes.
- ☐ 166 3-6V 1W Zener Diodes.
- ☐ 163 1 Valve Output Transformer G.P.
- ☐ 148 1-1 Watt Audio IC Amplifier-with circuit diagram
- ☐ 142 10-0.0022 Feedthrough Capacitors
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- ☐ 309 15-100uF 10V Pigtail Electros
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- ☐ 313 15 Asst. Lamps-low voltage 6-50V.
- ☐ 314 3 Sub-min Painton Preset Pots 1K.
- ☐ 315 3 Sub-min Painton Preset Pots 2.2K
- ☐ 316 2-90mfd 300VW Can Electros
- ☐ 317 1-200mfd ⅛ 100mfd 200VW Can Electros
- ☐ 138 2-12 Pin PCB Connectors.

DOLLAR STRETCHERS $2 PACS

- ☐ 137 30 Asst. ELECTOLYTICS. All good quality low voltage.
- ☐ 180 5 WAFER SWITCHES MSP rotary, std.mtg. ¼" diam. shaft, 1to4 bank, various positions, all new.
- ☐ 319 MSP. CAR SPEAKER 5"x4" — 15ohms.
- ☐ 320 8 ohm TWEETER 75mm-8 ohms.
- ☐ 321 3 Edge Connectors, 46 way, double sided 0.156" pitch, Plessey.
- ☐ 300 1-12V MINI RELAY — PCB mtg, 2A c/0 contacts, 200ohm coil.
- ☐ 217 10-TIC44 SCR's -40V 600mA rating, mini T092 plastic pkge.
- ☐ 181 1-SUPER SENSITIVE MICROPHONE. Hearing aid type by Shure, 1" diam.x¾" high, low imp. Ex. Govt. use.
- ☐ 318 15 Neons, 60-90V pigtail.
- ☐ 231 2-10 Amp Microswitches.
- ☐ 193 10 Asst. Switches:- Toggle, slide, rotary, all new, useful.
- ☐ 266 2-2SB337 Germ.Power Transistors.
- ☐ 198 50 TO-18 Asst. TRANSISTORS PNP&NPN, tested OK, marked.
- ☐ 218 250 Mixed Bulk RESISTORS:- 1/8W, ¼W, ½W, up to 10W.
- ☐ 156 10-20pf TRIMMER CAPS. Air-spaced, mini, cer. base.
- ☐ 154 4-100pf CERAMIC TRIMMERS. High Quality Air-Spaced, PC or chassis mtg., communications specs.

"SUPA" SPECIALS for DEC.

- ☐ 322 MOTOR SPEED CONTROL KIT. Suits most electric motors. 240V 750W max. $4.50
- ☐ 323 TRANSISTOR RADIO REPAIR KIT. Gang, speaker, semis, caps, pots etc. $4.50
- ☐ 324 5" B&W SHARP TV TUBE. New, ideal servicemen, experimenters. $5.95
- ☐ 199 600V 25A SILICON RECTIFIERS. International Rectifier. 10 for $6.50, 25 for $15.00 ea. .75
- ☐ 205 VHF Trans. TV TUNER. Miniature Sharp. 12 channels, 9 with biscuits, new, 2 for $11.00. $6.00 ea.
- ☐ 219 100 ASST. 1W RESISTORS. 5, 10/ mixed carbon composition. $1.50.
- ☐ 331 30 A 400 PIV SILICON RECTIFIERS. Heavy duty STC RS640 stud mounted. $1.50.
- ☐ 332 CATHODRAY COND. 0.5mfd 2KV. Stud mtg. hi qual. special purpose. $1.00 ea.
- ☐ 249 HP 5082-7300 LED DISPLAY. 7 Segment 4x7 dot matrix, in built decoder-driver and memory, L.H. decimal pt. 0-9 Readout, buy 4 for $26.00. $7.00 ea.
- ☐ 9 BONANZA' JACKPOT A 500 gm (approx) lucky-dip offer, all useable parts, samples, specials, end-of-line components incl. semis. $5.00 ea
- ☐ 333 3 PIN MINI PLUG & SOCKET .60pr.
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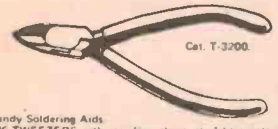
.01 TRANSISTOR NIPPER for very small gauge wires. 4½" (115mm) long. Spring opening insulated handles. Similar quality normally around $7.00. $4.50

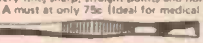


Cat. T-3200.

Handy Soldering Aids

P86 TWEEZERS with very fine, sharp, straight points and non-slip jaws. 125mm long. A must at only 75c (Ideal for medical cabinet tool!)

Cat. T-4630.

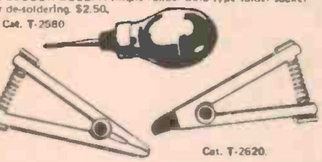


H3—C-R PULLER your extra hand for removing awkwardly located parts. Spring loaded to remove component as solder melts. Ideal for servicemen. $2.25.

Cat. T-2600

H9 SOLDER BULB. A simple rubber bulb type solder sucker for de-soldering. $2.50.

Cat. T-2580



Cat. T-2620.

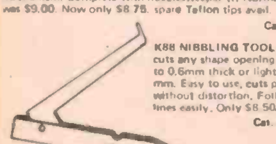
H72 HEAT SINK SET. Like alligator clips made of aluminium. A must for transistor work. $1.20.

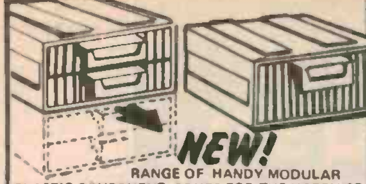
EL—1 SOLDER SUCKER. Full metal construction — better than plastic! With Teflon tip. Simple push/release thumb mechanism. Complete with nozzlesweeper (!) Normal price was $9.00. Now only $8.75. spare Teflon tips avail.

Cat. T-2560.

K88 NIBBLING TOOL. cuts any shape opening in sheet steel to 0.6mm thick or light alloy to 1.5 mm. Easy to use, cuts plastics too without distortion. Follows scribe lines easily. Only $8.50.

Cat. T-4940.





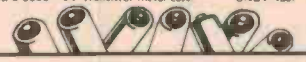
NEW! RANGE OF HANDY MODULAR PLASTIC COMPONENT BOXES FOR THE HOBBYIST OR HANDYMAN

Frankly, we have seen a lot of component drawers come and go over the years. In our opinion, these are the best ones that we have come across. Check these features: Large handle on the front of each drawer. Special index card slot moulded into handle for labelling. Outside of boxes have precision dovetail ways so that boxes may be securely fitted together. Wall or bench mountable. Trays do not seize inside box as many inferior other types do. Two types available. One with 2 drawers per box(H-2585). The other has one drawer(H-2584) per box. All boxes in smart white high impact plastic with the drawers moulded in a smart red. Overall dimensions 5 1/8in.D. x 4.1/2in.W. x 2.1/4in.H. Price is only $1.20. for either.

HUGE HI—WATT BATTERY SHIPMENT IN

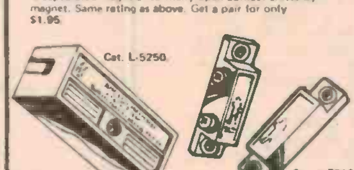
Specially imported, factory fresh, high capacity, long life batteries. Just look at these prices!

Cat. S-3001	D size metal jacket.	ONLY 25c.
Cat. S-3002	C size metal jacket.	ONLY 20c.
Cat. S-3003	AA penlite.	ONLY 15c.
Cat. S-3006	9V Transistor metal case	ONLY 45c.



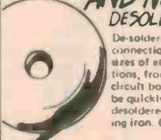
BURGLAR ALARM VIBRATION SWITCH. L-5250. Rugged little switch goes open circuit when it is shaken. Ideal for plateglass windows and safes, etc. Adjustable sensitivity. Tamperproof case, rugged PVC case. 5W.50V@0.1A. Only .75in x .85in x 2.25in. $2.50. Normally closed contacts.

MINI REED ALARM SWITCH. L-5210. Fully moulded in grey PVC with riveted case for extra security. Solder free screw terminals. Complete with PVC encapsulated magnet. Normally open contact closes by magnet. Same rating as above. Get a pair for only $1.95



Cat. L-5250. Cat. L-5210.

AND NOW.....Dickwick!
DESOLDERING DRY WICK



De-solders all sizes of electronic and electrical connections in one second without flux. All sizes of electronic joints and electrical connections, from integrated circuits and printed circuit boards to telephone connections, can be quickly, safely, neatly and economically desoldered with Dickwick and a regular soldering iron. Cat. N-1682.. .. ..$2.00.

HIMOUND HK705 MORSE KEY. Unfortunately, the instructions are in Japanese, but we can tell from the diagrams that this key has real ball-bearing pivots which can be adjusted. It is beautifully made and a delight to handle. Heavy duty construction throughout. Not a toy but a professional key. Screws adjust spring tension and knob travel. Measures 160mm x 90mm x 65mm high. Highly recommended for you CW enthusiasts

Cat. D-7104. Only $25.00!

Cat. M-9802

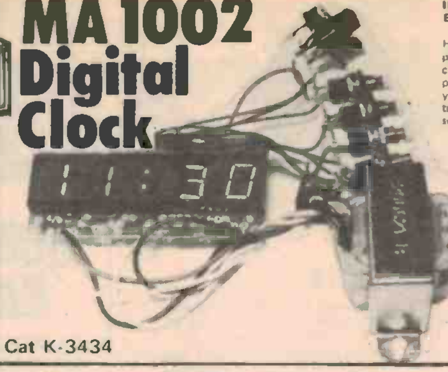
CHARGETTE. The neatest 12V, 1A trickle charger yet. Can be run continuously with special thermal overload protection switch. Looks like a big mains plug with leads straight to battery. A handy unit for car, boat, caravan owners — keeps your battery in tip-ton condition for just $15.00.

115V trannies for foreign gear

HANDS UP IF YOU WENT OS FOR THE HOLIDAYS. Have you got a red face like many overseas travellers have — buying an appliance in, say, Japan — only to find it's for 115 volts! We can help — our 115 volt transformer is rated at 30 watts, which suits many small cassettes, radios, etc. Has normal mains flex and plug, with 115V socket to plug appliance into. Fully approved by the electricity authority. Cat M-1158.. .. .. $22.00

HEY! THAT'S A SAVING OF NEARLY $8.00!!

MA 1002 Digital Clock



IDEAL FOR THE EXPERIMENTER!

Here's a neat little kit to play around with — this digital clock is four big LED digits, and is pre-assembled on its own PCB. All you do to finish it off is add the transformer and a couple of switches.

Complete kit — chip, trans, sw.

$19.75

Cat K-3434

CHIP ONLY — MA1002 clock chip only. Cat X-1052 $13.50

Metal Detectors

* Light indicator shows presence of metal objects.

WHAT VALUE! This 'Builders Mate' metal detector is ideal for finding pipes & wires in walls, or nails in wood before you saw throug them and ruin the saw! **UNDER HALF PRICE** Cat X-1060.. .. .. $4.75

FIND A FORTUNE: The quality metal detector shown at right is just the thing for searching for coins on the beach. Several stories from overseas prove that serious searchers can make the cost of one of these units back again! Cat X-1064 .. .. $59.50

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What a bewdy! A little cassette recorder ideal for personal recording, businesses, meetings, etc. Has inbuilt cond. microphone, takes standard cassettes. You'll see elsewhere for over $80.00. Our price near half! Cat A-4050 ..

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look at this for value!

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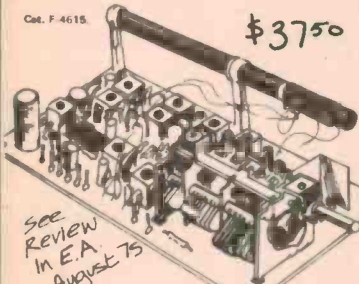
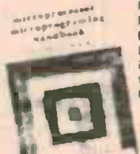


See Review In E.A. August 75

BOOKS BOOKS BOO BOO



MICROPROCESSOR MICROPROGRAMMING HANDBOOK. 294 pages. Phew! The titles almost a book in itself Tells you what they are, how they work, and how to work them. Cat B-2346 .. ..$9.50

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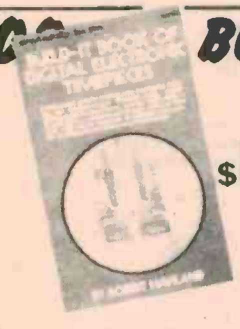

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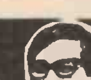

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Ideas for experimenters

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

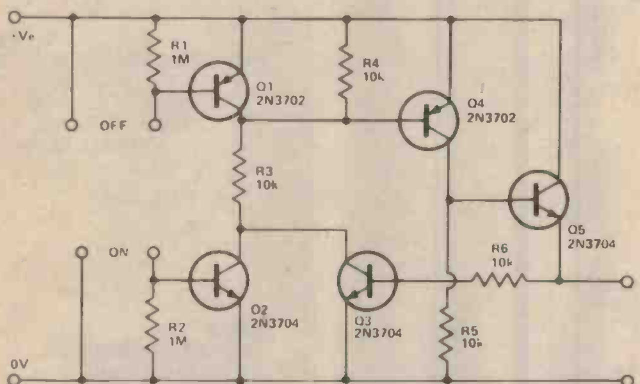
Solid State Switch

The circuit was designed for use as a solid-state calculator on-off switch, as the mechanical equivalent was found to be unreliable.

Layout is not critical and the switch will operate with a supply from +6V to +15V and current consumption in the 'OFF' state is a negligible 30μA.

A finger across the 'OFF' contacts turns Q1 off and takes the base of Q4 to the +ve rail, turning Q4 off. This in turn stops Q5 conducting, and R6 and Q3 latch the circuit in this state.

Touching the 'ON' contacts takes R3 to ground turning Q4 on. Q5 now contacts and again R6 and Q3 latch the circuit.

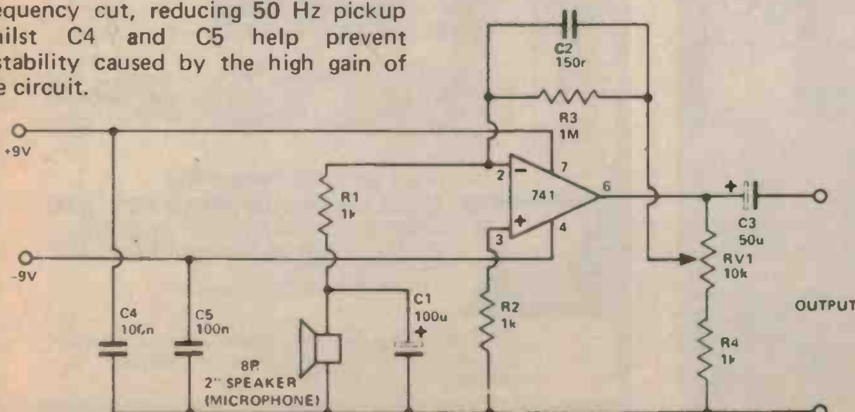


Heartbeat Preamplifier

This simple circuit, when connected to an audio amplifier, allows one to listen to heartbeats. The low frequency gain is set by R1 and R3, in conjunction with VR1 and R4. VR1 permits the gain to be varied over the range 60-80 dB.

C1 and C2 introduce some low frequency cut, reducing 50 Hz pickup whilst C4 and C5 help prevent instability caused by the high gain of the circuit.

The output should be connected to the magnetic cartridge input of the audio amplifier, with the bass turned up high.



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HEF 4006	1.28	HEF 4024	.99	HEF 4053	1.24	HEF 4093	.96
HEF 4007UB	.30	HEF 4025	.30	HEF 4066	.80	HEF 4510	1.34
HEF 4008	1.24	HEF 4027	.57	HEF 4068	.33	HEF 4511	1.76
HEF 4011	.30	HEF 4028	.99	HEF 4069UB	.35	HEF 4512	1.86
HEF 4012	.30	HEF 4029	1.50	HEF 4070	.32	HEF 4516	1.76
HEF 4013	.50	HEF 4030	.52	HEF 4071	.30	HEF 4518	1.56
HEF 4014	1.28	HEF 4035	1.28	HEF 4072	.32	HEF 4519	.74
HEF 4015	1.24	HEF 4040	1.37	HEF 4073	.32	HEF 4520	1.41
HEF 4016	.52	HEF 4041	.99	HEF 4075	.32	HEF 4528	1.02
HEF 4017	1.24	HEF 4042	1.96	HEF 4076	1.86	HEF 4531	2.74
HEF 4018	1.28	HEF 4043	1.24	HEF 4077	.39	HEF 4539	1.12
HEF 4019	.73	HEF 4044	1.24	HEF 4078	.32	HEF 4555	1.02
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C 122E 8A 500V	2.54	ST4	.60	013T2 (2N6027)	1.18

signetics TTL LOW SCHOTTKY

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74LS04	.38	74LS51	.36	74LS85	1.99	74LS164	1.76
74LS10	.36	74LS55	.36	74LS86	.56	74LS196	1.70
74LS20	.36	74LS73	.47	74LS90	1.73	74LS367	1.19

signetics LINEAR

UA 741	.56
LM 301	.56
LM 308	1.43
LM 381	3.04
LM 382	2.69

TIMERS

NE 555	.64
NE 556	1.43

REGULATORS

LM 309K	2.56
LM 340T(V)	2.10
LM 723	.65
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Transistors

AC127	65c
AC128	65c
AC187	65c
AC188	65c
80137	60c
80138	60c
80139	65c
B0140	65c
8C547	22c
8C548	22c
BC549	22c
BC557	22c
BC558	22c
BC559	22c
2N3638	18c
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.001 - .01	8c	6c
.012 - .033	10c	7c
.039 - .056	12c	9c
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.39 - .56	22c	18c
.68 - .82	28c	24c

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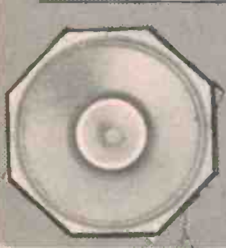

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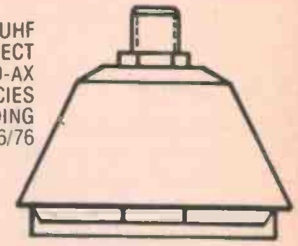
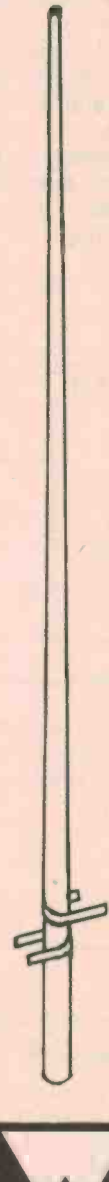
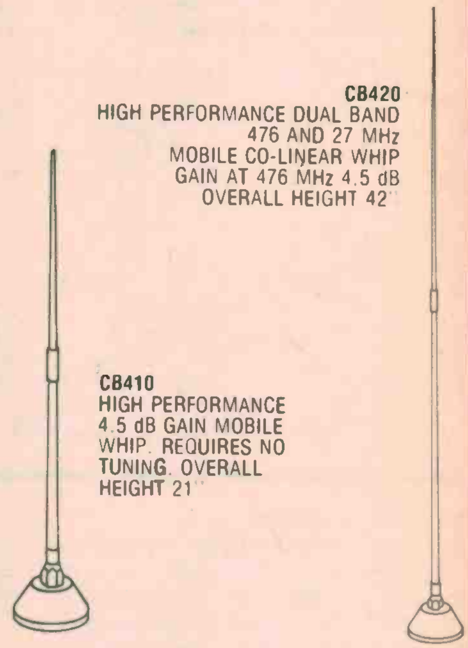


MODEL OB





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Ideas for experimenters

CLASS A AMPLIFIER

The main advantage of class A amplifiers is the absence of crossover distortion. Against this major advantage must be weighed the disadvantage of permanently hot heatsinks and large capacity power supplies.

The circuit shown here contains several novel features and will deliver 5W of pure class A sound into an 8 Ω load.

Q1 and Q2 form, with the associated components, a high quality voltage amplifier with overall ac and dc feedback applied from the collector of Q2 via R6 to the emitter of Q1.

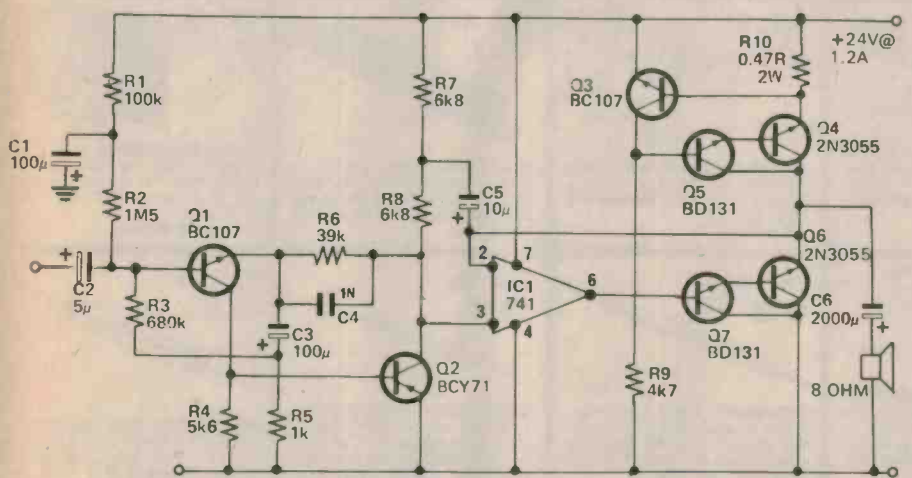
The output stage proper, consists of Q6 and Q7 connected as an emitter follower darlington pair. These transistors are driven by IC1, a 741 op amp, and are included in the latter's feedback loop.

These three form a near perfect output stage with an input impedance of several megohms and a bandwidth extending from dc to over 100 kHz.

Quiescent current is provided by the constant current source Q3, Q4, Q5, R9 and R10. The use of a constant current source here effectively isolates the output from line variations and ripple.

With the components shown, the circuit has a bandwidth of 10Hz – 30kHz at -3dB, a distortion of less than 0.1% before the onset of clipping, an input impedance of 1.5MΩ and a sensitivity of 180mV for full output.

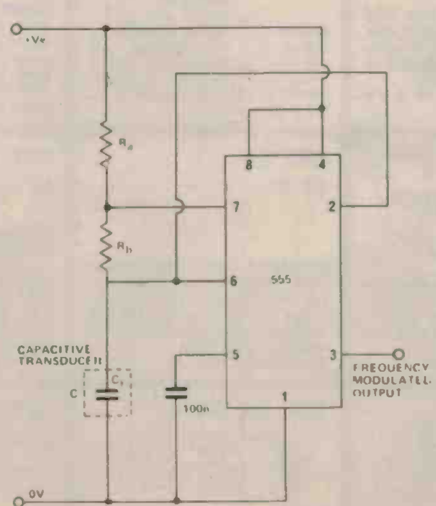
Transistors Q4 to Q7 must be mounted on an adequte heatsink, a 5" by 4" finned type is suitable, but must be mounted vertically and in such a position as to allow ample ventilation.



Low Cost Transducer Amplifier

Capacitative transducers are often used to measure displacement or pressure. The versatility of the low-cost 555 integrated circuit timer can be utilised with these types of transducer to provide a frequency modulated output. This output, fed into a frequency-to-voltage converter, will give an analog output voltage proportional to the capacitance of the transducer.

The 555 module is connected with the transducer C_t substituted for the external timing capacitor. Precise setting of the duty cycle is obtained with resistors R_a and R_b and with pins 2 and 6 connected together, the device will trigger itself and thus free-run as a multivibrator. As the output will source or sink current up to 200 mA or drive TTL circuitry, it can be fed directly into most types of frequency-to-voltage converter.



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CAT No. CP.37.

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POWER TRANSISTORS IN TO26 'Flat-pak' package. The following NPN types are available: BD283, BD281, BD375 & BD377. Hfe between 30 & 200. Fantastic value at only 35c each or the 4 for $1.30. p & p 30c

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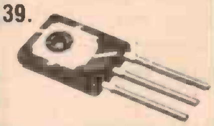
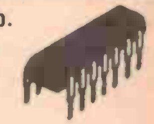


As CP.38 to 'The following' PNP types are available: BD284, BD376, BD378, BD282. Hfe between 65 to 200. Same prices as NPN types in CP.38.

CAT No. CP.40.



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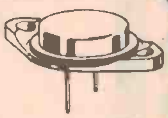

2N3055 Power Transistors. Unmarked but all guaranteed useable. Below spec's. 20 for $3.00. We have now sold 1000's with very little returns. p & p 75c

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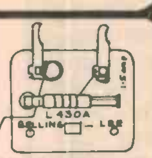

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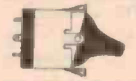

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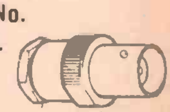

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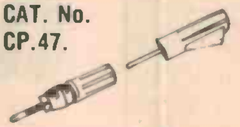

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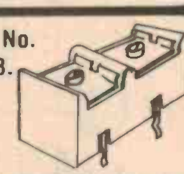

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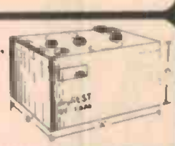

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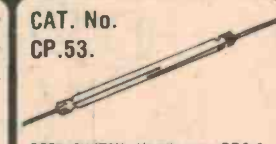
CAT. No. CP.53.



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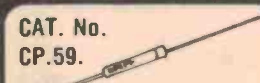
'RODAN' Digital Indicator Tube. Type GR-211. Reads 1 to 0. Supply volts 300. Cath. Current 5mA. Ht. of digits, 35mm. Full data supplied. Only at 'SHERIDANS' at $2.00 each. p & p 50c. or 6 for $11.00. p & p $1.50.

CAT. No. CP.58

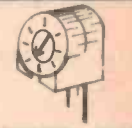
MINIATURE MOOEL MOTORS by LENCO. 6-12 VDC. Precision made with inbuilt speed regulation. Length: 70mm Dia: 35mm. Spindle length: 20mm. $1.75 ea. or 2 for $3.25 p & p 40c each.

CAT. No. CP.59.



DIODES . . . 1N914 (1N4148) Silicon small signal switching. Everyone should know this one as being a very popular diode. We've gone 'NUTS' again. Only 6c each or 10 for 50c . . . HOWZAT FOR VALUE please add approp. post.

CAT. No. CP.60.

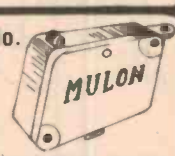


MINIATURE PRECISION POTENTIOMETERS by COPAL. Screwdriver adjust. on graduated scale. In 1K vertical mounting or 500 Ω horizontal mounting. Dia: ½''. 75c each or 2 for $1.35. p & p 30c.

CAT. No. CP.61.

SPRING REVERB. UNITS. Specs: Input current — 350mA, Driving Coil impedance — 16 , Pickup coil impedance — 10k , Frequency response — 100 to 3000 Hz, Attenuation — 30 dB, reverberation time — 25 to 30 msec, Dimensions — 253 x 36 x 26mm. Only $6.95. SAVE — SAVE — SAVE. Only from us at this price. p & p $1.25.

CAT. No. CP.62.



MULON MICRO-SWITCH Miniature type. Size: 28mm x 16mm x 10mm. Normally closed on/off switch. 250VAC 5 amps. Only 95c each or 5 for $4.50. p & p 30c ea or 5 for 60c.

CAT. No. CP.63.

INTEGRATEO 3 WATT AUDIO POWER AMPLIFIERS in Modified JEDEC 10 pin T03 case. Operate on Vcc plus 13.8V — Max 18V. Data supplied. LAST FEW AT ONLY $2.00 each to CLEAR. P.C. Board to suit $1.50 ea. p & p 40c ea. item.

CAT. No. CP.64.

SINCLAIR Power Supply Units. Type PZ.6 Stabilised mains supply unit delivers 35 volts at 1.5 amps with ripple less than 20mV at any output up to max. current. Size: 3.9'' x 2.8'' x 1.6''. ONLY A FEW LEFT SO RUSH YOUR OROERS . . . Only $10 ea. Were $29. p & p $2.00.

CAT. No. CP.65.

CRYSTAL MIKES. Very neat about the size of a large egg. Complete with shielded lead and stand. High impedance. Great value at only $2.50 each. p & p 60c.

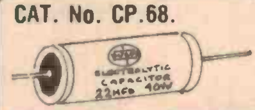
CAT. No. CP.66.

AMPHENOL 57 Series Micro ribbon Miniature connectors. 14 way Plug & Socket. Spring type latch on panel receptacle. SUPERB QUALITY for that extra special piece of equipment. Only $6.00 per pair. Less than half price. p & p 60c.

CAT. No. CP.67.

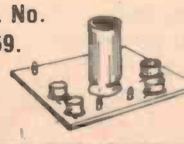
A & R POWER TRANSFORMER. Type 6413. Pri: 240VAC. Sec: 32V 2A D.C. Bridge rectifier condenser output. Wt: 4lbs. Ht: 3½''. Overall base: 3'' x 3¼''. A KNOCKOUT SPECIAL AT ONLY $6.00 each. p & p $2.50.

CAT. No. CP.68.



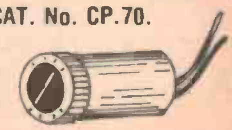
DUCON Bi-polar Electrolytic capacitors. 22mfd 40VW. Very handy for that cross-over at a 5th of the price. Size: 57mm x 25mm. Axial leads. ONLY 25c each or 10 for $2.25. p & p singles 20c or 10 for $1.00.

CAT. No. CP.69.



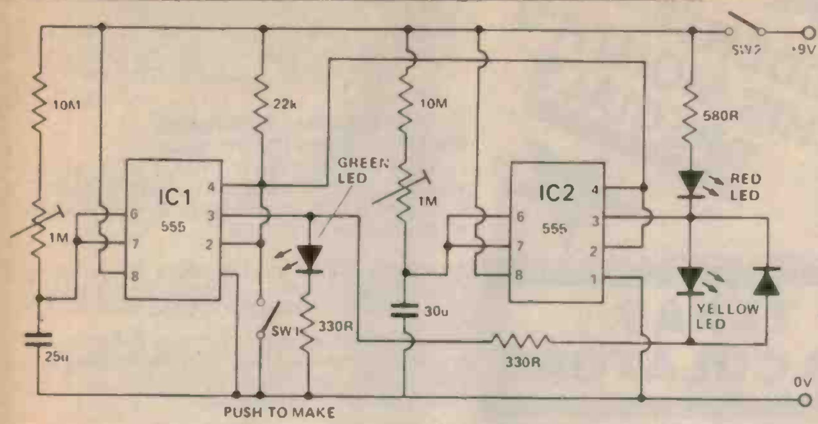
FULL-WAVE BRIOGE RECTIFIER ASSEMBLIES. Fully filtered 3amp 200W. OIRT CHEAP at only $2.00 ea. p & p 50c.

CAT. No. CP.70.



BATTERY INOICATOR LEVEL METER . . . Made by SONY. Size: 15mm x 10mm. ONLY 75c each p & p 30c.

Ideas for experimenters



Talk Timer

This circuit was designed for use as a timer for educational talks, providing a timing period of 5 minutes. During the talk, a green LED is turned on, but half a minute before the end, the green LED is extinguished and the yellow LED lit, giving a warning that only half a minute remains. At the end of the 5 minutes, the yellow LED turns off and the red LED turns on.

The circuit is simply two one-shot monostables connected together, the first with a timing period of 4½ minutes, and the second ½ minute.

Timing is started by momentarily closing S1, pin 3 of both ICs go high turning on the green LED and off the red and yellow LEDS.

At the end of the first timing period, pin 3 of IC1 goes low turning the green LED off and the yellow LED on. When at the end of the second timing period, pin 3 of IC2 goes low, the yellow LED is turned off and the red LED lit.

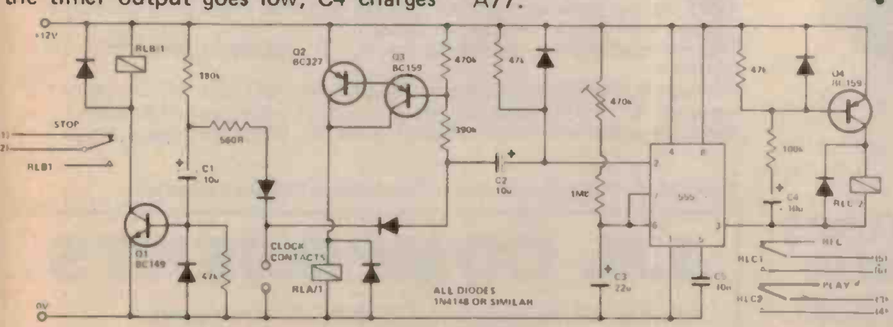
Tape Recorder Controller

The circuit shown enables a solenoid operated tape recorder to be left to record a programme unattended. It was originally designed to be used on a Revox A77, in conjunction with a digital clock based on the Caltex CT7001, but could be adapted for other recorders, clocks, or mechanical time switches. The clock is set to switch on one minute before the programme starts, and switch off as it finishes.

When the clock contacts close, RLA is operated via Q2 and Q3, applying power to the receiver and recorder. At the same time C1 is discharged, and C2 applies a negative pulse to pin 2 of the timer, which triggers, discharging C4. The output of the timer goes high for one minute, allowing time for the recorder and receiver to warm up. As the timer output goes low, C4 charges through Q4 momentarily, operating RLC which starts the recorder.

At the end of the preset time the clock contacts open, discharging C2 through Q2 and Q3 which delays RLA from dropping out by approximately 5 seconds. As the clock contacts re-open C1 charges through Q1, operating RLB opening the normally closed stop contacts for a short period, stopping the recorder. After the 5 second delay has elapsed, RLA opens, removing power from the equipment.

RLB and RLC may have light contacts, but RLA must be a heavy duty mains rated type. Ideally the digital clock should by crystal controlled, to eliminate short term mains frequency fluctuations. The numbers shown in brackets are the appropriate pin connections on the 10 way remote control plug of a Revox A77. •



SR51 II $55 (SAVE $6)
THE ULTIMATE NON-PROGRAMMABLE CALCULATOR, 3 FULLY ADDRESSABLE MEMORIES, MORE KEY-BOARD FUNCTIONS THAN ANY OTHER MODEL.

Ti57 $75 (SAVE $9)
COMPUTOR LIKE PROGRAMMING, 50 MERGED STEPS — UP TO 150 KEY STROKES, 8 MULTI-USE MEMORIES, SUBROUTINES, LOOPS AND CONDITIONAL BRANCHING.

Ti58 $115 (SAVE $14)
UP TO 480 STEPS, OR UP TO 60 MEMORIES, PLUS PLUG-IN MODULE WHICH RETAINS 5000 PROGRAMME STEPS (1 MODULE WITH CALCULATOR — 5 OTHERS AVAILABLE).

Ti59 $265 (SAVE $34)
UP TO 960 STEPS, OR UP TO 100 MEMORIES, PLUS PLUG-IN MODULES, PLUS CARD PROGRAMMABLE. (THE MOST POWERFUL POCKET CALCULATOR AVAILABLE).

STUDENTS — THIS MONTH'S SPECIALS

TEXAS CALCULATORS

NATIONAL SEMICONDUCTOR CALCULATORS
4650 $33 (SAVE $14), 4640 and 4660 EACH $43 (SAVE $17). PERFECT POCKET MODEL — LIQUID CRYSTAL NS100 (MEMORY %) $22. NS100 BATTERY LIFE — 2000 HOURS, BILLFOLD-STYLE CARRYING CASE.

PC-100A ALPHA-NUMERIC PRINTER $225 (SAVE $30)
FOR Ti58 AND 59, OVER 60 CHARACTERS, WRITES WORDS, LISTS PROGRAMMES, PLOTTS GRAPHS, ETC. (N.B. ALL CALCULATORS EXCEPT NS100 HAVE RECTANGULAR TO POLAR).

ALL PRICES QUOTED EXCLUDE SALES TAX — AND 15 PERCENT IF NOT EXEMPT — SALES TAX FORMS MUST BE DULY SIGNED AND STAMPED BY COLLEGE, UNIVERSITY OR SCHOOL.
PACKAGING AND POSTING — EXTRA $1.50 FOR N.S.W., ELSEWHERE $2.50 PER ORDER. SAVE BY ORDERING WITH YOUR FRIENDS. (S/T FORMS AVAILABLE — WRITE FOR FULL PRICE LIST OF ALL MODELS).

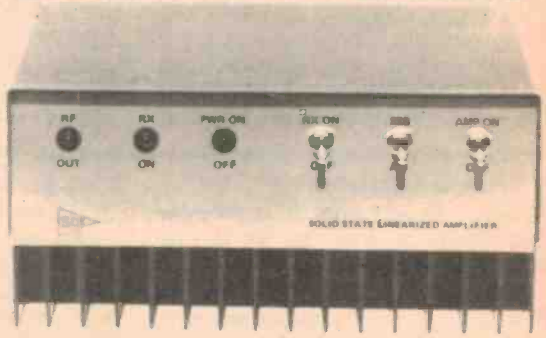
★ ELECTRONIC CALCULATOR DISCOUNTS ★

P.O. Box 106, BAULKHAM HILLS, N.S.W. 2153. Phone: (02) 6248849 (8am till 3pm)

NEW MODEL, 3-30 MHz BI-LINEAR AMPLIFIER

HF-3-100L2

Frequency Range 3-30 MHz
Input Power: 10W Nom, 5-20 W PEP range
Output Power: 100W Nom ± ½ dB across band 200-250W PEP output
Input Impedance: 50 Ω nom, adjustable to match exciter range under 2 1 across band
Output Impedance: 50 Ω nom, up to 3:1 VSWR acceptable with little degradation
Current Drain: 16A nom. 20 A supply recommended at 13.6 VDC
Power Supply: 13.6 VDC recommended for best results, 11.14 VDC acceptable positive or negative ground
Pre-amp: 18 dB nom. gain across entire HF band, 15 dB typ at 50 MHz, 3-4 dB NF
Size: 19.1 x 16.5 x 8.9 cm wt 1½ Kg



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SOLE AUSTRALIAN DISTRIBUTORS FOR SCS LINE OF LINEAR AMPLIFIERS

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7 DIGIT FREQUENCY METER KIT

'Electronics Australia' March 1977 design High Stability Crystal (30 P.P.M. -10°C to +60°C) in cold-welded HC18/U holder.
ALL high quality components (National, Fairchild, etc.) Fibreglass P.C. Boards with component overlay 'Polaroid' front panel, L.E.D. readouts, 'BNC' socket standard — 'UHF' socket optional. Pre-drilled aluminium chassis with black 'Marviplate' cover.
240 volt operation — provision for 12 Volt operation. Instructions included.
Postage N.S.W. $2. Interstate $4. Registration $2, "Comet" — Sydney $2 insured. 'T.N.T.' Air-road courier, insured $6 anywhere in Australia.
Separate components (post free) Crystal $8, 95H90 prescaler $9.50.

Please Note: The prices shown in December ETI were a misprint.

COMPLETE KITS	ASSEMBLED UNITS
20 MHz $82.00	20 MHz $122.00
200 MHz $89.50	200 MHz $129.50

J.R. COMPONENTS

P.O. Box 128, Eastwood, N.S.W. 2122 Ph: (02) 853976.

INTERNATIONAL ELECTRONICS UNLIMITED

DISCOUNT ON ALL IC'S AND LED'S
10% OFF ON $25.00
15% OFF ON $50.00

TTL

7400	.11	7451	.20	74155	.75
7401	.18	7453	.20	74156	.75
7402	.14	7454	.20	74157	.85
7403	.14	7460	.20	74158	1.39
7404	.16	7464	.35	74160	1.23
7405	.19	7465	.35	74161	.95
7406	.29	7470	.38	74162	1.39
7407	.28	7472	.35	74163	.95
7408	.22	7473	.35	74164	.95
7409	.17	7474	.31	74165	.95
7410	.16	7475	.49	74166	1.19
7411	.25	7476	.34	74170	1.90
7413	.43	7483	.68	74173	1.49
7414	.65	7485	.88	74174	1.19
7415	.25	7486	.38	74175	.95
7416	.35	7489	2.25	74176	.84
7417	.35	7490	.43	74177	.84
7420	.16	7491	.75	74180	.95
7423	.37	7492	.48	74181	2.30
7425	.35	7493	.48	74182	.85
7426	.22	7494	.75	74185	2.20
7427	.35	7495	.75	74190	1.25
7430	.20	7496	.75	74191	1.15
7432	.23	74100	1.15	74192	.89
7437	.25	74107	.37	74193	.85
7438	.25	74121	.37	74194	1.15
7439	.50	74122	.38	74195	.74
7440	.15	74123	.45	74196	.98
7441	.85	74125	.54	74197	.95
7442	.59	74126	.58	74198	1.69
7443	.65	74132	.75	74199	1.69
7444	.73	74141	.85	745200	3.95
7445	.65	74145	.90	74279	.79
7446	.81	74150	.98		
7447	.59	74151	.68		
7448	.79	74153	.60		
7450	.17	74154	1.20		

LINEAR CIRCUITS

LM300H	$ 71	LM372N	2 93	LM733H	79
LM301CN	29	LM376CN	59	LM739N	99
LM302H	85	LM380N	1 29	LM741CN(8)	32
LM304H	80	LM380 8CN	95	LM741CN(14)	32
LM307CN	26	LM381N	1 75	LM741CH	35
LM307H	30	LM382N	1 75	LM747H	79
LM308H	89	LM385K	45	LM747N	71
LM309H	1 05	NE531V	2 90	LM748CN	35
LM309K	99	NE540L	2 90	LM1310N	2 80
LM310CN	1 07	NE548A	1 09	LM1414N	1 59
LM311CN	89	NE550A	75	LM1456CN	1 29
LM311H	89	LM555CN	39	LM1458CN	59
LM311N	89	NE556A	85	LM1496N	89
LM319N	1 13	LM560N	2 95	LM1800N	2 48
LM320K		LM561N	2 95	ULN2208	89
5, 5 2, 12, 15	1 29	LM565N	1 19	ULN2209	89
LM320T		LM565H	1 39	CA3046	1 10
5, 12, 15	1 19	LM566H	1 39	CA3081	1 49
LM322N	1.59	LM566CN	1 19	LM3900N	49
LM324N		LM567CN	1 29	LM7524	79
(LM2902N)	1 52	LM567H	1 49	LM7525	79
LM339N	1 58	LM703H	59	8038B	4 59
LM340K		LM703CN	39	75451CN	35
5, 6, 8, 12,		LM709N	.25	75452CN	36
15, 18, 24	1 29	LM709H	29	75453CN	35
LM340T		LM710N	59	75454CN	35
5, 6, 8, 12,		LM711N	39	75491N	71
15, 18, 24		LM723H	55	75492N	.85
(78 — — Equiv)	1 19	LM723N	.52		

XR320	1.15	XR2567	1.99	XR4212	1.75
XR2206	2 95	XR4136	1.75	XR4739	1 15
XR2207	2.95	XR4202	1.75		

CMOS

4000A	.26	4018A	1.39	4066A	.89
4001A	.25	4020A	1.72	4068A	.44
4002A	.25	4021A	1.18	4069A	.44
4006A	1.35	4022A	.94	4071A	.26
4007A	.26	4023A	.25	4072A	.35
4008A	1.52	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4082A	.35
4012A	.25	4030A	.44	4518A	1.56
4013A	.45	4035A	1.27	4528A	1.56
4014A	1.27	4040A	1.39	4585A	2.10
4015A	1.27	4042A	1.47		
4016A	.48	4049A	.59		
4017A	1.01	4050A	.59		

IC SOCKETS

Solder Tail - low profile

8 pin	$ .17	24 pin	.42
14 pin	.20	28 pin	.59
16 pin	.22	40 pin	.69
18 pin	.29		

CERAMIC DISC CAPACITORS

1pf 50V	56pf 50V	270pf 50V	.01uf 1000V
5pf 50V	68pf 50V	390pf 50V	.022uf 50V
7pf 50V	82pf 50V	470pf 50V	.030uf 50V
10pf 50V	100pf 50V	600pf 50V	.050uf 50V
22pf 50V	120pf 50V	820pf 50V	.1uf 50
27pf 50V	150pf 50V	.001uf 50V	
33pf 50V	180pf 50V	.0047uf 50V	
47pf 50V	220pf 50V	.01uf 50V	

(each) (Minimum 10 per value)

0- 100	$.10 ea	$.05 ea
100-		$.04 ea

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Jumbo LED'S

green - yellow
amber - clear 16¢ ea.

ZENER DIODE — 400MW

3.6V 5.1V 6.8V 15V
4.7V 5.5V 10V **$ .15 EA.**

8/$1.00 ANY MIX

LED'S

MAN 72	.99
NSN 74R	.99
DL702	.99
FND 359	.59
MV10B	

6/$1.00

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7416	$ .19
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7432	.19
7437	.19
7440	.13
7442	.29
7460	.07
7495	.59
74141	.68
74145	.59
74151	.59
74165	.79

SIGNAL DIODES — 400 MW

20/$1.00

SHIFT REGISTERS

2510	$1.75
2511	1.95
2518	2.50
2522	1.95
2532	2.29
5016	[illegible]

LINEAR SPECIALS

LM301	mini dip	$ .20
LM308	TO-5	.65
LM311	mini dip	.65
LM340T	6V	.89
LM565	dip	.89
LM567	mini dip	1.09
LM747	dip	.50
LM1458	mini dip	.50
CA3046	dip	.75

6 Digit Clock Kit

MM5314 with 6 NS71 .27" displays 2 P.C. boards — Display board may be remote. Internal or wall transformer can be used. 50-60 Hz, 12-24 hour. Includes all necessary transistors, resistors, capacitors, diodes, 3 switches and complete assembly instructions.

CK6-3 .... **$12.95**

8038 FUNCTION GENERATOR

Voltage controlled oscillator — sine, square, triangular output. $3.95

CALCULATOR DISPLAY

9 MAN 3 M ON PC BOARD

99 ¢

5738

CALC. CHIPS FUNCT WITH MEMORY
$2.95

KEYBOARD

20 KEYS
2 SLIDE SW
3" x 3¼"

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CALCULATOR KIT

LITRONICX 1502 MEMORY

CALC. KIT ONLY **$7.95**
ADAPTER -60Hz **$3.95**

MM 5330

4½ DIGIT DVM LOGIC **$ 4.95**

CERAMIC DISC CAPACITOR PACKAGE

10 EA. OF FOLLOWING VALUES — 50 VOLT

1pf	33pf	82pf	220pf	820pf	.022uf
5pf	47pf	100pf	270pf	.001uf	.030uf
10pf	56pf	150pf	470pf	.0047uf	.050uf
22pf	68pf	180pf	600pf	.01uf	.1uf

240 CAPACITORS **$10.95**

PRECISION RESISTOR PACKAGE

METAL FILM ± 1% ¼ WATT
4 EA. OF FOLLOWING VALUES 240 RESISTORS **$21.95**

10.5	100	499	1.65K	4.53K	7.50K	13.0K	22.1K	44.2K	80.6K
20.0	130	604	2.00K	5.11K	8.45K	14.0K	24.9K	48.7K	90.9K
30.1	162	750	2.49K	5.49K	9.09K	15.0K	27.4K	52.3K	100K
49.9	200	1.0K	3.01K	6.04K	10.0K	16.2K	30.1K	57.6K	147K
60.4	301	1.21K	3.48K	6.49K	11.0K	17.8K	34.0K	63.4K	210K
76.8	402	1.40K	4.02K	6.98K	12.1K	20.0K	40.2K	69.8K	464K

2708

FULL SPEED EROM **$10.95**

5314 6 DIGIT CLOCK CHIP

$2.95

1702A

$ 4.75

74S200

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AY51013A **$6.95**

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SET **$24.75**

82S23

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2513

CHARACTER GEN
64 x 8 x 5 ASCII **$8.95**

ELECTRONIC DOOR CHIME KIT

WITH TI TMS 1000 MICROPROCESSOR CHIP PROGRAMMED TO PLAY 24 DIFFERENT TUNES

INTERNATIONAL FLAVOR — PLAYS NATIONAL ANTHEMS OF [illegible], BRITAIN FRANCE AND WEST GERMANY PLUS OTHER FOLK TUNES, CLASSICAL AND TRADITIONAL MELODIES.

- SUPPLIED WITH ALL PARTS INCLUDING PC BOARD, SPEAKER, CASE AND COMPLETE INSTRUCTION MANUAL WITH FULL CIRCUIT DETAILS.
- USES 1.9V TRANSISTOR BATTERIES (NOT SUPPLIED).
- LOW POWER CONSUMPTION.
- INTERNAL SELECTION OF TUNE, VOLUME, TEMPO AND TIMING FUNCTIONS.
- PROGRAMMED MATHEMATICALLY TO PLAY IN PERFECT PITCH PERMANENTLY.
- ATTRACTIVE CASE, CONVENIENT WALL MOUNT.

$39.50 SHIPPING $1.00

TANTALUM CAPACITORS

Solid dipped ±20%

.1 mfd	35V	$ .25	10 mfd	16V	$ .40
.33 mfd	35V	.25	10 mfd	25V	.45
1 mfd	35V	.25	15 mfd	10V	.40
2.2 mfd	20V	.25	15 mfd	20V	.45
2.2 mfd	35V	.30	22 mfd	16V	.45
3.3 mfd	35V	.30	33 mfd	10V	.40
4.7 mfd	16V	.30	47 mfd	6V	.40
6.8 mfd	6V	.30	56 mfd	6V	.45
6.8 mfd	50V	.40	150 mfd	15V	1.50

DISCRETE LED's

		EACH
ME4	INFRARED CLEAR DOME .170"	.29
MV10B	CLEAR DOME .170"	.25
MV50	CLEAR — AXIAL .09"	.12
MV50	RED — AXIAL .09"	.12
HSL100	RED .19"	.12
RL209	RED DIFF. SUBMINIATURE .12"	.12
RLT-T1-03	WHITE DIFF. SUBMINIATURE NO FLANGE .124"	.15
RLC-200	RED DIFF. CURRENT REG. .190" CONST BRIGHTNESS 4.5-12.5V	.25
RLC-201	RED DIFF. CURRENT REG. CONST. BRIGHTNESS 4.5- .190"	.25
RL-4403	RED DIFF. FULL FLOOD .190"	.15
GREEN	SPOT .190"	.18
CLEAR	POINT .190"	.15

LED S

		EA.
DL10A	RED CA .27" LHD	$1.89
DL 707	RED CA .30" RHD	1.49
DL 507	RED CA .50" RHD	1.49
FND 359	RED CC .375" RHD	.89
DL 702	RED CC .30" LHD	1.39
NSN 74R	RED CC .30" RHD	1.49
DL 500	RED CC .50" RHD	1.49
MAN5	GREEN CA .27" LHD	1.39
MAN8	YELLOW CA .27" LHD	1.39
MAN82	YELLOW CA .3" LHD	1.89
MAN66	RED CA .6" LHD	2.19
DL747	RED CA .6" LHD	2.39

MM5369 Divider mDIP 2.49
Crystal 3.58 MHZ color TV 1.75
Crystal 2.010 MHZ 3.95

RESISTOR PACKAGE

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