COMMUNICATIONS WITH INTERPLANETARY SPACECRAFT

electronics today INTERNATIONAL

JULY 1978

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ROBOTS

TOYS FOR KIDS OR TOOLS FOR SOCIETY

EPROM Programmer

Electronic Tacho

8080 Educational Interface

The competition don't like the sound of this at all.

For quite some time, other manufacturers have been trying to produce tape with the qualities of the Maxell UD-XL. At the same time, Maxell have been quietly perfecting an even better series.

The UD-XL I and UD-XL II tapes are designed to attain maximum performance at the ferric and chrome position on your tape deck. Whichever tape position you choose, Maxell can give you a better performance.

UD-XL I TAPE, FOR FERRIC (norm.) POSITION (120us)

UD-XL I offers an excellent sensitivity of 1 dB higher than even UD-XL. MOL performance is also 1 dB higher over the entire audio frequency spectrum. The result is a new standard in ferric tape, with wider dynamic range and less distortion than ever before.

How does the UD-XL I compare then, with ordinary low-noise tapes?

Sensitivity is higher by 2.5 dB, and MOL performance by as much as 6 dB.

Yet, for all this UD-XL I requires no special bias or equalization. Simply set your tape selector as you normally would at the ferric position – but there the comparison ends.

UD-XL II TAPE, FOR THE CHROME POSITION (70us)

UD-XL II tape is such a dramatic improvement on most other tape that can be used in this position, that comparison is really unfair.

For example, if you're familiar with conventional chromium-dioxide tape, you'll know of the associated problems of head wear, poor output uniformity and relatively high price – plus low maximum output level and rather high distortion.

UD-XL II tape offers you excellent MOL, sensitivity, and an output improvement of more than 2 dB over the entire frequency range.

Maxell's unique 'Epitaxial' process gives you absolute sensitivity and stability, and no drop-out problems. What's more, the shells are moulded in diamond cut dies, and made to tolerances 5 times greater than the Philips standard. And, like all Maxell tapes, UD-XL II has the unique 5-second cleaning leader.

In short, if you're recording in the chrome position, you can now achieve all the advantages – with none of the drawbacks.

A prospect we think you'll find very exciting – even if the competition don't.

UD XL II

UD XL I

maxell®
simply excellent

For details on all Maxell Recording Tape write to Maxell Advisory Service, P.O. Box 49, Kensington, N.S.W. 2033

WT3/79

AUSTRALIAN OWNED AND PRODUCED

July 1978, Vol. 8 No. 7

electronics today INTERNATIONAL

Editorial: Les Bell

Publisher: Collyn Rivers

Cover: Are robots merely toys for kids, or are they really evolving into useful tools for society. Two major articles this month examine this question, while next month we ask: is it feasible to build your own robot? Photograph by John Knight.

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PROJECTS

FEATURES

NEWS & INFORMATION

News Digest

Salt of the Earth?

XIT Rod Co. of Covina, California, has developed a grounding rod which grows electrolytic 'roots' to decrease the rod-to-earth resistance dramatically. The hollow tubular body condenses moisture from the air which trickles through a bed of coarse granulated metallic salt, dissolving a small quantity of it to form an electrolytic solution. This solution seeps through the bottom of the rod, thus growing 'roots' and dropping the earth resistance to a fraction of the value otherwise obtainable.

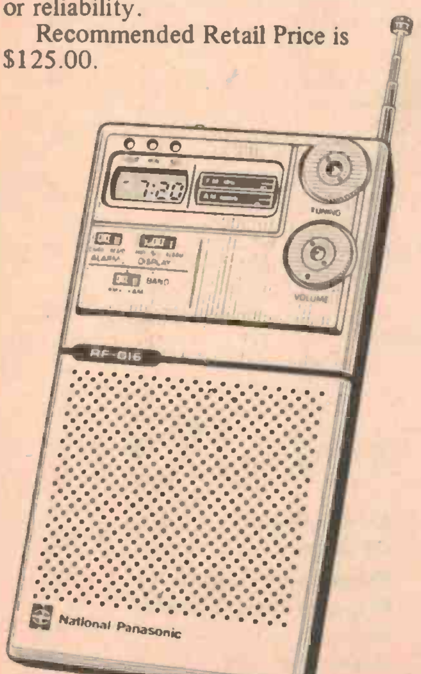
Ultrathin Radio

A new ultrathin AM/FM radio which incorporates a quartz clock and alarm will be on display at the National exhibit, Stand 57 in the Commemorative Pavilion, at the forthcoming Consumer Electronics Show to be held at the Sydney Showground, July 13-17.

Although this new unit, designated Model RF 016, is only 17.3 mm (less than ¾") thick and weighs a mere 180 g (6.4 ozs) with batteries, it contains a remarkable concentration of features.

These include a high-performance FM/AM radio receiver, an extremely accurate quartz clock with liquid crystal digital display, a light for night-time use, and a two-way alarm which either chirps or turns the radio on at a pre-selected time. This has been achieved by National's advanced technology in the miniaturisation of such components as speakers, capacitors and intermediate frequency transformers to achieve compactness and light weight without loss of performance or reliability.

Recommended Retail Price is $125.00.



New Taxi System

The Minister for Transport, the Hon. Mr. Peter Cox, has commissioned a new taxi status, identification and alarm system for Taxis Combined Services Pty Ltd., in Sydney.

The Managing Director of Taxis Combined Services, Mr. R. L. Kermode, said more than 1200 taxis would be connected to the system. The fleet is one of the world's largest fleets of radio-controlled taxis.

The new Status and Identification System, designed by Philips-TMC Radio Division in Melbourne, is the first in its field in Australia and is capable of identifying up to 10,000 mobiles. Digital techniques combined with digital transmission are used to provide high speed data communication.

The system, in addition to speeding communication between the base and the taxi fleet, will provide facilities which should result in a reduction in the number of attacks on taxi drivers. A high standard of accuracy is achieved by using rapid data transmission methods, which ensure minimum possibility of human or transcription errors.

Mr. Kermode travelled extensively overseas in 1976 looking at transport systems and communications systems before deciding on the Australia-designed Philips equipment.

"The uniqueness of the system lies in the fact that it places control in the hands of the base operator," Mr. Kermode said. "Control is essential when dealing with the fleet of more than 1200 cabs which make up Taxis Combined Services and which operates on an 8 channel radio network in peak hours.

"When the base operator sends out a call, those drivers wishing to 'bid' for the job simply press a button on a small, dash-mounted console. The first driver to register his 'bid' on the operator's console gets the job. The base operator then informs the first driver that he has the job and gives him all the relevant information of address, person's name and any other details.

"Once the driver has the message he just presses a 'roger' button to let his base know he is on his way. If he did not understand some part of the information, he presses another button marked 'repeat' and the operator repeats all the information. On the other hand, if the driver wishes to speak to the operator, perhaps to tell him that the street number he was given does not exist, he presses another button marked 'query' and the base operator then allows him to use his normal microphone for a brief period.

"This system has real advantages. Instead of using valuable air-time to 'bid' verbally for a call, with possibly several drivers calling at the same time, and even causing a 'lock-out' situation, the driver is able to press a button that will send out a very short signal (milliseconds) but still register his 'bid'. This means that the radio channel is free to accept many more calls from many more taxis. The fast response time is invaluable during peak traffic conditions and its importance in emergency situations cannot be overstressed."

The system also has a built-in alarm system that could help to reduce the number of attacks on taxi drivers and lead to the capture and conviction of more attackers.

If a driver fears he may be attacked, he activates a hidden switch which automatically turns on the taxi transmitter and sends a special 'alarm' signal. This registers on the base operator's console.

At the base station, the operator knows immediately which driver is in trouble because his taxi number is flashed up on a separate display. The operator then presses a button which allows him to tell all other taxis on the frequency to keep off the air because of the emergency.

From this point, a series of events takes place that will help the operator to locate the driver and indicate the sort of trouble he is in. But, to spell out those events would only alert any would-be attacker and defeat the security aspects of the system.

What Philips will say, however, is that the system does work, it does have the support of the taxi industry, and with quick action by the base operator and police, more taxi driver attackers will be caught – and would-be attackers will be deterred.

Laser Scalpel

A new scalpel with a transparent blade, developed at the University of Washington, uses light from an argon laser to cauterise blood vessels. The light is 'piped' to the scalpel through a fibre optic guide and emerges from the cutting edge of the blade, which is made from quartz or sapphire. As the scalpel cuts, pressure from the blade forces the blood vessels closed, and the light cauterises them.

Several advantages are claimed over the conventional electrosurgical scalpel, which cauterises with an intense RF field, including less blood loss, less damage to adjacent tissue and the absence of a ground electrode, which can cause burns.

High Accuracy DMM

Dick Smith is now stocking the Seif Digital Multitester, "an instrument which offers an unusually high degree of accuracy considering it sells for only $145", says Dick.

"We compared the Seif with five similar units selling for up to $205, and none of them could match the 0.1% accuracy yet at the same time offer 100 μV resolution, the number of ranges and the big (11 mm height) LED readouts. The closest any of them came to the Seif's DC accuracy figure was 0.25%."

Specifications of the Seif Digital Miltitester are as follows:

DC Volt Ranges:	200mV, 2V, 20V, 200V and 1000V
AC Volt Ranges:	100mV, 2V, 20V, 200V and 700V
DC Current:	200uA, 2mA, 20mA, 200mA, 2A
AC Current:	200uA, 2mA, 20mA, 200mA, 2A
Resistance:	2K, 20K, 200K, 2M, 20M Ohms
Readouts:	11 mm high LED
DC Accuracy:	± 0.1% ± 0.2% RDG. ± 1 digit
Resolution:	100uV

Price: $145.00 Catalogue No: Q-1440. Available at all Dick Smith Electronics stores.

Reversing Buzzer

An instant audible warning device to tell pedestrians, especially children, of a vehicle reversing is being marketed by Swann Electronics.

A valuable safety aid for cars, trucks, vans and buses, the buzzer can be operated also from a switch mounted on the dashboard.

Obtainable from the Swann merchandiser at automotive accessory outlets, the warning buzzer costs $6.21 plus tax.

Also available is a dashboard warning buzzer which can monitor oil pressure or water temperature, and a hazard warning light flasher.

Asynchronous Communications Element

A new Asynchronous Communications Element from National Semiconductor Corporation is claimed to incorporate many software-programmable and hardware control features that reduce system complexity and micprocessor overhead during serial data transfers.

In addition to being a UART to perform serial-to-parallel and parallel-to-serial conversions, the INS8250 provides programmable baud-rate generation, programmable serial-message formatting, status reporting, and complete modem control.

The device contains a programmable baud-rate generator that accepts any clock input from dc to 3.1 megahertz, dividing it to select baud rates from 50 to 56,000. Divisors, loaded during initialization, are stored in two 8-bit latches using a 16-bit binary format. The device has double buffers on both the transmit and receive sections to compensate for any asynchronous anomalies.

The microprocessor specifies asynchronous data format through the INS8250 line-control register. Characters may have 5, 6, 7, or 8 bits; even, odd or no-parity bits and, either 1, 1½ or 2 stop bits. The unit deletes start/stop and parity bits from the serial data stream prior to converting to parallel for the system data bus. It also adds standard asynchronous communication bits to output serial data stream. Contents of the line control register can be retrieved for inspection, eliminating the need for separate storage in system memory.

Status registers inform the CPU of line and modem conditions at any time. Data ready, transmitter register conditions, as well as overrun, parity and framing error are signalled by the line status register. The modem status register indicates various clear, set, ready and other conventional data signals from the modem.

The INS8250 has on-chip interrupt capability that permits complete flexibility in interfacing to all popular microprocessors. To reduce software overhead during data character transfers, the device prioritizes interrupts from receiver line status, receive data ready, transmitter holding-register empty, and modem status.

In 100-unit quantities, the INS8250 is priced at $8.10 each. Delivery is from stock.

16K from Rifa

Rifa recently announced details of the 16,384 bit MOS RAM manufactured by Fujitsu, one of the largest IC manufacturers in Japan. The Fujitsu MB 8116 is a full decoded, dynamic NMOs random access memory organized as 16,384 one-bit words. The design is optimized for high-speed, high performance applications such as mainframe memory, buffer memory, peripheral storage and environments where low power dissipation and compact layout is required.

Multiplexed row and column address inputs permit the MB8116 to be housed in a standard 16 pin DIP. Put-outs conform to the accepted industry standard.

Clock timing requirements are non-critical, and power supply tolerances are 10%. All inputs are TTL compatible; the output is three-state TTL.

For further information contact: Rifa Pty. Ltd., 202 Bell Street, Preston, Vic. or 23 Sloane Street, Marrickville, N.S.W.

New Heatsinks

A range of compact finger type and fan top heat sinks designed for use in computers, audio amplifiers, power supplies and calculators are available from Melbourne based company, Swann Electronics Pty. Ltd., of *P.O. Box 350, Mt. Waverley, Vic. 3149.*

fact:
you can choose your microphone to enhance your individuality.

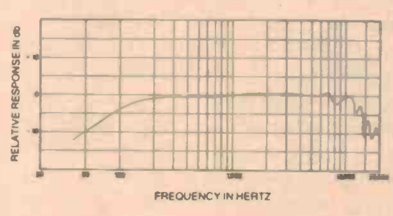
Shure makes microphones for every imaginable use.
Like musical instruments, each different type of Shure microphone has a distinctive "sound," or physical characteristic that optimizes it for particular applications, voices, or effects.
Take, for example, the Shure SM58 and SM59 microphones:

SM59

Mellow, smooth, silent...

The SM59 is a relatively new, dynamic cardioid microphone. Yet it is already widely accepted as a standard for distinguished studio productions. In fact, you'll often see it on TV . . . especially on musical shows where perfection of sound quality is a major consideration. This revolutionary cardioid microphone has an exceptionally flat frequency response and neutral sound that reproduces exactly what it hears. It's designed to give good bass response when miking at a distance. Remarkably rugged — it's built to shrug off rough handling. And, it is superb in rejecting mechanical stand noise such as floor and desk vibrations because of a unique, patented built-in shock mount. It also features a special hum-bucking coil for superior noise reduction!

Some like it essentially flat...

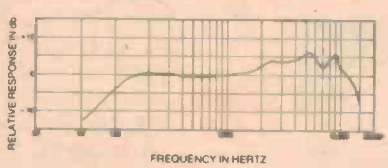


SM58

Crisp, bright "abuse proof"

Probably the most widely used on-stage, hand-held cardioid dynamic microphone. The SM58 dynamic microphone is preferred for its punch in live vocal applications . . . especially where close-up miking is important. It is THE world-standard professional stage microphone with the distinctive Shure upper mid-range presence peak for an intelligible, lively sound. World-renowned for its ability to withstand the kind of abuse that would destroy many other microphones. Designed to minimize the boominess you'd expect from close miking. Rugged, efficient spherical windscreen eliminates pops. Lightweight (15 ounces!) hand-sized. The first choice among rock, pop, R & B, country, gospel, and jazz vocalists.

...some like a "presence" peak.



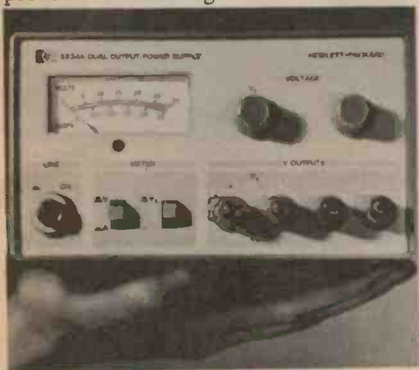
professional microphones...by SHURE®

AE130/FP

AUDIO ENGINEERS P/L	AUDIO ENGINEERS (Vic.)	AUDIO ENGINEERS (Qld.)	ATHOL M. HILL P/L
342 Kent Street. SYDNEY 2000 N.S.W	2A Hill Street. THORNBURY 3071 Vic	51A Castlemaine Street. MILTON 4064 Qld	33 Wittenoom Street. EAST PERTH 6000 W.A.

HP Lab Supply

Intended for engineers who design and test breadboards and prototypes, a new low-cost, dual-output bench power supply from Hewlett-Packard offers two independently adjustable and isolated power sources in one compact unit. Both of the dc power sources are of the constant voltage/current limit type with each output voltage being adjustable continuously over a 0 to 25V range. The maximum current available per output is 0.2A and is limited automatically to prevent overloading.



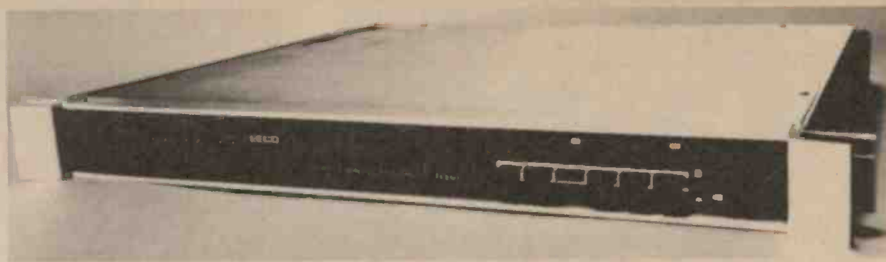
The HP 6234A offers considerable flexibility to the user with output voltages that can be arranged to provide identical or different voltages in any polarity combination with respect to 0 or other common positive or negative voltage points. The outputs can also be connected in series to provide up to 50V at 0.2A. Both sources are fully isolated to permit either of the output terminals to be grounded.

With dimensions of only 90 mm high, 155 mm wide and 190 mm deep (3 5/8" x 6 1/8" x 7 1/2"), the HP 6234A supply takes up a minimum amount of bench space. Its weight is 2.3 kg (5 lbs.). The unit can be powered from a 115V or an optional 230V, 47-63Hz ac input.

The Hewlett-Packard Model 6234A dual-output power supply is priced at $185.00. Deliveries are eight weeks from date of order. For further information contact *Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St. Blackburn, Vic. 3130.*

EMR-clean Room

A theory that electromagnetic radiation may in some way affect the health and recovery of patients is being tested at the General Hospital of Vienna, Austria, where Siemens have built 12 shielded rooms. The spectrum from 1 Hz to 10 GHz is blocked by steel walls and windows covered by honeycomb shields. Over 30 lines permit connection to instrumentation outside, allowing measurements down to 1 μV.



Edit Code Generator

Ampex Australia Pty. Ltd. has announced the introduction of the EECO MTG 550 Series master time code generator which generates standard SMPTE/EBU Edit Code formats used for electronic indexing of video and audio tapes.

The generator incorporates the LSI time code generator chip which contains all the basic logic necessary for presetting the display time; inserting user bits, locking to video or other reference sources; external selection of 25 or 30 frames-per-second frame rates; and selection of drop or non-drop frame code.

Standard features of the MTG 550 include the ability to slave the generator to an external source of serial time code for add-on recording and the ability to derive proper reference sync from NTSC, PAL and SECAM video standards with an option to generate 24-frame code for the film industry. Encoding the auxiliary binary word from four different sources allows the user to insert 32 bits of information into the serial Edit Code output for additional scene identification.

Special status/alarm signals alert the user to loss of time code, loss of video/sync as a reference, loss of phase lock and of momentary power loss. Hexadecimal display is employed to allow selection of either Binary Word or Edit Code for display.

Further information is available from *Ampex Australia Pty Ltd, 4 Carlotta Street, Artarmon, N.S.W. 2064,* who are the distributors of EECO products in Australia.

Metal Glaze Resistors

Soanar Electronics Pty. Ltd. now include ¼, ½ and 1 Watt Metal Glaze resistors in their comprehensive range of resistors and resistive components. Designated GLP and GL1, these thick Metal Glaze Resistors are Australian made and designed to provide the trade with economically priced 5% resistors of unusually small size.

The GLP resistor in particular, is dual rated for ¼ or ½ Watt operation and exceeds the requirements of British Standards Specifications BSE 9111-N002 (Style FX) even at the ½ Watt (70°C ambient) rating. It measures a mere 5.5 mm x 2 mm in size and occupies less board space than most ¼ Watt carbon types.

GLP and GL1 Metal Glaze Resistors are available at Soanar Branches and Agents throughout Australia, and may be purchased as individual or bandoliered units. The resistance range covers 2.2 ohms to 1 Meg ohm.

Further information may be obtained from: *Soanar Electronics Pty. Ltd., 30 Lexton Road, Box Hill, Vic. 3128.*

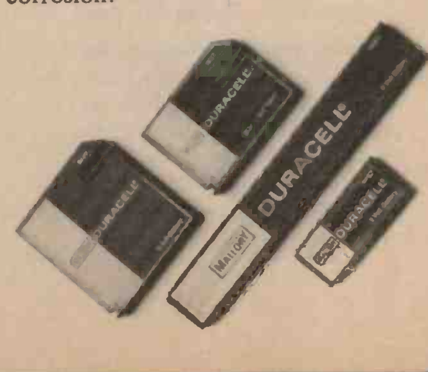
New Design Duracells

The release in Australia of a completely new design of the well known Duracell long life alkaline dry battery has been announced by the manufacturers and distributors, *Mallory Batteries (Australasia) Pty. Ltd., of North Ryde, New South Wales.*

Known as the 'FLAT-PAK', the alkaline battery is of the flat cartridge type and is presently available in several sizes and voltages, including the type 7K67, a 6-volt cartridge as used in Kodak instant picture cameras, and the type 5K65, a 9-volt being used in some models of calculators.

The new design of cartridge battery has been developed to assist designers of battery operated products to improve appearance and performance of their products, as well as simplify design and reduce assembly costs.

The consumer also enjoys benefits with the use of the 'FLAT-PAK' because (a) the design makes it virtually impossible to insert a battery incorrectly, (b) the internal welding of intercell connections ensure positive contacts, and (c) the ultrasonically sealed plastic battery casing reduces risks of possible equipment damage from leakage or corrosion.



Power Engineering Scope

The BWD 880 Powerscope, produced by BWD Electronics Pty. Ltd., is claimed to be the first instrument of its kind dedicated to measurement of voltage, current, phase angles and time in the field of power engineering. World patent rights have been lodged for this innovative instrument, which should have an immediate appeal to power engineers needing a safe means of measuring high voltages and displaying them for visual evaluation.

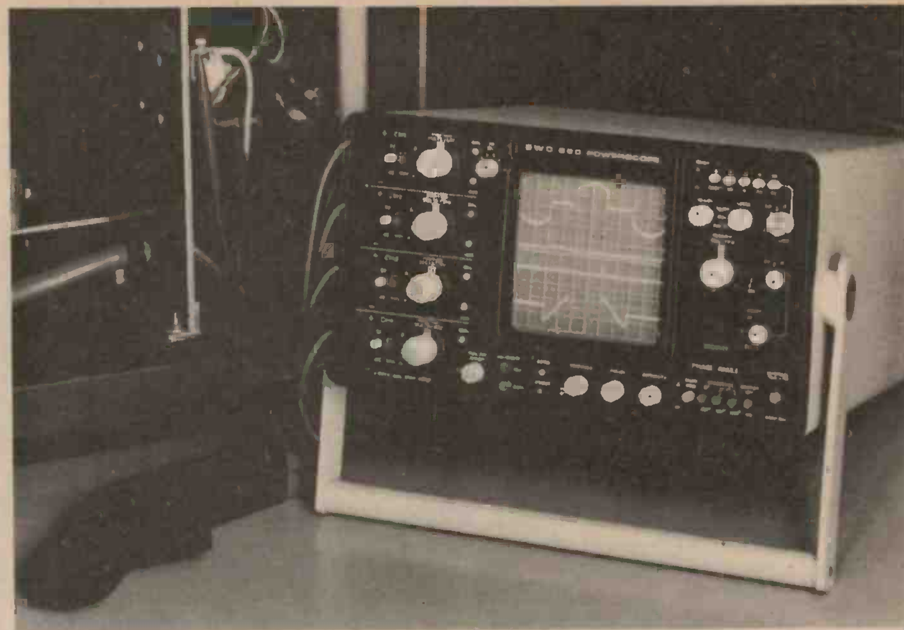
Industries, utilities and educational establishments using thyristors, triacs, ignitrons, magnetic amplifiers, etc. to control 1, 2 or 3 phase power for motors, lights, heaters or welders can employ Powerscope for design, monitoring, field service and teaching.

Operator safety is provided by a fully insulated panel, controls and probes, fitted with shrouded high voltage connectors and closed conformity to IEC 348 saftey requriements.

The high CMR of each amplifier enbles signals down to 100mV p-p to be measured across components operating in 600V RMS 3 phase or 350V RMS single phase supplies.

Phase measurement is by a 1° wide intensified marker pulse with digital readout, selectable by an up/down counter from 0° to 359°. Zero reference is also selectable in 60° steps from 0° to 300°. Phase circuit operates automatically over the range 25Hz to 2KHz and may also be used to provide digital trigger delay in 1° steps for the time base.

Further details can be obtained from: *BWD Electronics Pty. Ltd., Miles Street, Mulgrave, Victoria, 3170.*



New DMM

Parameters has announced the new B & K-Precision Model 2810 which has a combination of features uncommon in a portable digital VOM. Basic DC accuracy is 0.5% with a 3½-digit display. Auto zeroing on all but the 10 ohm range minimizes set-up time, while the 100% overranging capability reduces the need for frequent range changes.

A highly valuable feature is the 10 ohm range. This range, with its .01 ohm resolution, is ideal for locating a shorted winding in a transformer, motor or coil. For high accuracy, a front panel 10 ohm ZERO control allows the user to zero-out the minute amount of test lead resistance.

The high/low power ohms switch is operated independently from the range switch allowing high/low selection on four ranges. The low power ohms position permits resistance measurements in solid-state circuitry without biasing semiconductor junctions.

Unlike many electronic voltmeters, the 2810 can also be used in RF energy fields. This includes use near business band, CB and amateur radio transmitters. When working with RF circuitry, the optional PR-21 probe is also helpful.

Like other B & K-Precision instruments the 2810 is well protected against overloads on all ranges. The ohms circuitry is protected against momentary overloads up to 1000 volts, DC or AC peak. Continuous ohms range protection is + 100 V and – 450 VDC or 300 VAC. Current ranges receive the double protection of diodes and a fuse.

For further information contact Bruce McCarthy, *Parameters Pty. Ltd., 68 Alexander Street, Crows Nest, NSW 2065.*

ETI/Unitrex Contest

In the May issue, we posed a coin-tossing problem, and asked whether young Simon was wise to approve of a modified scheme with three coins. Needless to say, Simon ended up checking the contest entry envelopes one more time. You see, there are eight possible combinations in which the three coins could land, and four of them are winning combinations for Simon and four for me. So the situation was not better for Simon, it stayed the same, in fact, so he wasn't entirely wise. Garry Dunn, of Heathcote, NSW, was wise, and won the Unitrex calculator for his correct answer.

We've had a few easy contests recently, so here's a real toughie: Using the digit 4 four times in an arthmetic expression, with the standard mathematical operators +, -, x, /, and also parentheses, y^x and !, it is possible to make equations with several different values. For example (4+4)/(4+4)=1, 4/4+4/4=2, (4+4+4)/4=3 and a more complex example would be 4^4-(4x4!)=160.

Now you've got the idea, we'd like you to find equations for as many numbers as possible between 70 and 75 inclusive. If it's any consolation, we've only just started working these out ourselves, but have been assured that it can be done!

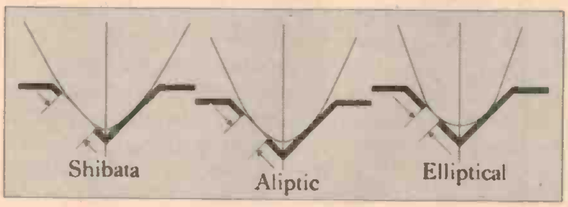
Seal an empty envelope, write your answer on the back of it and send it to: Unitrex Calaculator Contest (July), ETI Magazine, 15 Boundary Street, Rushcutters Bay, NSW 2011. The closing date is Friday, 18 August.

A major independent research company proved that the ADC XLM MKII incurred no perceivable record wear over the life of your records!
Since then ADC's massive research programme has created a new state-of-the art, top of the line model–the ZLM Aliptic–designed for ultimate stereo performance combined with the concept of zero record wear.

Greatly reduced tip mass
The ZLM has a tiny nude diamond with a ·004" x ·008" rectangular shank.
This achieves more lateral strength than the fashionable ·006" square shank, plus a 10% reduction in mass.
The diamond is mounted on a new tapered stylus, which again reduces mass.
In fact, the ZLM has only half the tip mass of the famous ADC XLM MkII.

Less mass by patent
The patented ADC Induced Magnet system, where the magnet is suspended over the moving stylus arm instead of being attached to it, inherently means less mass for the record groove to move. This, coupled with major innovations in the pivot block stylus suspension (which have solved deficiencies in the old system), has resulted in greatly improved frequency response characteristics.

New low-wear ALIPTIC shape
The ZLM has a new tip shape that combines the advantages of the elliptical and Shibata shapes, while eliminating their disadvantages.



It is basically elliptical (·0003" x ·0007"), but its bottom radius has been modified to extend the vertical bearing surface on the groove wall by 100%.
Large enough to greatly reduce record wear, while still small enough to prevent dirt particles being reproduced.
This new shape is called ALIPTIC.™

The best polish available
We decided it was worth the extra cost to get the ultimate polish for the ZLM.
The method involves a cam action to shape and polish evenly while forming the elliptical surfaces simultaneously with the other radii. This Pathe-Marconi method is expensive, but the result makes another important contribution towards reducing record wear.

Spatial sound
You'll notice a distinct difference in sound quality.
Words such as 'open,' 'spatial,' 'uncoloured' and 'true' spring to mind. Individual instruments are easily identified, and there's no hint of listening fatigue.
That's strictly for the competition with its peakier response.

The new ZLM Aliptic
The culmination of all ADC's research has resulted in the new ZLM Aliptic.
Its specifications below are some of the most impressive around, and with each cartridge you receive an individual, signed, frequency response testimonial.
Certain ZLM's fall within a range of ±½db 10Hz to 20kHz and ±1dB out to 26kHz.
These rare cartridges are called ZLM Select and are only available on special order.

The best cartridge we've ever made
The ZLM is without doubt the best cartridge we've ever made, but it's well worth taking a closer look at the new ADC XLM III which incorporates all of the reduced mass accomplishments of the ZLM, but with a tiny elliptical diamond. This also includes an individual specification.
Complementing the range, we have the new four-cartridge QLM Mk III series, incorporating our new design criteria and exciting innovations like the Diasa (diamond + sapphire) elliptical tip.

ZLM Aliptic specifications

Diamond tip	Nude Aliptic
Tracking force	½ to 1¼ gram
Frequency response	10Hz to 20kHz ±1dB 20kHz to 26kHz ±1½dB
Output	1.0mV per cm/sec
Output balance	1dB max. diff.
Channel separation	30dB at 1kHz/20dB at 10kHz
Inductance	580mH
Resistance	820 Ohms
Load resistance	47,000 Ohms
Load capacitance	275pF
Cartridge weight	5.75 grams
Accessories	Stylus brush, screwdriver, all mounting hardware and signed frequency response curve.

Please write for our illustrated brochure.

The new ZLM Aliptic™ cartridge. The difference between playing your records and wearing your records.

ADC

Audio Dynamics Corporation,
A Division of BSR (A'asia) Pty. Ltd., Anne Street, St. Mary's, NSW 2760.

A SOUND SO PURE

GOLDRING G 900 SUPER E

"Micro Mass" Moving Magnet Cartridge

The key to the outstanding performance of the G 900 SE lies in its extraordinary low stylus tip mass of only 0.32 mg — considerably less than most of its competitors. The following are comments quoted from various international reviews which, we believe, speak for themselves.

"The Goldring G 900 SE offers performance comparable to the best moving coils, and is superior to all moving magnets. Its mid range and high end are remarkably clear and low in distortion. Imaging and depth reproduction are also outstanding.

The Goldring is an outstanding value, offering performance comparable to the best cartridge systems costing 2 and 3 times as much.

("Sound Advice", the well respected American magazine for Hi-Fi enthusiasts)

"Its incredibly clear with a strong but fairly liquid treble quality. This helps to throw up much more detail; but strong treble signals that sound so bad, although reproduced with brutal honesty, sounded perfectly normal and acceptable through sheer naturalness. The bass end was very firm, in good balance tonally and at times showed its true ability by turning out a real low that was frightening in realism.

Remembering that everybody has personal preferences in sound, I would class the G 900 SE as one of the very best cartridges available. Personally, I believe it is THE best cartridge that is widely available, especially considering the retail price."

(Philip Mount in his column "Test Bench" published in "Gramophone" U.K.).

"Goldring have good reason to be proud of their achievements, for the G 900 SE displays characteristics that place it in the forefront of high-grade cartridges. It yields a firm, clear and fairly explicit sound with excellent stereo imagery. Its freedom from hard tonal quality or undue forwardness in the upper range offers an interesting contrast with some prestigious models."

(Clement Brown in the British publication "On Test".

High praise indeed! But check for yourself.

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GFC Hadcock pickup arm

G.F.C. Hadcock is the manufacturer of an advanced unipivot pickup arm, the GH228 super. The arm, we understand, was originally designed with the Decca cartridges in mind, although this does not preclude its use with other cartridges, especially low-compliance moving coil models.

The Rev. George Hadcock has a fine background of audio experience including service with the BBC and his grasp of the problems of playing records is evident from the design of the 228 arm. It is a very rigid device, with a surprisingly secure unipivot based on an upward pointing shaft with a conical tip, and an inverted bearing cup fitted with a ball-race. Whilst this regime, also featured in the KMAL Mk. III mercury contact arm, is potentially less free of friction than the jewelled bearing system of the Formula 4 by JH, it is rather more rigid, minimising the tendency toward resonances in the pickup system. Complementing this, a substantial main tube, made from hard aluminium alloy, and a lightweight but very rigid metal headshell are employed.

The counterweight is fitted to a tube of similar diameter projecting from the rear of the bearing housing support hub. A decoupling bush is used to secure this tube, and the counterweight itself, which is mounted eccentrically, can be moved fore and aft using a set-screw. A further resilient bush is also used in the counterweight to provide a tight fit, so that it stays put when rotated to give correct lateral balance.

As with all unipivots, some form of pivot damping is needed to prevent wobbling when a record is being played. The usual viscous damping system is used, the bearing cup skirt extending into a reservoir filled with fluid about the bearing shaft. The damping rate can be adjusted by lowering the shaft so that the skirt can penetrate deeper into the fluid; in addition, the bearing cup can be lowered to prevent fouling of the main hub on the pedestal.

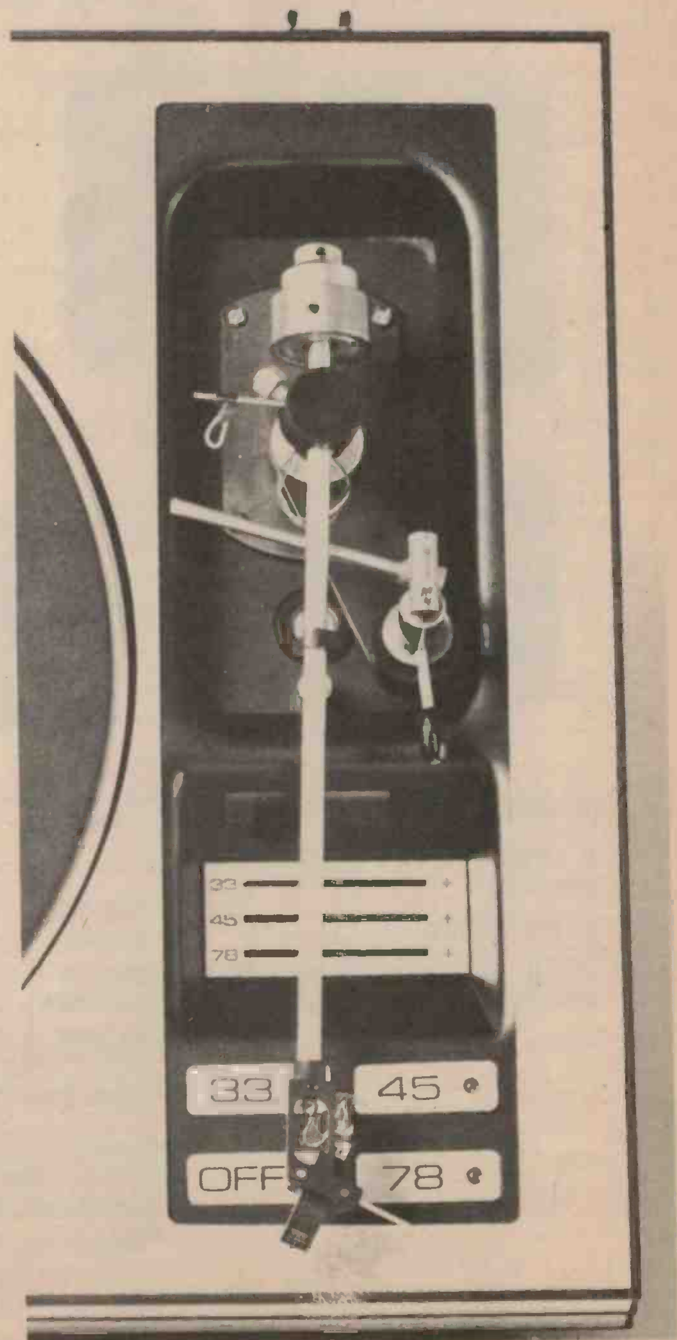
Routing of lead-out wiring is always a problem with unipivots. In the Hadcock, the four wires emerge from a small hole in the bottom of the main hub, and are looped round to disappear into a small hole in the pedestal. The loop is unshielded but could hardly give rise to hum and gives negligible resistance to arm movement in either plane.

The pedestal is a tight fit into a mounting base, which is itself threaded and fitted with an enormous brass securing nut, enabling the arm to be bolted very securely to the motor board.

Installation

Hadcock supplies an adaptor for use with turntables previously fitted with SME arms, and by good fortune we had at our disposal a Linn-Sondek board already drilled for an SME. Assuming the original SME cut-out to be correctly positioned, the arm is accurately lined up by use of this adaptor. Installation without the adaptor poses no problems, however, although a template would be useful. Nevertheless it is a simple job to make one up.

One of the most appealing features of the arm is its ability to be fully adjusted. The headshell, particularly, can be lined up without difficulty using the top of the main hub as a sighting reference. Allen-key grubscrews are used throughout and can be tightened very easily to produce rigid metal/metal interfaces.



SOUND

Included with our sample was the Unilift Mk.III, fitted to a spacer strut which was secured to the pedestal during installation. The Unilift appears somewhat complex at first sight with its double shaft/link/lifter bar system. This gives a very flexible range of adjustment however, and there is also an adjustment for speed of descent. The operating lever swings laterally around the device rather than pivoting vertically as is more common. We found the Unilift was easier to use than most lifters because of this.

A generous quantity of damping fluid, rather less viscous than the sort supplied by SME, JH, Decca and KMAL, was supplied ready for use in a disposable hypodermic syringe, making the task of filling the fluid reservoir easy and accurate. The syringe also makes removal of excess fluid a simple operation (SME suggests you spoon their fluid out with a matchstick!).

A consequence of the particular design of the arm is that the entire carrying arm section can be lifted from the pivot, enabling cartridges to be mounted and changed without difficulty. Although no plug-in system is provided, and no cartridge position adjustment relative to the headshell is allowed for, spare headshells can be supplied and these are easily fitted. Fine adjustment can be carried out by moving the headshell along the arm tube.

The counterweight is made in two sections – the main weight with its captive set screw and an outer supplementary weight. Three of these outer weights are provided, each of different size allowing a very wide range of cartridge weights to be accommodated whilst maintaining the main arm/cartridge resonance at an optimum frequency.

We were very impressed at the ease of installation and setting up the arm, although the bias adjustment using a thread-and-weight system was fiddly and could be improved. The arm looked functional rather than beautiful although the precision of fit of each part was exemplary.

Performance

Tests using Decca 6E, Dynavector 20B and Supex 900 Super cartridges revealed the arm was perfectly at home with lightweight and heavyweight low-compliance cartridges. The Decca tracked better in this arm than in any we've previously encountered, reducing the high frequency and stereo confusion observed in other situations. Bass sounded tighter and even more detailed than ever, and the definitive midrange performance for which this cartridge is renowned was further enhanced.

The Dynavector seemed less bass-shy and far smoother in the treble region than usual although we still feel the Dynavector arm (at a far greater cost) serves it best. Even so, the Hadcock gave an exemplary performance with the 20B and the combination can be recommended.

Likewise with the Supex, which is normally partnered with the Grace 707, suitably modified by decoupling and augmenting the mass of the counterweight. The high-frequency 'featheriness' of the Grace/Supex was not evident using the Hadcock, and while the sound was, perhaps, a trifle less 'spacious' it was also more detailed with improved dynamic contrasts.

This was also true of the other cartridges, which provided better transient performance than usual (although the Dynavector arm probably gives better transients than the Hadcock with the 20B).

Overall, we found the Decca/Hadcock combination by far the most dynamic, giving a very fine illusion of musical sound with superbly defined perspective and excellent side-to-side stability.

Conclusion

Like so many British products, the Hadcock arm looks rather untidy and its standard of finish simply doesn't compare with the best of Oriental products. The signal cable of our sample was poor and it was terminated in equally unimpressive RCA plugs. The cartridge connecting tags were too big and had to be replaced to fit the Supex. These criticisms aside, the arm was well engineered and certainly provided excellent conditions for the cartridges tested. A brief session with the Garrott P77 confirmed its suitability for medium/high compliance cartridges. At a price (complete with Unilift) of around $165 rrp, the GH228 Super is highly recommended especially if you're a Decca freak.

Technics SB10000

MANUFACTURERS' and technicians' investigations into phase of crossovers and drive unit mounting as a dual entity were prompted by jet propulsion engineer Richard Heyser.

Heyser started the formulation of phase coherence in a 1967 J.A.E.S. paper, "Accoustical Measurements by Time Delay Spectrometry." This was followed by "Loudspeaker Phase Characteristics and Time Delay Distortion: Part 1," of 1969.

It appears that similar investigations were underway in non-English speaking countries. In Japan, the Matsushita

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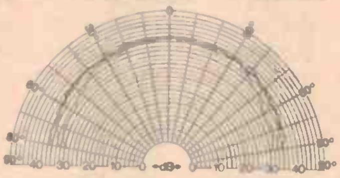

Frequency Dispersion of the L110
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JBL's new L110 loudspeaker is part of the same research and development breakthrough that created our no-tradeoff, top-of-the-line L212 system.

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Now look at the L110. The most acoustically transparent grille JBL has ever created is visually transparent, too. You can see right through to the satin black components inside.

If you'd like a lot more technical information on the L110, write us and we'll send you an engineering staff report. Nothing fancy. Except the specifications.

But you really should come listen to the L110. And ask for it by its first name: JBL. You'll be getting the same craftsmanship, the same components, the same sound heard in the very top recording studios in the world.

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JBL
GET IT ALL.

Electric Company's Technics division evolved a linear phase three-way speaker system that was first shown in 1975, the SB7000.

Demonstration

The Matsushita Hall of Science contains dozens of their patented components and, for the audio enthusiast, a most convincing display of loudspeaker phase is demonstrated. A two-way system, the SB 6000, is connected to an oscillator and dual beam oscilloscope. A microphone reads the speaker output which is compared to the original. The high range loudspeaker is motor driven on a sled .... backwards and forwards .... while a square wave signal is processed through the system. It is easier on the ears and eyes when the tweeter is correctly phased and both speakers unite in presenting a recognisable 1 kHz square wave.

With ideal driver matching and a phase coherent crossover network combined with ideal speaker driver placement all waveform components undergo an equal number of reflections and arrive at the same place, or plane, simultaneously.

The latest Technics linear phase speaker system is the giant SB 10000. This three-way system employs a 460 mm bass driver in a 226 litre vented cabinet; midrange and treble are horn loaded.

Each speaker system weighs in at 140 kg net. This is 22 stones in the old measure and about the weight of a junior sumo wrestler.

An important part of the linear phase requirement is wide range speaker units. The 15 Hz free air resonance of the bass driver naturally assists with low frequency response in such a large cabinet but the high range output seems to extend to around 1500 Hz although crossover frequency is 700 Hz.

The midrange horn has a reasonably flat response from about 450 Hz to nearly 8,500 Hz but is used from 700 Hz to 6,500 Hz.

A boron vacuum deposited high frequency diaphragm drives the treble horn through a range of about 1,500 Hz to 20,000 Hz with the lower frequency crossover point of 6,500 Hz.

No doubt the Technics crossover design follows earlier driver tailoring such as a tweeter resonance cancellation circuit and rising impedance controls.

Performance

The power handling of the SB 10000 is claimed to be 200 watts continuous and 300 watts peak. The dynamic range using much lower powered amplification such as Radford 50 watt amplifiers was sufficient to elicit natural level fortes in a large living room.

These unique speakers were never strained in their presentation and appeared to never "squash" the dynamic range while reproducing such wide range discs as the Beethoven Appassionata direct cut piano recording or the Philips Rite of Spring with Colin Davis.

The output sound pressure level is quoted as 95 dB for one watt input measured at one metre.

The Technics speaker factory assembles and tests three of these speaker boxes every day. The factory studiously checks all speaker systems from the lowliest to this giant in an 'on-line' anechoic chamber with automated B & K oscillator and chart level recorder. The author has visited the room where these charts are preserved and obtained copies of charts for Technics systems he has heard in Australia.

The complete story of this company's loudspeaker system manufacture is most complex. This particular SB 10000 occupies some half dozen employees for a complete day; they work at nothing else. The internal bracing and framework is of knot-free dense pine about 75 mm by 100 mm while the cabinet itself is 44 mm thickness high density chipboard. The curved front and radiussed matching front verticals are made right alongside the complete assembly section. All sawdust is immediately extracted by suction piping.

This speaker system has a similar crossover design to previous Technics linear phase systems but also incorporates a set of external binding posts giving access to the individual drivers. These posts are situated within the cabinet top at the rear and underneath the removeable cover plate. Cabling ducts are adjacent to each separate input and against the built-in crossover, or normal, input.

These are very handy cable holes and make for a neat appearance. The cover has to be seen to be believed as tremendous attention to design has been lavished on an otherwise unseen item.

The terminal posts are sturdy two part metal items that allow light or heavy gauge wiring. Knotting the cables together and fixing to the binding posts ensures positive connection.

Impedance is quoted as six ohms with crossover frequencies of 700 Hz to 6,500 Hz. Separate tri-amplification crossover frequencies are suggested between 600 and 1,000 Hz for low to mid; and 4,000 Hz to 8,000 Hz for the mid to high frequencies, all at a minimum of 12 dB/octave with an 8Ω impedance for each driver.

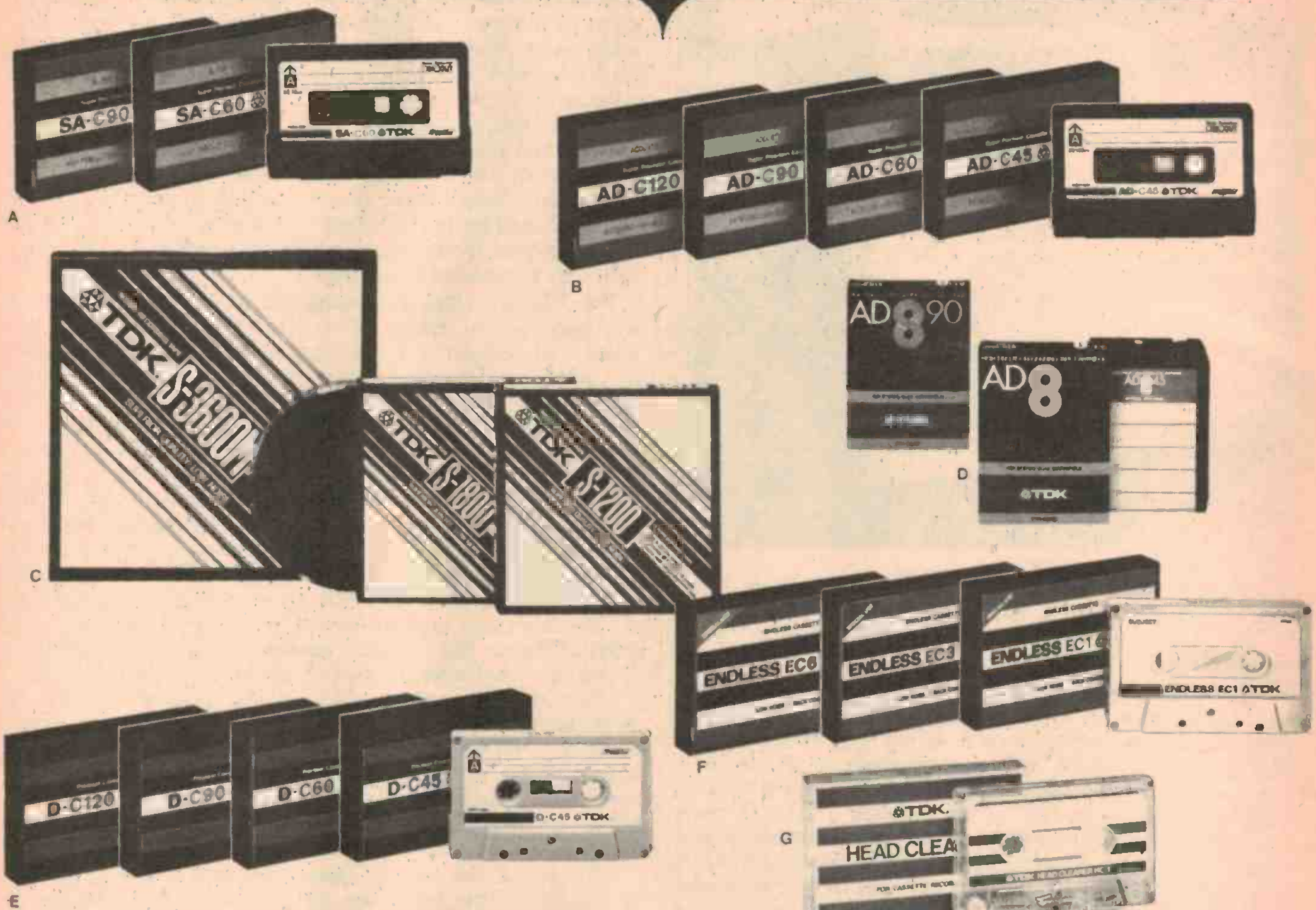
Acid Test

The SB 10000's were tried in a known difficult position along a ten metre wall fitted with built-in shelves. They were spaced 2.75 metres between centres and some 4.2 metres was the average listening distance. The treble horn was centred 1150 mm above floor level and presented a good relationship between apparent height and recorded perspective on most modern orchestral recordings.

With the cabinets toed-in at about 30° this left about three metres of clear space before wall surfaces caused late reflection.

This position did not give any apparent degree of bass boost. This was later confirmed through tests with pink noise with the cabinets fractionally moved (they are very heavy).

Wait till you hear what you have been missing



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B • AD Acoustic Dynamic cassettes. Higher maximum output and lower noise levels for dynamic range. Use on any cassette recorder without need for special bias/EQ settings. Cassette mechanism same premium quality as S.A.

C • S Series Reel-to-reel. High signal-to-noise ratio, broad dynamic range across the entire wide frequency response spectrum.

D • D Dynamic cassettes. Broad dynamic range for good "real-life" sound. High signal-to-noise ratio low harmonic distortion and noise levels assures bright, warm and mellow sound reproduction on all recorders with "Normal" bias settings.

E • AD 8 Track cartridge. Extended high-range performance. Excellent signal-to-noise ratio and broad dynamic range. Precision molded, jam-proof mechanism with mirror smooth coating prevents shedding and oxide rub-off, reduces headwear.

F • EC Endless Loop cassettes. Provides continuous-run repeat-message operation for sales displays, telephone answering, background music, point of purchase advertising. For use on most conventional cassette players and recorders.

G • HC–I Head cleaner. Recommended for periodic use in all cassette recorders to clean and keep the recording head in good condition thus preventing serious loss of high frequency response and assure proper tape to head interface.

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STUDIO A

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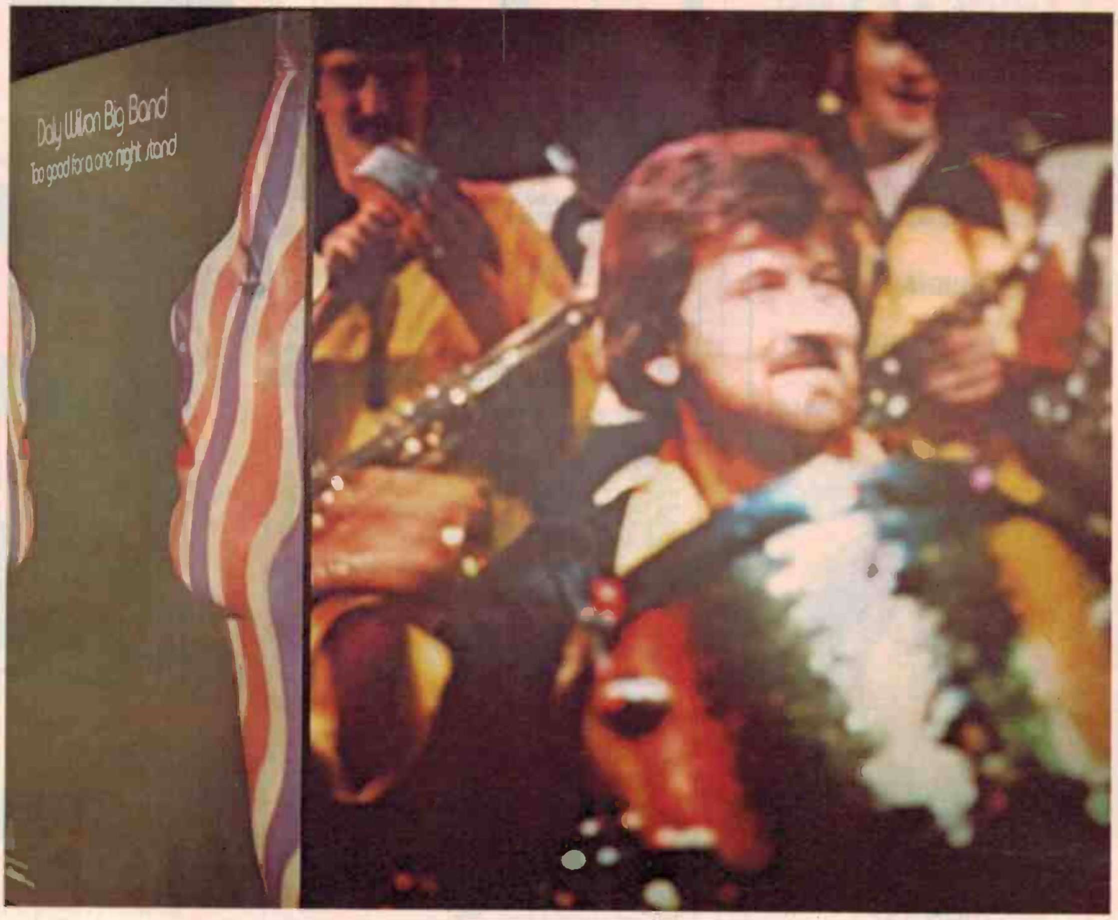

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The Durufle Requiem on CBS 235881 side two is a good test of low soft bass (quite apart from the beauty of the music). With the SB 10000 system at extremely low volume the bass speakers give a most thrilling account of held organ notes. Such ease of bass speech, apparently in good balance with higher output levels, indicates linear output with input. This is not often accomplished in a bass speaker.

This quality bass driver, a big cabinet and perhaps a knowledge of the pioneering work of Thiele and Small have produced a welcome change to well defined deep bass.

The midrange and high frequency horns have once or twice sounded 'horny'. The initial occasion was when demonstrating the speakers transient response with Maxwell Davies' "L'homme arme" on l'Oiseau-Lyre DSLO-2. Vanessa Redgrave actually used a megaphone in this section of the disc and for a few sides following this playing occasional horniness seemed to appear.

Midrange and high frequency controls are behind the front panel and were preferred slightly reduced from the marked 'normal' position.

Although furniture removalists delivered the units, they were easily slid on carpets to another much larger room where there was about three metres of clear space behind each cabinet. With a similar toe-in, half a metre to the side walls and a centres distance of 3.4 metres, the speakers were given a more realistic listening distance of 5.1 metres which is more in keeping with their size.

However, the three open archways against which the speakers were placed did not assist with forward projection. In fact, it was almost as if the units were deliberately misplaced to cause complete acoustic imbalance.

This listening distance gave an almost straight ahead perspective which was not unpleasing with loud piano solos but the source could have been higher on orchestral music. Personal preferences and live music experiences in the normal concert and opera halls are always at odds with manufacturers' presentations.

Again, the bass performance was unique for a commercial loudspeaker. The upper range became noticeably more coherent (perhaps due to the increased listening distance blending the bass-mid-treble driver spacing). Now, Indian drums, the tabla, originated in line with other instruments whereas, at a closer listening distance, they appeared to occasionally run from top to bottom of the speaker array.

Apart from the truly staggering size, appearance, weight, and, of course, the anticipated extreme five figure cost, the question of the value of linear phase applies.

Personal preferences of apparent source height could definitely favour available linear phase systems if the listening seats are not higher than about 400 mm and situated not more than about three metres from the speakers.

In any event, linear phase designed speaker systems offer the user a virtually tailored pair of sound sources. When correctly placed such 'matched' pairs offer the music lover equal amplitude outputs at all frequencies resulting in solid imaging.

Whether these particular Technics SB 10000 speakers will appear on the Australian market is now unknown. However, they will be on view at the 1978 Consumer Electronics Show. It is doubtful if they will be powered as their high efficiency could cause problems through inadvertant selection after less efficient speakers have been used.

PLC 590—Pioneer

Latest Pioneer Turntable

The new PLC-590 is Pioneer's first venture into an "armless' Quartz controlled, direct drive turntable which can meet the demands of the studio professional and advanced audiophile alike, and is the first Pioneer turntable which will accept most precision tone arms by means of a universal-type mounting panel to complete the custom-built component.

The PLC-590's drive system is based on a Hall element, high-torque brushless DC servo motor which reaches true speed within ½ rotation. To maintain rotational accuracy, a quartz crystal element is employed in the reference oscillator together with a PLL circuit.

Pitch Indicator

When the Quartz Lock Control is switched off, one may adjust the speed by ±6% and see a direct readout on the illuminated pitch indicator. The adjustment range represents approximately a half-tone interval, enough to "tune" your records with your piano or other musical instruments.

The PLC-590's controls also include a Quick Stop button, which when pushed reverses the polarity of the motor, applying torque in the opposite direction, and bringing the platter to a quick and sure stop. This same circuit comes into use when changing speeds, say from 45 RPM to 33 1/3 RPM, and provides a "quick down" effect not available on ordinary direct-drives.

Specifications on wow and flutter (no more than 0.25% WRMS) and signal-to-noise ratio (75dB) reach and exceed many professional requirements.

In comparison with other Pioneer units, the PLC-590 is rather conservative in appearance; the rrp of $699.00 seems to be spent on the technology and not trimming.

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SOUND BRIEFS

Hi-Fi & Music

Most of our readers will know that our sister publication (previously) Hi-Fi Review recently changed its title to Hi-Fi & Music: its content being expanded to take in more music material.

The change has apparently been a great success. The July issue is extra-big as it contains the official Consumer Electronics Show catalogue. Also included are test reports on – Technics RS-1500US tape deck; Kenwood L-07C amps; B & W DM7 speakers; JVC's SM3 micro loudspeakers; Shure V15/IV cartridge. There's also a totally fascinating feature on record and tape production plus a special feature for opera lovers on the making of 'Norma'. The issue is on sale until the end of July. If you are in to hi-fi and/or music don't miss this special issue.

Sansui – New Distributor

A new Melbourne-based company valled Vanfi has been formed to take over marketing and servicing of all Sansui products.

The company is headed by Clarrie Pearce – who has been associated with Sansui for over 12 years. He is backed up by Geoff Brown in Melbourne and Don Oates in Sydney.

There's a huge range of new Sansui products some of which will be seen at the Sydney CES this month.

Chrome Dioxide Super

Many tape manufacturers claim that the compact cassette system first achieved hi-fi quality with the introduction of chrome dioxide.

Then followed cobalt-doped ferric-oxide cassette tapes with a good output in the lower frequency range but a lower output in the higher frequency range. Anti-chrome campaigns started claiming increased headwear with chromium dioxide compounds. These claims had to be withdrawn, as tests proved that headwear with chrome tapes was often less than experienced with ferric oxides.

Further proof of chrome's characteristics is the video technique, where chrome tapes are replacing cobalt-doped tapes because they no longer meet the high requirements of colour-recording today.

BASF have now introduced a "Chrome Dioxide Super" tape. With this tape the high level control in the area between 10,000 and 20,000 Hz is now up to 6 dB above the values of the "normal" chrome dioxide. Low level control is improved by approximately 2 dB and noise reduced by approximately 1.5 dB.

Manufacturers claim that the tapes surpass the dynamic of a studio tape with a speed of 38 cm/s in the low ranges.

One-sixth Octave Analyser

White Instruments, manufacturers of audio filters, equalisers and real time analysers have announced a new range of active equalisers.

Features include one-sixth octave resolution from 40 Hz through 894 Hz and one-third octave resolution from 1000 Hz through 15 kHz. The adjustment range is +/- 10 dB using Mil-spec rotary controls. Optional plug-in low-level crossover networks facilitate either bi-amp or tri-amp outputs to the power amplifiers.

The company also offers one-sixth octave real time analysers to be used in conjunction with the new one-sixth octave equalisers.

For further information contact Harman Australia Pty Ltd, PO Box 6, Brookvale, NSW 2100. Tel: 939-2922.

Record Playing Revolution

A totally new record playing system in which **digitally recorded discs are played back via a diode laser** is under development by Philips.

The technique is basically similar to that used in Philips' about-to-be-released video-disc system but modified specifically for audio.

The 'Compact Discs' resemble the earliest 78s in that **only one side is encoded**. Nevertheless the 114 mm discs carry **one hour's stereo playing time**. As a laser is used to pick the information off the disc there is no need for physical contact between disc and 'styli' – this allows the disc to be coated with a protective film. The discs will therefore withstand very rough handling without sound degradation.

Philips' new system is scheduled to go **on sale in the early 1980s** – price is obviously not yet known but Philips hope it will be about the same as a top quality conventional turntable set-up.

Marantz' New Turntable

A low profile direct-drive turntable has been released by Marantz. Designated 6350Q the unit has phase locked loop servo using a **quartz crystal timing reference**. Wow and flutter is specified as less than 0.025%.

Hall-Effect Playback Head

Hitachi's new model D-7500 cassette tape deck uses a **Hall effect semi-conductor element** instead of the normal inductive pick-up playback head.

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High-Fidelity Pre-Amplifier
The AH 572 High-Fidelity Stereo Pre-Amplifier is an ultra-low distortion (0.008%) two-channel unit featuring high-accuracy step detent controls, illuminated function readouts and touch switches with LED indicators for smooth, silent, sophisticated programming. It also includes adjustable phono input levels and a tape selector that provides five separate tape modes.

High-Fidelity Stereo AM/FM Tuner
The AH 673 High-Fidelity Stereo AM/FM Tuner incorporates touch switches with LED indicators and illuminated function readouts. Other features include ASNC (Automatic Stereo Noise Cancelling). Separate level controls for AM and FM. An FM interstation disturbance mute. And an exclusive AM centre-tuned meter for wide-band full fidelity AM reproduction.

High-Fidelity Stereo Power Amplifier
The 210 watts RMS per channel high-performance AH 578 High-Fidelity Stereo Power Amplifier completes the Philips Hi-Fi Laboratories range. It comprises high-accuracy step detent controls, touch switches with LED indicators and illuminated power meters and protection indicators. Also incorporated in the AH 578 are a sub-sonic filter, thermal and overload protection, and provision for connecting two pairs of loudspeaker systems.

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DEEP SPACE COMMUNICATIONS

Brian Dance examines the challenges of communications with interplanetary craft.

IT IS ONE of the triumphs of modern science that we can establish reliable communications with spacecraft at any point in the solar system provided they are not in the radio shadow of some large object as seen from the earth.

Deep space communications are required for three main purposes:

(i) To track spacecraft velocity and distance. This information is required to calculate trajectory and to compute velocity corrections so that the desired trajectory is obtained.

If a pulse is sent to the spacecraft and the on-board transponder immediately sends a pulse in response, the time delay before this pulse is received on earth is a measure of the distance of the craft. The Doppler frequency shift of this signal is a measure of its velocity to or away from the earth.

(ii) To transmit command or instruct signals to the spacecraft. Such a command signal may, for example, switch on a small jet so as to alter the velocity of the craft or it may cause a television camera to point in a certain direction and transmit a picture or it may switch on a piece of equipment. Many craft have a memory which will store command signals for use at a time when communications are not possible because the craft is behind a planet.

(iii) To send data and television pictures to the earth by telemetry.

During the past twenty years the USA has built up a world-wide network of Deep Space stations for interplanetary communication. This is in almost continuous use and is often receiving signals from quite a number of spacecraft simultaneously.

Brief History

The US Deep Space Communications Network is managed for NASA by the Jet Propulsion Laboratory of the California Institute of Technology (at Pasadena). Pioneering work on liquid and solid rocket propellants was carried out on the Pasadena site of the Guggenheim Aeronautical Laboratory as early as the mid-1930's. However, it was the Jet Propulsion Laboratory's work on tracking and data recovery systems for the US army's guided missiles during the early 1950's which resulted in the development of the present Deep Space Network.

The US space programme commenced on 31st January 1958 with the launching of satellite "Explorer I" This 14 kg spacecraft continued transmitting from earth orbit until 23rd May 1958; it sent data to a three-station network established by the Jet Propulsion Laboratory incidentally confirming the existence of the Van Allen radiation belts around the earth.

In September 1958, NASA was created by the US Congress for investigating problems for flight within and outside the earth's atmosphere 'for peaceful purposes to the benefit of mankind'. Two months later the control of the Laboratory was transferred from the US Army to the California Institute of Technology.

The Deep Space Network has provided tracking, command and data acquisition facilities for the Ranger, Surveyor and Lunar Orbiter projects for exploration of the moon, for the Mariner missions to Mars, Venus and Mercury and for the Viking missions for orbiting and landing on Mars. It also supported the Manned Space Flight Network and the Apollo lunar landing programme, apart from collecting data from Pioneers 10 and 11 and the Helios 1 and 2 craft which as the name implies were used to explore space close to the sun.

The Deep Space Network will be involved in even more work during the coming years. The current Pioneer mission to Venus involves receiving signals simultaneously from one large probe, three small probes, a 'bus' carrier vehicle and a Venus orbiting craft. The long duration Voyager 1 and 2 missions to the outer planets (Jupiter in 1979, Saturn in 1980/81 and possibly Uranus in January 1986 and Neptune in 1989) will be carried on simultaneously with work with the Viking craft on Mars and orbiting Mars. In addition, communications must be maintained with Pioneers 10 and 11 outside the orbit of Jupiter, support must be given to the West German space communications facilities working with the two Helios craft, and various other demands made by Deep Space Communications. A Jupiter Orbiter Probe is planned for launching by the Space Shuttle in January 1982 for arrival at Jupiter some two years and eight months later.

Seeking Life Out There

The Deep Space Network is used for many purposes besides deep space including pulsar and quasar studies. The aerials of this network are ideal for radar mapping the surfaces of the planets and the rings of Saturn. It is intended to use two of the aerials for Search for Extra-Terrestrial Intelligence (SETI) — starting about 1979 over a five year period and covering some 80% of the sky. A search will be made for evidence of radio signals from intelligent extra-terrestrial life — advanced data processing being used to survey the sky over a million different frequency bands. A companion project to be undertaken by the Ames Research Centre will examine 500 selected stars to ascertain if any planets orbiting them are transmitting signals.

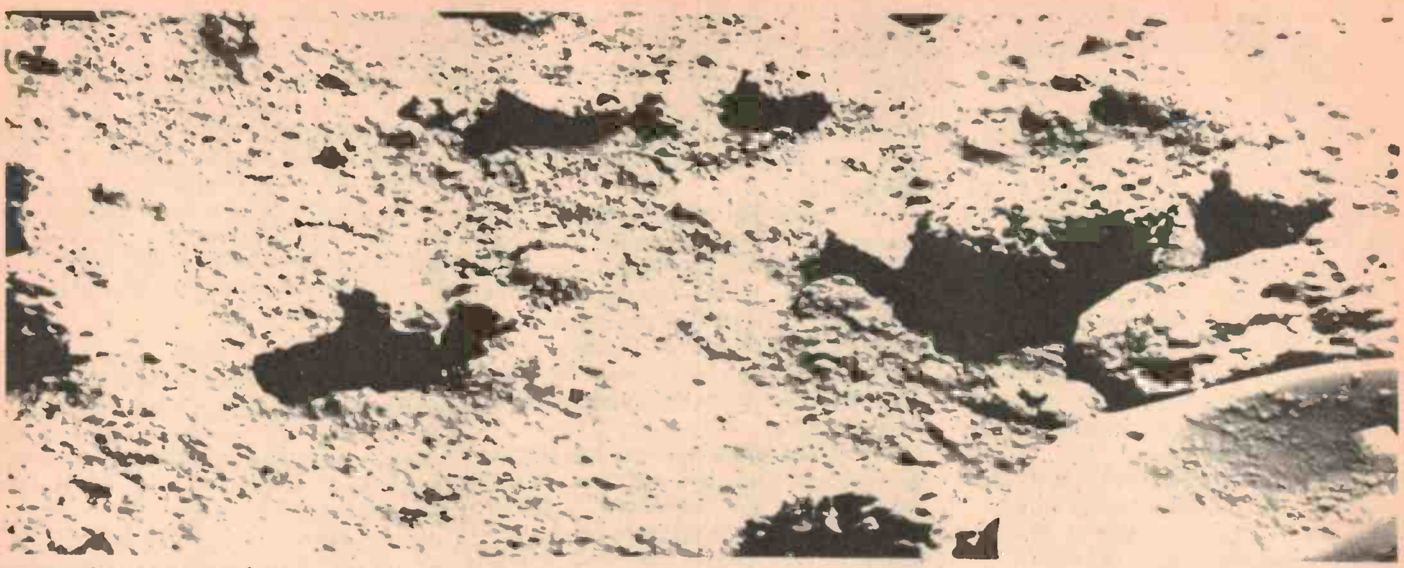
The DSN

The American Deep Space Network employs huge high-gain parabolic dish aerials and very low noise receivers at widely separated places at various longitudes around the globe; this ensures that a spacecraft travelling beyond earth orbit is never out of view of all of the Deep Space Network stations unless it is behind a large object as seen from the earth. Thus at least one of the stations can communicate with any craft at any time when it is not in radio shadow.

Deep space Network stations are located in groups at three places, Goldstone, California; at Madrid, Spain; and at Tidbinbilla, near Canberra, Australia. Each of these stations is equipped with a huge 64 m diameter dish aerial and two smaller 26 m aerials. Grouping the stations together saves money and avoids excessive duplication of equipment. All stations are linked by a special ground communications network which is part of the larger "NASCOM" network which provides communications between all of NASA's stations.

The ground communications facilities used by the Deep Space Network include INTELSAT communications satellite links and sub-oceanic cables as well as microwave links. Data received from spacecraft are transmitted over high speed data circuits. Wide bandwith circuits may carry television pictures of planets and their moons from a Deep Space Network station to the Control Centre at a rate of up to one picture in 48 seconds. In addition, range and velocity information about the spacecraft are transmitted from the receiving station to the Control Centre for navigational purposes. Command signals are sent to the Deep Space Network stations for transmission to the craft. Before transmission they are loaded into a command processing computer which automatically checks them.

The Deep Space Network is not used during the launching phase of a mission. Launches take place from Cape Canaveral, Florida and use the near-earth facilities of the US Air Force Eastern Test Range in the Atlantic together with the down-range elements of the NASA Spaceflight Tracking and Data Network



A view of the Martian surface.

(STDN) at Merritt Island, Florida. Communications ships and instrumented jet aircraft may also be employed during the launching stage. The STDN system is essentially concerned with manned space flights, earth satellites and lunar probes together with the launching phase of any spacecraft; it consists of 16 stations located throughout the world.

The Goddard Space Flight Centre located in Greenbelt, Maryland operates the STDN network and the NASCOM network which links all STDN and DSN stations with control centres. The NASCOM network permits the transmission and reception of written messages, facsimile, voice, telemetry and commands by high speed data lines.

The STDN system provides tracking and communications with the spacecraft during the launching phase, but about the time the launching vehicle is jettisoned and the spacecraft has been put onto its correct trajectory towards the desired planet, the Deep Space Network takes over all communications. It maintains a two-way radio link throughout the remainder of the deep space mission.

Frequencies

The standard frequency band used for deep space communications is 2.1 GHz for the up-link from earth to spacecraft and 2.3 GHz for the down-link from spacecraft to earth, these frequencies being in the 'S' band. However, some spacecraft are also equipped with 8.4 GHz (X band) transmitters. Mariner 10 carried a low power X band transmitter not modulated with telemetry, but used with the S band signal for a dual signal for a dual frequency radio experiment. Voyagers 1 and 2 will have both S and X band high power transmitters. The X band down link will be able to send at 115 000 bits/second from Jupiter, but satisfactory reception at distances of 6.88×10^8 km at the first encounter with this planet (9.27×10^8 km at the second encounter) may depend on weather conditions at the earth receiving station. Rain and other forms of precipitation can seriously degrade reception at X band frequencies, affecting the polarization of the signal, etc.

Power Levels

The 64 m antenna at Goldstone, California is equipped for radiating power levels up to 400 kW – the Spanish and Australian 64 m aerials have 100 kW transmitters. Each of six 26 m stations is operated at 20 kW. Klystrons are used to generate the radio frequency power.

The Viking Mars craft use transmitters of about 30 W power output, the power being obtained from sunlight by the use of solar panels. The Viking craft which landed on the planet can transmit either directly to earth or to the orbiting craft which can relay the signal to earth.

The Venus Pioneer craft will use solar panels to provide over 200 W of power and will be equipped with a number of aerials. The individual probes from the multi-probe craft will be powered by batteries for a short period after they have separated from the main craft and will transmit directly to earth at levels of 10 W to 40 W. However, the data rates will be relatively low owing to the simple aerials used on these probes. Nevertheless, these data rates should be adequate, since no picture data links are needed.

The Voyager Jupiter craft have to be able to communicate with the earth from enormous distances. The intensity of sunlight is inadequate to provide enough power and therefore plutonium –238 radioisotope thermoelectric generators will be employed. Each craft has three of these generators which are 584 mm in length and 398 mm in diameter and which weigh 12.1 kg. Each of these three generators provides 155 W initially, about 135 W after five years and about 125 W after 10 years, but only a fraction of this power is available for the transmitter.

The instruments on Voyager require some 99 W. Voyager will be equipped with a 3.7 m diameter dish aerial which will direct the beam towards the earth; this is the largest dish aerial yet built into a spacecraft.

At Jupiter it is expected that the Voyager craft will provide data rates of up to 115200 bits/second when used with a 64 m earth station and about 640 bits/second when used with a 26 m aerial. When the craft are in the vicinity of Saturn, the data rate will be limited to about 30000 bits/second when working with a 64 m aerial and 80 bits/second with a 26 m aerial.

The reason for this is that noise introduces errors. A lower rate enables a narrower bandwidth to be employed and this reduces noise. Errors of about one bit in thirty bits are tolerable for TV pictures, however, errors in command signal transmissions *to a craft* must be far smaller to avoid the craft being sent on an incorrect trajectory. Typically the error should be less than one bit in 100000 bits – command signal errors can be extremely expensive!

Data rates have greatly increased since Mariner 4 transmitted pictures from Mars at 8.3 bits/second – the increase is about 14000 over a period of ten years.

Sixty Four Metre Aerials

The first of the huge Deep Space Network 64 m aerials was constructed at

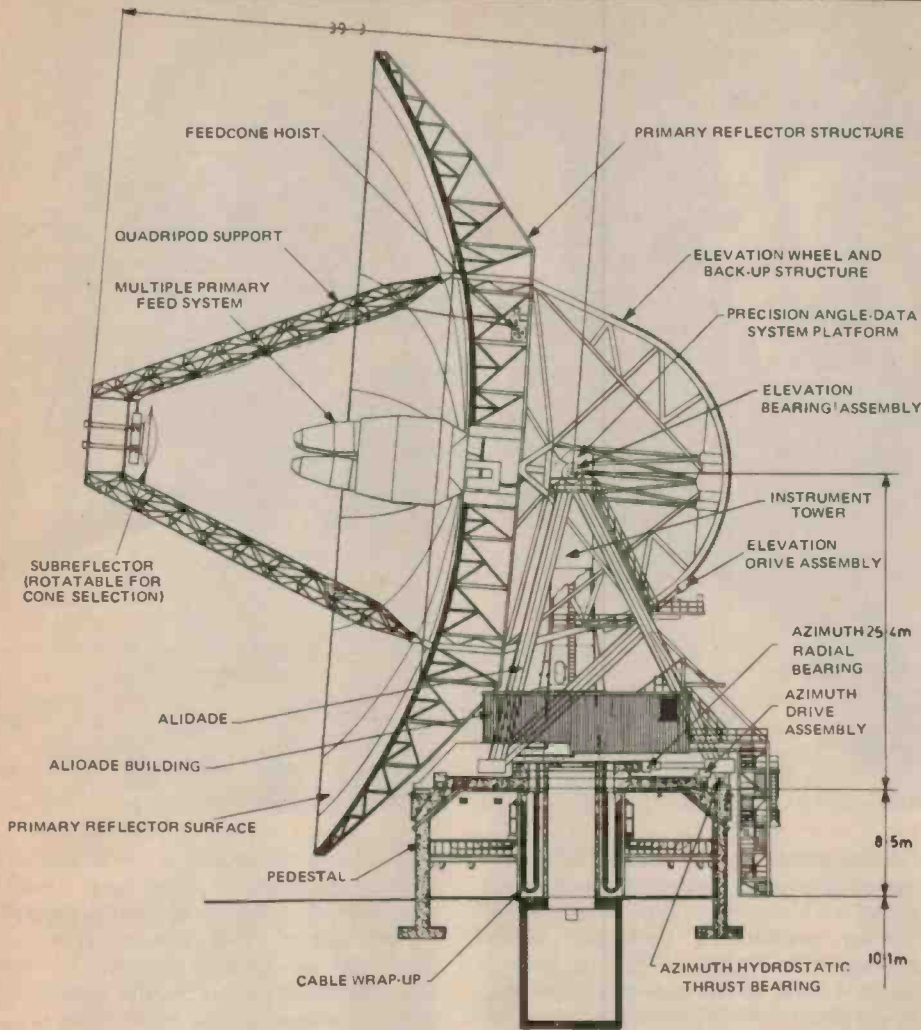


Table 1: Antenna Dimensions

Diameter of reflector	64	metres
Total height (stowed)	73.2	metres
Diameter of sub-reflector	6.4	metres
Focal length	27.109	metres
Focal length/diameter ratio	0.4235	
Surface area	3,483	square metres
Depth of reflector	9.4	metres
Pedestal wall thickness	1.07	metres
Outside diameter of pedestal	25.3	metres
Overall height of instrument tower	42.4	metres
Volume of concrete used in construction	1,912	cubic metres
Antenna Component Weights:		
Overall	7.257,600	kg
On elevation bearings	1,147,600	kg
On azimuth bearings (including bearings)	2,268,000	kg
On soil	7,257,600	kg
Total on azimuth bearings	2,268,000	kg
Total on elevation bearings	1,134,000	kg
Components:		
Sub-reflector	1,860	kg
Feed cone and equipment	29,500	kg
Quadripod	17,700	kg
Primary reflector surface	26,300	kg
Reflector assembly (including reflector, wheels and elevation counterweight)	1,075,000	kg
Alidade and buildings	997,900	kg
Azimuth bearings	181,500	kg
Pedestal and foundations	4,536,000	kg
Instrument tower (including wind shield)		
Steel	43,500	kg
Concrete	422,100	kg

Goldstone, California, part of the design being based on the Australian Radio Telescope aerial at Parkes, NSW; the Goldstone aerial became operational in 1967. Some six years later the Australian 64 m aerial at Tidbinbilla (named "Ballima", Aboriginal for "very far away") was brought into regular service, although it assisted with Apollo 17 tracking in 1972.

A 64 m antenna collects over six times the signal power compared with the earlier 26 m diameter aerials – since the area of a 64 m diameter aerial is so much greater. However, other improvements have been made which enable signals of ten times lower intensity to be received than the minimum required by a 26 m aerial.

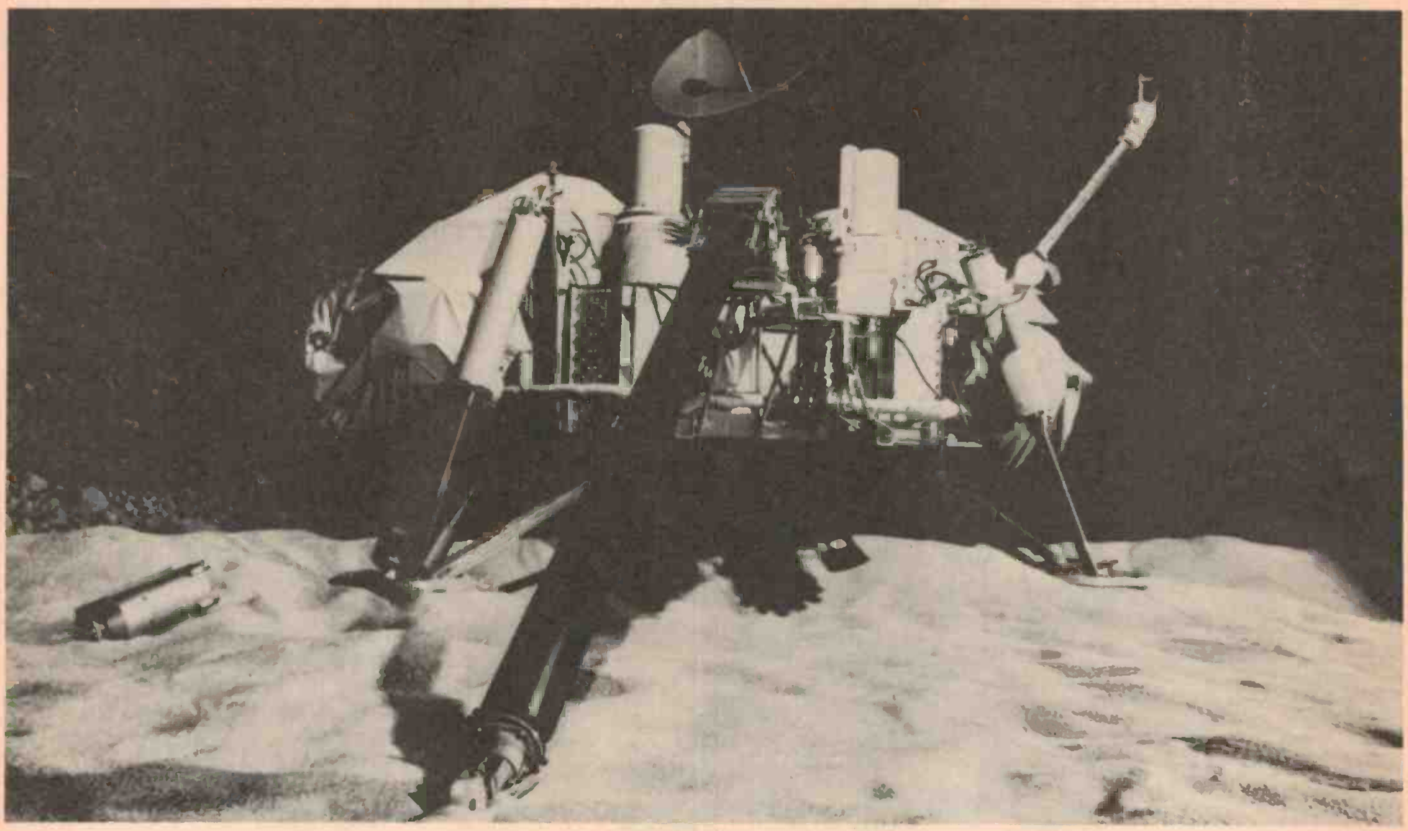
The signal strength from a distant spacecraft is essentially inversely proportional to the square of the distance of the craft from the earth (inverse square law). If a spacecraft at a certain distance produces a signal which is just adequate to be satisfactorily received by a 26 m aerial, the same spacecraft will produce a satisfactory signal into a 64 m aerial when it is three times farther away. Alternatively a considerably greater data rate can be used with a 64 m aerial than with a 26 m aerial from the same craft at the same distance.

A 64 m diameter aerial is an enormous structure with an overall height of some 73.2 m when the aerial is in the horizontal position. The enormous dish must be contoured to an accuracy of ±1 mm even at its edges so that the incoming signals of extremely low intensity are concentrated towards the focus of the huge paraboloidal aerial.

Table 1 shows the enormous weight and dimensions of the Tidbinbilla aerial, but the other two aerials of 64 m diameter in California and Spain are very similar. These enormous structures must be able to operate in winds of at least 80 km/hour and withstand gales of 190 km/hour when the dish is stowed horizontally.

The antenna must be able to point anywhere above the horizon. Motors with a total power of some 300 kW are used to achieve this. The antenna can be directed to any position in space above the horizon with an accuracy of a few thousandths of a degree, yet the huge structure can completely rotate and be moved from horizontal to vertical in about three minutes. The dish must move so that it continues to point at a spacecraft as it moves across our sky despite earth's rotation. Tracking the spacecraft is performed automatically by the station equipment.

Signals can be received as soon as the craft appears above the horizon, since



the aerial can be pointed in precisely the required direction beforehand. However, the establishment of two-way communication takes longer if the craft is at any distance; for example, a signal sent to a spacecraft in the vicinity of Jupiter will take about 45 minutes to arrive (depending on the position of Jupiter relative to the earth) – a further 45 minutes will elapse before any responding signal can be received back at the earth.

The 64 m Tidbinbilla aerial employs Cassagrainian feeds mounted in cones near the centre of the main dish. This type of Cassegrainian feed was first used in optical telescopes. A signal from a distant craft is reflected from the 3480 square metre surface of the main dish which focuses it onto a sub-reflector mounted on a quadripod structure above the main reflector. The sub-reflector can be positioned so that the signal is directed into the feed horn of any one of three cones.

A maser in the feed horn is used to amplify the signal by some 50 dB. The maser is cooled in liquid helium to a temperature of –269°C – four degrees above absolute zero. This type of amplifier introduces less noise than any other type of amplifying device, but if it were not cooled, thermal motion of the molecules would add a considerable amount of noise to the signal.

The signal from the maser output is then fed to a receiver where it undergoes further amplification before being converted to a lower frequency signal which is fed to a control station. The control station contains a computer which processes the signal so that it is in a suitable form for recording on tape and, in the case of the Spanish and Australian stations, for transmission by a satellite or sub-oceanic link to the Network Control Centre.

Control room computers at each station also process information and commands for transmission to the spacecraft and extract precise velocity and range information from the received signals for the navigation of the craft.

Apart from the 64 m or 26 m parabolic aerials, each station must have computers, special receivers, analogue and digital processing equipment, black and white and colour television screens, high speed printers able to read engineering data at 80000 characters per minute and communications equipment plus engineering laboratories, offices, canteens and dormitories which enable it to be self-sufficient. It must also have its own power plant to supply all of the station requirements – one cannot lose signal through power failure when one is performing such expensive experiments. Each station must also have an atomic time generator so precise that it is accurate to one second in 3000 years!

Future Improvements

In order to improve the facilities of the Deep Space Network, it is hoped to increase the diameter of at least one of the 26 m diameter aerials to 34 metres by the end of 1978. The construction of a 100 m diameter antenna is also being considered, but as one moves to larger diameter aerials, engineering problems become more and more difficult and expensive relative to the increase in signal strength. The possibility of an orbital relay station in deep space is also being considered. The 64 m aerials give a gain of well over one million.

Time standard improvements could be achieved by replacing the rubidium vapour oscillators with hydrogen masers. Time standards are vital when one is calculating spacecraft trajectories. Very-long-baseline interferometry techniques are being considered for increasing the precision with which the location of each of the Deep Space Network stations is known.

Conclusions

The Deep Space Network is a vast engineering project which had to be provided to enable us to obtain information about conditions on other planets and in inter-planetary space. Although most of the work of planetary exploration has been carried out by Americans, Australia has provided a very substantial contribution to this work. There will be an increasing demand on the Network during coming years for higher data rates from more distant planets.

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5. Maximum discharge current with standard terminals	25 amperes	9 amperes
6. Maximum short-duration discharge current	300 amperes	90 amperes
7. Permissible temperatures Charge	5°F - 113°F(-15°C - 45°C)	Can be operated, charged, or stored in any position without leaking.
Discharge	5°F - 122°F(-15°C - 50°C)	
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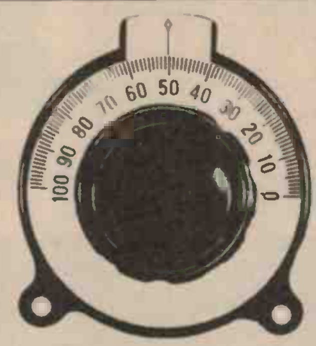
3 months	90%	
6 months	80%	
9. Sealed construction	Can be operated, charged or stored in any position without leakage.	



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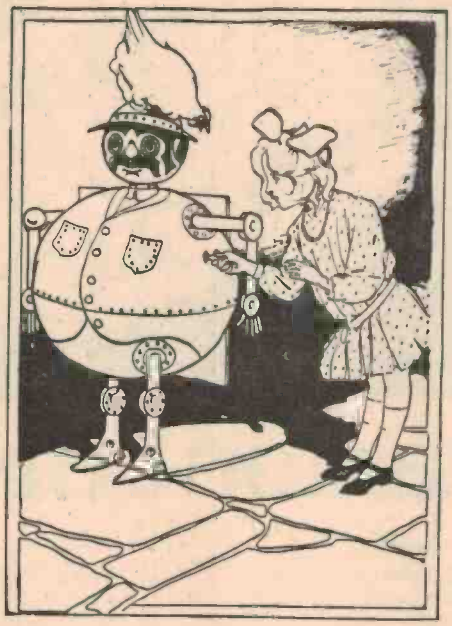
Robots-the facts

Robots may take many forms. They are not necessarily Artoo-detoo like machines. An automated washing machine for example can be seen as one form of simple robot as can the Strasborg clock made way back in 1354 — this contains a cock which moves, stretches and crows.
Here ETI's special correspondent Associate Professor Peter Sydenham, M.E.,Ph.D., F.Inst.M.C.,F.I.I.C.A.,M.I.E.Aust presents the basic facts and analyses the many separate requirements common to robotics.

TERMS

Robot — In Gothic it is akin to a word meaning "inheritance", in German to "work". An old Slavic word that is equivalent is "rabota" and in Czech and Polish "robota" means servitude or forced labour. Professor George's book (see list) says it is "a machine devised to function in place of a living agent".
Robotics — Gaining rapid acceptance, this term describes the discipline that designs and creates robot device structures and sub-assemblies. The following word is reserved for its system organisation.
Cybernetics — Study of multiple feedback loop, self-governing systems, usually of great complexity, as are found in living organisms and advanced man-made control systems.
Automaton — Any device that has apparently spontaneous action. (Plural is automata).
Humanoid — Robot form of man.
Android — Automaton of man-like form.
Homunculus — Inferior robot form of man.
Prosthesis — Man-made, human body replacement parts.
Exoskeleton — Robot frame that fits around human to give power to limbs.
Golem — Man-made creature not having man-like form.
Manipulator — Handling device.
Telechiric — Derived from Greek for "distant hand".

IN THE first half of the 17th century Descartes suggested that the physiological animal can be thought of as no more than a vastly complex machine. Intolerance of ideas, especially those that had religious implications, was extreme in those times and no doubt Descartes only spoke and wrote a little of his concept. Pascal, for example, was dangerously close to being the subject of a witch hunt after people saw his simple



(to us!) add-and-subtract calculator — after all, it could do the tasks attributed then to a god.

The idea that animals are merely machines is known as the reductionist or mechanistic philosophy. As we cannot prove, by any means whatsoever, that there is more to man than man can ultimately devise, we cannot, at present, resolve this issue.

Nevertheless, there is much about animal systems that is reducible to plain engineering. It is these known facts that suggest that many jobs that were considered as man-suitable in the past could well be done by machines. The justification is, to use a well-known quotation, "to make human use of human beings". If an automaton can do the same tediously repetitive task that is done now by a bored and dehumanised human operator, then there is a case to make use of it. This is the story of man's industrialisation, especially since the 18th century.

The human animal is a fine example of a general-purpose, mobile, self-repairing, self-reproducing machine, one that can adapt to new tasks and new environments as need arises. It is not perfect for all jobs, but does provide a fine basis for modelling robots of work, even though the materials and strategies used are different in practice.

Animals can be thought of as hardware systems, consisting of several kinds of sub-systems put together to form the whole system. The complete system is capable of many modes of behaviour. A diagrammatic representation is given in Fig. 2. Let us look at the building blocks first.

Structural framework — This is the mechanical part holding everything together. Bones, skin, tissues can be equated to metal, wood or plastic frames. The framework is developed to satisfy, as a compromise, requirements of lightness, rigidity, appropriate articulation, protection for vital parts, and correct location of one part with respect to another. Note that robot machines do not use the same materials that are found in animal systems. To date it has been more profitable to use quite different substances because man knows too little about the production of regenerative, self-repairing materials used by nature.

Actuators — On to the frames are added converters that change the available energy form into mechanical work. On animals these are the muscles; on robots they are usually electric, hydraulic or pneumatic motors. Again, although muscle-like devices have been made, robot actuators use different principles of conversion and different energy sources from animals. Actuators cause limbs to move, hands to hold, and the whole to translate where needed.

Sensors — Automata that, for instance, play music, are pre-programmed. Regardless of external influences, once set going, they will attempt to keep playing despite changes to their environment. Robots can be much more sophisticated for they possess sensors, or receptors, that observe what is happening around and to the robot. Sensors provide signals that, after data processing, tell the actuators how and when to work in a way that modifies an otherwise hardwired kind of performance.

It seems that many animal senses work on the basis of having a multitude of on-off digital sensors built into each sensing device, the combined, parallel, signal output being a measure of sensor signal strength. Robot sensors rarely work this way for we are unable to handle as many parallel channels as nature. Robots usually incorporate especially if one sticks to industrially marketed units in order to keep costs low.

Data Processing Centre – Signals from sensors are routed to data processing (DP) centres. The brain is the central unit of humans. Not all animals have only one brain. Some early prehistoric animals are believed to have had *two* brain centres. Signal pre-processing goes on in animals before a stimulus reaches the brain. This can also be the case in robots. Robots can have local brain-power plus a central unit.

We cannot make much of a comparison between DP of robots and animals, for we still have only a meagre idea of how the physiological brain can make use of Nature's concepts but not her hardware methods.

Energy Supply – Animals derive energy from the conversion of foodstuffs into energy by chemical means in muscular tissue. Robots cannot do it this way, but make use of the sources known to man at this time. Electricity can be generated by converting fuel to electric current. In mobiles a usual source of energy is electricity from storage cells. Restricted mobility and fixed robots can obtain power by an umbilical supply cable. Hydraulic and pneumatic systems derive energy from their compressor unit – the lines act as energy transmission links to the converter unit.

Fig. 1. Projects of the Warwick University Robot Laboratory. Project on the left uses an inboard microprocessor. At the rear is a hand-like short arm manipulator. The tracked vehicle is originally sold as the army bomb-disposal unit – it acts as a ready made vehicle to conduct research on. (Keystone Press Agency).

analogue output sensors – the so-called linear signal in integrated circuit jargon. To detect the seat of a fire, an automatic fire extinguisher will use a proportional signal infra-red detector homing the robot towards the position of maximum signal output. In some cases man-made robots do use digital output sensors but not so commonly as analogue ones. An example might be a digital shaft encoder sensor mounted to measure an arm's angular position.

We cannot measure every variable that arises in the material world. Even so, literally thousands upon thousands of sensors have been devised so the robot designer of modern times can go a long way with what exists already, operates. Insight that we do have is enough to say that robot brains will be quite different in physical structure from animal brains. We tend to opt for non-redundant data processing methods using a limited number of binary locations. The brain appears to make use of massive redundancy and enormous bit storage capacity (10^{20} is an estimate).

Communication Links – Sensors feed signals to actuators via DP centres. The links we know and use in automatic machines are electric wires, optical fibres, air and oil tubes. Nature, however, uses the nerve links in which pulse signals are regenerated in mysterious ways by electrochemical methods. We

Robots that perform work will be somewhat inefficient for all energy systems will have losses. The human system consumes around 100 W at a rest condition (of which most is lost as heat) and can provide about three times this power as work for limited periods. This would, by implication, suggest that a robot doing the full tasks of a man needs a 400 W supply capability.

The man machine looks quite puny: 400 W is not exactly powerful. Robots are not so limited. For a start, a man begins to tire after a few hours at 200 W output – a machine equivalent can go on tirelessly. Robot manipulators can provide whatever power level is desired. They are made to lift huge loads. An example is a framework that a man fits into, giving him arms that follow his own with greatly increased load capability.

Motivational Mode — There must be some inbuilt means to ensure that the robot constantly goes about the business for which it was created. This mode is temporarily given lower priority when circumstances dictate. As a simple example, a mobile designed to cut the grass of a lawn may need to divert its attention from grass cutting toward a battery recharge. After charge it must return to its duty.

Survival Mode — The programming basics must incorporate means to put the robot into behaviour modes that reduce and, hopefully, eliminate damage to the robot. The lawn cutter must cause the robot to go and look for a task. In animals this is seen as inquisitiveness. Without it humans are referred to as lazy and unmotivated — as would appear a robot.

Maintenance and Self-repair — The good robot is one that does not deteriorate in performance. This is not a reality, however, for although wear rates of mechanical implements can be reduced by better design and more expenditure, it usually can only be done at greatly increased cost. It is to be expected that robots, at least for many years yet, will require greasing, bearing replacement and sliding surface repair.

The first thing the robot will need to do in this mode is diagnose its own troubles, deciding what repair action is to be taken. Then it must organise some way to replace parts. This mode is probably

(3) A robot must protect its own existence as long as such protection does not conflict with the First and Second Laws.

Asimov never intended the laws to be the one and only guide to robot designers — far from it, they were the result of science-fiction writing. They are not foolproof and do not extend to all situations, but do remind us of some basic ideals to consider in programming a robot's behaviour pattern.

Programming the robot

A fully determined robot performance, that is, one that will obey instructions that are all preset before it begins to work, is little better than a special-purpose machine. It cannot do other than what is expected by its programmer. This basic level of performance is required

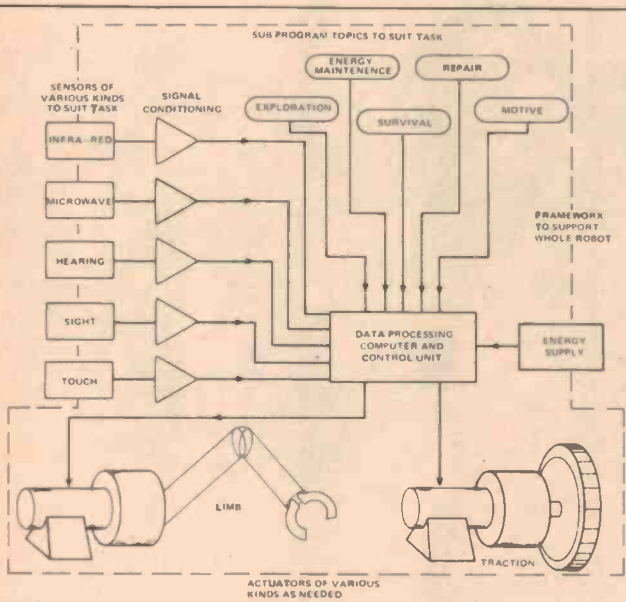


Fig. 2. Robot systems are made up from sensors, actuators and data processing systems operating together to satisfy a number of operational requirements.

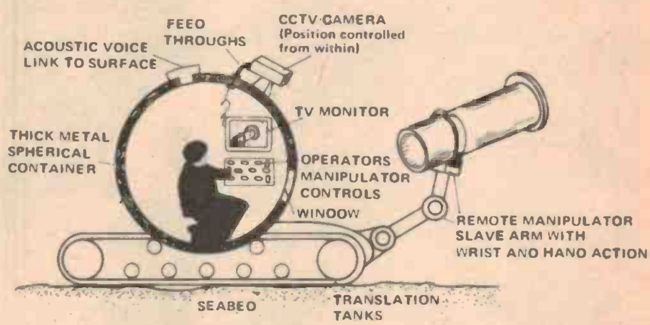


Fig. 3. Underwater a robot manipulator provides an operator with an effective ecoskin and increased ability to do work.

recognise that the concrete edging or stray stone must not be brought into contact with its blades. The survival mode must also extend to preventing the robot doing damage to its environment.

Energy Maintenance Mode — As well as the obvious need for the robot to ensure that it has power enough available for instantaneous load, it should also be able to prepare an energy budget of near future need. If it is a battery-fed mobile, it may find itself out of energy before it can return to the recharge point.

Exploratory Mode — Robots can have greater than one purpose. Such purposes may not exist all of the time and all in one place. When no purposeful sensor signals are received, actuators should be set by a sub-program to more idealistic than real for most robots at present, but the software programmer and robot designer must, at least, give some consideration to this need.

Robots and people

In 1942 Isaac Asimov put into words three laws of robotics that have become famous in this field. They refer to the relationship between robots and people that designers should bear in mind for obvious reasons. The laws are:

(1) A robot may not injure a human being or, through inaction, allow a human being to come to harm.

(2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

of many robots, but is not the complete capability. It might be preset by a punched-tape or magnetic tape in the same way as are many domestic knitting machines. Most manipulator robots get these instructions via an initial man-operated run using special controls that allow the operator to run the manipulator through the required manipulative routine. Once done it becomes a stored program routine.

Far better, if possible, is to servo the output required according to inputs of error. For example, to put a pin in a hole is better done by viewing the error between the pin and hole, reducing the error to zero, rather than presetting an arm to put a pin where the hole is expected to be.

The latter open-loop method assumes that all relative positions of limbs of the robot are held within the final tolerances needed to put the pin into the hole — which are extremely tight limits in many cases. The former method makes use of feedback and it is a feature of servo systems that actuation components inside the loop can be reasonably inferior in quality. This is a most important system concept — think of the problem of finding a place on a map by dead reckoning from a set of distances and bearings, as opposed to improving one's situation as one goes by recognition of error still existing.

Recent robots

Many authors on robotics include mention of a wide variety of inter-disciplinary automatic devices. This broadens the subject enormously and is a quite reasonable thing to do for robots can take any form. For reasons of space, we restrict ourselves here to mobiles and manipulators.

It is said that the term "robot" gained public acceptance as the result of a 1923 play by Karel Capek. It was at that time in history that ideas about automation began to flourish in earnest because of the favourable technological atmosphere. Electronic amplification was just available, mass production of consumer goods was established, sophisticated industrial control was emergent at a seat-of-the-pants level (theoretical considerations came later in the late 1940s).

Electrical computation began in the late 1930s, resulting in the first working vacuum tube system in the 1940s. Computer research no doubt stimulated interest in artificial intelligence (AI for short). Things were really happening by the 1950s. Studies of adaptive control, self-organising systems, AI and a new discipline called cybernetics were developing rapidly — research workers became very optimistic that machines would soon be able to design better machines. But they found over the successive years that it was not so easy!

Cybernetics was the term popularised by Norbert Wiener in 1947 for the discipline covering self-governing systems of all kind, seeing them basically as all the same thing, regardless of application. The term is derived from the Greek and means the art of steersmanship. It is of interest to include the fact that Ampere had previously used the term to describe the science of government.

Theory of automata became an established pursuit a little later. Pattern recognition was another related area that became fashionable to work on. By the early 1970s the realisation that these ideas would not blossom so quickly, if ever, to give regenerative machines and robots replacing men in all their faculties, was accepted. Such goals are now seen to be much further away.

Today, the past efforts of many people have been tidied up, extended, ignored and much has been weeded out as irrelevant or false, leaving today's robot designers with a very useful and full theoretical and practical background to work from.

Mechanical design aspects of robots have advanced through work in prosthesis, in nuclear materials handling, in a relatively few academic engineering departments and within a small number of industrial groups.

Data processing for robotics concentrated on seeing what could be learnt from biological systems — maybe this was not so fruitful considering that designers have to work with different materials than nature uses. Then came the mini computer, almost small enough to build into a reasonable size robot device. Costs at first were prohibitive. Computing power and speed were very limited for operating robots at the motional speeds and precisions needed. Today we now have the quite cheap microprocessor, where the larger part of its sale price is for market promotion, mechanical packaging and application notes.

Before time

Advanced ideas usually meet opposition in a society. Bruno was burnt at the stake in the 1500s for suggesting astronomical theory was wrong. Pascal nearly went the same way for making his adding machine. Even Ohm had his simple law of the 1830s opposed by men of learning. The road car was held up in development for over 60 years by the need to walk in front of a vehicle with a red flag. Fear, preservation of the status quo, misplaced motives, politics and the natural and more healthy need for cautious acceptance usually emerge before a new concept finds acceptance.

So it has been with robots. Science fiction writers paint both gloomy and happy scenarios with robots. We tend to remember only the former. Robots are merely machines of greater capability and versatility than man has made to date. As with all of man's technology, he has to learn to use them appropriately. We should not fear the robot but

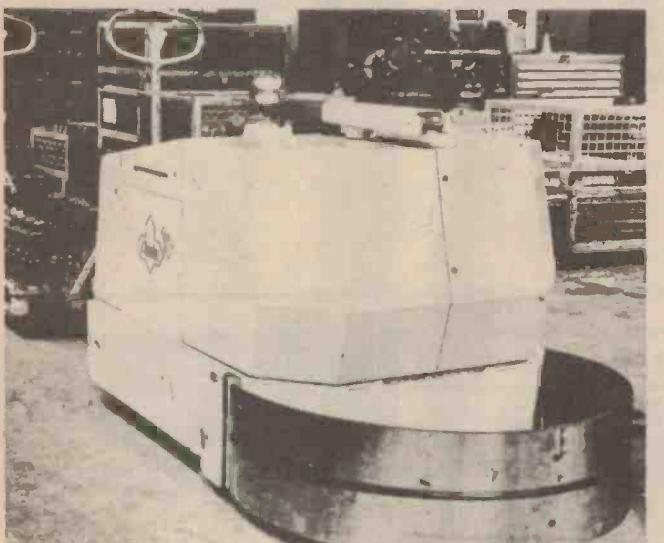


Fig. 4. The Ameise Teletrak driverless tractor train guides itself to follow a guide-wire set into the floor. One day it may be economic to provide the robot with navigational ability that compares with that of humans.

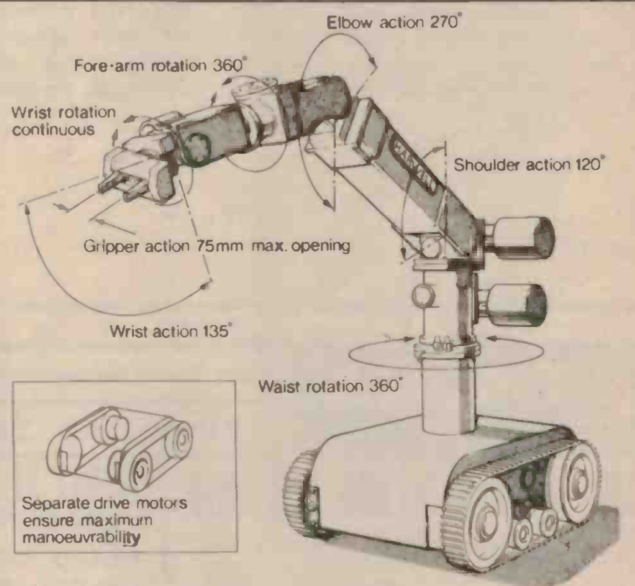


Fig. 5. ROMAN, a recent Harwell mobile, is made for use in hazardous industrial situations. It is electrically powered using cable control.

look deeply into its value to us.

Returning to earth from the levels of philosophy, it is quite certain that the robots we build over the next decade will not challenge our existence. We know too little at this time to build them with such powers. There are, however, numerous requirements where robot devices can replace men performing tasks too hazardous for men to do. Machines are the extension of man on earth and no force is likely to stop man's use of tools which has been part of his culture from the very beginning.

University research

Robots of the future will make use of techniques discovered and developed in research groups working on artificial intelligence, robotics, computing science, electronics, plus many more areas.

The Science Research Council of Britain supports robot research. The main laboratory of the Robot group at Warwick University is shown in Fig. 1. In the same room is the computer terminal to which the four projects shown are hooked-up to give them significant data processing ability. Around the walls are placed acoustic transducers used in positioning work.

A group at Edinburgh University works on putting artifical intelligence into robot devices. They have built a servo-controlled, computer-based, handling system.

A prime purpose of University research is to seek better ways to achieve goals. Theirs is not really a task of building devices that are totally engineered. For this reason one seldom sees a finished robot but more units in stages of change.

Never before has the field of robotics been so ready for development. Simple robots with quite sophisticated brainpower are in the price range of the nonprofessional. Amateurs can now enter the field knowing that the capability of their effort made now will be improved as efficient and powerful strategies are transferred to the general public domain at low cost via mass-produced integrated circuitry and software packages. A good comparison is seen by remembering that visual display units that write words were wonders of the time ten years ago. Now the equipment is reasonably standardized, far more advanced and within the price range and building capabilities of many teenagers.

Organisations

British Robot Association
Secretary, Dr. M. Larcombe, Robot Laboratory, Department of Computer Science, University of Warwick, Coventry, U.K. (A professional body with leading manufacturing companies as members.)

Robot Institute of America
20501 Ford Road, Dearborn, Michigan 48128, U.S.A. (This professional U.S. body has recently inaugurated a medal – the RIA Joseph G. Engleberger Award – for individual outstanding contributions to the science and practice of robotics.)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Robots – brain power

Robots have logic systems that make them think they think! Dr. Michael Larcombe of Warwick University's Robot Laboratory explains.

ROBOTS do not have brains. 'Wet logic' technology — brains to you — is many orders more complex than the world's most complex machine (which is probably the International Telephone system, not any supercomputer). Robots are however extremely bright — for machines. They are much smarter than computers — which suffer from the so-called GIGO syndrome (Garbage In, Garbage Out). Unlike the dumb computer they answer back — ask a smart robot to walk through the wall and you will get the robot equivalent of a flea in the ear. Give them an unreasonable task and they will either (a) refuse to do it, (b) try to do it for a while and then give up, (c) have a seizure (badly designed robots only — as we do not yet really know what makes a good design, this means most of them).

Through a robot's eyes . . .

It is easy to be patronising while watching a robot at work — especially as their vision is either poor or non-existent. A few minutes attempting to perform the same task using the same robot body under remote control and using the robot's own sensors soon convinces the human that the robot itself is best qualified to control its body. Without direct visual feedback remote control becomes exceedingly difficult. When dealing with feedback from non-human sensors such as sonar or doppler radar it is virtually impossible. In its own sensory environment the robot is a master of control. In our laboratory at Warwick where robots use sonar their behaviour in the dark is much superior to that of their designers.

No undisclosed miracle of technology lies hidden within the robot's carapace — no 'positronic brain' is required. Most of the more advanced robots contain — or are controlled by — computer, and frequently by multiple computers. With the advent of reasonably powerful micro-computers, with 16 bits or more to chew the computer power can now be contained within the robot body. The smaller 8-bit micro-processors tend to wheeze and groan under the processing load required for even a small robot. The really high IQ robots still tend to cling to the apron strings of a big computer but it is only a matter of five years or so before they can cut loose.

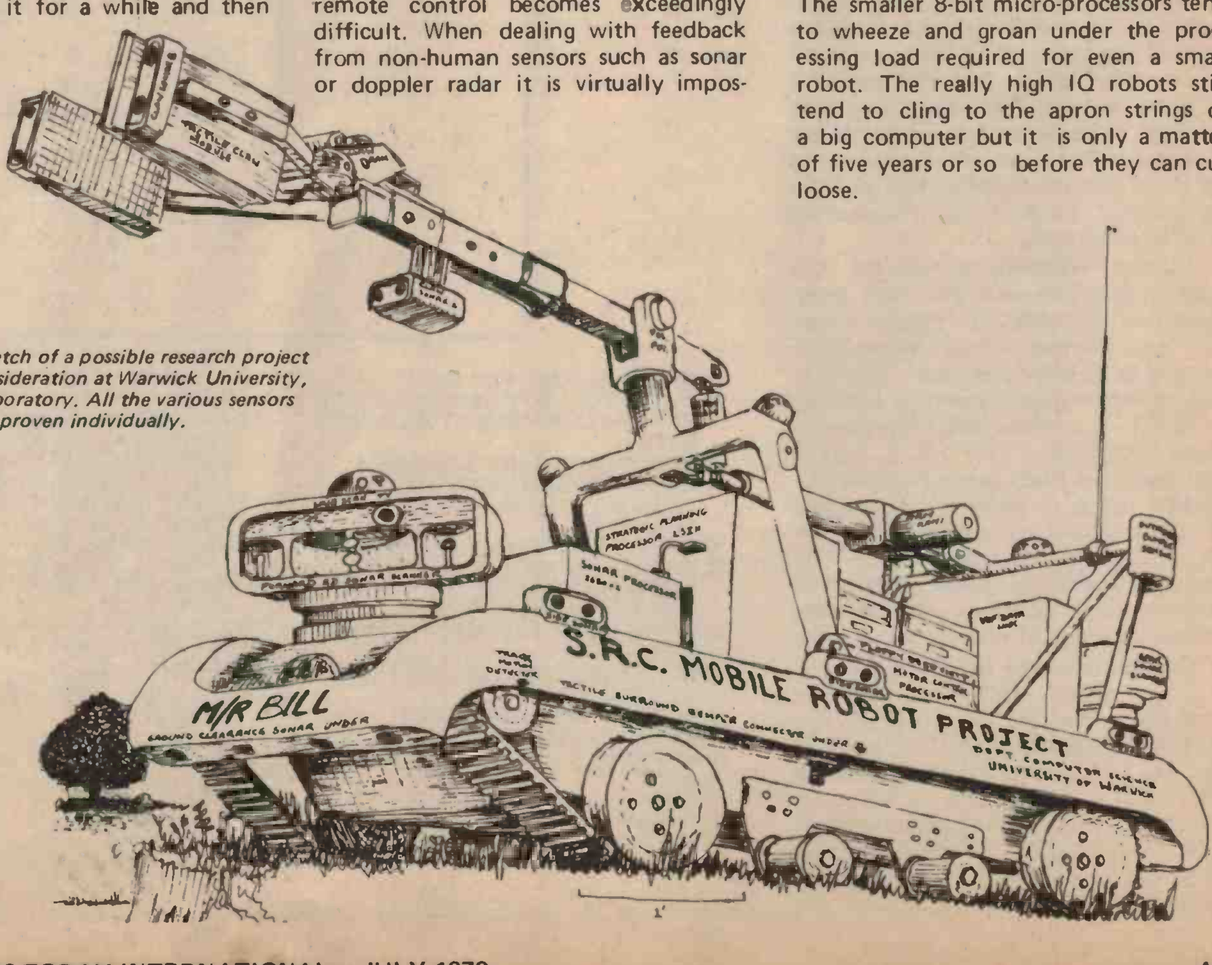


Fig. 1. Sketch of a possible research project under consideration at Warwick University, Robot Laboratory. All the various sensors have been proven individually.

In the first paragraph I was somewhat disparaging about computers. Yet computers control robots – how come the robot is smarter? Well the robot is a lot more than just computer – it has sensors and actuators and perhaps a boxful of specialist processing functions such as motor acceleration-deceleration control or positional servo systems. A small robot will have more input-output channels than many of the larger time-sharing computers. The robot's necessary data handling load may well exceed 10 megabits/second – much of this load is trivial – such as limit switch logic – and is easily handled by special logic. Nevertheless it must be handled. The road to automatic control is littered with sad and pathetic figures who thought all they had to do was connect the wires into a computer and it would do it all, 10 megabits/second requires a great deal of computer and a great deal of money!

Flexibility

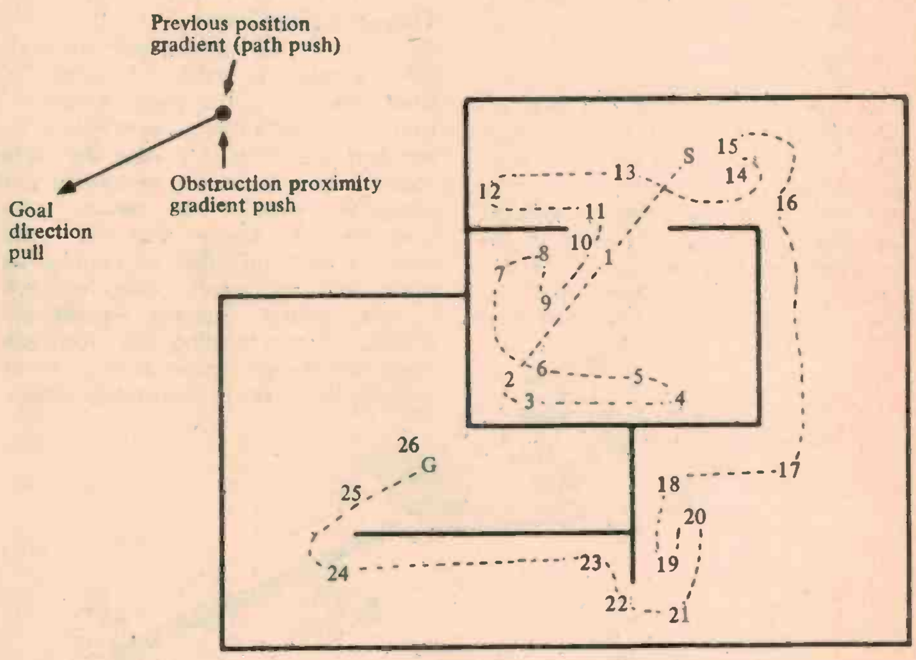
A robot program is unlike an ordinary computer program (such as a payroll program). A payroll program is a set of sequential steps moving data, making decisions and ultimately stopping. A robot program is attempting to weigh up a continuously changing 'situation' and assess what to do in that situation – much as an analogue computer is continuously monitoring both its inputs and its internal state. It is no good having a robot which does not realise it is about to – or has – run into a 'wall because the program has not got to the wall bumping bit yet. (I am supposed to be a bit absent-minded myself, but this is carrying 'thinking about something else' to extremes).

Further distinctions between the payroll programs and the robot programs may be made. The payroll computer does not require any knowledge of the nature of space and time – indeed it has no 'knowledge' of what it is doing. In fact it is a classic GIGO program – input 'BLOGGS, F PAY RATE – 97.5' and poor old Fred, gets a negative pay packet and is unlikely to be mollified by the apparent tax rebate and returned Medical Benefits contribution. The program does not know about the positive nature of pay – much less the negative attitude of Fred!

Central to many robot programs is a set of stored information which is generally called the world model. The complexity of this model is chosen to give the robot some knowledge of the real world without giving useless information. It is no use informing a robot that trees and grass are green if it uses infra-red vision – whereas the information that grass is on the ground and trees stick out of it is useful.

The robot program need no longer take sensor or command data at face value. It compares incoming data with world model data for 'reasonableness'. If a well appears to be moving (program checks sonar range to expected wall with world model distance between computed position and wall position and finds continuous variation) the program can quickly check with other fixtures to see whether it is sliding about itself or an unknown flat intruder is present or the wall is actually moving (the latter two cases may not be distinguishable). If an external command to move forward occurs the program can first check with the world model to ensure that no obstruction is to be expected and then check during the movement that an unexpected obstruction does not exist.

The unexpected obstruction leads us into a really intriguing area of robot technology. Having found a palpably real 'thing' and perhaps having discovered a few useful facts about it (does it move by itself, is it round, how wide is it? can it be circumnavigated, does it emit ultrasound, does it emit light etc., etc.) these facts may then be entered into the world model by the robot itself. This may seem a small step, but for robot-kind it is a giant wheel-turn. The robot's behaviour is governed by comparing the incoming data with the stored world model data, but the robot itself is modifying this data – therefore the robot is modifying its future behaviour. This is at the very least a form of learning – that is to say, it is to some extent unpredictable.



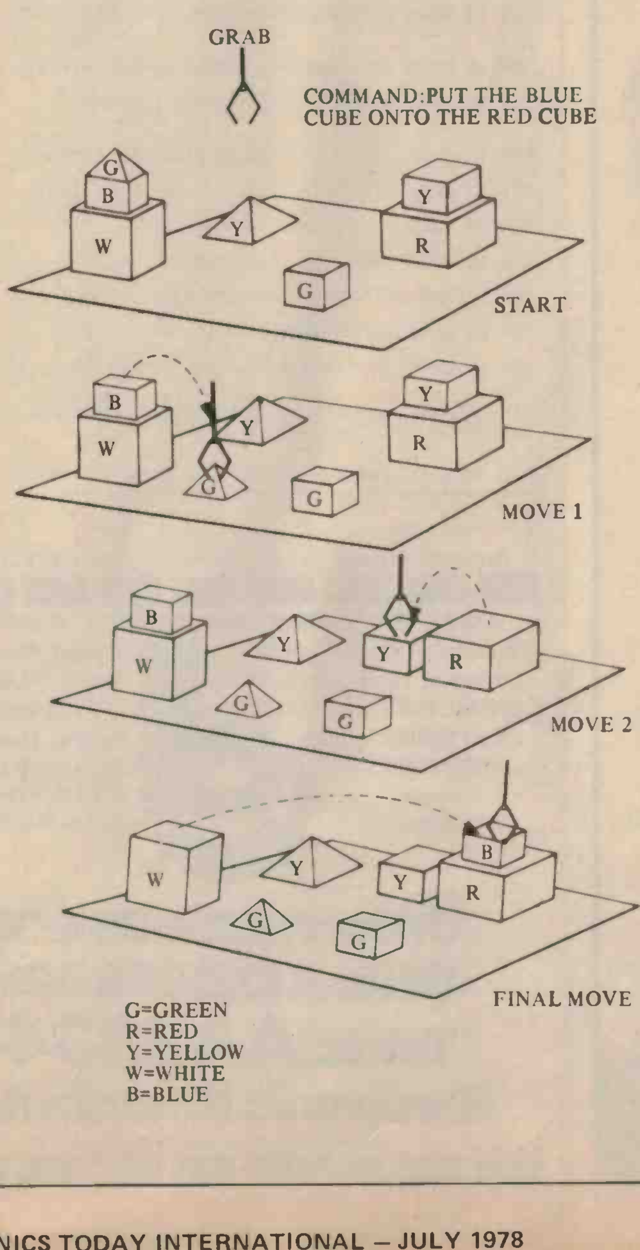
1 MAKES BEELINE FOR GOAL
2 WALL PROXIMITY DEFLECTS PATH
3 NEXT WALL PROXIMITY DEFLECTS PATH
4 PREVIOUS POSITION GRADIENT FALLS OFF AND OBSTRUCTION PROXIMITY & GOAL CAUSE TURNBACK
5 PATH AVOIDS PREVIOUS PATH
6 INERTIAL EFFECT OF PREVIOUS POSITION GRADIENT CARRIES IT ACROSS PREVIOUS PATH
7 CORNER CAUSES ROBOT TO TURN AGAIN
8 GOAL DIRECTION PULLING-PATH AT 7 PUSHING
9 TOO MUCH PREVIOUS PATH REPULSION ROBOT EXISTS
10 AVOIDING WALL AND PREVIOUS PATH
11 GOAL PULL TURNS ROBOT
12 CORNER CAUSES FOLDBACK
13 THE DOORWAY 1 10 11 TOO FULL OF PREVIOUS POSITION REPULSION-INERTIA EFFECT CAUSES PATH CROSSING
14 15 16 DITHER CAUSED BY RAPID CHANGES IN RELATIVE IMPORTANCE OF GOAL PULL AND PATH OR OBSTRUCTION PUSH
17 CLEAR RUN DOWN WALL DIRECTED BY GOAL PULL AND OBSTRUCTION PUSH
18 19 20 FOLDBACK RESOLVED – PATH PUSH AND GOAL DIRECTION SORT IT OUT
21 22 DORWAY NEGOTIATED BY GOAL PULL AND OBSTRUCTION PUSH
22 DOORWAY NEGOTIATED BY GOAL PULL AND OBSTRUCTION PUSH
23 24 WALL FOLLOWING – INERTIAL EFFECT OF PATH PUSH OVERCOMES CHANGE IN GOAL DIRECTION
25 CLEAR HOME RUN
26 TWO JOULES OF DRAUGHT DC AND A PACKET OF CRISPS PLEASE!

Free will

The robot is not deterministically programmed. There is an old saying about computers to the effect that the program is only as good as the programmer. In the case of robots this is no longer true in its original sense since two programmers are at work. In addition to the human programmer the totality of the robot's environment acts as a 'programmer'. Since the mechanics of the world are imprecise this second programmer never repeats is program exactly.

This indeterministic nature becomes clear when during a robot operation something surprising occurs and I am asked what is it doing. I usually have to say I do not know since the only way to find out for sure is to get the robot to explain in some way or to stop it and inspect its memory. Either way can take some time. There is a well-known robot simulation program (illustrated) which deals with manipulations of stacks of geometric solids such as cubes upon cubes and pyramids on cubes (you cannot stack anything on a pyramid). This program has the advantage for the layman of communicating via a computer terminal in a reasonable fascimile of English. Having completed some long sequence of moves to stack a small blue cube on a big red cube (involving clearing everything on top of both cubes out of the way) the computer pauses and the programmer asks it: "Why did you move the green pyramid off the blue cube?: the computer answers 'To reach the blue cube." The programmer probes further: 'Why did you move the yellow cube off the red cube?': The computer answers 'So that the blue cube may be placed on the red cube.' The programmer in great inquistorial enthusiasm asks 'Why did you place the blue cube on the red cube?'. With the reserve only computers can muster, it replies 'Because you told me to.'

This 'back-tracking' is relatively easy in a simulation program and the computer used was very large. However, in a small mobile robot program space is at a premium and exotic 'chatty' communication impossible. The same space premium forbids the storage of all events — it is necessary to build in methods of selectively removing surplus data — a 'forgetory' if you like. This is akin to the short term memory system we appear to use: important stuff is kept and the junk is forgotten. This selective 'purging' may remove the data required for back-tracking and it may be impossible to determine why the robot behaved as it did in a particular situation. The robot may be given a bag of problem-solving tricks for using in conjunction with its memory, one of these may, for example allow it to solve the problems of getting about a maze-like environment as quickly as possible by 'mentally' finding the route before actually covering it (Fig. 2). There may be other specific strategems for manipulation and so on. At the moment of writing however, the robot is not really capable of learning new tricks for itself. This may require an extension of the world model concept to cover more of the dynamic and sequential aspects of task learning.



Here, boy . . .

Robots are not yet capable of the full range of intelligence we expect even from an animal. They cannot learn new tricks, yet they can solve goal-seeking problems which would baffle a dog and can communicate in English with some degree of understanding. Clearly they do not fit into our usual categories for intelligence. The term 'machine intelligence' should be considered for the moment as standing apart from our normal spectrum of intelligence. When we know where to put it in that spectrum we will have learned much more about intelligence itself. Experiments with robots and in the field of artifical intelligence will help to elucidate this age-old puzzle of thinking. I suspect that just as in movement the robot is more likely to use wheels than legs it will use something dissimilar in structure to the brain for its 'thinking'. What is important is that as we understand the dynamic principles which govern both wheel and leg we also find the principles that govern both machine and biological intelligence.

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Digital Electronics By Experiment pt5

Ian Sinclair has more to say on the subject of flip-flops. . .

WE HAVE SEEN earlier how the toggling action of a 7476 J-K flip-flop, which occurs when J=1 and K=1, gives an output pulse train at half the frequency of the input clock pulses. We can use this output as the clock pulse for a second flip-flop, and we will make up a circuit to find the practical outcome of this.

Frequency Divider

With power to the board switched off, set up the first flip-flop as before with J=1, K=1. Connect a wire link from pin 15 (Q1) to pin 6(CK 2), and attach a resistor and LED in the usual way to pin 11 (Q2) and a spare pad. This LED will indicate the state of the output of the second flip-flop whose J and K pins can be left floating.

With power applied, the output pulses from Q2 should now be at one quarter of the frequency of the oscillator so that this complete circuit is a divide-by-four, producing one complete pulse at the output for each group of four complete clock pulses into pin 1. This is shown in the clock pulse diagram of Fig. 1(b).

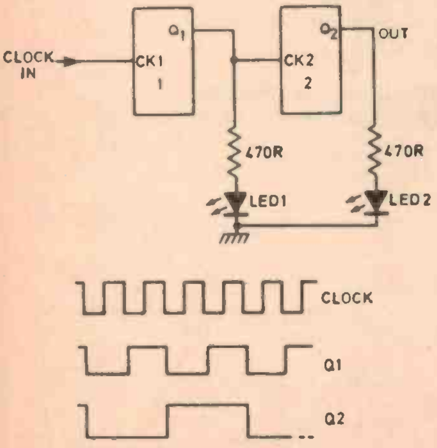

Fig. 1. Cascading 7476 flip-flops.
(a) Circuit.
(b) Pulse diagram.

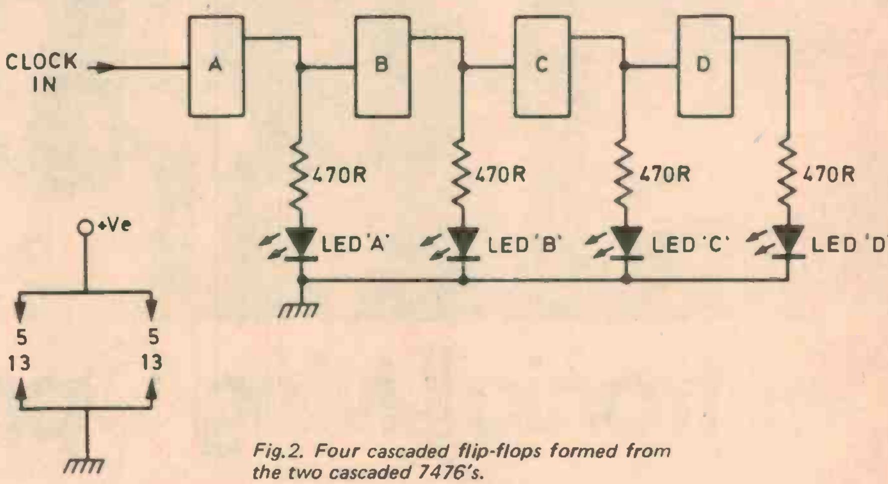

Fig.2. Four cascaded flip-flops formed from the two cascaded 7476's.

With the supply disconnected again, connect up both halves of the second 7476 as shown in Fig.2, so that we now have four toggling flip-flops in sequence. Connect a resistor and LED in the usual way onto the final Q output.

Can you predict what the count number of this circuit will be? (The count of a circuit is the number of complete pulses in to give one complete pulse out.) Using the slow clock pulse from the 7414 oscillator, count input pulses for one complete output pulse (0 to 1 to 0), and draw a clock pulse diagram.

Asynchronous Counters

The type of circuit described above is a frequency divider, with each stage dividing the clock frequency by two. It can also be thought of as a scale-of-two counter, with a serial input and a parallel binary output.

Let us elaborate on this.

The pulses into the first clock input need not be at a steady rate, so long as each is separated from the next. This is a serial input — meaning one after the other. The output of each flip-flop can be read, by means of an LED attached to each Q output, for example, and since all can be read together, this is a parallel set of outputs. Our counter, therefore, has serial input and parallel output.

More importantly, if we started putting the pulses into the input when the output of each flip-flop was zero (the counter cleared, or reset), we could tell how many pulses had appeared at the input if we stopped counting at some stage.

If we label our flip-flops A, B, C, and D (Fig. 2), with A the flip-flop at the input and D at the other end of the line, then we could also label B as 2, C as 4, and D as 8. We are able to do this because, starting at zero, QB will go to 1 after two input pulses (and back to zero on pulse number four), QC will go to 1 after four input pulses (and back to zero at eight), and QD will go to 1 after eight pulses, returning to zero at the sixteenth pulse. We would expect, for example, that after seven pulses, QD=0, QC=1, QB=1, and QA=1 because 4+2+1=7.

This circuit is a binary asynchronous counter – binary because the counting is carried out in the scale of two instead of the more familiar ten, and asynchronous because the flip-flops are being clocked at different rates. The truth table of Fig. 3 shows the relation between the binary figures (the outputs from the Q terminals) and the number of pulses in (using decimal figures). Note that this arrangement counts to 15, and that all the flip-flops reset to zero on the sixteenth pulse.

PULSES	QA	QB	QC	QD
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
16	0	0	0	0

Fig. 3. Truth table for four cascaded flip-flops.

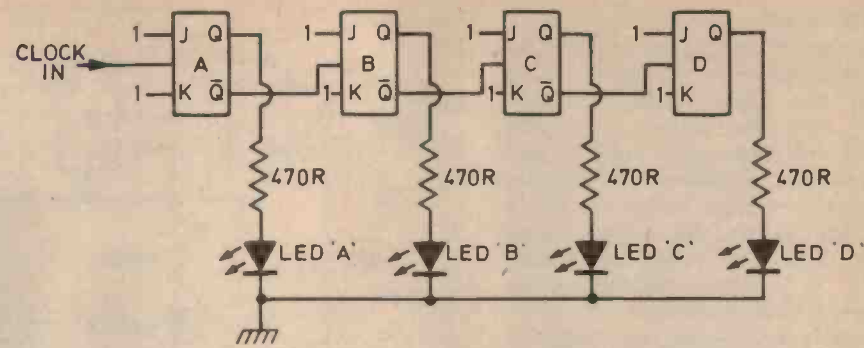

Fig. 4. Cascading from the $\bar{Q}$ terminals – what does this counter do?

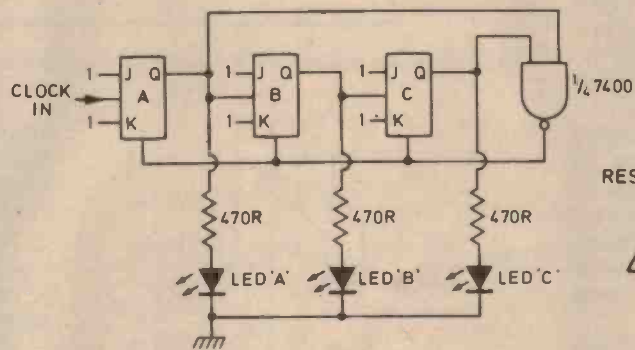

Fig. 5. A scale-of-five counter.

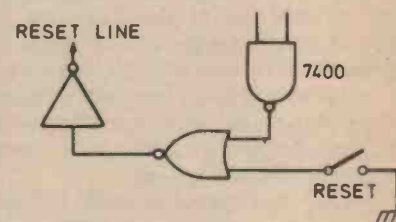

Fig. 6. Using a push-button reset with the circuit of Fig. 5. This could be accomplished in several other ways.

Four-Stage Counter

Set up a four stage asynchronous counter on your board with a resistor and LED to indicate the state of each Q output. Label the LEDs to avoid confusion – QD furthest from the pulse input should be labelled 8, QC labelled 4, QB labelled 2, and QA labelled 1. Take the oscillator output through a gate which can be controlled by a switch, and connect the reset terminals (pins 3 and 8 of each 7476) to another switch so that all the outputs can be reset to zero by pressing the switch to connect the reset pins to the 0 V line.

Now apply power and check that the count sequence is as shown in the truth table of Fig. 3 when the gating switch is ON. Try switching the gate off and resetting.

Switch off the power and alter the connections between flip-flops A, B, C and D so that $\bar{Q}$A is connected to clock B, $\bar{Q}$B to clock C, and $\bar{Q}$C to clock D. Leave the LED indicators connected to the Q outputs as before (Fig. 4). Now switch on, and start the count. What is happening now?

Could you, (not necessarily using only the ICs on the board) design a counter using two 7476s which would count either up to 15 and reset, or down to zero (resetting) according to the position of a single switch, or the voltage on a gate? The number of gates needed makes this impossible on our board.

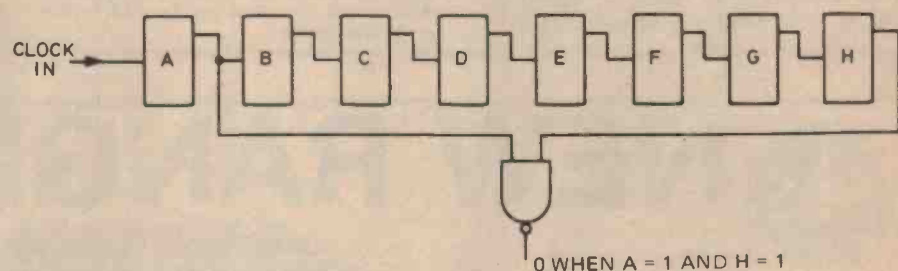

Fig. 7. A 'ripple counter'. This type of counter can suffer from 'race hazards'.

Interrupted Counts

We seldom want a counter which counts up to 15 and then resets to zero. We may want a decimal counter (0 to 9 and then reset to zero), or a counter which stops at some definite count, or which counts to some number, resets to zero and then stops. These operations can be achieved by using the Q outputs of the flip-flops together with gates.

Suppose, for example, that we want to count up to four, reset to zero at the fifth pulse, and then start again. What we need is some way of detecting the output at a count of five and using this to operate a reset. Detecting a count of five is easy enough since it is when QD=0, QC=1, QB=0, and QA=1. We can detect this by taking the Q outputs from C and A and connecting them to the inputs of a NAND gate, as shown in Fig. 5. When QC=1 and QA=1, the output of the NAND gate will be zero. The simplest and most obvious way to use this is to connect the output of the NAND gate directly to the reset line of the flip-flops, replacing the reset switch we used previously.

Set up this circuit on your board. Use wire connections from QC and QA to the inputs of one of the 7400 NAND gates, and disconnect the switch from the reset line. Now switch on, with the slow oscillator input to the flip-flop first clock, and observe the count.

Can you now design a counter using four flip-flops which would reset at the tenth inward pulse? This will be a scale-of-ten (decimal) counter. Remember that ten in the binary scale is when QD=1, QC=0, QB=1, and QA=0. If, for any reason we want to use a separate switch-operated reset with this counter, we shall have to arrange an input through either an OR gate or a NOR gate as shown in Fig. 6.

Ruined By Ripple

We can use this gating system to construct asynchronous counters which reset at the highest designed count number, but the system runs into problems with large count numbers and with high speed operation. For example, the first stage counter runs at the speed of the input pulses, and if these pulses are fast, then we may find "Race Hazards" — problems caused by the time delay in each flip-flop.

To take an example, we may be detecting the state 10000001. Now the 1 on the flip-flop H (Fig. 7), called "The Most Significant Figure", appeared just after the count had been 01111111, and if there is a time delay in the system flip-flop A may have gone to zero, to 1 and back to zero again before the clock pulse to flip-flop H has had time to work its way through all the stages in the counter. This time delay, caused by the need for a change to *ripple* through all the flip-flops, gives us the name "Ripple Counter", and can cause miscounting at high speeds.

Leaving this problem aside for the moment, our simple asynchronous counter has used the reset line for its reset action. For other types of count interruption we can make use of the J and K terminals of the J-K flip-flop, which is why they are provided. Construct the circuit of Fig. 8 on your board. Can you predict what will happen? Try it out and draw up a count table.

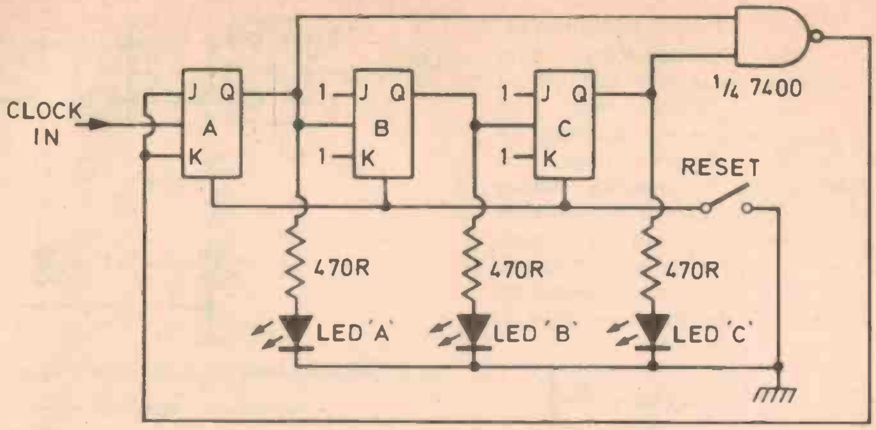

Fig. 8. What does this counter do? Build the circuit on your blob-board and draw up a truth table.

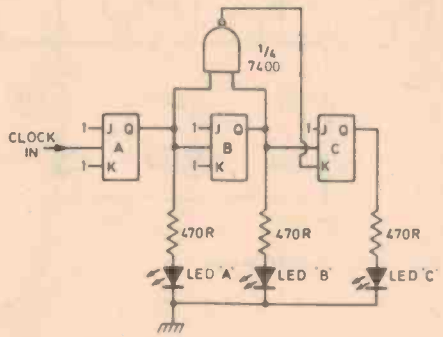

Fig. 9. What does this circuit do? Try to find out in theory, and then build up the circuit on the blob-board.

Now try the circuit of Fig. 9. Can you predict what will happen when this is switched on? Try it and see if you were correct.

Could you now design and try a ripple counter which could start at any binary number selected by switches connected to the SET terminals of the flip-flops, then count down, stopping at zero, but leaving the reset terminals free to be used with a switch?

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INTERFACE

TYPE	PRICE $	+ Sales Tax $
N8T20N	4.87	0.50
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N8T24N	2.29	0.18
N8T26N	3.43	0.23
N8T28N	3.43	0.23
N8T38N	3.24	0.18
N8T96N	2.14	0.16
N8T97N	2.14	0.16
N8T98N	2.14	0.16
S1757	8.50	0.63
S1883P	7.25	0.60
S2350	15.00	1.50
TMS6011	7.74	0.36
MO1-0185-5	8.25	0.42
75107	2.49	0.12
75108	2.49	0.12
75109	2.49	0.12
75110	2.49	0.12
75112	2.99	0.17
75154	3.99	0.30
75189	3.58	0.10
75363	3.99	0.28
75365	3.69	0.23
75451	0.81	0.05
75452	0.81	0.05
75491	1.18	0.08
75492	1.29	0.08

CPU's

TYPE	DESCRIPTION	PRICE $	+ Sales Tax $
MC6800L	8-Bit Ceramic	25.50	3.00
MC6800P	8-Bit Plastic	18.95	2.20
MC6802P	8-Bit On Board Ram & Clock	25.50	3.20
MC6820L	Per Interface Adaptor	11.95	1.35
MC6821P	Per Interface Adaptor	8.25	0.90
MC6850L	Asynch Com Interface Adaptor	11.50	1.25
MC6860L	0-600BPS Modem	12.00	1.40
MCM6830L8	Min BUG	13.05	1.50
MEC68MIN2	Min BUG II	50.00	3.70
MEC68MIN3	Min BUG III	75.00	4.10
MC6840P	Prog Timer Mod	17.50	2.00
MC6871A	MPU Clock 1MHz or 921.6 KHz	27.00	2.05

74LS00

TYPE	PRICE $	+ Sales Tax $
74LS00	0.40	0.03
74LS01	0.40	0.03
74LS02	0.40	0.03
74LS03	0.40	0.03
74LS04	0.47	0.03
74LS05	0.47	0.03
74LS08	0.40	0.03
74LS09	0.40	0.03
74LS10	0.40	0.03
74LS11	0.40	0.03
74LS12	0.40	0.03
74LS13	0.86	0.06
74LS14	2.25	0.16
74LS18	0.40	0.03
74LS20	0.40	0.03
74LS21	0.40	0.03
74LS27	0.40	0.03
74LS28	0.51	0.02
74LS30	0.40	0.03
74LS32	0.40	0.03
74LS37	0.51	0.04
74LS38	0.51	0.03
74LS40	0.81	0.04
74LS42	1.77	0.07
74LS51	0.40	0.02
74LS73	0.59	0.04
74LS74	0.61	0.04
74LS75	0.95	0.05
74LS76	0.59	0.03
74LS78	0.59	0.03
74LS83	2.24	0.11
74LS86	0.67	0.05
74LS90	1.54	0.05
74LS92	1.54	0.05
74LS93	1.54	0.05
74LS95	2.13	0.07
74LS107	0.81	0.04
74LS279	1.23	0.09
74LS298	2.89	0.12
74LS365	1.48	0.05
74LS366	1.48	0.05
74LS367	1.48	0.05
74LS375	0.99	0.05
74LS109	0.60	0.04
74LS112	0.66	0.04
74LS113	0.66	0.04
74LS114	0.66	0.04
74LS123	1.74	0.07
74LS124	2.22	0.16
74LS132	1.55	0.09
74LS136	0.67	0.04
74LS138	1.81	0.08
74LS139	1.91	0.09
74LS151	1.89	0.06
74LS153	1.89	0.06
74LS154	2.84	0.20
74LS155	2.21	0.12
74LS156	2.21	0.11
74LS157	1.59	0.06
74LS161	2.51	0.12
74LS162	2.51	0.12
74LS163	2.51	0.12
74LS164	2.20	0.12
74LS165	2.15	0.12
74LS174	2.03	0.08
74LS175	2.03	0.10
74LS181	4.83	0.24
74LS190	2.86	0.22
74LS191	2.86	0.12
74LS192	2.86	0.20
74LS193	2.86	0.09
74LS194	2.13	0.08
74LS195	2.13	0.15
74LS196	2.13	0.11
74LS221	2.01	0.11
74LS240	2.69	0.20
74LS241	2.69	0.20
74LS243	2.59	0.20
74LS244	2.69	0.20
74LS245	2.69	0.20
74LS247	2.20	0.10
74LS353	2.17	0.09
74LS257	2.17	0.09
74LS261	3.54	0.10
74LS266	0.71	0.04
74LS279	1.04	0.08
74LS283	1.83	0.12
74LS295	2.30	0.18
74LS298	2.30	0.18
74LS385	1.04	0.08
74LS366	1.04	0.08
74LS367	1.04	0.08
74LS368	1.04	0.08
74LS376	1.04	0.08
74LS393	2.30	0.18

4000 CMOS

TYPE	PRICE $	+ Sales Tax $
MC14000	0.35	0.02
MC14001	0.35	0.02
MC14002	0.35	0.02
MC14006	1.81	0.09
MC14007	0.35	0.02
MC14008	1.46	0.10
SCL4009	0.80	0.05
SCL4010	0.80	0.05
MC14011	0.35	0.02
MC14012	0.35	0.02
MC14013	0.67	0.06
MC14014	1.81	0.11
MC14015	1.16	0.12
MC14016	0.67	0.08
MC14017	1.81	0.11
MC14018	1.81	0.18
SCL4018	0.84	0.05
MC14020	1.71	0.12
MC14021	1.61	0.12
MC14022	1.51	0.11
MC14023	0.35	0.02
MC14024	1.20	0.09
MC14025	0.35	0.02
SCL4026	2.00	0.13
MC14027	0.67	0.06
MC14028	1.42	0.10
SCL4029	1.21	0.09
SCL4030	0.60	0.04
MC14032	1.81	0.14
SCL4033	2.00	0.13
MC14034	3.52	0.25
MC14035	1.81	0.13
MC14040	1.81	0.11
MC14041	1.20	0.06
MC14042	1.30	0.09
MC14043	1.81	0.11
MC14044	1.51	0.11
MC14046	2.32	0.14
MC14049	0.80	0.08
MC14050	0.80	0.06
MC14051	1.20	0.08
MC14052	1.20	0.09
MC14053	1.20	0.09
SCL4060	1.31	0.11
MC14066	1.01	0.08
MC14068	0.35	0.02
MC14069	0.35	0.02
MC14070	0.35	0.02
MC14071	0.35	0.02
MC14072	0.35	0.02
MC14073	0.35	0.02
MC14075	0.35	0.02
MC14076	1.81	0.12
MC14077	0.35	0.02
MC14078	0.35	0.02
MC14081	0.35	0.02
MC14082	0.35	0.02
MC14093	0.76	0.05
MC14099	3.20	0.25
MC14160	1.71	0.12
MC14161	1.71	0.12
MC14162	1.71	0.12
MC14163	1.71	0.12
MC14174	1.74	0.12

FLAT CABLE GREY

		PRICE $	+ Sales Tax $
14 Wire	per ft	0.44	0.05
16 Wire	per ft	0.50	0.05
20 Wire	per ft	0.54	0.06
40 Wire	per ft	1.25	0.13

SHIFT REGISTER

TYPE	PRICE $	+ Sales Tax $
SYP1404A	4.45	0.33
2527V	5.35	0.45
2532B	4.78	0.34
2533B	7.07	0.50
SYP2533	6.80	0.25
TMS3113NC	5.93	0.45
TMS3120NC	5.93	0.45
TMS2501NC	10.78	0.70
3258A	4.00	0.30
MCM6571P	8.75	0.76
MCM6575P	8.75	0.76
MCM6574P	8.75	0.76
MCM6576L	10.80	1.01

7400 TTL IC's

TYPE	PRICE $	+ Sales Tax $	TYPE	PRICE $	+ Sales Tax $
7400	0.35	0.03	74100	2.80	0.13
7401	0.35	0.03	74107	0.61	0.04
7402	0.35	0.03	74109	0.83	0.05
7403	0.35	0.03	74116	2.79	0.25
7404	0.40	0.03	74121	0.80	0.03
7405	0.40	0.03	74122	0.73	0.06
7406	0.76	0.04	74123	1.06	0.09
7407	0.76	0.04	74126	0.85	0.04
7408	0.36	0.03	74128	0.85	0.03
7409	0.35	0.03	74132	1.37	0.07
7410	0.35	0.03	74136	0.64	0.04
7411	0.43	0.03	74141	1.58	0.07
7412	0.40	0.03	74144	0.87	0.03
7413	0.76	0.04	74145	1.87	0.05
7414	2.38	0.08	74147	2.83	0.16
7415	0.40	0.03	74150	2.36	0.10
7416	0.73	0.03	74151	1.54	0.08
7417	0.73	0.03	74152	1.54	0.08
7420	0.35	0.03	74153	1.84	0.04
7423	0.40	0.03	74154	2.46	0.09
7425	0.40	0.03	74155	1.49	0.03
7426	0.62	0.03	74156	1.10	0.08
7427	0.47	0.03	74157	1.37	0.06
7428	0.66	0.03	74158	1.70	0.11
7430	0.36	0.03	74160	1.73	0.15
7432	0.47	0.03	74161	1.77	0.09
7437	0.66	0.03	74162	1.73	0.12
7438	0.66	0.03	74163	1.89	0.10
7439	0.66	0.04	74164	1.73	0.12
7440	0.36	0.02	74165	1.73	0.09
7441	1.43	0.02	74166	1.73	0.09
7442	0.99	0.03	74172	8.29	0.08
7443	1.80	0.07	74173	2.95	0.13
7444	1.80	0.08	74174	1.89	0.08
7445	1.87	0.08	74175	1.77	0.07
7446	1.81	0.08	74176	1.77	0.13
7447	1.72	0.08	74177	1.77	0.07
7448	1.72	0.10	74178	1.89	0.13
7450	0.35	0.02	74179	1.89	0.07
7451	0.36	0.02	74180	1.84	0.03
7453	0.36	0.02	74181	3.92	0.15
7454	0.36	0.02	74182	1.80	0.07
7460	0.35	0.02	74184	2.69	0.18
7470	0.66	0.04	74185	6.84	0.72
7472	0.64	0.02	74190	2.33	0.12
7473	0.61	0.02	74191	2.33	0.05
7474	0.61	0.03	74193	1.99	0.08
7475	0.96	0.04	74194	1.86	0.10
7476	0.66	0.02	74195	1.30	0.04
7480	1.18	0.08	74196	1.65	0.11
7483	1.67	0.08	74197	1.65	0.08
7485	2.32	0.14	74221	1.70	0.11
7486	0.64	0.03	74251	1.37	0.08
7489	3.84	0.18	74259	2.50	0.18
7490	0.80	0.04	74265	0.99	0.05
7491	1.42	0.07	74273	2.50	0.22
7492	0.80	0.08	74287	TBA	
7493	0.80	0.06	74298	2.13	0.17
7494	1.81	0.10	74365	1.84	0.05
7495	1.10	0.08	74367	1.84	0.05
7496	1.84	0.07	74368	1.84	0.05
7497	2.83	0.27	8602-9602	2.00	0.20

PHOTO OPTO DEVICES

TYPE	DESCRIPTION	PRICE $	+ Sales Tax $
MRD148	Photo Darl 12V BVceo TO92	0.55	0.04
2N5777	Photo Darl 25V BVceo TO92	1.32	0.20
MRD150	Micro T Transistor	1.20	0.11
MRD450	T1¾ Transistor	1.13	0.10
LPT100	TO106 Transistor	0.90	0.09
LPT110	TO106 with Lens Transistor	0.90	0.09
TIL78	T1 Transistor	0.74	0.05
TIL138	Source & Sensor (Interrupter)	2.58	0.18
TIL148/MCA81	Source & Sensor (Interrupter)	2.42	0.23

UJT SCR TRIACS

TYPE	PRICE $	+ Sales Tax $
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2N4441	1.20	0.12
2N4443	1.88	0.13
2N4444	2.95	0.21
2N4870	0.75	0.16
2N5061	0.66	0.12
2N6027	0.27	0.09
2N6069B	1.02	0.17
2N6070	1.32	0.18
2N6073A	1.50	0.25
2N6073B	1.35	0.30
2N6110	2.02	0.16
2N6155	0.78	0.17
2N6237	1.30	0.27
2N6240	0.55	0.10
C103Y	0.80	0.12
C103YY	0.84	0.16
C106B1	1.12	0.14
C106D1	1.32	0.15
C122B1	1.95	0.16
C122E1	7.02	0.80
C228D	0.40	0.09
C228E3	0.68	0.10
MU10	0.74	0.10
MBS4991	1.39	0.13
SC141D	1.99	0.27
SC141E	0.44	0.20
SC146B	1.84	0.27
SC146D	3.85	0.46
SC146E	4.64	0.48
SC250D	6.29	0.72
SC250E	0.52	0.08
SC260E3	0.59	0.09
TIC45	0.67	0.14
TIC46	0.41	0.09
TIC106D	1.23	0.28
TIC116D	1.76	0.28
TIC126D	1.14	0.28
TIC226D	1.41	0.27

OPTO

TYPE	DESCRIPTION	PRICE $	+ Sales Tax $
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DL701	.3" 7-Seg + 1 Overflo	2.40	0.17
DL702	.3" 7-Seg LH Decimal C	2.40	0.17
DL704	.3" 7-Seg LH Decimal C	2.40	0.17
DL707	.3" 7-Seg LH Decimal C	2.40	0.17
DL707R	.3" 7-Seg RH Decimal C	2.40	0.17
DL721	.5" Dual 7-Seg + 1 & Fu	8.50	0.46
DL722	.5" Dual 7-Seg + 1 & Full	8.80	0.46
DL727	.5" Dual 7-Seg Common	6.50	0.46
DL728	.5" Dual 7-Seg Common	6.50	0.46
DL746	.63" 7-Seg + 1 Overflo	4.20	0.32
DL747	.63 7-Seg Common An	4.20	0.32
DL749	.63" 7-Seg + 1 Overflow	4.20	0.32
DL750	.63" 7-Seg Common Cat	4.20	0.32
RL54	Red Diffused	0.25	0.03
RL55	Red Diffused	0.40	0.05
RL209	Red Diffused T1	0.40	0.05
RL209-03	White Diff T1	0.40	0.05
RL2000	Red Diffused T1¾	0.56	0.05
RL4403	Red Diffused T1¾	0.45	0.05
RL4484	Red Diffused T1	0.20	0.03
RL4850	Red Diffused T1¾	0.20	0.03
RL5054-1	Red diffused T1¾	0.20	0.03
DL4530	.2 4-Digit Anode MUX	8.15	0.80
TIL305	.3 5 x 7 Alphanumeric	2.92	0.24
TIL311	.3" Hexadecimal Logic	11.68	0.80
TIL312	.3" 7-Seg Anode Red	1.62	0.16
TIL313	.3" 7-Seg Cathode Red	1.62	0.18
TIL314	.3" 7-Seg Anode Green	3.72	0.16
TIL315	.3" 7-Seg Cathode Green	3.72	0.16
TIL316	.3" 7-Seg Anode Amber	3.72	0.16
TIL317	.3" 7-Seg Cathode Ambe	3.72	0.16
TIL321	.5" 7-Seg Anode Red	1.74	0.12
TIL322	.5" 7-Seg Cathode Red	1.74	0.12
YL4850	Yellow T1¾	0.45	0.05
GL4850	Green	0.45	0.05
TIL209	Red Diffused T1	0.21	0.02
TIL211	Green T1	0.27	0.03
TIL220	Red T1¾	0.24	0.03
TIL222	Green T1¾	0.30	0.04
TIL224	Amber T1¾	0.30	0.04
	Mounting Clips (Black)	0.04	0.01

RAM's PROM's

TYPE	PRICE $	+ Sales Tax $
DYNAMIC RAM		
TMS4060NL	16.73	0.48
MCM6604P	14.00	0.84
STATIC RAM		
SYP21L02A	4.20	0.39
SYP21L02-1	3.70	0.30
21LC2-2N	3.91	0.34
SYP2102A-2	4.00	0.30
SYP2102-A4	1.95	0.20
SYP2112-A	4.20	0.30
SYP2112-1	3.70	0.27
2112-2B	4.69	0.46
SYP2114C	18.00	2.34
TMS4044-45NL	18.00	0.87
TMS4045-45NL	19.47	0.87
5101L	18.50	2.00
55810-1	5.50	0.56
MCM6810AP1	5.50	0.56
HM3 6501-8	9.90	0.60
HM3 65010-5	6.44	0.54
HM1 6508-9	8.25	0.92
HM1 6508D-5	5.95	0.83
UV PROM		
ML1702AR	5.50	0.55
TMS2708JL	15.00	1.50
TMS2716JL	40.00	4.50
58834	18.50	1.39
58834-1	16.50	1.15
FUSIBLE LINK PROM		
HPROM1 0512-5	12.82	0.84
HPROM1 1024-5	5.25	0.68
HM3 7602-5	2.67	0.30
HM3 7603-5	2.67	0.22
HM3 7610-5	3.12	0.34
HM3 7611-5	3.12	0.29
HM3 7620-5	5.94	0.87
HM3 7621-5	5.94	0.88
HM3 7641-5	11.88	1.11

74C CMOS

TYPE	PRICE $	+ Sales Tax $
74C00	0.35	0.04
74C02	0.35	0.03
74C04	0.35	0.03
74C08	0.35	0.04
74C10	1.60	0.10
74C20	0.35	0.03
74C30	0.35	0.03
74C32	0.40	0.04
74C42	1.42	0.12
74C48	3.66	0.21
74C73	1.10	0.09
74C74	0.87	0.06
74C76	0.90	0.08
74C85	2.88	0.15
74C86	0.99	0.04
74C90	1.20	0.11
74C107	1.89	0.11
74C161	3.80	0.21
74C164	6.67	0.44
74C157	3.50	0.28
74C160	1.96	0.16
74C161	1.96	0.16
74C162	1.96	0.16
74C163	1.92	0.15
74C164	1.81	0.13
74C165	1.81	0.11
74C174	1.75	0.14
74C175	1.55	0.12
74C192	1.48	0.12
74C193	1.82	0.16
74C195	1.65	0.13
74C221	2.05	0.16
74C902	0.95	0.06
74C926	14.20	1.10
80C97	0.64	0.05

ZENERS

	PRICE $	+ Sales Tax $
½ Watt 3.3V 5% (Min. qty. 4) – ½ Watt 33V 5% (Min. qty. 4)	0.23	0.03
1 Watt 3.3 Volts 5% (Min. qty. 2) – 1 Watt 32 Volts 5% (Min. qty. 2)	0.34	0.06
5 Watts 3.3 Volts 5% – 5 Watts 68 Volts 5%	1.00	0.15

IC SOCKETS

(D=TIN, SD=GOLD)

		PRICE $	+ Sales Tax $
8-Pin	SD	0.36	0.04
8-Pin	D	0.32	0.04
14-Pin	SD	0.48	0.05
14-Pin	D	0.45	0.05
16-Pin	SD	0.53	0.06
16-Pin	D	0.50	0.06
18-Pin	SD	0.64	0.07
18-Pin	D	0.63	0.07
22-Pin	SD	0.80	0.09
24-Pin	SD	0.81	0.09
24-Pin	D	0.80	0.09
40-Pin	SD	1.81	0.16
40-Pin	D	1.47	0.15

TRANSISTORS

TYPE	PRICE $	+ Sales Tax $	TYPE	PRICE $	+ Sales Tax $
2N217	0.66	0.05	2N5038	4.20	0.56
2N267	0.60	0.06	2N5086	0.24	0.04
2N277	3.80	0.65	2N5087	0.24	0.04
2N301A	1.50	0.30	2N5088	0.24	0.04
2N697	0.73	0.14	2N5089	0.24	0.04
2N918	0.80	0.10	2N5180	0.81	0.06
2N2102	0.80	0.07	2N5191	0.86	0.13
2N2219	0.55	0.06	2N5193	0.91	0.13
2N2219A	0.80	0.06	2N5194	1.08	0.14
2N2222A	0.40	0.04	2N5210	0.72	0.06
2N2369A	0.36	0.06	2N5458	0.45	0.06
2N2484	0.40	0.05	2N5459	0.60	0.07
2N2905A	0.45	0.05	2N5461	0.67	0.06
2N2906A	0.45	0.05	2N5484	0.50	0.07
2N2907A	0.45	0.05	2N5485	0.51	0.07
2N3053	0.55	0.05	2N5486	0.50	0.07
2N3054	0.70	0.10	2N5589	4.80	0.39
2N3055	0.85	0.14	2N5590	6.30	0.49
2N3302	0.75	0.21	2N5591	10.35	0.80
2N3440	0.79	0.20	2N5856	0.88	0.11
2N3441	2.40	0.21	2N5944	7.50	0.73
2N3442	1.49	0.30	2N5945	10.80	1.06
2N3443	3.00	0.50	2N5946	13.20	1.08
2N3564	0.25	0.04	2N6027	2.05	0.13
MPS3564	0.25	0.04	2N6049	1.18	0.13
2N3565	0.25	0.04	2N6080	5.45	0.47
MPS3565	0.25	0.04	2N6083	12.95	1.38
2N3566	0.25	0.04	2N6084	13.75	3.00
2N3567	0.25	0.04	2N6274	13.50	4.05
2N3568	0.25	0.04	2N6378	20.28	2.61
2N3569	0.25	0.04	2N6425	1.80	0.20
2N3638A	0.25	0.04	MPS6530	0.44	0.03
2N3638	0.25	0.04	MPS6565	0.47	0.06
MPS3638A	0.25	0.04	MPS6566	0.50	0.04
2N3642	0.25	0.04	2N6577	1.76	0.19
2N3643	0.25	0.04	2N6576	1.55	0.23
2N3646	0.30	0.06	2N6609	3.90	0.52
MPS3646	0.28	0.06	2N6660	1.45	0.23
2N3710	1.35	0.08	3N210	1.25	0.09
2N3739	1.82	0.33	AC126	0.85	0.08
2N3766	1.63	0.31	AC128	0.85	0.09
2N3772	1.89	0.30	AD148	1.79	0.12
2N3773	3.50	0.37	AD161	1.40	0.21
2N3789	2.20	0.33	AD162	1.40	0.21
2N3866	1.08	0.19	AF126	0.75	0.10
2N3904	0.27	0.05	AF127	0.75	0.10
2N3906	0.52	0.06	BC107	0.20	0.05
2N3924	3.20	0.25	BC108	0.30	0.05
2N4034	0.50	0.09	BC109	0.25	0.05
2N4121	0.27	0.05	BC177	0.35	0.05
2N4141	0.80	0.10	BC178	0.35	0.05
2N4220A	0.60	0.10	BC327	0.30	0.05
2N4236	1.73	0.41	BC328	0.30	0.05
2N4248	0.28	0.06	BC337	0.30	0.05
2N4250	0.28	0.04	BC547	0.20	0.04
2N4355	0.28	0.04	BC548	0.20	0.04
2N4356	0.28	0.04	BC549	0.20	0.04
2N4401	0.72	0.13	BC557	0.20	0.04
2N4403	0.72	0.13	BC558	0.20	0.04
2N4427	1.24	0.16	BC559	0.20	0.04
2N4919	0.99	0.14	BC635	0.31	0.04
2N4922	0.86	0.14			

TYPE	PRICE $	+ Sales Tax $	TYPE	PRICE $	+ Sales Tax $
BC636	0.31	0.05	MPSA63	0.42	0.05
BC637	0.33	0.05	MPSA66	0.42	0.07
BC638	0.33	0.05	MPSA92	0.58	0.07
BC639	0.34	0.06	MPSA93	0.63	0.07
BD135	0.55	0.07	MPSU02	0.58	0.07
BD136	0.55	0.07	MPSU52	0.61	0.08
BD137	0.65	0.07	OC28	1.50	0.16
BD138	0.65	0.07	OC74	0.50	0.07
BD139	0.70	0.08	SOT8203	2.50	0.27
BD140	0.74	0.10	SOT9204	4.50	0.42
BD235	0.90	0.10	TIP31A	0.70	0.07
BD236	1.10	0.14	TIP31B	0.74	0.09
BD237	1.10	0.14	TIP31C	0.83	0.12
BD263	1.20	0.15	TIP32A	0.75	0.10
BD437	1.20	0.18	TIP32B	0.79	0.10
BD438	0.63	0.08	TIP32C	0.90	0.13
BF115	0.61	0.08	TIP33A	0.87	0.15
BF185	0.80	0.08	TIP34A	1.13	0.22
BF337	0.80	0.10	TIP35A	2.20	0.40
BF495	0.23	0.03	TIP36A	2.75	0.42
BFR91	4.17	0.20	TIP41A	0.87	0.10
BU205	3.86	0.45	TIP41C	1.09	0.14
EB203	5.50	1.05	TIP42A	0.91	0.10
EB204	9.20	0.80	TIP42C	1.20	0.15
ED203	8.75	1.10	TIP2955	1.35	0.18
ED204	5.75	0.39	TIP3055	0.85	0.12
MJ423	2.55	0.37			
MJ802	4.15	0.46			
MJ900	1.42	0.16			
MJ1000	1.42	0.18			
MJ2501	2.03	0.31			
MJ2955	1.20	0.14			
MJ3001	2.03	0.31			
MJ4032	3.31	0.51			
MJ4035	3.31	0.48			
MJ4502	4.30	0.87			
MJ15003	4.30	0.87			
MJ15004	0.85	0.12			
MJE340	1.32	0.23			
MJE350	0.90	0.07			
MJE371	0.88	0.07			
MJE521	1.10	0.13			
MJE700	0.94	0.12			
MJE800	1.21	0.17			
MJE1091	1.95	0.30			
MJE1101	2.25	0.28			
MJE2801	2.25	0.28			
MJE2901	2.85	0.25			
MJE2955	0.97	0.15			
MJE3055	1.55	0.20			
MJE3055T	0.97	0.16			
MPF102	0.45	0.05			
MPF131	3.60	0.49			
MPQ6842	0.45	0.06			
MPSA05	0.48	0.06			
MPSA06	0.50	0.04			
MPSA12	0.48	0.05			
MPSA34	0.42	0.04			
MPSA43	0.52	0.04			
MPSA55	0.52	0.04			

DIODES, RECT.

TYPE	DESCRIPTION	PRICE $	+ Sales Tax $
1N21B	Microwave	3.00	0.52
1N23B	Microwave	3.00	0.52
1N914	Signal (Min. quantity 5)	0.08	0.02
1N1186A	Sil Rect DO5 Stud 200V 40A	3.70	0.33
1N1188A	Sil Rect DO5 Stud 400V 40A	5.27	0.36
1N1200A	Sil Rect DO4 Stud 100V 12A	1.40	0.14
1N1206A	Sil Rect DO4 Stud 600V 12A	3.30	0.33
1N4001	Sil Rect 50V 1A (Min. quantity 5)	0.08	0.02
1N4004	Sil Rect 400V 1A (Min. quantity 5)	0.08	0.02
1N4007	Sil Rect 1000V 1A (Min. quantity 5)	0.12	0.03
1N4148	Signal (Min. quantity 5)	0.08	0.02
1N5401	Sil Rect 100V 3A	0.35	0.06
1N5404	Sil Rect 400V 3A	0.35	0.06
1N5406	Sil Rect 600V 3A	0.40	0.06
A14D	Avalanche 400V 1.5A	0.28	0.03
A14M	Avalanche 600V 1.5A	0.30	0.03
MR752	Sil Rect Axial Lead 200V 6A	0.88	0.12
MR754	Sil Rect Axial Lead 400V 6A	1.00	0.13
MR758	Sil Rect Axial Lead 600V 6A	1.56	0.13
UES701	Fast Recovery 50VA	7.75	1.00
UES1101	Fast Recovery 50V 2.5A	2.80	0.35
UES1301	Fast Recovery 50V 8A	3.00	0.35
BYX21L/200	Auto 25A (Press Fit) 200V	1.71	0.13
BYX21L/200(R)	Auto 25A (Press Fit) 200V	1.71	0.13
BRIDGE RECTIFIERS			
MDA101A	1 Amp 100 Volts	0.66	0.10
MDA104A	1 Amp 400 Volts	0.78	0.11
MDA108A	1 Amp 800 Volts	1.16	0.16
MDA201	2 Amp 100 Volts	1.00	0.14
MDA204	2 Amp 400 Volts	1.18	0.18
MDA206	2 Amp 800 Volts	1.74	0.24
MDA3501	35 Amp 100 Volts	2.62	0.50
MDA3502	35 Amp 200 Volts	2.70	0.62
MDA3504	35 Amp 400 Volts	2.77	0.66
MDA3508	35 Amp 800 Volts	4.54	0.90
MDA3510	35 Amp 1000 Volts	5.77	1.10

LINEAR

TYPE	PRICE $	+ Sales Tax $
MLM301AP1	0.52	0.06
MLM301AG	0.87	0.10
LM301AP	0.48	0.05
LM306P	1.78	0.18
LM307T	0.99	0.07
LM307V	0.87	0.06
MLM307P1	0.63	0.07
MLM308P1	1.20	0.12
LM308T	1.77	0.16
LM308V	1.81	0.10
MLM309K	2.90	0.12
MLM310P1	2.80	0.18
MLM311P1	1.12	0.12
LM311T	2.74	0.24
LM311V	1.81	0.06
LM317KC	3.39	0.34
MLM324P	0.84	0.08
MLM339P	0.79	0.07
LM339AN	5.09	0.33
LM380N-8	0.70	0.13
LM380N-14	1.45	0.26
NE555/MC14..	0.82	0.08
NE556/MC34..	1.30	0.09
NE565/MLM5..	1.90	0.22
NE567V	2.78	0.34
UA709CV/MC..	0.84	0.04
UA709CA	0.64	0.04
MC1709CG	0.90	0.07
UA710CA	0.75	0.05
UA711CN/CA	0.78	0.05
UA723N/MC1..	0.90	0.05
UA723CL/MC1..	1.35	0.08
LM725CN	1.40	0.28
UA733CK	1.59	0.10
UA741CN-8/MC..	0.82	0.03
UA741CT/MC1..	0.75	0.05
MC1741SCP1	2.10	0.15
UA747CN	1.77	0.13
ML748CS	0.50	0.03
UA748CN-14	0.99	0.06
MC1776CG	3.75	0.34
UA777CN	1.21	0.07
MC1310P	4.29	0.70
MC1316P	2.80	0.35
MC1327P	1.95	0.33
MC1330P	1.50	0.22
MC1331P	1.82	0.25
MC1350P	0.98	0.17
MC1352P	1.37	0.20
MC1358P	1.30	0.22
MC1403U	2.60	0.28
MC1405L	8.95	0.70
MC1406L	5.90	0.48
MC1407L	5.30	0.41
MC1408L8	4.50	0.49
SSS1408A8	7.10	0.49
MC1413PA/ULN2..	1.45	0.18
MC1438R	13.00	1.55
MC1456CG/CT	2.85	0.23
MC1458CP1	0.82	0.05
MC1458CG	0.98	0.07
MC1458P/V	1.55	0.12
MC1463R	8.15	0.45
MC1461R	8.25	0.58
MC1466L	8.60	0.65
MC1468L	4.35	0.34
MC1469R	5.00	0.33
MC1488L	3.75	0.23
HO3 1488-5	3.00	0.20
MC1489AL	3.75	0.23
MC1489AN	3.33	0.21
MC1494L	8.00	0.40
MC1495L	5.25	0.34
MC1496L	1.48	0.08
MC1496K	2.43	0.18
MC1550G	1.50	0.16
MC3301P	1.30	0.09
MC3302P	1.12	0.05
MC3340P	1.21	0.10
MC3360P	0.81	0.05
MC3401P	0.75	0.05
MC3403P	1.30	0.09
MC3420P	8.75	0.45
MC3459P	3.30	0.23
LM3900	0.95	0.06
MC4558CP1	0.78	0.05
MC7805CP	1.20	0.08
MC7805CK	2.40	0.16
MC7806CP	1.20	0.08
MC7806CK	2.40	0.18
MC7808CP	1.20	0.08
MC7808CK	2.40	0.16
MC7812CP	1.20	0.08
MC7812CK	2.40	0.18
MC7815CP	1.20	0.08
MC7815CK	2.40	0.18
MC7824CP	1.20	0.08
MC7824CK	2.40	0.16
MC7905CP	1.65	0.10
MC7905CK	3.16	0.12
MC7906CP	1.65	0.10
MC7906CK	3.16	0.12
MC7908CP	1.65	0.10
MC7908CK	3.16	0.12
MC7912CP	1.65	0.10
MC7912CK	3.16	0.12
MC7915CP	1.65	0.10
MC7915CK	3.16	0.12
MC7924CP	1.65	0.10
MC7924CK	3.16	0.12
MC78L05CP	0.50	0.04
MC78L06CP	0.50	0.04
MC78L08CP	0.50	0.04
MC78L12CP	0.50	0.04
MC78L15CP	0.50	0.04
MC78L24CP	0.50	0.08
MC79L05CP	0.78	0.08
MC79L06CP	0.75	0.08
MC79L08CP	0.75	0.06
MC79L12CP	0.75	0.06
MC79L15CP	0.75	0.06
MC79L24CP	0.75	0.06
CMP01CJ	5.50	0.41
CMP01CY	5.50	0.41
CMP01EJ	8.20	0.80
CMP02CJ	8.20	0.45

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Project 318

DIGITAL CAR TACHO

Compact unit offers both 10 rev resolution and short response time.

WE HAD OFTEN considered the design of a digital tacho for automobile use, but had rejected several schemes as we were unable to get both good resolution and response time — the two seemed to provide a very good demonstration of Heisenberg's Uncertainty Principle.

Consequently, we were rather pleased when Mike Pratt of S M Electronics came to us with his phase-locked loop based design which got round the problem. Would we like to do it as a project, he asked? Obviously, we said yes, and here it is.

To make the project even more attractive, we arranged with Mike to do a special offer on a kit of parts — there's more information on the offer on page 53.

This tacho features a fast response time, coupled with 10 Hz resolution, through the use of a phase locked loop frequency multiplier. It can be set up, by means of a single link, to work on 4, 6 or 8 cylinder motors.

Design Features

To measure the revolutions per minute of a motor is simply a matter of counting the number of ignition pulses over a given time. With a four cylinder, four stroke motor there is such a pulse twice per revolution. Therefore if we count these pulses for 30 seconds we will have revs/min with a one cycle resolution. Obviously this is much too long a sample period for practical use in a motor car and some compromise has to be made.

The usual solution is to use a 100 rev resolution and a sample time of 0.3 seconds (on 4 cylinders). We considered this inadequate which is why we have not published a design until now.

In this design an oscillator is used which is phase locked to the ignition pulses except at a higher frequency (x8 for 4 cylinder) allowing a short sample time (0.375 sec) with a 10 rev resolution. By using a different multiplication factor compensation for different numbers of cylinders can be made. Unfortunately with the multiplication factors used (x8, x6, x4) the sample time for 6 cylinders is not exactly the same as that used for 4 and 8 cylinder motors. Altering the ratios to x12, x8 and x6 would enable a 0.25 sample time to be used for all ranges, but this is not possible with the divider IC utilised in this design.

Construction

Assemble the pc board with the aid of the overlay ensuring the components are orientated correctly. The tantalum capacitors normally have a + mark indicating the positive load, or a dot on the side. When soldering the CMOS ICs (4, 6, 7) earth the tip of the soldering iron.

Note that there is one feedthrough or link between the two sides of the board near C10.

Calibration

Initially place a link between the point 'C' and the terminal corresponding to the number of cylinders. Now with the power supply connected feed a 50 Hz signal of between 12 and 30 V into the points input using the 0 V as common. Now adjust RV1 until the display reads 1500 RPM for 4 cylinders, 1000 for 6 or 750 for an eight cylinder car.

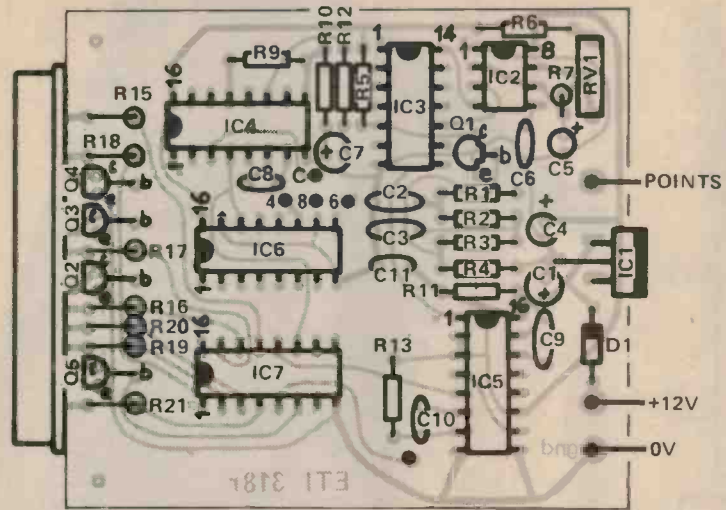


Fig. 1. The component overlay for the board. The board is double sided although only the lower surface is shown here. Note the link between the two surfaces of the board near C10.

SPECIFICATION – ETI 318

Range	100 to 9990 RPM
Resolution	10 RPM
Reading rate	
4 or 8 cylinders	2.66 per second
6 cylinders	3 per second
Power supply	7 to 15 V @ 400 mA
Suitable ignition systems	standard CDI transistor assisted * it will not operate on 'pointless' systems

PARTS LIST – ETI 318

Resistors all ¼ W, 5%

R1,2	39k
R3,4	22k
R5	1k5
R6	100k
R7	100R
R8	not used
R9	10k
R10	390k
R11	10k
R12	270k
R13	10k
R14	not used
R15–R21	27R

Potentiometer

RV1 . . . . 25k trim

Capacitors

C1	10µ 25V tantalum
C2,3	56n polyester
C4	10µ 25V tantalum
C5	4µ7 25V tantalum
C6	10n polyester
C7	1µ0 25V tantalum
C8	470p ceramic
C9	56n polyester
C10	10n polyester
C11	10n ceramic

Semiconductors

IC1	7805	regulator
IC2	555	timer
IC3	7413	dual schmitt
IC4	4046	PLL
IC5	74123	dual mono
IC6	4018	divide by n
IC7	74C925	4 digit counter
Q1	BC318	
Q2–Q5	BC338	
D1	1N4004	
Display	NSB5881	

Miscellaneous

PC board ETI 318
Case to suit

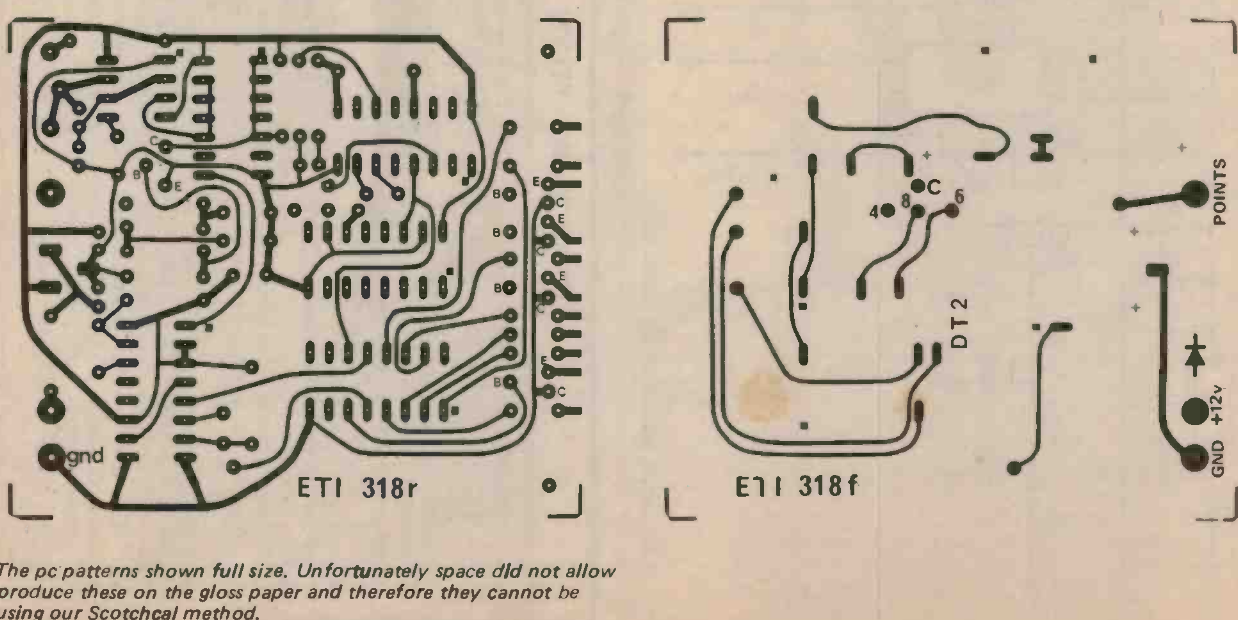


Fig. 2. The pc patterns shown full size. Unfortunately space did not allow us to reproduce these on the gloss paper and therefore they cannot be copied using our Scotchcal method.

DIGITAL CAR TACHO

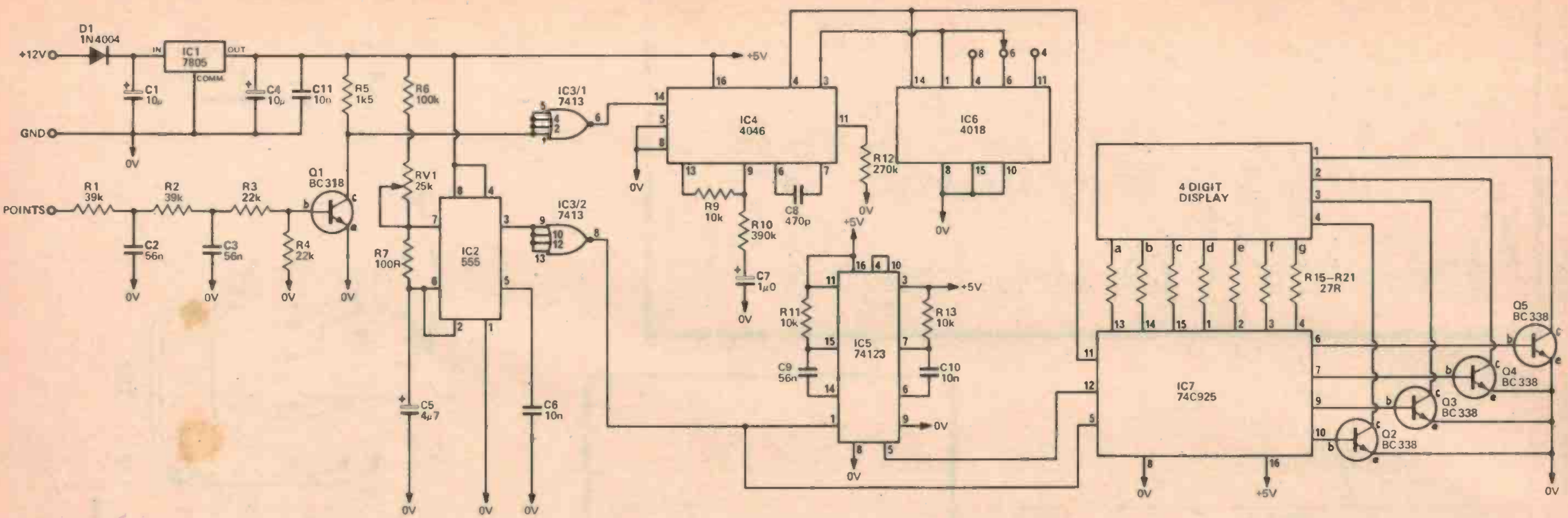


Fig. 3. The circuit diagram of the digital tacho.

HOW IT WORKS - ETI 318

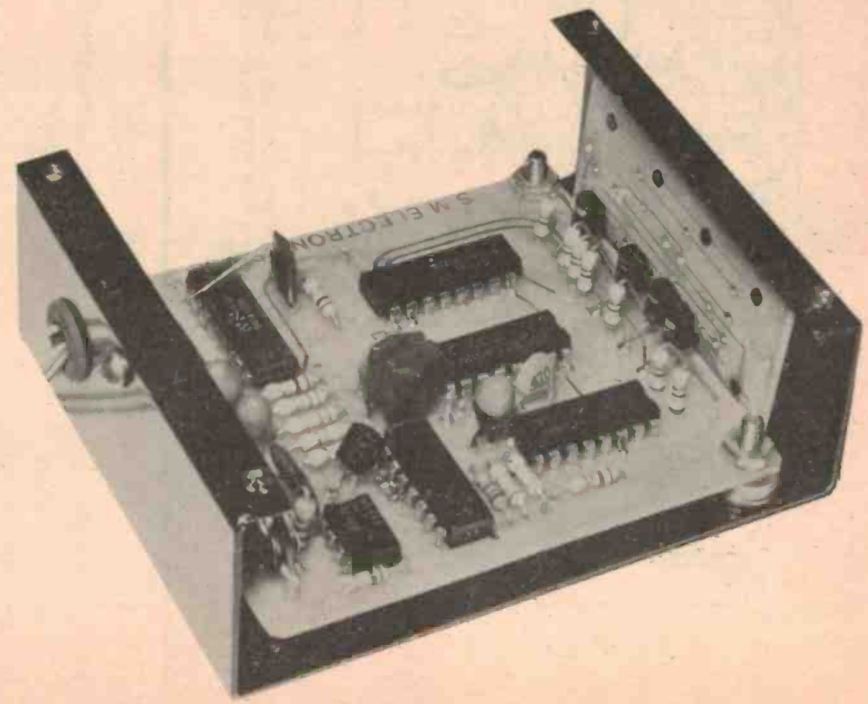
The output from the points of the distributor is basically a 0 to 12V square wave with a 200 volt pulse on the rising edge. A filter network, R1-R4, C2, 3 is used to remove the high voltage pulse (and points bounce) and Q1 buffers it giving a +5 to 0V output on its collector. As the filter network removes the sharp edge of the input a schmitt trigger is needed on the output of Q1 to give fast edges. IC3/1 is used for this.

The output of IC3/1 is connected to the input of the phase-locked loop IC (4046). This IC has an internal voltage controlled oscillator and its output is divided by 4, 6 or 8 by IC6 and this lower frequency is fed back to the phase-locked loop IC. The IC then compares this frequency to that at its input and adjusts the internal oscillator until it is the same. The result is a frequency which is an exact multiple of the input.

The time base is generated by IC2 (555) which has a negative output pulse, about 300 µs wide every 375 ms (or 333 ms for 6 cylinder). This is inverted by IC3/2 and is used as the strobe pulse for the 4 digit counter IC7. This pulse also triggers the first of the monostables in IC5 which gives a 200 µs delay before triggering the second half of IC5; this gives a 40 µs pulse to reset IC7 back to zero.

IC7 is a 4 digit counter with a latch (store) and seven segment decoder driver. It needs four external transistors to drive the digits but the segment drivers are internal. As we need only a three digit counter, i.e. for a 10 Hz resolution, with the right hand permanently zero the least significant digit is connected to the second right digit, etc., with the most significant digit connected to the right hand digit. Provided one does not exceed 9990 RPM this digit will remain on 0 as intended!

The 555 timer, the TTL and the 74C925 needs a regulated +5V and IC1 provides this with D1 preventing damage due to reverse polarity inputs.



SPECIAL OFFER

Tacho Kit $29.95

ETI 318

WE HAVE arranged with Mike Pratt of S M Electronics for him to offer ETI readers a complete kit of parts for this project at the special price of $29.95 plus $2.00 for packing and certified postage.

The kit includes all components necessary to build the project, including a metal case which has a rectangular hole in the front for the LED display.

To order, complete the coupon below, and send it, with a cheque for the appropriate amount, to: Tacho Offer, Electronics Today International, 15 Boundary Street, Rushcutters Bay, NSW 2011. Cheques should be made payable to 'Tacho Offer'. Please allow 4-6 weeks for delivery.

Send to: **Tacho Offer, Electronics Today International, 15 Boundary Street, Rushcutters Bay, NSW 2011.**

Please forward . . . . ETI 318 Tacho kits at $29.95 each plus $2.00 each certified postage and packing.

I enclose herewith cheque/postal order total . . . .

Please make cheques, etc., payable to 'Tacho Offer'.

Name . . . .

Address . . . .

. . . . Postcode . . . .

Offer closes 29 September, 1978 and is open to Australian residents only. Apologies to our overseas readers.

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Scotchcal® BRAND PHOTOSENSITIVE PRODUCTS

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These are both coated with a photo-sensitive emulsion which is exposed by ultra-violet light (the sun is ideal).

The aluminium sheet is usually used for front panels, name plates, etc, while the film is intended for transfering artwork into a form which enables exposure of panels, printed circuit boards, etc. Both products use the same developer, which is simply wiped on with a soft cloth or cotton wool.

NOTE: NO DARKROOM REQUIRED!

PHOTO-ALUMINIUM FOR PANELS AND LABELS

Either red or black emulsion, grey (aluminium) background. Simply expose to ultra violet light through suitable transparency (or artwork on clear or translucent film) and develop. Image is negative of artwork (clear areas remain, black areas develop away). Supplied with a FREE sheet of polyester material on which you can draw your artwork. 250 x 305mm.
RED emulsion, single sheet. Cat H-5692 .. .. .. $6.00
BLACK emulsion, single sheet. Cat H-5694 .. .. . $6.00

EXPOSURE FILM — FOR PANELS OR PCB's

Exposure and development identical to above process, but the base material is a clear polyester film. The image is orange, opaque to UV light. Ideal for exposing above or PCB resist. Also supplied with FREE artwork layout sheet. 250 x 305mm.
Cat H-5690 .. .. .. single sheet $3.90

SCOTCHCAL DEVELOPER

Suitable for either film or aluminium, enough for many sheets of material. Simply swab on with cloth or cotton ball.
Cat H-5696 .. .. $1.00

MATERIAL FOR MAKING PRINTED CIRCUIT BOARDS

As well as our Scotchcal range, we also offer everything for the easy manufacture of PCB's. Blank board, etchant, photo-resist, developer, touch-up pens, etc. You can make PCB's at home up to commercial quality — in a fraction of the time they used to take.

PHOTO—RESIST (POSITIVE)

For photographically transferring the printed circuit board pattern on to the blank PCB. Positive acting, so it's ideal for prototypes from 1:1 tapes & pads, etc. Exposed by UV light. Enough resist for around 240 square inches of board.
Cat H-5720 .. .. $3.75

POSITIVE DEVELOPER

Develops above resist. Washes off the unwanted section. 80g pack makes up to solution — instructions enclosed.
Cat H-5724 .. .. $1.85

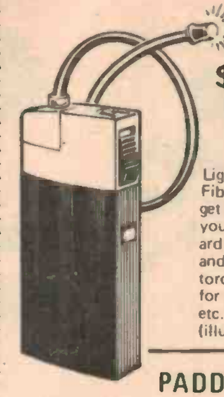
PHOTO—RESIST (NEGATIVE)

Similar to above resist, but is negative acting. Ideal for use with exposure film above to obtain patterns from magazines. Enough resistor for approx. 240 square inches.
Cat H-5722 .. .. $2.75

NEGATIVE DEVELOPER

Already made up in solution, enough to develop around 50g of negative photo resist.
Cat H-5726 .. .. $3.00

WOT'S NEW?



$3.95 X-1085 LITE-PROBE

Light right where you want it! Fibre-optic torch allows you to get over, under, up into, anywhere you need light. Takes two standard penlight batteries (not supp.) and can also be used as normal torch if required. A great idea for experimenters, servicemen, etc. Small enough for the pocket (illustration approx ½ size).

Having trouble with IC circuitry? Test clip brings out pins to where you can easily attach probes, leads, etc. Spring loaded for positive contact, should be in every hobbyists tool box! 16 pins — use with all DIL ICs up to 16 pins.

IC TEST CLIP $2.95 W-4600

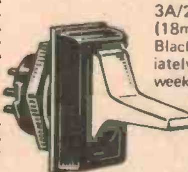
$1.95 FREE POWER! SOLAR CELL

Z-4825

Straight from space research — these little solar cells are ideal for the experimenter. We've checked them up to 60mA in bright sunlight, with no-load voltage up to 0.55V. Series or parallel them for greater output. Fantastic value.

PADDLE SWITCHES

Beautiful new switches will really make your project look pro! Piano-key-type paddle, DPDT 3A/240V switching. Through-hole (18mm) mounting from front. Black paddles available immediately, white (as shown) within 2 weeks. Classy!



$2.40 S-1393

4-WAY MAINS POWER BOX $16.50 P-5610

Throw away dangerous double adaptors. Power box plugs into wall socket and gives you 4 switched sockets where you need them. Each double pole switched and safety shuttered, too. Everyone needs extra power at times. Here's the safety way to get it!

WATCH THIS SPACE

AND FIND OUT WHAT YOU MISSED!

Each month, our stores and mail order dept. feature an outstanding BELOW COST special. All you have to do is go into any of our stores or buy from mail orders to find out what it is.

LAST MONTH:

A MULTI-TAP LOW VOLTAGE TRANSFORMER FOR ONLY $3.25 — NORMALLY $6.75

SAVING $3.50

WHAT'S THIS MONTH'S SPECIAL? CALL IN AND FIND OUT YOURSELF!

Pre-cut high quality PC blanks with copper (1oz laminate) on one side. Available in fibreglass or bakelite.

Size (mm)	Material	Cat No.	Price
150 x 75	Bakelite	H-5500	65c
150 x 150	Bakelite	H-5505	$1.20
300 x 300	Bakelite	H-5510	$2.95
150 x 75	Fibreglass	H-5540	$1.00
150 x 150	Fibreglass	H-5545	$2.10
300 x 300	Fibreglass	H-5550	$5.20
Double sided 1oz laminate			
228 x 150	Fibreglass	H-5560	$3.50

Blank 18 gauge aluminium sheet — ideal for making up heat sinks, small chasses, etc. Also use with rub-on lettering for your front panels, etc.

298 x 298mm	Cat H-2560	$2.00
149 x 149mm	Cat H-2558	$1.00

Ferric Chloride etchant for PCB's, etc. 4 oz jar to make up etching solution.
Ferric Chloride Cat H-5652 $1.90

Dalo touch-up pen, with unique ink that is also a resist to most common etchants. Ideal for repairing tracks in photo-resist (dust spots, etc) or for marking out simple PCB patterns. Valve-tip for fine ink control.
Dalo 33 pen Cat T-5170 .. .. $2.25

POT~POURRI

EXPERIMENTERS: CLOCKS ROCKS. Incredible scoop purchase of 3.58MHz clock crystals — big quantity buy enables us to sell them at less than half normal price!
Cat K-6031 .. .. Was $6.50 .. .. $3.00

AWA DIRECT DRIVE TURNTABLES — Only a few left!
See our advert on page 108 of June E.A. — this never-to-be-repeated offer is too good to miss out on. But you had better phone before coming in to the store — stocks may have already sold out! Don't dilly dally, pally.
Cat A-3072 .. ..$159.00

INSTANT MUSICIAN! You have to hear it — rhythm box gives a choice of 12, is ideal for bands, parties, etc. It is outstanding value at the price — compare others around. 240V.
Cat. F-3114 .. .. $115.00

CB ANTENNA ELIMINATOR won't give the game away — makes your car less of a target for the light-fingered lot. Uses your standard car radio antenna for the CB — and you can listen to both at once if you wish. Ideal for commercial travellers, etc, who aren't allowed to drill another hole in the car!
Cat D-5516 .. .. $24.50

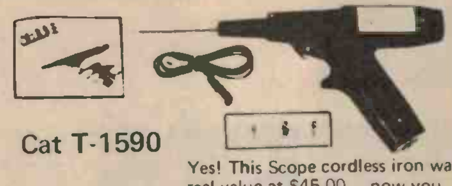
SAVE $30.00!!

Look what we found — hidden in a corner of the warehouse! Incredibly handy DC digital voltmeters — with the display in the probe, right where you want to see it! They sold like hot cakes at $89.50 — we thought we'd sold out. Because they've been removed from our computer memory we can't afford to have them lying around. So we're prepared to knock off an incredible $30.00 just to make sure they ARE sold out! But be quick — strictly limited stock. First in, first served!

$59.50

SPECIAL OFFER!

Buy this Scope cordless iron for only $45...



Cat T-1590

and we'll give you this $12.25 charger FREE!

Cat T-1592

$12.25 ~~$12.25~~

JULY ONLY

Yes! This Scope cordless iron was real value at $45.00 — now you get the iron PLUS a matching charger for the same low price. That has to be the bargain of the year ... Handy Scope iron goes with you on the job, no trailing wires or power problems to worry about. Easily available spare parts (uses Miniscope bit) and now the plug-pack charger to go with it. It's ideal for the serviceman, for the technician, for the hobbyist, for YOU. This offer is valid only for the month of July (or until stocks run out) and is not applicable in states where it contravenes consumer laws.

Gozinta

Wotsa Gozinta? Itsa thingamejig ya put thingsinta, of course!

Yes! The handiest carry box we've seen around. It's ideal for the handyman, the hobbyist, the service technician ... even the wife for a sewing box, or for the fisherman, the mechanic ... the list goes on and on. Neat, fold-away sections (2 trays and 15 compartments) Sturdy carry handle and lockable catch. 42 x 23 x 20cm. It's a little bottler!

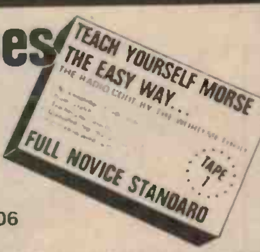
BUY ONE FOR MUM, TOO ...

$17.50

Cat H-2600

2 tapes

$7.90



Cat D-7106

WANT YOUR NOVICE LICENSE?

You know what the biggest hurdle is — the Morse Code. Dick's Morse tapes will help you get that coveted piece of paper. Starts off with the letters then forms them into words so you aren't learning the hard way. Ideal for the beginner or for exam practise. Two tapes — white is tape one and yellow tape two.

WIN A TRIP FOR TWO TO TOKYO

FLYING QANTAS

AUSTRALIA'S AIRLINE TO THE WORLD.

Every purchaser of Yaesu equipment from Dick Smith or participating dealers receives an entry form in the fabulous 'Win a trip for two to Tokyo' contest, flying Qantas and staying in a luxury hotel. Full details wherever Yaesu/Dick Smith products are sold.

YAESU

REMEMBER — THE CONTEST CLOSES IN JULY — AND YOU NEED TO THINK ABOUT YOUR ENTRY. SO DON'T DELAY!

CONTEST CLOSES 28TH JULY

PARTS FOR NEW KITS

NEW FANTASTIC TV GAME (See July E.A.)
10 games — sound — on screen scoring ...
See our full page advert and the constructional article in this issue for full details of this exciting project.
Complete kit, including instructions .. Cat K-3472 .. $49.50
SEPARATE PARTS:
- PC Board (only) ... Cat H-8344 .. $3.95
- Fully built RF modulator ... Cat K-6040 .. $3.00
- Fully built audio modulator ... Cat K-6042 .. $4.50
- AY-3-8600 IC ... Cat Z-6852 .. $15.00

TRANSISTOR TESTER (See July E.A.)
See this issue for full details.
Full kit with instructions: Cat K-3052 ... $17.90
SEPARATE PARTS:
- PC Board (only) ... Cat H-8350 .. $1.95
- 1mA panel meter ... Cat Q-2010 .. $7.90

PHOTO TACHOMETER (See July E.A.)
Although we do not produce a full kit for this project, all parts are normal stock lines at our branches:
- PC Board (only) ... Cat H-8353 .. $1.80
- FPT100 photo transistor ... Cat Z-1950 .. $2.00

SIMPLE CRYSTAL CHECKER (See July E.A.)
Not produced as a special kit — all parts are normal stock lines except the front panel.

STUNT MOTORCYCLE GAME (See June E.T.I.)
A game of incredible skill and excitement yet it's so easy to build. Kit includes quartz crystal and pre-built, pre-aligned modulator — no tuning required.
Full kit with instructions ... Cat K-3474 .. $29.50
SEPARATE PARTS:
- PC Board (only) ... Cat H-8615 .. $3.85
- Fully built RF modulator ... Cat K-6040 .. $3.00
- AY-3-8760 IC ... Cat Z-6854 .. $19.50
- 3.58MHz xtal (new low price) ... Cat K-6031 .. $3.00

AUDIO OSCILLATOR (See June E.A.)
Easy to build, very handy piece of test of test gear.
Complete kit: Cat K-3469 ... $25.00
- PC Board (only) ... Cat H-8614 .. $3.65

VK POWERMATE (See May E.A.)
Short form kit, includes all electronic components, but not metalwork, mains wiring or terminals.
Short form kit: Cat K-3449 ... $32.00
SEPARATE PARTS:
- PC Board (only) ... Cat H-8342 .. $2.00
- Special electros (5600uF/40V) .. Cat R-4570 .. $3.90
- Power transformer ... Cat M-2000 .. $17.32

R-C-L BRIDGE (See March E.A.)
Complete kit, supplied with printed, but un-punched front panel. Handy piece of test gear, real value price.
Full kit with instructions: Cat K-3468 ... $34.50
- PC Board (only) ... Cat H-8339 ... $2.50

ELECTRONIC MORSE CODE KEYER (See March E.A.)
Complete kit, supplied with paddle. Supplied in case with plain, un-drilled panels.
Full kit with instructions Cat K-3470 ... $37.50
SEPARATE PARTS:
- PC Board (only) ... Cat H-8340 .. $3.75
- Paddle only ... Cat D-7103 .. $17.50
- 9 volt battery (special type) ... Cat S-3200 .. $2.00

If your project is not listed, don't despair: Parts for most of the magazine articles are stocked at Dick Smith Electronics stores.

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Hitel Hi Fi	145 Queen St, St Marys. NSW. Ph 623-4442
Don House Electronics	2 Merriwa St, Gordon NSW. Ph 498 1398
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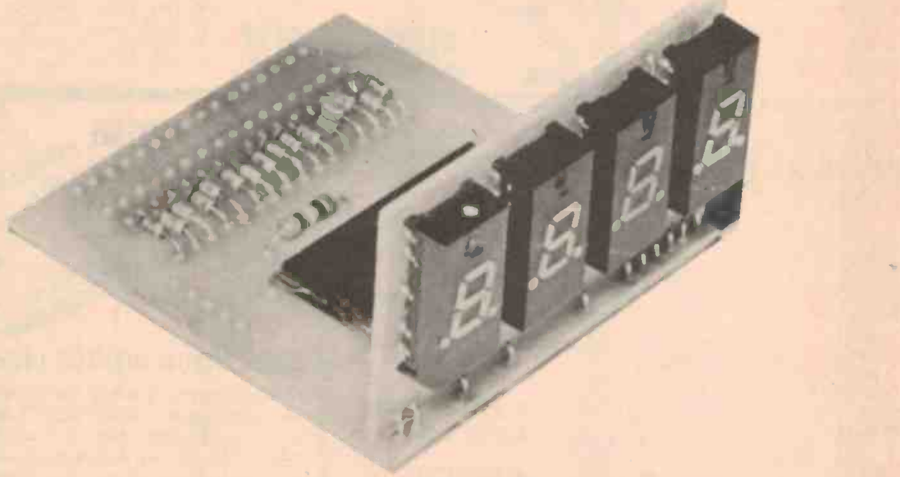
Double Diamond	18 Russel St, Goulburn NSW. Ph 21-5440
Greg McCartney	99 Fitzmaurice St, Wagga NSW. Ph 21-3044
Rivercom	9 Copeland St, Wagga NSW. Ph 21 2125
GCG Communications	385 Mulgrave Rd, Cairns QLD. Ph 54-1035
The Elect. Hobby Centre	1168 Gold Coast Hwy, Palm Beach QLD. Ph 34-1248
Premier Sound	239 Musgrave St, Rockhampton QLD. Ph 27-4004
Sumner Electronics	97 Mitchell St, Bendigo, VIC. Ph 43-1977
Aero Electronics	123A Bathurst St, Hobart TAS. Ph 34-8232
Tasmanian Hi Fi	87A Brisbane St, Launceston. TAS. Ph 31-5815
Devon Electronics	45 Ashburner St, Devonport TAS. Ph 24-4216.
A E Cooling	Town Centre, Peoples St Bldg, Elizabeth SA. Ph 255-9196
Hutchesson's Communic.	5 Elizabeth St, Mt Gambier, SA. Ph 25-6404
Altronics	105 Stirling St, Perth WA. Ph 328-1599
BP Electronics	11 Duke St, Albany WA. Ph 41-2681.

UP/DOWN PRESETTABLE COUNTER

- *4 digit
- *up/down counting
- *drives LEDs directly
- *latch
- *presettable
- *second register
- *equal and zero outputs
- *DC to 2MHz
- *5V operation



THE THREE DIGIT display (ETI 533) we previously published has proved to be one of our most popular projects. We have used it in a number of projects and we know of several commercial companies using it in their own equipment.

Many people have asked us for a 4 digit version and we have been looking round at ICs available. We have chosen this Intersil device because we believe it offers the best versatility at the moment. Apart from being a 4-digit counter-latch-decoder driver needing no external components except the displays, it also is an up-down counter and can be preset to any number. In addition, it has a separate register which also can be set to any number and comparators which give outputs when the counter is equal to the register and when it is zero - all in one IC!

Construction

The unit is built on two small pc boards which are connected together with short links of tinned copper wire. Be careful to orientate the IC correctly as it is expensive!

The preset system is designed to use a 4 digit BCD thumbwheel switch (closed = '1') but individual switches can be used if required. Input is in BCD, therefore the switches will have the weighted values 8, 4, 2 and 1. If the preset is not needed then the diodes can be left out. If a preset is needed, but always to a fixed number, links can be inserted to replace the "on" switches and the other diodes left out.

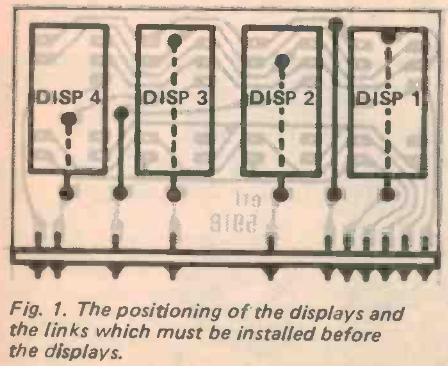


Fig. 1. The positioning of the displays and the links which must be installed before the displays.

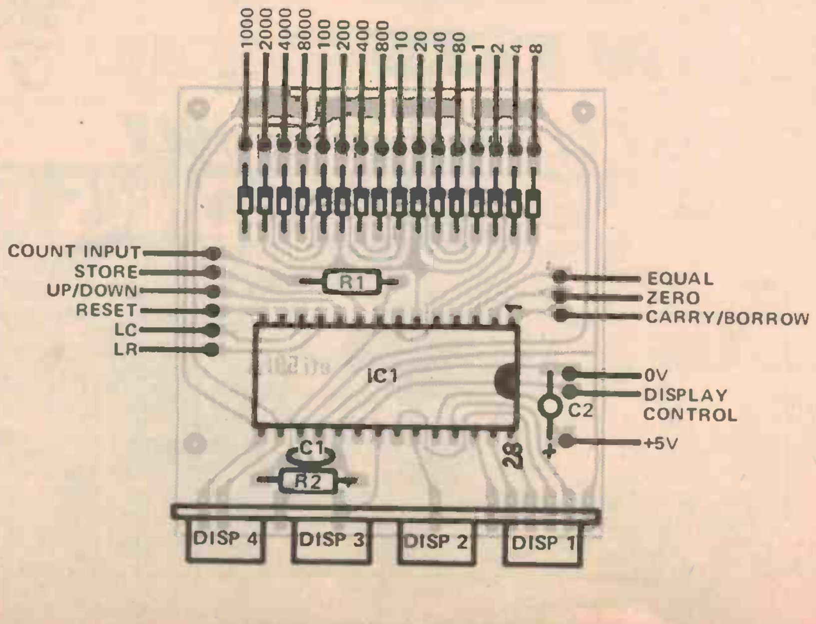


Fig.2. The component overlay for the main board. The common connection from each of the thumbwheel switches goes to the track next to the other connections.

HOW TO USE IT - ETI 591

This section is normally How it Works but as it is only one IC there is not much to be said!

Count Input - Pin 8
The counter is incremented or decremented on the leading edge of this input. A schmitt trigger is provided with a 500 mV hysteresis on a 2V trigger point. For high speed operation, or operation from a digital output, delete R2 and C1 and short out R1. Maximum frequency of operation is about 2 MHz.

Up-Down - Pin 10
If this pin is left open or taken to +5V the counter will be incremented by the count input. If it is taken to 0V the counter will be decremented by the count input.

Reset - Pin 14
If this pin is left open or taken to +5V the counter is free to be incremented or decremented. If it is taken to 0V the counters will be reset to zero and held there until reset is taken high again.

Store - Pin 9
If this input is left open or taken to +5V the latches are "closed" and the information which was in the counters at the time the store input went high will be remembered, decoded and displayed. The counters can be reset, incremented or decremented without affecting the display.

If it is taken to 0V the counter contents will continuously be displayed for as long as this input is at 0V. Any change in the counter contents will be shown on the display.

Load Counter - Pin 12
This is a 3 level input. If it is left open the counter works normally. If it is taken to +5V the counter is loaded with the BCD data which is set on the thumbwheel switches. If the latch is open, this number will also be displayed. If this input is taken to 0V the BCD I/O pins become high impedance. If a 3 level input is to be controlled by other logic outputs they must be tristate devices.

SPECIFICATION – ETI 591

Number of digits	4
Readout	LED
Maximum frequency	2MHz
Input impedance	100k
Output drive	1 TTL load
Supply voltage	4.5 – 5.5V
Supply current	
low power mode	500μA
all eights	100mA

PARTS LIST – ETI 591

Resistors all ½W, 5%
R1 . . . . . 100k
R2 . . . . . 1M

Capacitors
C1. . . . . . 33n polyester
C2. . . . . . 1μ0 35V tantalum

Semiconductors
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D1–D16 . . 1N914
DISPLAYS. DL704

Miscellaneous
PC boards ETI 591A, ETI 591B

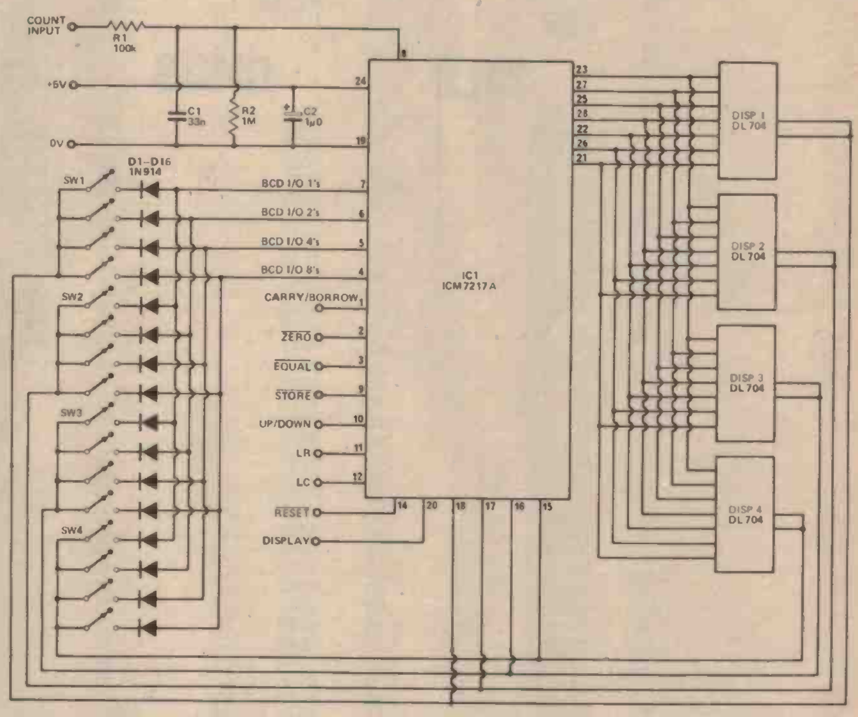

Fig. 3. The circuit diagram for the counter board.

Load Register - Pin 11
This is also a 3 level input. If it is left open the counter works normally. If it is taken to +5V the register is loaded with the BCD data. If taken to 0V the circuit goes to a low power state with the multiplexing oscillator stopped, the display off and the BCD I/O pins in a high impedance state. The operation of the counter is unaffected except that there is no display.

Display Control - Pin 20
This is also a 3 level input. If it is left open, leading edge blanking occurs. If all digits are zero then all are blanked. If it is connected to +5V the display is completely blanked irrespective of the value. If taken to 0V all digits are ON irrespective of value.

Scan - Pin 13
The internal multiplexing frequency is nominally 10 kHz giving a digit repetition rate of 2.5 kHz. With a 20 pF capacitor from this point to 0V the frequency drops to 5 kHz and with 90 pF it is about 1 kHz.

BCD I/O - Pin 4-7
This is a multiplexed data port, normally an output which can drive 1 TTL load. It becomes an input when either LC or LR is at +5V. Pin 7 is the least significant bit.

Digit Drives - Pins 15-18
These are used both to drive the LEDs and to provide data indicating which digit is being presented at the BCD I/O port. Pin 18 is the least significant digit.

Zero - Pin 2
If the value of the counter is zero this output will be at 0V.

Equal - Pin 3
If the value of the counter is equal to the value of the register this output will be at 0V.

Carry/Borrow - Pin 1
When the counter goes from 9999 to 0000 or from 0000 to 9999 a 500 ns positive pulse occurs on this output. This is connected to the count input of a second unit when an eight digit display is needed.

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7400	.28
7401	.28
7402	.28
7403	.28
7404	.37
7405	.37
7406	.50
7407	.50
7408	.34
7409	.34
7410	.30
7411	.37
7413	.54
7414	1.03
7416	.60
7417	.60
7420	.30
7422	.30
7426	.45
7427	.45
7430	.30
7432	.43
7437	.50
7438	.50
7440	.30
7441	1.50
7442	.70
7447	1.25
7448	1.25
7450	.35
7451	.35
7453	.35
7454	.30
7460	.35
7470	.65
7472	.45
7473	.60
7474	.65
7475	.65
7476	.45
7480	1.25
7483	1.25
7485	1.45
7486	.65
7489	1.20
7490	.75
7491	1.00
7492	.75
7493	.75
7494	1.10
7495	.95
74100	2.45
74107	.65
74121	.60
74123	1.10
74132	1.25
74150	1.80
74151	1.10
74153	1.10
74154	1.70
74157	1.10
74160	1.55
74164	1.55
74165	1.55
74173	2.75
74175	1.65
74180	1.35
74192	1.40
74193	1.40
74221	1.50
74367	1.40

74LS

74LS00	.30
74LS01	.30
74LS02	.30
74LS03	.30
74LS04	.35
74LS05	.35
74LS08	.30
74LS09	.30
74LS10	.30
74LS11	.30
74LS12	.30
74LS14	1.20
74LS20	.30
74LS21	.30
74LS27	.30
74LS28	.40
74LS30	.30
74LS32	.33
74LS37	.45
74LS38	.45
74LS40	.30
74LS42	1.20
74LS73	1.20
74LS74	.50
74LS75	.70
74LS78	.50
74LS85	1.50
74LS86	.50
74LS90	1.20
74LS92	1.20
74LS93	1.20
74LS95	1.50
74LS109	.50
74LS113	.55
74LS114	.55
74LS138	1.20
74LS151	1.20
74LS154	1.60
74LS157	.90
74LS163	1.20
74LS164	1.30
74LS174	1.00
74LS175	1.00
74LS191	1.20
74LS192	1.20
74LS193	1.20
74LS194	1.20
74LS195	1.20
74LS196	1.20
74LS221	1.20
74LS253	1.85
74LS279	.65
74LS365	.80
74LS367	.80
74LS368	.80

CMOS

4000	.25
4001	.25
4002	.25
4006	1.40
4007	.25
4008	1.25
4011	.25
4012	.25
4013	.55
4014	1.35
4015	1.20
4016	.50
4017	1.40
4018	1.40
4019	.75
4020	1.60
4021	1.40
4022	1.60
4023	.25
4024	.90
4025	.40
4027	.80
4028	1.25
4029	1.90
4030	.40
4040	1.30
4041	1.25
4042	1.25
4043	1.50
4044	1.50
4046	1.95
4049	.60
4050	.60
4051	1.20
4052	1.20
4053	1.20
4060	2.65
4066	1.00
4068	.40
4069	.35
4070	.40
4071	.40
4072	.40
4073	.40
4074	.40
4076	1.85
4077	.40
4078	.40
4081	.40
4082	.40
4510	1.50
4511	1.50
4518	1.50
4520	1.45
4528	1.20
4555	1.20
14553	7.50
14584	1.25
74C00	.40
74C02	.40
74C04	.40
74C08	.40
74C10	.40
74C14	1.90
74C48	2.55
74C73	1.20
74C75	1.20
74C76	1.35
74C90	2.25
74C93	2.25
74C175	1.85
74C192	2.25
74C193	2.25

LINEAR

301	.40
307	.65
308	1.35
311	.85
324	1.35
339	.90
349	2.25
356	1.65
380	2.00
381	2.00
382	2.00
386	1.95
555	.35
556	.85
565	1.95
566	2.50
567	2.65
709	.75
723(VR)	.55
741	.35
747	1.25
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7805	1.30
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7808	1.30
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7815	1.30
7818	1.30
7824	1.30
7905	2.25
7912	2.25
7915	2.25
78L05	.50
78L12	.50
78L15	.50
79L05	.85
79L12	.85
79L15	.85

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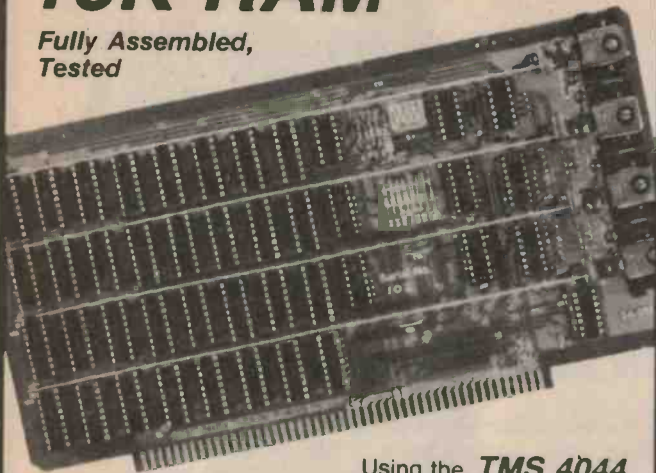

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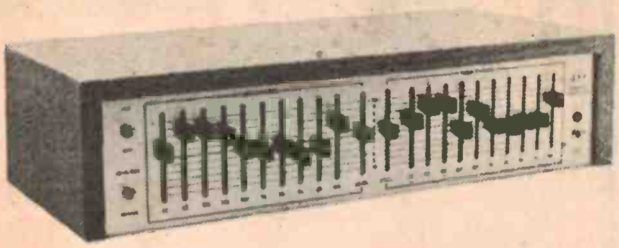

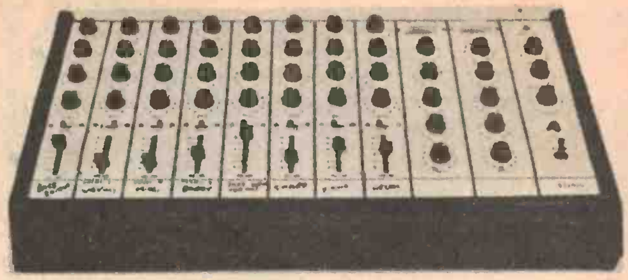

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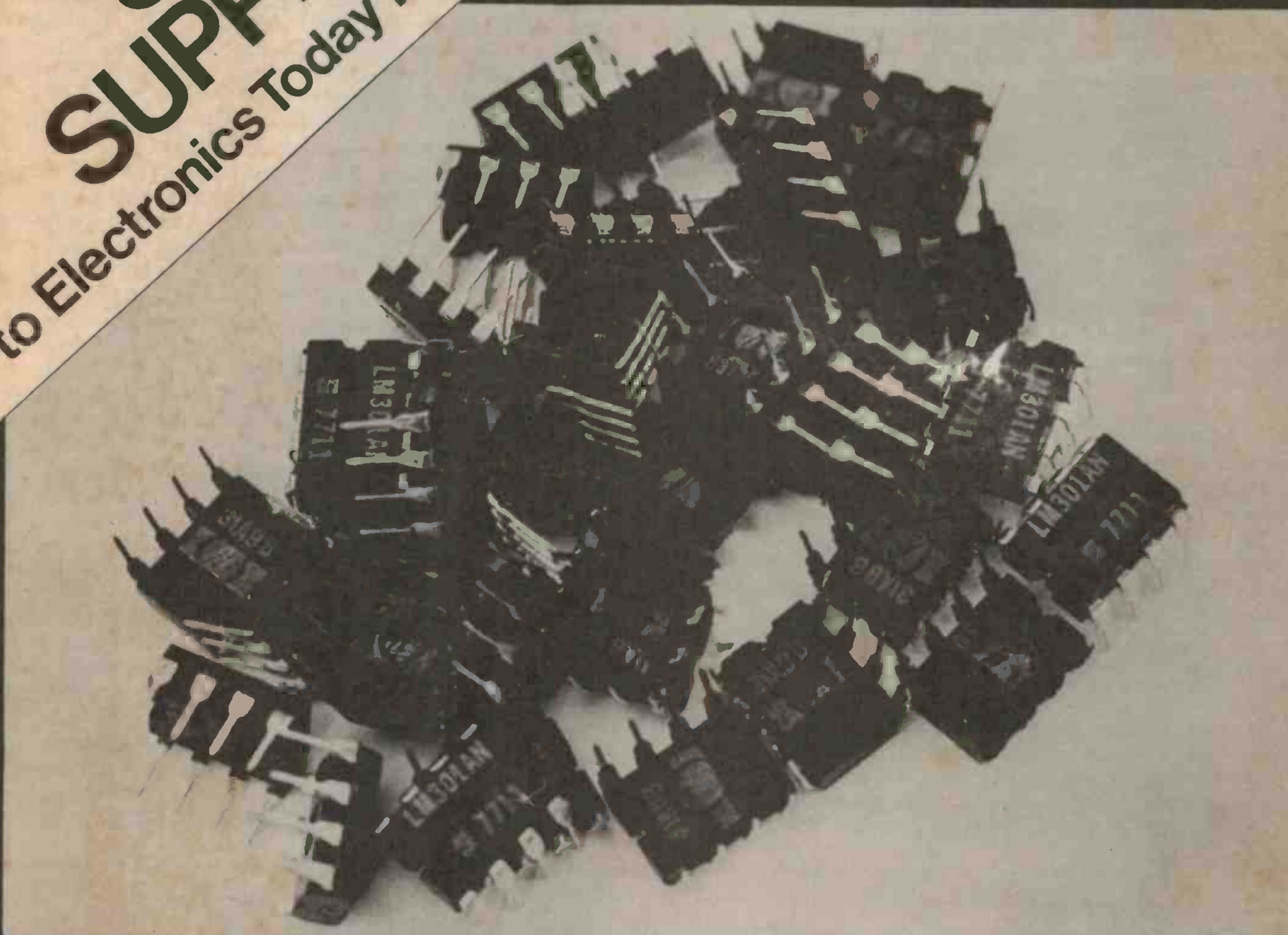


OPERATIONAL AMPLIFIERS

28 USEFUL CIRCUITS

OP-AMPS

An operational amplifier is just a high gain amplifier — you stick a voltage in and a much larger one comes out. But you'd never know this from the data sheets. 'Overkill' confuses all but the most experienced. It really doesn't have to be so. Tim Orr explains. . .

OP-AMPS HAVE TWO inputs, inverting and non-inverting, denoted by — and + respectively. The op-amp amplifies the difference in the voltages applied to these two inputs, the output going positive if the + input is positive with respect to the — input, and vice versa. Without extra circuitry, though, an op-amp is virtually useless, for the gain is too high to be useable and distortion is excessive. Fortunately both parameters can be controlled by feedback.

An op-amp with negative feedback is shown in Fig. 1. Two resistors set the closed loop voltage gain, and as long as this is small compared to the open loop gain, it will be determined by the resistor ratio RF/RI. The open loop gain, the voltage gain when RF is removed, is typically 1 000 000. This massive gain is clearly much too large to be used without feedback. Closed loop voltage gains of 100 are about as much as it is practical to use.

Biased example

The arrangement in Fig. 1 is known as a 'virtual earth' amplifier. The non-inverting input is connected to earth, and the inverting input is maintained by the feedback applied via RF at a voltage which is virtually earth potential.

The input impedance of the amplifier in Fig 1 is simply R1. The output impedance is a little more complicated, approximately:—

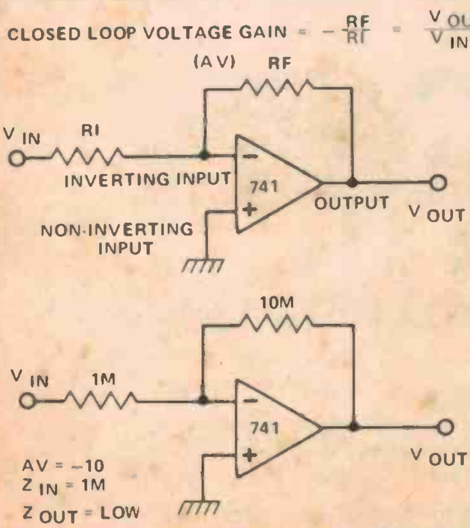
$$\frac{\text{output impedance of the op amp} \times \text{closed loop gain}}{\text{open loop gain}}$$

Suppose we want an amplifier with a gain of 10, and an input impedance of 1M. This means that RI is 1M. Therefore RF must be 10 M (see Fig. 2). With a 1 V sinewave as the input signal we get a 10 V sinewave as the output. However, when the input signal is held at 0V, it is positive! This is an error voltage, which may be undesirable. The cause of the problem is the 'INPUT BIAS CURRENT' of the op-amp. The input of many op-amps looks like the circuit shown in Fig. 3. If these transistors are to operate correctly they need a standing emitter current which implies that they need an input base current. It is this base current which is the op-amp's 'INPUT BIAS CURRENT'. For a 741 this current can be as large as $0.5\,\mu A$. In the arrangement of Fig. 2 this current can only come through RF, which means that the output voltage could be as large as $0.5\,\mu A \times 10\,M$, which is +5 V! One way to remedy this error is to use the circuit shown in Fig. 4. A resistor has been inserted between the non-inverting input and ground. This resistor has the value of RF in parallel with RI. It allows both the inputs to sink slightly and thus maintain the voltage balance at the inputs. The output voltage is then nearly 0 V. However, the two input transistors may not be that well matched, so the bias currents into each input may be different. This is known as the 'INPUT OFFSET CURRENT' and its effect can be nulled by making the 910 k resistor in Fig. 4 a variable resistor. But even if the bias currents (for say a 741) were zero, then the output voltage would still not be 0 V.

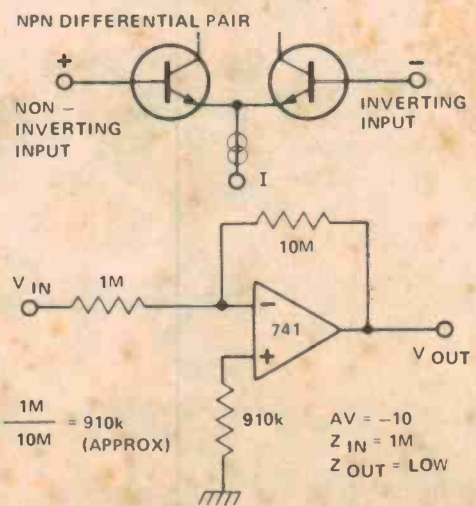
Get set, they're off

The output voltage could range between ±60 mV. This is due to the 'INPUT OFFSET VOLTAGE' which for a 741 can be as much as ±6 mV, which is then multiplied by the closed loop voltage gain of the stage (in this case 10 giving us ±60 mV. This can be compensated by using the circuit shown in Fig. 5. Terminals 1 and 5 on a 741 can be used to compensate for the input offset voltage. The input offset voltage is the V_{be} imbalance between the two input transistors.

Now that we know how to eliminate the spruious dc offsets, we can try designing some dynamic circuits and find out why they don't work as expected! For example, try



Figs 1 and 2 show (upper) the basic inverting op-amp stage. Gain is given by the ratio of resistors RF/RI, input impedance is simply RI, while the output impedance is more complicated (see (text). Fig. 2 (lower) shows a stage with a gain of 10 and an input impedance of 1 M.



Figs 3 and 4 (left) show (upper) a typical op-amp input stage. This is a differential amplifier made up of a pair of NPN transistors driven by a constant current source. Fig.4 (left) shows a 910 k resistor in series with the + input of the op-amp. This reduces the effects of the input offset current.

putting a 1 V sinewave at 200 kHz into the circuit shown in Fig. 5. What you would expect is a 10 V, 200 kHz sinewave at the output — but you don't get one. What appears is a rather bent 200 kHz triangle waveform. This is because the 'SLEW RATE' of the op-amp has been exceeded. The slew rate is the speed at which the output voltage can move, and for a 741 is typically 0.5 V/μs when it crosses zero, so the op-amp, faced with this demand, just gives up and slew limits, drawing out straight lines as it does so.

Listen to the band(width)

Another limitation is 'BANDWIDTH'. A 741 has a GAIN BANDWIDTH product of approximately 1 MHz. This means that the product of the voltage gain times the operating frequency cannot exceed 1 MHz.

For example, if you want the amplifier to have a gain of 100, then the maximum frequency at which this gain can be obtained is 10 kHz. Figure 6 illustrates this phenomenon. Curve A is the open loop response, note that the voltage gain is 1 at 1 MHz, hence the gain bandwidth product of 1 MHz. The slope of the curve is −20 dB/decade, which is caused by a single 30 pf capacitor inside the IC. Now, if the resistor ratio is set to give a voltage gain of 100, then the op-amp gives a frequency response shown by curve C, which is flat up until 10 kHz. A gain off 10 rolls off at 100 kHz (D) and a gain of 1 000 rolls off at 1 kHz (B). Thus it is very easy to see just what the closed loop frequency response will be. However, don't forget the slew rate problem. You may be able to construct an amplifier with a voltage gain of 10, which works up to 100 kHz, but the output voltage will be limited to less than 3 Vpp! Another problem is distortion in the op-amp. Negative feedback is used to iron out any distortion generated by the op-amp, but negative feedback relies on there being some spare voltage gain available. For instance, say the op-amp generates 10% distortion and there is a surplus voltage gain of 1 000,

$$\text{i.e. } \left(\frac{\text{open loop gain}}{\text{closed loop gain}}\right),$$

then the distortion will be reduced to approximately,

$$\frac{\text{open loop distortion}}{\text{surplus voltage gain}} = \frac{10\%}{1\ 000} = 0.01\%$$

So, negative feedback is used to eliminate distortion products, However, if there is no surplus voltage gain, as in the case of a 741 amplifier working at 10 kHz, with a closed loop gain of 100, the distortion will rise dramatically at this point.

Current thinking

Most op-amps have a voltage output, although some have a current output. If you short-circuit a voltage output then large currents could flow and thermal destruction might follow. To overcome this problem, most op-amps have a current limited output so that they can tolerate an indefinite short to ground. A 741 is limited to about 25 mA. Another current of note is the supply 'BIAS CURRENT'. This is the current consumed when the op-amp is not driving any load. For a 741 this current is typically 2 mA, which makes it unsuitable for some battery applications.

There are some op-amps which can be programmed by inserting a current into them so that their supply current can be controlled. This means that they consume only micropower when in their 'standby' mode, and can be quickly turned on to perform a particular task.

Voltages differently

In the few examples shown so far, the op-amp has been used to amplify voltages which have been generated with respect to ground. However, sometimes, it is required to measure the difference between two voltages. In this case you would use a 'Differential' amplifier, Fig. 7. By using two matched pairs of resistors, the formula for the voltage gain is made very simple. It is thus possible to sumperimpose a 1 V sinewave on both the inputs, and yet have the output of the amplifier ignore this common mode signal and amplify only differential signals. The amount by which the common mode signal is rejected is called the CMRR (the Common Mode Rejection Ratio) and is typically 90 dB for a 741. Thus a common mode 1 V signal would be reduced to 33 μV.

Another rejection parameter to be noted is the supply voltage rejection ratio. For a 741 the typical rejection is 90 dB; that is, if the power supply changes by 1 V the change in the output voltage will be 33 μV.

When designing with op-amps it is very important to know what voltage range the inputs will work over, and the maximum voltage excursion you can expect at the output. For instance, the 741 can operate with its inputs a few volts from either power supply rail, and its inputs can withstand a differential voltage of 30 V (with a power supply of 36 V).

This is not true of all op-amps, some have a very limited differential input voltage range, for instance the CA3080 will zener when this voltage exceeds 5 V and the amplifier performance will then be drastically changed.

The output excursion of the op-amp is also important. The 741 can only typically swing within about 2 V of either supply rail, whereas the CMOS op-amp can swing to within 10mV of either rail so long as the load into which they are driving is a very high impedance.

Continued on page 80. . .

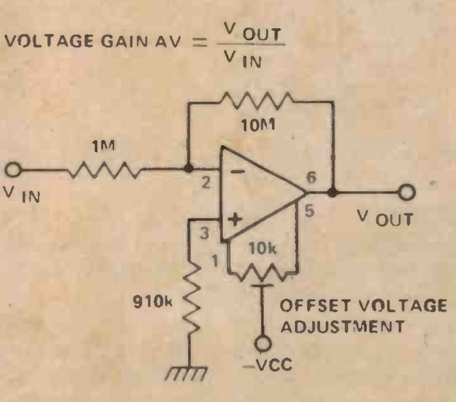
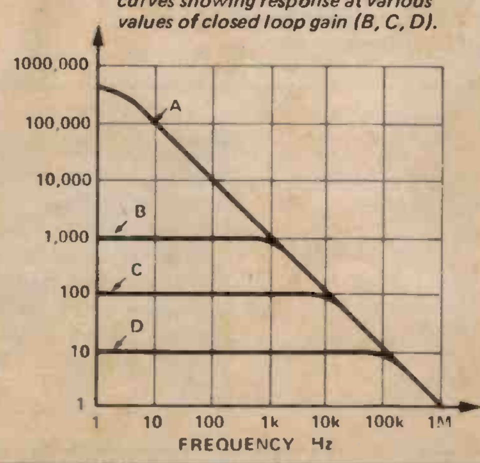


Fig. 5. A variable resistor connected between pins 1 and 5 of a 741 can be used to reduce the effects of the input offset voltage.

Fig. 6. Graph of open loop response of a 741 (A) together with curves showing response at various values of closed loop gain (B, C, D).



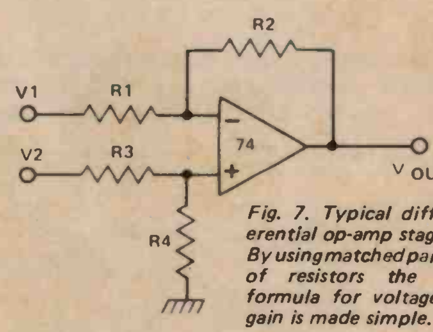


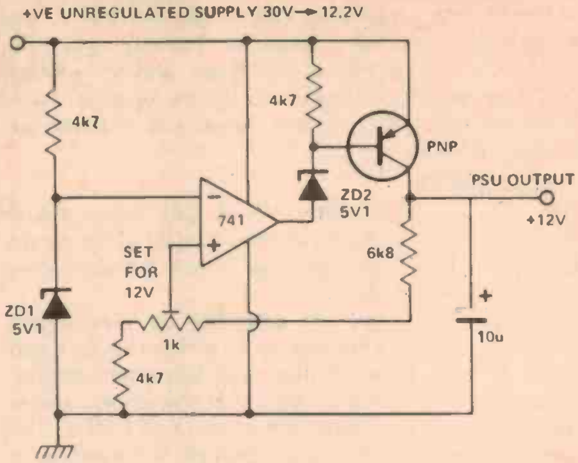
Fig. 7. Typical differential op-amp stage By using matched pairs of resistors the formula for voltage gain is made simple.

$$V_{OUT} = \left(\frac{R1 + R2}{R3 + R4}\right)\frac{R4}{R1}V2 - \frac{R2}{R1}V1$$

BUT IF WE MAKE R1 = R3
AND R2 = R4
THEN $V_{OUT} = \frac{R2}{R1}(V2 - V1)$

12 V REGULATED POWER SUPPLY

The large open loop voltage gain of an op-amp is very useful in providing a regulated low output impedance power supply. A 5V1 voltage reference is generated by a zener diode ZD1 (this voltage reference could be made more stable by running it at constant current). A PNP transistor is used as a series regulator. However, this transistor inverts the signal from the op-amp output, and so, in order to get negative feedback, the feedback is taken to the non-inverting input! The operations is as follows. The inverting input is held at 5V1. If the 'PSU OUTPUT' tries to fall, the voltage at the non-inverting input falls. Therefore the op-amp's output will also fall, thus turning on the PNP transistor which then pulls up the 'PSU OUTPUT'. Thus the output voltage is stabilised. Also, the output impedance is very low, due to this negative feedback. The output impedance at high frequencies (where the op-amp gain is low) is further reduced by the 10 μ capacitor. To squeeze the last drop of voltage out of the system, before a collapsing unregulated supply rail causes the regulated supply to drop out, a 5V1 zener diode (ZD2) has been included. This allows the op-amp output to work at about 7 volts below the unregulated supply rail. Thus, a regulated output is maintained until the PNP transistor saturates. This means that the unregulated rail can fall to within about 200 mV of the regulated rail!



SIMPLE INTEGRATOR

An op-amp and a capacitor can be used to implement, to a high degree of accuracy, the mathematical process of integration. In this case, current is summed over a period of time and the resultant voltage generated is the integral of that current as a function of time. What this means that if a constant voltage is inputted to the circuit, a ramp with a constant slope is generated at the output. When the input is positive, the output of the op-amp ramps negative.

In doing so it pulls the inverting terminal negative so as to maintain a 'virtual earth' condition. In fact the input current (Vin/R1) is being equalled by the current flowing through the capacitor, thus equilibrium is maintained. The equation governing the behaviour of a capacitor is C x dV/dt = i, where dV/dt is the rate of change of voltage across the capacitor.

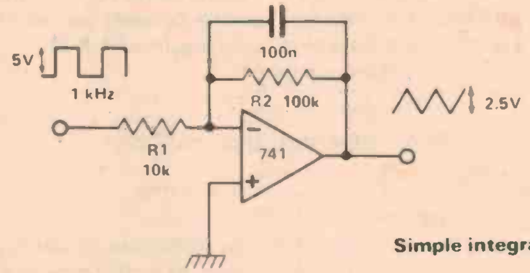
Therefore

$$\frac{dV}{dt} \quad \frac{i}{C}$$

Thus

$$\frac{dV}{dt} \quad \frac{Vin}{R1C}$$

So, when a square wave is applied to the circuit in Fig. 10, triangle waveforms are generated. R2 was added to provide DC stability. Its inclusion does slightly corrupt the mathematical processes, but not enormously. A good point about this integrator design is that it has a very low output impedance. You can put a load on the output and the op-amp will still generate the same waveform — that's what is so nice about negative feedback.



Simple integrator.

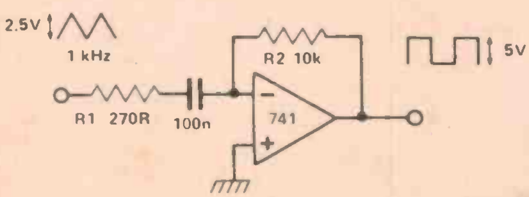


Fig. 11. Simple differentiator.

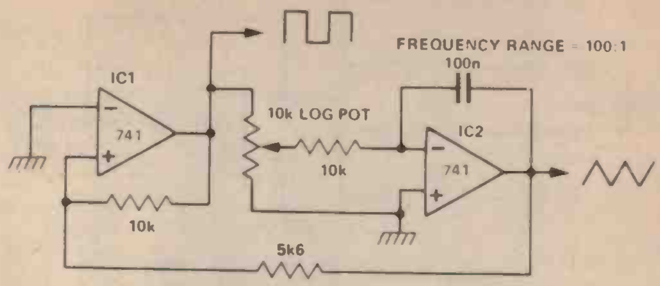
SIMPLE DIFFERENTIATOR

Mathematically, differentiation is the reverse process to integration. Thus, in the differentiator circuit the C and the R are reversed with respect to the integrator circuit.

The input waveform is a triangle with a constant rise and fall slope. This constant slope, when presented to a capacitor will generate a constant current. When the slope direction reverses, then so will the current flow. This current when passed through a resistor (R1), will then generate a square wave.

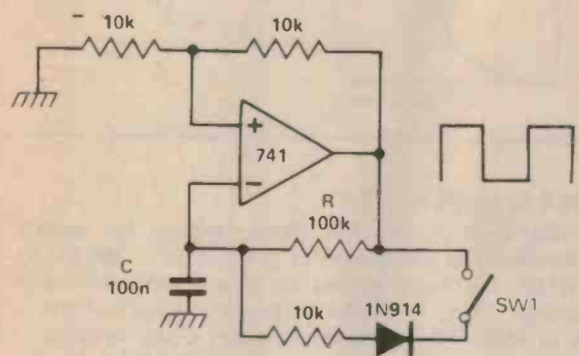
TRIANGLE SQUARE OSCILLATOR

A Schmitt trigger and an integrator can be used to construct a very reliable oscillator which generates triangle and square waveforms. The operation of the circuit is very simple and always self starting. The Schmitt trigger is formed from IC1, the integrator from IC2. Suppose the output of the Schmitt is positive. This will cause the integrator to generate a negative going ramp. This ramp is then fed back to the input of the Schmitt. When the lower hysteresis level has been reached the output of the Schmitt snaps into its negative state, current is taken out of the integrator which then generates a positive going ramp. The integrator's output ramps up and down between the upper an lower hysteresis levels. The speed at which the integrator moves is determined by the magnitude of the voltage applied to it. In this circuit, the magnitude of the voltage and hence the oscillation frequency, are controlled by a potentiometer, giving a 100 to 1 control range. This circuit is the basis of most function generators. By bending the triangle it is possible to synthesise an approximation to a sinewave. With a bit more electronics it is also possible to make the oscillator voltage controlled.



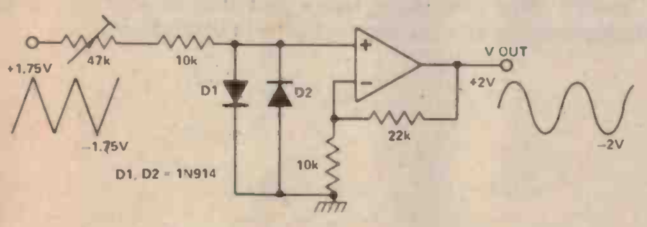
SINGLE OP-AMP OSCILLATOR

This circuit has a Schmitt trigger and a 'sort of integrator' all built around one op-amp. The positive feedback is via the 10 k resistors. The 'integration', (the timing) is controlled by the RC network. The voltage at the inverting input follows that of the RC charging exponential, except that it is confined to be within the upper and lower hysteresis levels. Thus the hysteresis levels and the RC time constant determine the frequency of operation. It is possible to make the output square wave have a large mark to space ratio. By closing the switch SW1, the discharge time of the capacitor becomes eleven times faster than the rise time. Thus a square wave with an 11:1 mark space ratio is generated.



SIMPLE TRIANGLE TO SINEWAVE CONVERTER

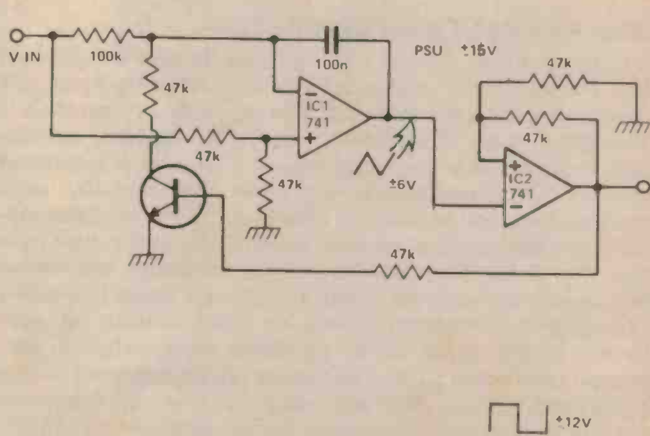
Here is a simple way of converting a triangle to a sinewave. The logarithmic characteristic of the diodes is used to approximate that of a sine curve. Distortion is 5% or so. However, the distortion may be tolerable if the sinewave is only used to generate audio tones.

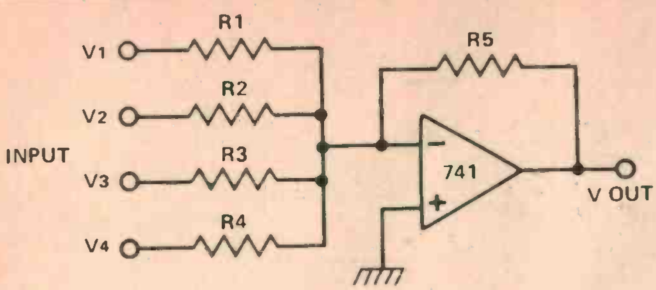


LINEAR VOLTAGE CONTROLLED OSCILLATOR

This oscillator is very similar to the triangle square wave oscillator shown on this page, except that this one is voltage controlled. The integrator and Schmitt trigger action are the same as before, but the feedback has been altered. The input voltage Vin, is applied differentially to the integrator via the resistor network. The larger the value of Vin, the faster the integrator ramps up and down. Thus the frequency of the operation is determined by an external positive control voltage. The frequency is linearly proportioned to this control voltage.

When the output of the Schmitt is low, Q1 is off and all the input voltage is applied to the inverting input. Half of the input voltage is always applied to the non-inverting input. Therefore the integrator's output ramps downward until the Schmitt flips into its positive state. Now, Q1 is switched on and the voltage at the inverting input is negative with respect to the non-inverting input. Hence the integrator now ramps upwards.





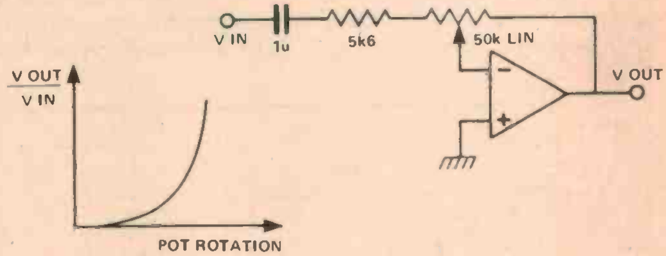
$$V\ OUT = -R5\left(\frac{V1}{R1}+\frac{V2}{R2}+\frac{V3}{R3}+\frac{V4}{R4}\right)$$

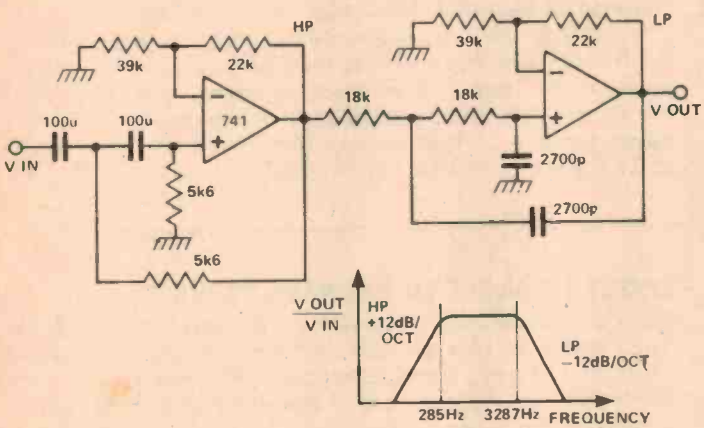
BASIC SUMMING CIRCUIT (MIXER)

A virtual earth amplifier can be used to mix several signals together. The output voltage is a mixture of all the inputs. The amount of an input that appears at the output is inversly proportional to the input resistor. If the input voltages are fed into potentiometers before being fed to the mixer, then their individual levels can be manually adjusted. This is the basis of most audio mixers, although the cheaper units use op-amps. Most op-amp mixers will degrade the signal to noise ratio of the signals by more than a good discrete component amplifier.

TURNING A LINEAR POT INTO A LOG POT

By using the virtual earth characteristic of an op amp, a linear pot can be made to have the characteristics of a log pot. It seems to be fair to say that low cost linear pots are far more linear than log pots are logarithmic. Thus the linear pot can be turned into a better log pot than the actual log pot itself. By varying the resistor ratio 5k6 to 50 k, other laws can be produced, such as something in between log and linear or maybe a law that is even more extreme than log.





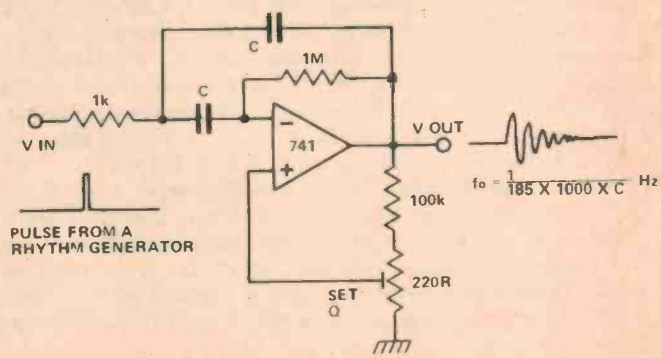
SIMPLE SPEECH FILTER

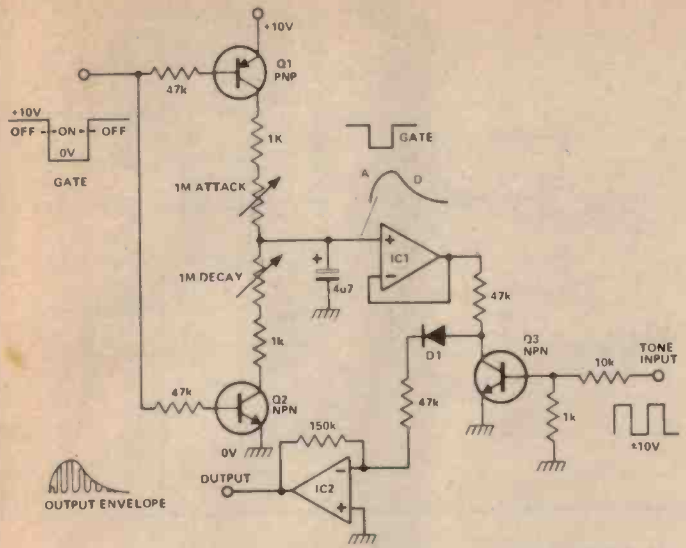
The telephone system has been designed for speech communication. The bandwidth of the system is 300 Hz to 3400 Hz, which has been arrived at after many years of experimentation. Thus, it is true to say that much of the information in speech is contained between these frequency limits. The circuit shows a filter structure that will simulate the telephone bandwidth. It could have many uses, for instance as a 'speech filter' for noisy radio reception or land line communications, or as a voice detector for a light show.

SIMPLE MUSICAL CHIME GENERATOR

The circuit shown is that of a multiple feedback band-pass filter. The present is used to add some positive feedback and so further increase the Q factor. The principle of operation is as follows. A short click (pulse) is applied to the filter and this makes it ring with a frequency which is its natural resonance frequency. The oscillations die away exponentially with respect to time and in doing so closely resemble many naturally occuring percussive or plucked sounds. The higher the Q the longer the decay time constant. High frequency resonances resemble chimes, whereas lower frequencies sould like claves or bongos, By arranging several of these circuits, all with different tuning, to be driven by pulses from a rhythm generator an interesting pattern of sounds can be produced. There may be some stability problems when high Q or high frequency operation is involved. To achieve better performance, an op-amp with a greater bandwidth than the 741 should be used.

Alternatively, a different structure, such as a state variable filter could be used. Qs of up to 500 can be obtained with this latter circuit.





MUSICAL ENVELOPE GENERATOR AND MODULATOR

A gate voltage is applied to initiate the proceedings. When the gate voltage is in the ON state, Q1 is turned on, and so the capacitor C is charged up via the attack pot in series with the 1 k resistor. By varying this pot, the attack time constant can be manipulated. A fast attack gives a percussive sound, a slow attack the effect of 'backward' sounds. When the gate voltage returns to its off state, Q2 is turned on and the capacitor is then discharged via the decay pot and the other 1 k resistor, to ground. Thius the decay time constant of the envelope is also variable.

This envelope is buffered by IC1, a high impedance voltage follower and applied to Q3 which is being used as a transistor chopper. A musical tone in the form of a squarewave is connected to the base of Q3. This turns the transistor on or off and thus the envelope is chopped up at regular intervals, the intervals being determined by the pitch of the squarewave.

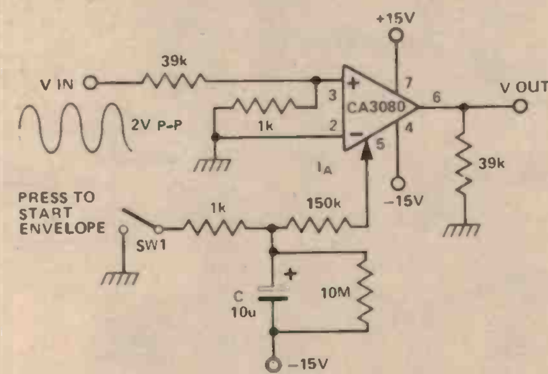
The resultant waveform has the amplitude of the envelope and the harmonic structure of the squarewave. IC2 is used as a virtual earth amplifier to buffer the signal and D1 ensures that the envelope dies away at the end of a note.

SIMPLE MUSICAL ENVELOPE GENERATOR

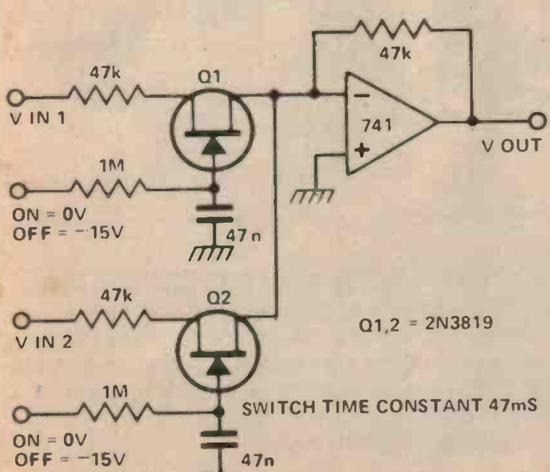
A simple generator can be constructed using the CA3080 (made by RCA). This circuit will also enable the use of an audio waveform the harmonic structure of which will not be significantly affected as it is modulated. The CA3080 is an op amp with a difference. It has a current output and an extra input into which a current, I_A is fed. The output is the product of the input voltage X I_A. Thus the I_A can be used to control the amplifier's gain.

The input voltage range for low distortion operation is very low, of the order of ± 25 mV.

The CA3080 is being used as a two-quadrant multiplier. A small voltage, (± 25 mV), is applied to its non-inverting input. When the switch S1 is closed, the capacitor C is charged up and a current of about 150 μA flows into the IA input terminal. When S1 is opened, C discharges through the 150 k resistor into the I_A input. This current dies away exponentially. As the output is the product of the input voltage X I_A, then



an exponential envelope is generated. Breakthrough after the decay is very good, better than −80 dB.

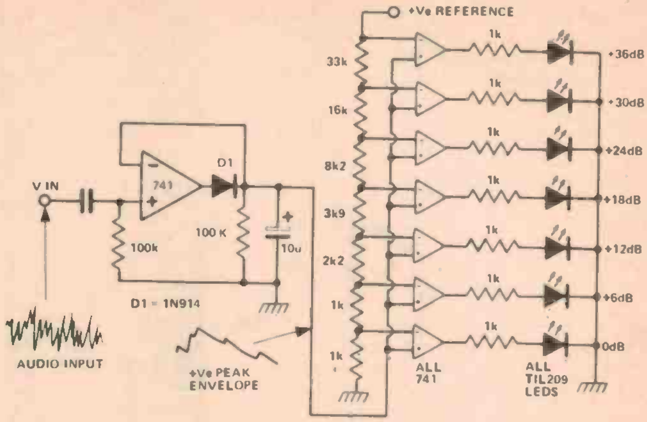


SILENT AUDIO SWITCHING

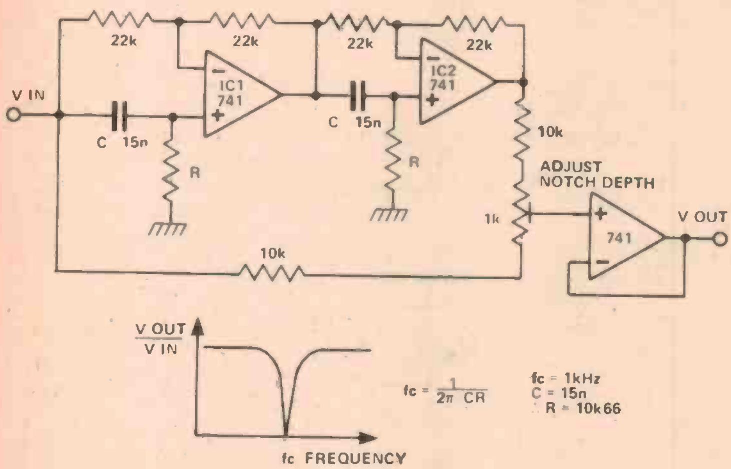
Sometimes electronic switches for audio signals are required. FETs can be used to perform the switching, but they can cause distortion, the resultant output impedance is not very low and clicks generated by the switching signal can break through. The circuit shown virtually eliminates all of these problems. By using an op-amp a very low output impedance is obtained as well as the possibility of selecting or mixing one or more of many input channels. Because of the virtual earth mixing, the voltage across any FET that is switched on is very small. If the output voltage is 1V and the FETs ON resistance is 470R, then the voltage across the FET is about 10 mV. When large voltages are applied to a turned on FET, the distortion is large, but if the voltage is small, (10 mV say), the distortion could be less than 0.1%. Thus the virtual earth mixing enables low distortion operation. Lastly, to stop the generation of switching clicks, a time constant of 47 msec has been enforced at the gate of the FETs.

LED BAR PPM DISPLAY FOR AUDIO

The peak voltage detector can be used to control an illuminated audio level monitor having the same characteristics as a PPM (Peak Programme Meter). A bar column of LEDs is arranged so that as the audio signal level increases, more LEDs in the column light up. The LEDs are arranged vertically in 6 dB steps. A fast response time and a one second decay time has been chosen so as to give an accurate response to transients and a low 'flicker' decay characteristic. The op-amps that drive the LEDs are used as comparators. On each of their inverting inputs they have a dc reference voltage, which increases in 6 dB steps up the chain. All of their non-inverting inputs are tied together and connected to the positive peak envelope of the audio signal. Thus as this envelope exceeds a particular voltage reference, that op-amp output goes high and the LED lights up. Also, all the LEDs below this are illuminated.



ALL-PASS NOTCH FILTER

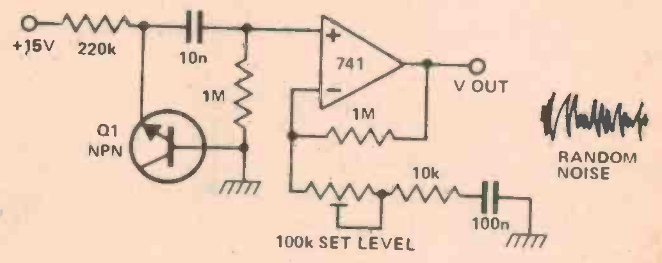


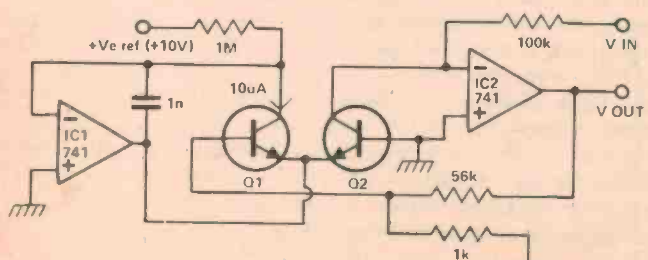
Sometimes when processing analogue signals a constant tone causes a nuisance and so an active filter is called upon to 'notch' it out. The filter can be tuned so that its notch is at exactly the same frequency as the unwanted signal so that it can be selectively attenuated. This method is sometimes used to remove mains hum. The circuit works as follows IC1 and 2 are a pair of all-pass filters. These filters have a flat frequency response, but their phase changes with frequency. Their overall maximum phase shift is 360°, a phase shift of 180° occurring at a frequency of 1/2CR Hz. At this frequency the signals are inverted. Thus, by mixing the phase delayed signal with the original, cancellation can be produced which forms a notch in the frequency response. The preset is used to get the deepest notch available. The operating frequency can be changed by varying the two resistors R. For instance for 50 Hz operation, R should be:—

$$10.66\text{k} \times \frac{1000}{50} = 213.2\text{ k}$$ Nearest E12 fit is 220 k

NOISE GENERATOR

The zener breakdown of a transistor junction is used in many circuits as a noise generator. The breakdown mechanism is random and so generates a small noise voltage. Also this voltage has a high source impedance. By using the op-amp as a high input impedance, high ac gain amplifier, a low impedance, large signal noise source is obtained. The preset is used to set the noise level by varying the gain from 40 to 20 dB.

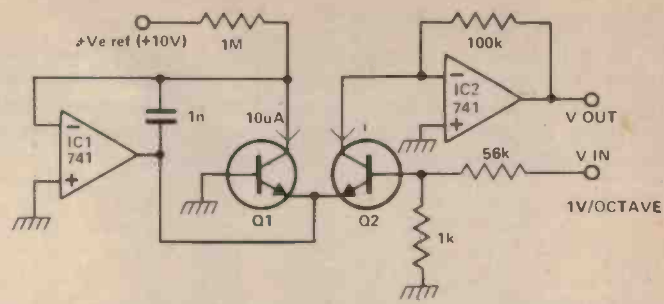




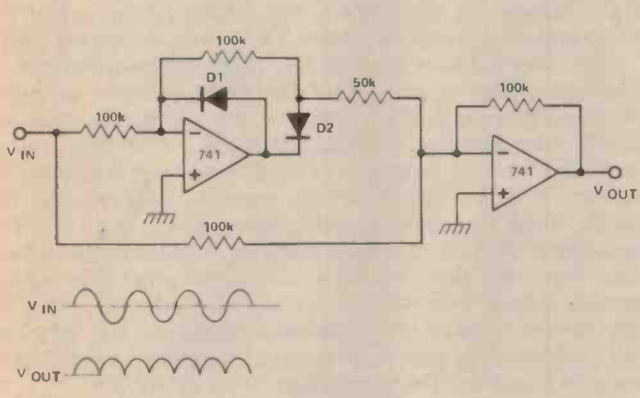
LOGARITHMIC VOLTAGE TO VOLTAGE CONVERTER

The output voltage is logarithmically proportional to the input voltage. The difference between this circuit and the previous is that the exponentiator is in the feedback loop of the op-amp and hence the mathematical function has been inverted. The circuit is useful for performing true logarithmic compression or for converting linear inputs into dBs.

EXPONENTIAL VOLTAGE TO CURRENT/VOLTAGE CONVERTER



The circuit shown converts a linear input voltage into an exponential current or voltage. This type of circuit is used in music synthesisers to change linear control voltages into musical intervals. That is, if the circuit were used to control an oscillator, input increments of 1 V would change the pitch by one octave. The exponential characteristics of a transistor are exployed to generate the correct transfer function. Q1 and !2 are matched pairs of transistors, preferably a transistor dual. IC1 maintains Q1 at a constant current. Thus, the op-amp serves only to bias the emitter of the second transistor Q2 into a suitable operating region. The purpose of Q1 is to generate this bias voltage. The base emitter junction of a transistor has a high temperature coefficient (−1.9 mV/°C) and so the reason for using a matched pair is to use the first transistor, Q1, to provide temperature compensation for the second.



PRECISION HALF WAVE RECTIFIER

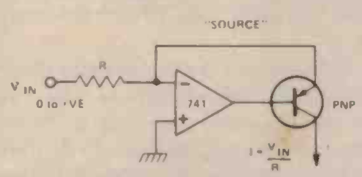
Rectifying small signals with any accuracy can be very difficult using diodes only due to their forward voltage drop of about 0.6 V. However, an op-amp can be used to reduce this voltage drop to virtually nothing. Consider the circuit shown. There is negative feedback so that 'virtual earth' circumstances exist. When Vin is positive, D1 conducts to maintain the virtual earth, D2 is reverse biased and so the output is just a 100 k resistor connected to 0 V. When Vin goes negative, the output rises positively, D2 is turned on and D1 turned off. As the virtual earth is being maintained, the output voltage is the exact inverse of the input voltage. This is true for all negative inputs. Therefore, the output is composed of positive going half sinewaves. Precision half wave rectification has occurred. In fact the diode error is very small, being equal to

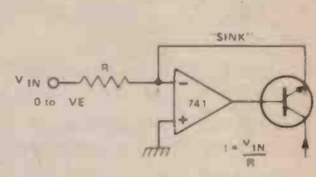
$$\frac{600 \text{ mV}}{\text{(surplus voltage gain)}}$$

Therefore as the input frequency increases, and the surplus voltage gain decreases, precision falls.

By adding together the original and the half wave rectified signals together in the right ratio, it is possible to fill in the half cycle gaps and thus to generate precise full wave rectification. The addition of one summing op-amp and three resistors is all that is needed as shown opposite.

VOLTAGE TO CURRENT CONVERTER



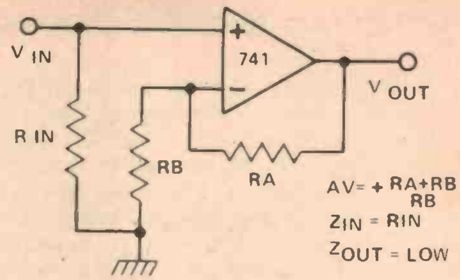


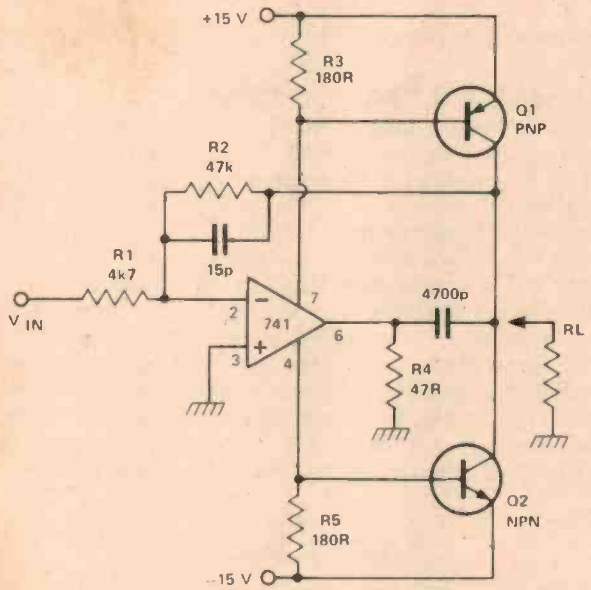
The virtual earth of an op-amp and the current source characteristic of a transistor can be combined to produce a precision linear voltage to current converter. Consider the 'SOURCE' circuit. A positive voltage is applied and the op-amp adjusts itself so that a 'virtual earth' condition is maintained. This means that a current i flows through the input resistor R, where i = Vin/R. Now this current has to go somewhere, and so it flows through the PNP transistor and comes out of the collector and into its load. Thus, the input voltage generates a current which is linearly proportional to it. There are, however, three sources of error that will affect this linearity. First the input offset voltage of the op-amp may become significant at low levels of Vin. Second, the input bias current may well rob a lot of the current when Vin is low. Third, the base current of the transistor must be subtracted from the final output current. Note that the current gain of the transistor will change with collector current variations, and so the base current loss is not a fixed percentage. However, a precise voltage to current converter can be made using an op-amp with a FET input so that the bias current is low. Also, an input balance can be used to zero out the input offset voltage, and if a FET is used to replace the bipolar transistor, then the base current problem can be removed.

The 'SINK' circuit merely swaps the transistor to an npn type. Note that the input voltage now must be negative.

NON-INVERTING AMPLIFIER:

An op-amp is used to provide voltage gain, but in this case the output is in phase with the input. The minimum voltage is unity and occurs when RB is an open circuit. The op-amp has maximum bandwidth at unity gain, and any increase in the gain will cause a reciprocal decrease in bandwidth.





HIGH SLEW RATE AMPLIFIER

The slew rate of the op-amp has been increased by increasing the overall current generating capability, by the addition of a pair of transistors. These transistors increase the output voltage range by allowing the voltage to swing to within 0V5 of either supply rails. The output of the op-amp hardly moves at all. Without an input signal, the output voltage is 0 V and the op-amp drains approximately 2 mA from the supply rails.

This current passes through the 180R resistors and sets up a voltage which is not quite sufficient to turn on either transistor. When a positive voltage is applied to the input, the op-amp tries to swing negative but it has a 47R (R4) resistor connected from its output to ground. Thus, as it tries to swing negative, it draws lots of current from the negative rail. This current flows through R5, and in doing so turns on Q2. This transistor then pulls R2 down and thus provides negative feedback. The same sequence of events occurs when the input is negative except that R3 and Q1 are then involved. Thus the high current capabilities of discrete transistors are combined with a high voltage gain of an op-amp to produce a moderately powerful amplifier. The voltage gain is set by R2/R1.

Transistors Q1 and Q2 introduce a phase shift, which may give rise to a high frequency instability and oscillation. This can be cured by some frequency compensation applied to the amplifier or by increasing the overall voltage gain.

SCHMITT TRIGGER

When dc positive feedback is applied around an op-amp, its output will come to rest in one of two states, that is in its most positive or most negative position. This type of circuit is known as a Schmitt Trigger and it is said to exhibit the property of hysterisis.

Consider the circuit shown in Figure 15. Let us assume that RB is 2 k and RA is 1 k and the output voltage is +10 V. Therefore the voltage at the non-inverting terminal is 3V3. When the input voltage becomes more positive than 3V3, the output of the op-amp will start to swing negative and in doing so will increase the voltage difference between the inputs. This will in turn make the output swing even more negative. Thus the process becomes regenerative, the output finally 'snapping' into its negative state (−10 V say). The only thing that will now change the op-amp's output is if the inverting input goes more negative than the non-inverting input. When this occurs it will revert back to its original state. The two input voltages at which these transitions happen are known as the upper and lower hysterisis levels.

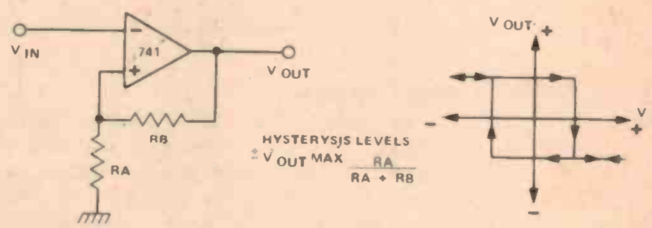
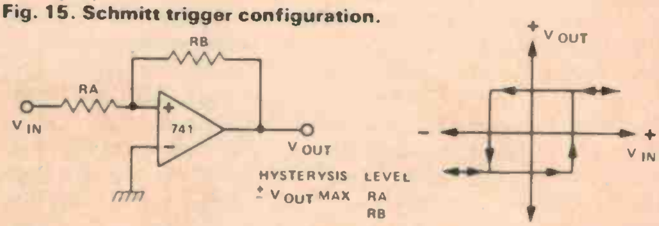


Fig. 15. Schmitt trigger configuration.



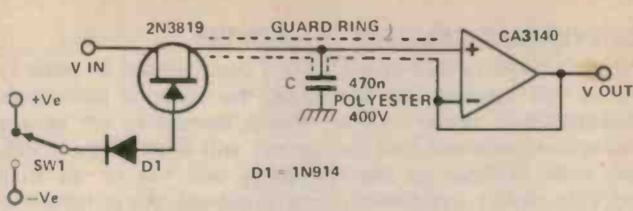
HIGH PERFORMANCE SAMPLE AND HOLD

It is often necessary to have a circuit that will sample an analogue voltage and then remember it for a long time without any significant degradation of that voltage. This is known as a sample and hold circuit and one of its uses is to store the voltage from the keyboard connected to an electronic music synthesiser. The voltage is then used to control the pitch of a voltage controlled oscillator and so it is very important to have a high performance sample and hold. A drift of less than one semitone, (80 mV), in ten minutes is required. A sample and hold is simply an electronic switch, a storage capacitor and a high input impedance voltage follower. In the circuit shown, when switch SW1 is positive the FET is turned on, and has a resistance of about 400R. Thus the input voltage charges up the capacitor through the FET. When SW1 is negative, the FET is turned off, (pinched off), and can have a resistance of thousands of megohms. To get a long storage time the op-amp must have a very low input bias current. For the CA3140, this current is about 10 pico amps, i.e., 10^{-11} amps. Therefore the rate at which the capacitor will be discharged by this current can be worked out from the equation, $C(dv/dt) = i$
where dv/dt is the rate of change of voltage on the capacitor.

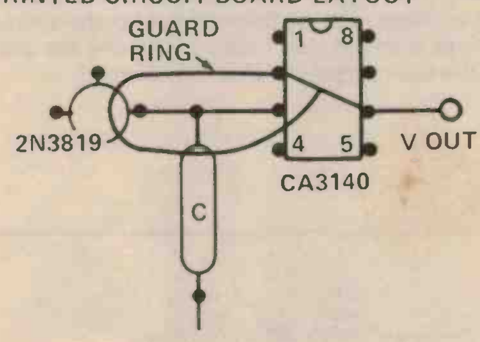
Therefore:

$$\frac{dv}{dt} = \frac{i}{C} = \frac{10^{-11}}{0.47 \times 10^{-6}} \quad 22\ \text{uV/s}$$

This is a very low drift rate, much better than we need. However, the actual drift rate will probably be in excess of this, due to surface leakage on the printed circuit board, leakage through the FET, and internal leakage in the capacitor. It is advisable to use a high voltage, non-polarised capacitor in this circuit to keep the leakage currents to a minimum. Also, to stop surface leakage a simple PCB trick can be used, that of making a guard ring around the sensitive components.



PRINTED CIRCUIT BOARD LAYOUT

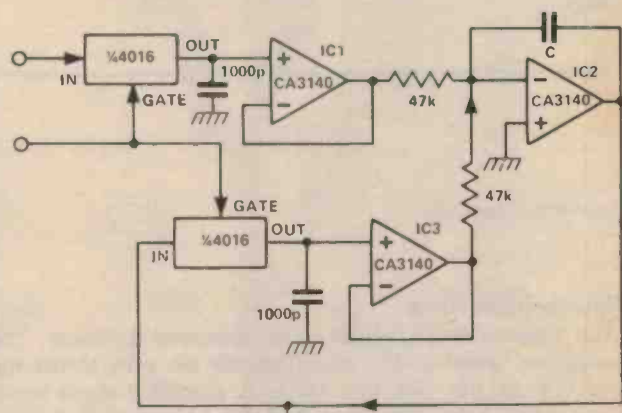


Normally any potential stored on the capacitor may leak to ground across the surface of the PCB, but if we make the surrounding surface a conducting track held at the same potential as that of the capacitor then the potential difference is virtually always zero, and hence the surface leakage is greatly reduced.

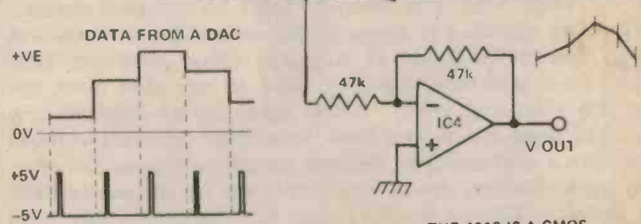
CLEANING UP DIGITALLY GENERATED SIGNALS WITH TWO SAMPLE AND HOLDS AND AN INTEGRATOR

The output from a digital to analogue converter (dac) is composed of a series of steps which have been selected by a series of binary numbers. The output of the dac may represent the result of some computation done by a microprocessor or the contents of a digital memory. If the number of bits that control the dac is low (less than eight), then the output will look like a series of discrete steps, plus lots of digital 'glitches'. Therefore, if this signal is to be displayed on an oscilloscope, the overall picture quality will be very poor. One way to clean up would be to join up all the steps with straight lines and if done successfully a great improvement can be obtained. The only problem is that the distance between steps is continuously varying and so the slope of the straight lines will need to be variable as well. This process is known as linear point interpolation and can be achieved with two sample and holds and an integrator.

A delayed gate pulse is generated, so that once the dac's output has settled, the sample and hold switches momentarily open, sample the information and then close. The output of the first sample and hold (IC1) drives an integrator (IC2), the output of which drives the second sample and hold (IC3). The second unit provides negative feedback around the integrator, but it is delayed by one time interval. Thus a momentary positive going signal will pass through the first sample and hold and cause the integrator to ramp in a negative direction. When the next time interval arrives, the first sample and hold returns to OV, and the second obtains a negative voltage. This then causes the integrator to ramp positively. The size of the integrator's capacitor C should be chosen to suit the clock speed of the dac. An inverter, IC4 has been included to correct the invertion caused by the integrator.



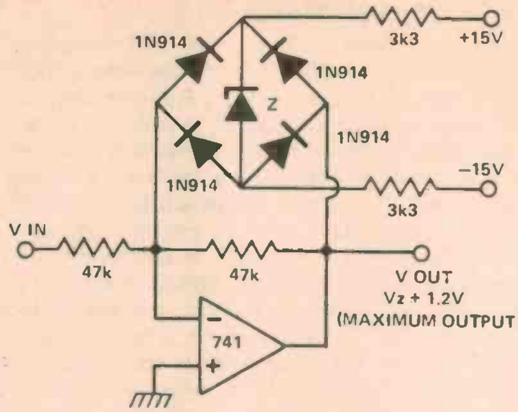
THE 4016 IS A CMOS ANALOGUE TRANSMISSION GATE



DELAYED GATE PULSE. DATA MUST CHANGE AT REGULAR INTERVALS

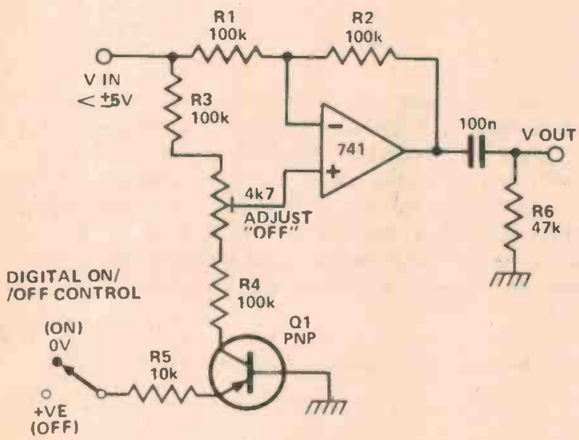
FAST SYMMETRICAL ZENER CLAMPING

There are several problems with using zeners, back to back in series to get symmetrical clamping, the knee of the zener characteristics is rather sloppy, charge storage in the zeners causes speed problems and the zeners will have slightly different knee voltages so the symmetry will not be all that good. This circuit overcomes these problems. By putting the zener inside a diode bridge the same zener voltage is always experienced. The voltage errors due to the diodes are much smaller than those due to the zener. Also the charge storage of the bridge is much less. Lastly by biasing the zener on all the time, the knee appears to be much sharper.



TRANSISTOR USED TO TURN AN OP AMP ON OR OFF

When transistor Q1 is switched off, the circuit behaves as a voltage follower. By applying a positive voltage to the emitter of Q1 via a 10 k resistor, the transistor is made to turn on and go into saturation. Thus the lower end of R4 is shorted to ground. The circuit has now changed into that of a differential amplifier (see fig. 7), but where the voltage difference is always 0 V. Now as long as the resistors in the two branches around the op amp are in the same ratio then there should be zero output. A 4k7 preset is used to null out any ratio errors so that the 'OFF' attenuation is more than 60 dB. The high common mode rejection ratio of a 741 enables this large attenuation to be obtained.



Continued from page 63.

No Noise is Good Noise

The last op-amp characteristic to be discussed is 'Noise'. The noise figures given in the specifications are very confusing. This is due to the fact that noise is specified in so many different ways that it is often difficult to compare devices. One may be specified in terms of Equivalent Input Noise and another device in terms of nV/√ Hz (nano volts per root Hertz)! As a generalisation it is true to say that most op-amps are relatively noisy. Some op-amps are labelled low noise, and these are quieter than the average op-amp but more noisy than a well designed discrete component amplifier. For audio work you can use ordinary op-amps for processing high level signals (100 mV to 3 V), but for amplifying low level signals (1 mV to 100 mV) you would be advised to use a low noise device. The larger the voltage gain you obtain from an op-amp stage, the worse will be the noise, therefore keep the closed loop gain to a bare minimum.

That is the end of the theory, now for some practical examples of op-amps in use.

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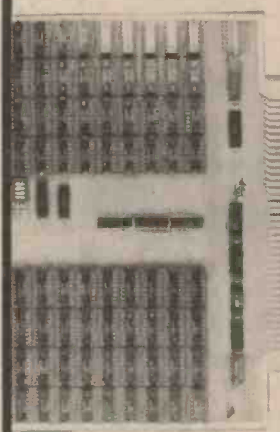

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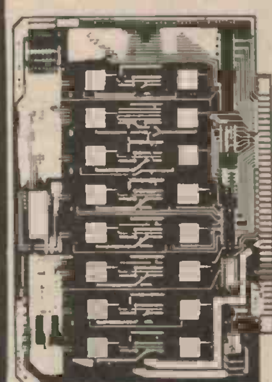

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.015	— 8c	.15	— 14c
.018	— 8c	.18	— 14c
022	— 8c	.22	— 16c
.027	— 8c	.27	— 16c
.033	— 8c	.33	— 18c
.039	— 9c	.39	— 19c
.047	— 9c	.47	— 22c
.056	— 9c	All	
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.082	— 10c	in uF	

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(per 100 prices in brackets)

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10 uF	5c($3½)	6c($3¾)	7c($4)
22 uF	6c($3¾)	7c($4)	8c($5)
33 uF	8c($4)	9c($5)	10c($6)
47 uF	9c($5)	10c($6)	11c($7)
100 uF	10c($6)	12c($7)	14c($11)
220 uF	12c($8)	16c($10)	35c($17)
470 uF	16c($12)	22c($16)	45c($30)
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10A	400V SC146D	—	$1.50
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DIAC ST2		—	35

Chart to identify leads
Plus trigger info. 15

DIODES:

1N4001	—	7c (1A 50V)
1N4002	—	8c (1A 100V)
1N4004	—	9c (1A 400V)
1N4007	—	12c (1A 1000V)
1N4148	—	6c $4.50/100 $38/1000

TRANSFORMERS

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Ref. No.	Amps 12v	Amps 24v	Wt. Gms.	Secondary Windings	$
242	300MA	150MA	198	0-12V at 150 MA x 2	3.50
111	0.5	0.25	283	0-12V at 0.25A x 2	4.50
213	1.0	0.5	425	0-12V at 0.5A x 2	5.00
71	2	1	793	0-12V at 1A x 2	7.20
18	4	2	1020	0-12V at 2A x 2	9.00
70	6	3	1538	0-12V at 3A x 2	11.40
108	8	4	2268	0-12V at 4A x 2	15.00
116	12	6	2722	0-12V at 6A x 2	16.80
115	20	10	5300	0-12V at 10A x 2	24.90

15/30 Volt Range: Primary 220-240 volts: Secondary Windings 0-12-15v at 5 amps, 0-5-9-15v at 5 amps. Voltages obtainable: 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, or 12-0-12 or 15-0-15.

Ref. No.	Amps 15v	Amps 30v	Wt. gms.	Secondary Taps	$
51	10	5	3120	0-12-15, 0-5-9-15	18.00

30 Volt Range: Primaries 220-240 volts
Voltages obtainable 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, or 12-0-12 or 15-0-15.

Ref.	Amps	Wt.Gms.	Secondary Taps	$
112	0.5	623	0-12-15-20-24-30	6.00
79	1	737	0-12-15-20-24-30	7.50
3	2	1361	0-12-15-20-24-30	10.20
21	4	2600	0-12-15-20-24-30	12.60
89	10	5670	0-12-15-20-24-30	26.10

50 Volt Range: Primaries 220-240 volts
Voltage obtainable: 6, 7, 8, 10, 14, 15, 17, 19, 21, 25, 31, 33, 40, 50, or 25-0-25

Ref.	Amps	Wt.	Secondary Taps	$
102	0.5	737	0-19-25-33-40-50 V	8.40
103	1	1304	0-19-25-33-40-50 V	9.60
104	2	2495	0-19-25-33-40-50 V	12.60
105	3	3176	0-19-25-33-40-50 V	15.00
106	4	4100	0-19-25-33-40-50 V	18.00
107	6	5444	0-19-25-33-40-50 V	26.40

60 Volt Range: Primaries 220-240 volts
Voltages obtainable: 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 or 24-0-24 or 30-0-30.

Ref.	Amps	Wt.	Secondary Taps	$
124	0.5	737	0-24-30-40-48-60 V	7.80
126	1	1361	0-24-30-40-48-60 V	9.60
127	2	2495	0-24-30-40-48-60 V	12.60
125	3	4083	0-24-30-40-48-60 V	18.60
40	5	5670	0-24-30-40-48-60 V	25.20

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212	1A 1A	595	0.6 0.6	6.60
13	100	113	9.0.9	3.50
236	330, 330	198	0-9, 0-9	3.50
207	500, 500	566	0-8-9, 0-8-9	6.30
205	500, 600	1077	0-15-20, 0-15-20	7.20
214	300, 300	623	0-20, 0-20	5.00
221	700 (DC)	737	20-12-0012-20	7.80
206	1A 1A	1304	0-15-27, 0-15-27	10.80
203	500, 500	822	0-15-27, 0-15-27	10.20
204	1A 1A	1417	0-15-27, 0-15-27	14.40

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Project 638

EPROM PROGRAMMER

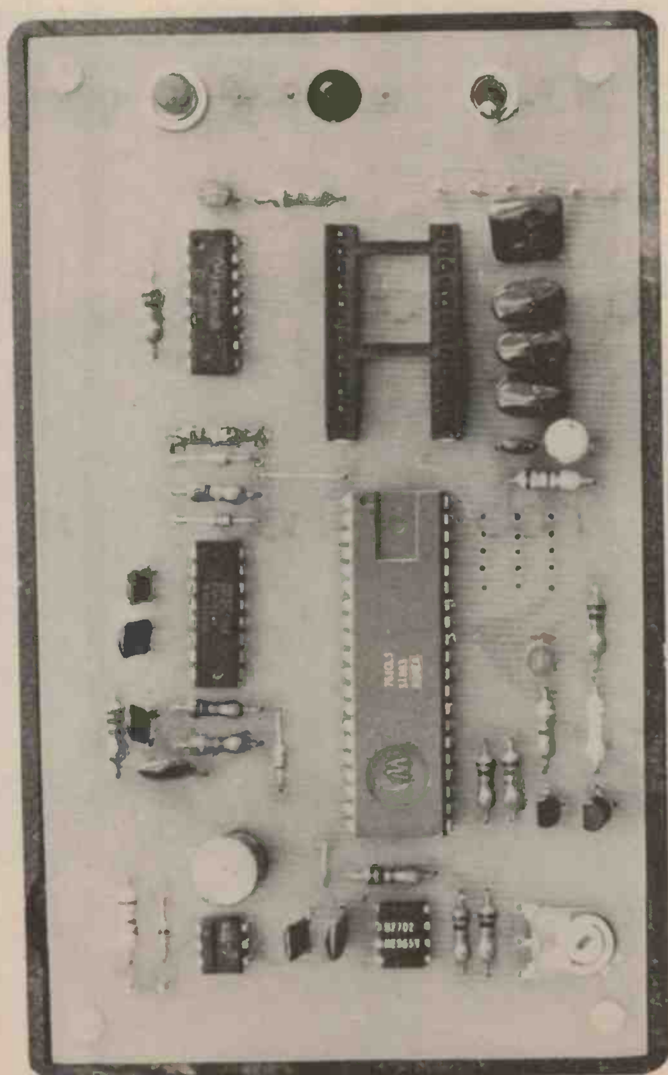
This low-cost device will interface to just about any microcomputer, and requires only simple software to drive it. Based on a design by N.D. Hammond.

SO, YOU'RE BUILDING an ETI 640 VDU, you've written some I/O routines to drive it, and you're looking forward to the day when you'll be running BASIC and graphics and good stuff like that. Initially, at least, you'll have to use the keypad, or front panel, on your Morrow or D2 or whatever, to get the system started, and then load your VDU driver from cassette in order to use the VDU.

But wouldn't it be nice if the VDU driver was in there at power-up, so you didn't have to bootstrap the system into life? Well, the way to do this is to blow a PROM (Programmable Read Only Memory) with your routines and sit it in memory so that it is the first thing the processor looks at when it starts up. In fact, most hobbyists now use EPROMs (Eraseable PROMs) of the 2708 type, which are not now as expensive as they used to be, and have the advantage of allowing you to correct those inevitable bugs in your program, or reuse the EPROM for some completely different program.

That's all very well, I hear you say, but I don't have a way of programming 2708's. Plus, commercial EPROM programmers are too expensive for me to justify since I only program an EPROM a month. Thanks to reader N D Hammond of Torrens, ACT, (and of course ETI) your troubles are over. Here is an inexpensive, nay, cheap, 2708 programmer suitable for individuals or impecunious clubs.

The programmer is, in fact, slightly different from the original design submitted to us by Mr Hammond; we have replaced some TTL in his design with CMOS and added a data time-out synchronisation facility, on which more later.



Design Features

The objectives of the original design were simplicity of construction and operation, and low cost. Another requirement which must be met is simplicity and versatility of interfacing — one of our bigger headaches is the fact that everyone's system seems to be different.

This project meets these objectives very well. The interface to the user's computer is *serial*, i.e. through a 20 mA current loop. Most computers, except for some evaluation kits, have a suitable serial I/O port, so this is a pretty well universal interface. As a bonus, the UART and a couple of one-shots provide all the necessary timing signals, so the component count is low and cost is low.

A useful by-product of our switch to a completely CMOS design was a spare gate, which we put to good use in providing a 'synchronisation' facility. The idea is that if a supply glitch or noise causes the UART to miss a byte of data, so that the 2708 addressing is out of step with the desired addressing, a ¼ second pause at the end of each cycle will reset the 4040 to zero. This means that only that cycle will be affected and subsequent cycles will be correct, increasing the programmer's tolerance to glitches.

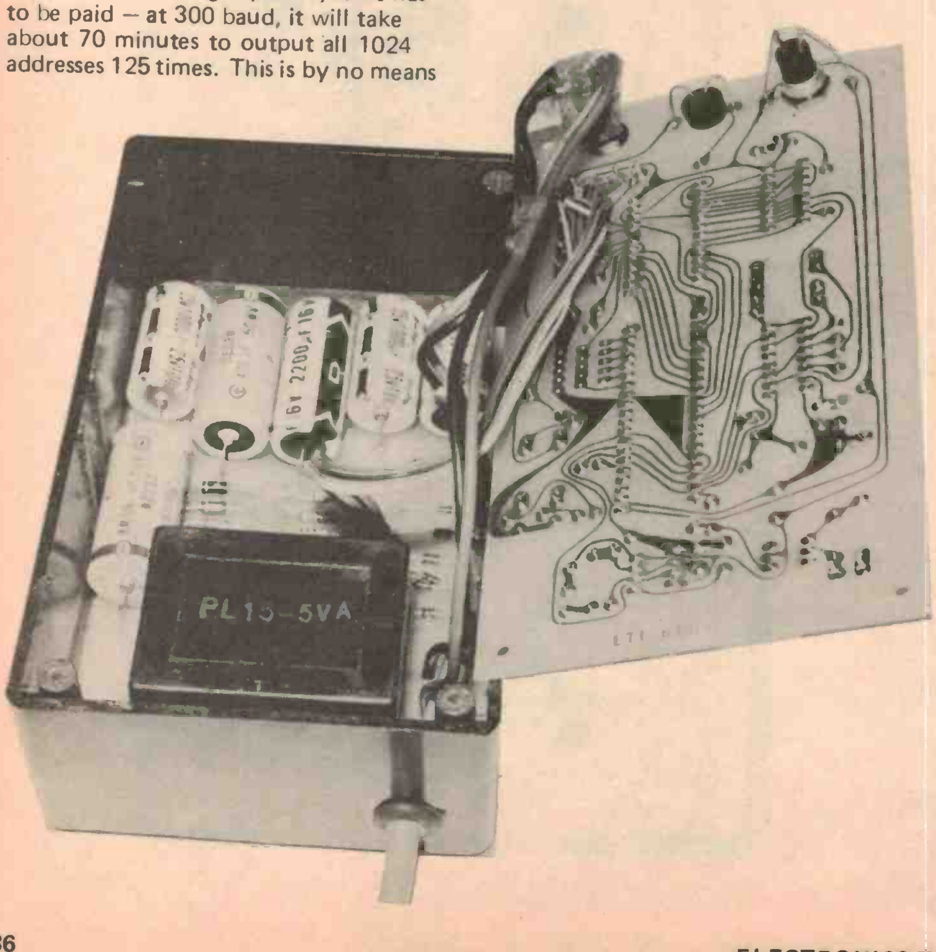
There is one slight penalty that has to be paid — at 300 baud, it will take about 70 minutes to output all 1024 addresses 125 times. This is by no means brilliantly fast compared to the theoretical minimum programming time of 104 seconds but it is a lot better than the several days that would be required by a commercial firm.

Mr Hammond originally supplied software for the 8080, but our tests of the circuit were done on a MEK6800D2, for which we have written a routine, reproduced here. Our routine incorporates a time delay of approximately ¼ second at the end of each run through the 2708 addresses, in order to take advantage of the time-out synchronisation feature. Mr Hammond's 8080 program does not include this facility, but it is easy to add a time delay loop which decrements (say) the BC pair using the DCX instruction. We hope to give this program next month (so much to do, so little time, sigh!), but Mr Hammond's routine should work with no modification.

Adjustment

Before adjusting the oscillator frequency first fit the links which set the start-stop bit arrangement of UART.

Now with power connected adjust RV1 until IC2 is operating at 4800 Hz.



PARTS LIST – ETI 638 A

Resistors all ½W 5%

R1 . . . . . . 180R
R2, 3 . . . . . 10k
R4, 5 . . . . . 1k
R6 . . . . . . 10k
R7 . . . . . . 4M7
R8 . . . . . . 180k
R9 . . . . . . 100k
R10 . . . . . . 470R
R11 . . . . . . 10k
R12 . . . . . . 1k
R13 . . . . . . 10k
R14 . . . . . . 33k
R15 . . . . . . 10k
R16 . . . . . . 47R
R17 . . . . . . 180R

Potentiometer

RV1 . . . . . 25k trim

Capacitors

C1 . . . . 8n2 polyester
C2–C4 . . . . 10n polyester
C5 . . . . 33n polyester
C6, 7 . . . . . 10n polyester
C8, 9 . . . . . 100n polyester
C10 . . . . . . 100µ 25V electro
C11, 12 . . . . 100n polyester
C13 . . . . . . 10µ 35V electro

Semiconductors

IC1 . . . . . . 4N33 Opto coupler
IC2 . . . . . . 555 timer
IC3 . . . . . . MM5303 UART
IC4 . . . . . . 4049 Hex inverter
IC5 . . . . . . 4040 12 stage counter

Q1 . . . . . . PN3638
Q2 . . . . . . BC548
Q3 . . . . . . BC558
Q4 . . . . . . BC548

D1–D4 . . . . 1N914
LED1

Miscellaneous

PC board ETI 638A
24 pin IC socket
Push button
Plastic box 158x96x50mm

PARTS LIST – ETI 638 B

Resistors all ½W 5%

R1 . . . . . . 1k
R2, 3 . . . . . 120R
R4, 5 . . . . . 47R
R6 . . . . . . 470R
R7 . . . . . . 100R

Capacitors

C1 . . . . 470µ 50V electro
C2 . . . . 2200µ 16V electro
C3–C5 . . . . 1000µ 25V electro
C6 . . . . 470µ 50V electro

Diodes

D1–D6 . . . . 1N4004
ZD1 . . . . . . 27V 1W
ZD2 . . . . . . 12V 400mW
ZD3 . . . . . . 12V 1W
ZD4 . . . . . . 5.1V 400mW
ZD5 . . . . . . 5.1V 1W

Miscellaneous

PC board ETI 638B
Transformer PL15–5VA
Switch DPDT toggle
3 core flex & plug
Cable clamp

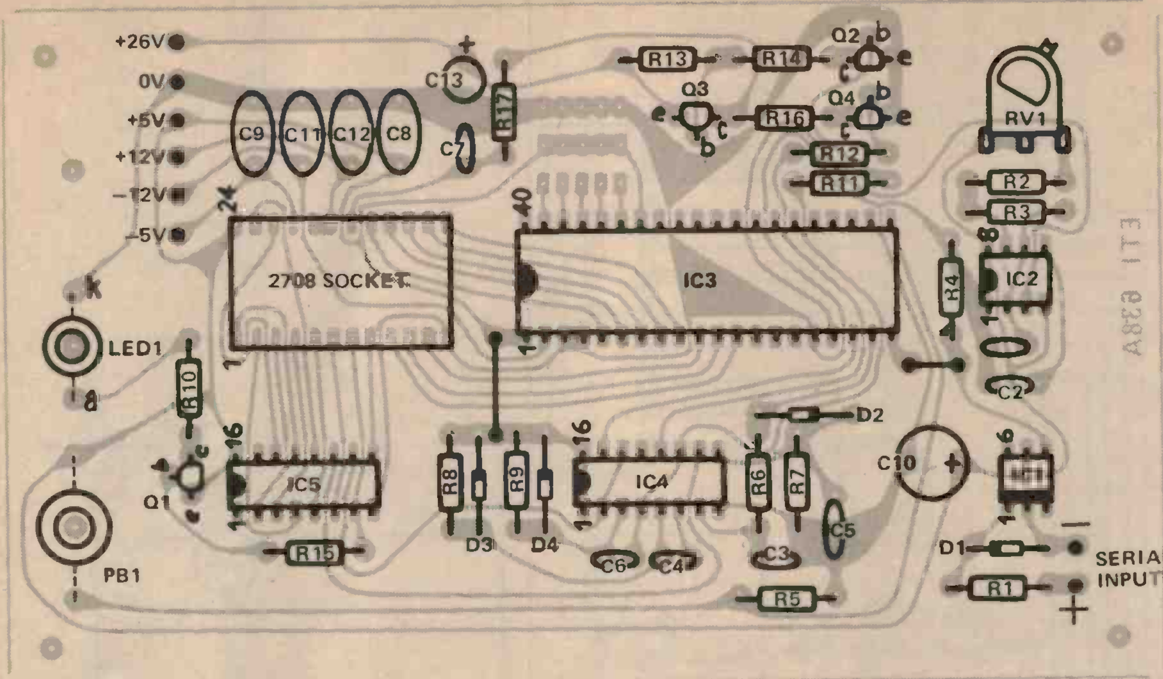


Fig. 1 The component overlay of the main board.

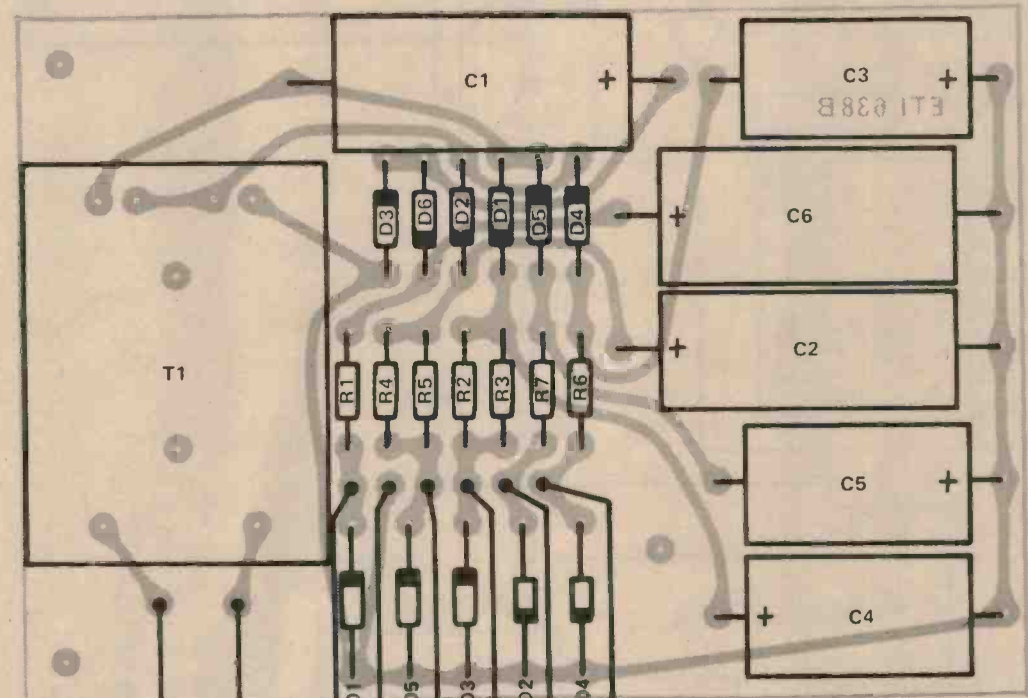


Fig. 2. The component overlay of the power supply.

Construction

We built our prototype into a plastic box with the power supply on one board in the box itself while the logic board was used in place of the lid.

These boards should be assembled according to the overlays provided. Normal handling procedures should be taken with the SMOC ICs and the UART. A good quality socket should be used for the EPROM as it will be used a lot. The pushbutton, LED and power switch are mounted on the logic board and connected from the rear.

With the power switch, due to the closeness of the capacitors on the lower board, the wires should be taken parallel to the pc board and the rear of the switch epoxied over to give protection. The connection between the power supply and logic board can be done with a piece of ribbon cable as the connections follow the same sequence.

We used pc pins for the data input points but a socket could be used if desired.

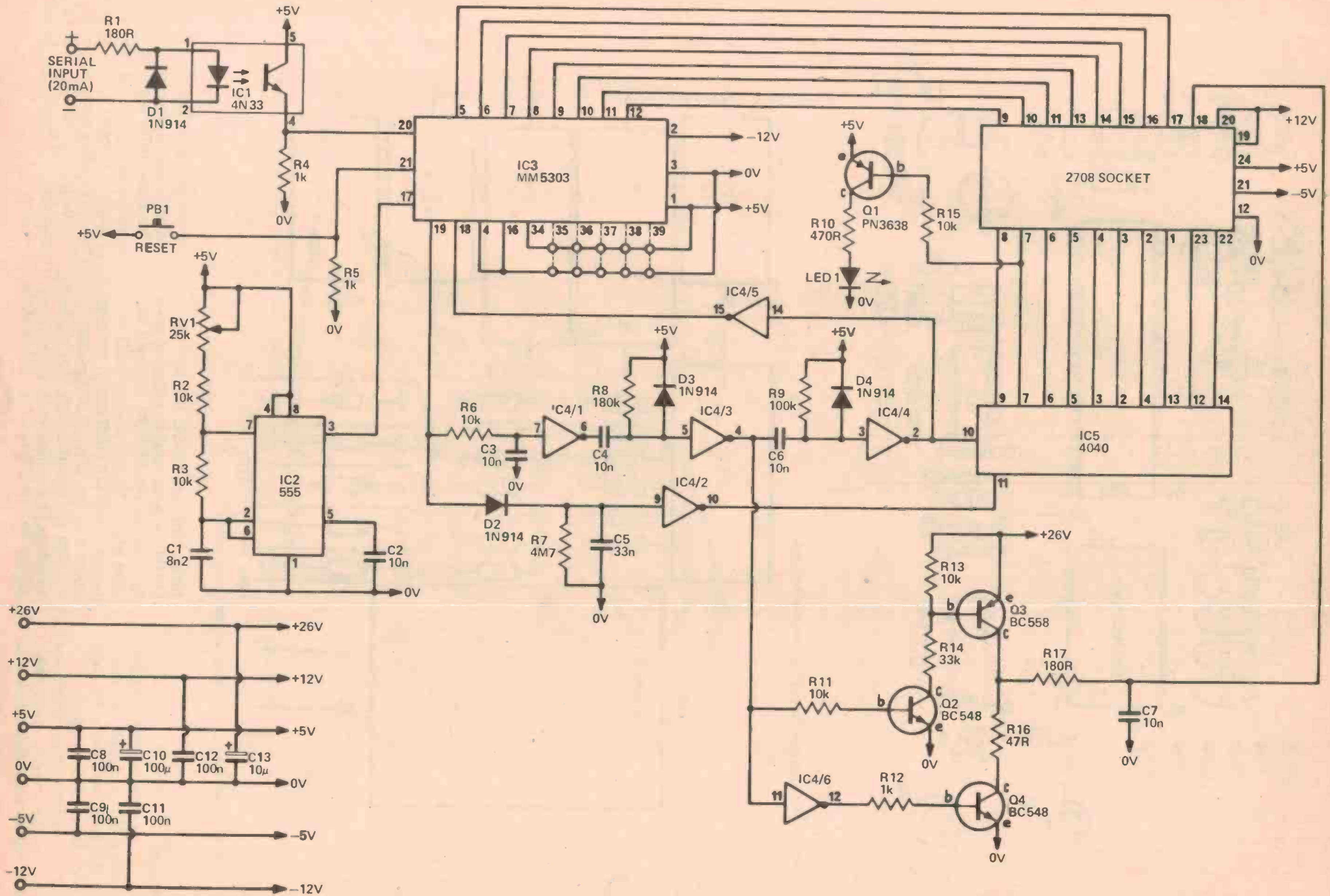


Fig. 3. The circuit diagram of the main circuit.

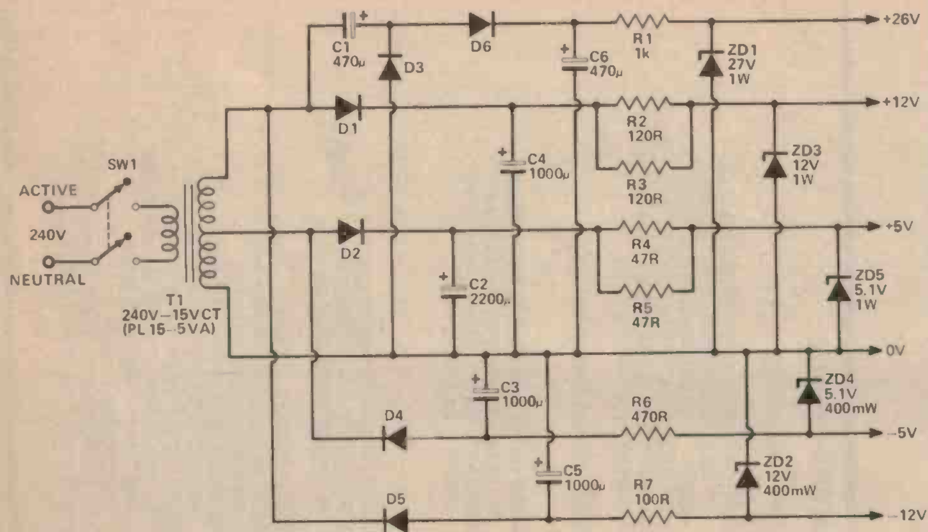


Fig. 4. The circuit diagram of the power supply.

HOW IT WORKS - ETI 638

A fully erased EPROM has every bit set to the "1" state. Programming sets selected bits to "0" To program a 2708 the selected address and corresponding data has to be presented to the EPROM and a 26V pulse applied to the program input pin. To make life more difficult each location has to be selected and programmed in sequence. Also a total time the program input has to be high for each location is 100 ms but the pulse used cannot be less than 100µs or longer than 1ms with about 1 ms recommended. This means that the IC has to be cycled through completely around 100 times for best results!

As we have a computer any way, (otherwise why the need for an EPROM!) we use it to provide the sequencing and timing needed.

The computer is programmed to copy data in its memory (1024 bytes) and sequentially transmit in serial form each byte 125 times. It also pauses for about ¼ second each 1024 bytes.

The serial information is transferred from the 20 mA loop into a 0-5V signal by the opto coupler, IC1, whose output is fed into the input of the UART IC3. This IC then converts this information into parallel form on pins 5-12 which is presented to the EPROM on its data lines. This IC needs a clock input at 16 times the Baud rate (4800Hz for 300 Baud) and IC2 is used for this.

The address lines for the EPROM are supplied by IC5 which is a 12 bit binary counter (we use only the first 10 bits) and this is reset to zero when no data is being received. On pin 19 of the UART we have an output which goes high when the serial data has been received and after this has been delayed by about 100 µs (R6/C3) the output of IC4/1 goes low. This triggers a 1 ms monostable (C4, R8, IC4/3) which drives the transistors Q2-Q4 to provide a 26V pulse to pin 18 of the 2708. At the end of this 1ms pulse a second mono is triggered (C6, R9, IC4/4), the UART is reset (pin 19 goes low again) and the address counter IC5 is incremented. The output (pin 19) of IC3 also charges C5 via D2 when it goes high. This causes the output of IC4/2 to go low allowing IC5 to be toggled (pin 11 of IC5 is the reset line). Provided the output of IC3 goes high regularly corresponding to data being received at 300 Baud C5 does not have time to discharge and the reset line remains low. If there is a pause at the end of a complete cycle the reset line will go high and will correct any error which may have been caused by a possible glitch.

The power indicator LED is driven by one of the outputs of IC5 and is turned on and off quickly indicating data is being received.

The 2708

At this point we digress to describe the 2708 and the steps involved in using and programming it.

The device is a static 8192 bit EPROM organised as 1024 x 8. It is packaged in a 24 pin DIP with a quartz window which allows the data stored in the memory to be erased by exposure to ultra-violet light.

Reading the device is quite straightforward. The appropriate address is applied at the ten address pins, the chip select pin is taken low and after the appropriate access time (120ns from CS or 450ns from address select) the data is available at the eight output pins.

Fortunately, and in contrast to its predecessors, the 2708 is also simple to program. The chip select pin is taken to the 'write enable' level of +12 V and the applied address is cycled from 000H to 3FFH with the appropriate data applied at each address. After the data and address lines have settled at each address, a 26 V pulse of 0.1 ms to 1 ms duration is applied at the programming pin. The entire cycle of 1024 addresses is repeated until each address has received a minimum of 100 ms program pulse time.

Erasure is the simplest operation of all. The window is uncovered and the chip placed an inch or so away from an ultra violet tube. After half an hour or so, the memory is fully erased (to all '1's) and is ready for re-programming.

Operation

A fully erased EPROM has every bit set to the '1' state. Programming sets selected bits to '0'. It follows that a 2708 can be reprogrammed without erasing if there are no cases where a bit must be changed from '0' to '1', otherwise the device must be erased by exposure to ultra violet light. Any 'germicidal' UV tube is suitable for erasing (eg: General Electric G15P8). The chip(s) should be placed about an inch or so from the tube and left for at least half an hour to ensure complete erasure.

To program the device, the pattern to be written should be available in RAM. The programmer is connected to the microprocessor's serial port which is configured for the appropriate signal format selected for the programmer (see table 3). The programmer is then reset to initialize the UART and ensure that the address counter starts at address zero. All that remains is for the microprocessor to output the contents of the selected RAM page, byte by byte at the port. As the programming pulse width is approximately 1ms, the whole 1024 bytes should be output at least 100 times. In practice, this should be increased by 25% or so to allow for the effects of component tolerances.

Programmer Design

Use of the UART considerably simplifies the software requirements of the system which will drive the programmer, all that is necessary is a program which will output the required memory contents in order and repeat this for the required number of times.

TABLE 1. 6800 EPROM DRIVER FOR D2

```
6800 EPROM PROGRAMMER DRIVER FOR D2

          OUTCH       EQU   E37A
          PAGESTART   EQU   04
          NEXTPAGE    EQU   08
          ACIAS       EQU   8008
          ; INITIALISATION OF ACIA
0000  86  55                         LDA  A   # %0101001
0002  B7  80   08                    STA  A
          ; MAIN PROGRAM
0005  C6  7D                         LDA  B     125
0007  CE  00   00   NEWCYCLE:  LDX  PAGESTART
000A  A6  00        NEXTBYTE:  LDA  A,   X
000C  BD  E3   7A                    JSR  OUTCH
000F  08                             INX
0010  8C  04   00                    CPX  NEXTPAGE
0013  26  F5                         BNE  NEXTBYTE
0015  36                             PSH  A
0016  37                             PSH  B
0017  86  FF                         LDA  A     $FF
0019  C6  FF                         LDA  B     $FF
001B  5A                  LOOP:      DEC  B
001C  26  FD                         BNE  LOOP
001E  4A                             DEC  A
001F  26  FA                         BNE  LOOP
0021  33                             PUL  B
0022  32                             PUL  A
0023  5A                             DEC  B
0024  26  E1                         BNE  NEWCYCLE
0026  3F                             SWI

For Test:
000A  86  XX        NEXTBYTE:  LDA  A      XX
outputs ASCII character XX
  or
000A  4C            NEXTBYTE:  INC  A
000B  01                       NOP
outputs incrementing characters.
```

TABLE 3 SIGNAL FORMAT OPTIONS

OPTION		INPUT	UART PIN	LEVEL
No OF DATA BITS	8	NDB2	37	H
		NDB1	38	H
	7	NDB2	37	H
		NDB1	38	L
PARITY	EVEN	NPB	35	L
		POE	39	H
	ODD	NPB	35	L
		POE	39	L
	INHIBIT	NPB	35	H
		POE	39	X
No OF STOP BITS	1	NSB	36	L
	2	NSB	36	H

H=HIGH (+5V)   L=LOW (0V)   X=DON'T CARE

TABLE 2 – INTERFACE PROGRAM FOR 8080/Z80

```
               ;***** INTERFACE PROGRAM FOR 2708 EPROM PROGRAMMER *****
               ;
               PAGESTART:   EQU   04H          ; HIGH ORDER BYTE OF RAM ADDRESS
                                               ;   TO BE LOADED IN EPROM ADDRESS
                                               ;   ZERO – LOW ORDER BYTE IS ZERO
               NEXTPAGE:    EQU   08H          ; HIGH ORDER BYTE OF PAGESTART + 1024
               CTRL:        EQU   0            ; ADDRESS OF I/O STATUS & CONTROL PORT
               DATA:        EQU   1            ; ADDRESS OF I/O DATA PORT
               ;
               ; INITIALIZATION – NOTE: SYSTEM DEPENDENT. THIS SEGMENT WRITTEN
               ; FOR AN INTEL 8251 SERIAL I/O PORT
               ;
0000: 3E 4E                 MVI   A, 4EH       ; MODE INSTRUCTION. SELECT 1 STOP,
0002: D3 00                 OUT   CTRL         ;   8 DATA AND NO PARITY FORMAT
0004: 3E 11                 MVI   A, 11H       ; COMMAND INSTRUCTION. RESET 8251
0006: D3 00                 OUT   CTRL         ;   AND SET TX ENABLE
               ;
               ; MAIN PROGRAM
               ;
0008: 06 7D                 MVI   B, 125       ; NO OF PROGRAMMER CYCLES TO B
000A: 26 04    NEWCYCLE:    MVI   H, PAGESTART ; HIGH ORDER ADDRESS OF BYTE 1 TO H
000C: 2E 00                 MVI   L, 0         ; LOW ORDER ADDRESS TO L
000E:          NEXTBYTE:
000E: DB 00    TESTPOINT:   IN    CTRL         ; READ I/O PORT STATUS
0010: E6 01                 ANI   01H          ; MASK ALL EXCEPT READY BIT
0012: CA 0E 00              JZ    TESTPORT     ; LOOP UNTIL READY BIT SET
0015: 7E                    MOV   A, M         ; MOVE SELECTED BYTE TO ACC
0016: D3 01                 OUT   DATA         ;   AND SEND TO PROGRAMMER
0018: 23                    INX   H            ; SELECT NEXT BYTE TO BE SENT
0019: 7C                    MOV   A, H         ; TEST CONTENTS OF H TO SEE WHETHER
001A: FE 08                 CPI   NEXTPAGE     ;   LAST BYTE HAS BEEN SENT
001C: C2 0E 00              JNZ   NEXTBYTE     ; IF NOT, REPEAT LOOP
001F: 05                    DCR   B            ; ELSE DECREMENT CYCLE COUNTER
0020: C2 0A 00              JNZ   NEWCYCLE     ; IF NOT FINISHED START NEW CYCLE
0023: 76                    HLT                ; ELSE HALT
```

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2N2907A	0.84	2N4354	0.46
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NG7 6 amps — $57.00 including tax. High power single side band CB radios, service bench repairs, 2-way radio base supplies. Input 240V AC, Output 11 to 16V DC, Regulation 0-6A 30 mV. Ripple at 6 amps-4mV. Dimensions: 5" wide x 5¼" deep x 6" high. Weight approx 8 lb.

NG12 12 amps — $115.00 including tax. Heavy duty model. Ideal for operating high power linear amps, hybrid 2-way radios, etc. Input 240V AC. Output 11 to 16V DC, Regulation 0-12A 10mV. Ripple at 12 amps-1.5mV. Dimensions: 10" wide x 5¼" deep x 6" high. Weight approx 16 lb.

Manufactured by Radio Parts Group. Trade enquiries welcome.

TMK VF4

$21.27 including tax. Specifications:— Sensitivity: 2K Ω /Volt DC, 2K Ω /Volt AC; DC Voltage: 0.25V, 2.5V, 10V, 50V, 250V, 1000V; AC Voltage: 10V, 50V, 250V, 1000V; DC Current: 0-500 μA, 10MA, 250MA, 10A; Resistance: x1, x10, x100, x1K, (6,60,600,6K Centre Scale); Capacitance: 500 μμF to 1 μF (in two Ranges); Decibels: —15 to plus 32dB (in four Ranges); Dimensions: 145 x 95 x 45 mm.

TMK TP5SN

$25.18 including tax. Specifications:— Sensitivity: 20K Ω /Volt DC, 8K Ω /Volt AC; DC Voltage: 0.5V, 5V, 50V, 250V, 500V, 1000V; AC Voltage: 10V, 50V, 250V, 500V, 1000V; DC Current: 0-50 μA, 5MA, 50MA, 500MA; Resistance: x1, x10, x100, x1K (60, 600, 6K, 60K Centre Scale); Capitance: 50 μμF to 0.1 μF (in two Ranges); Decibels: —20 to plus 36dB; Dimensions: 135 x 95 x 40 mm.

TMK200

$27.91 wncluding tax. Specifications:— Sensitivity: 20K Ω /Volt DC, 10K Ω /Volt AC; DC Voltage: 0.6V, 6V, 30V, 120V, 600V, 1200V; AC Voltage: 6V, 30V, 120V, 600V, 1200V; DC Current: 0.06MA, 6MA, 60MA, 600MA; Resistance: 0-10K Ω, 100K Ω, 1M Ω, 10M Ω; Capacitance: .002 μF to 0.2 μF Decibels: —20 to plus 63dB; Dimensions: 130 x 90 x 35 mm.

TMK500

$41.22 including tax. Specifications:— Sensitivity: 30K Ω /Volt DC, 13K Ω /Volt AC; DC Voltage: 0.25V, 1V, 2.5V, 10V, 25V, 100V, 250V, 1000V; AC Voltage: 2.5V, 10V, 25V, 100V, 250V, 500V, 1000V; DC Current: .05MA, 5MA 50MA 500MA, 12A; Short Test; Internal Buzzer; Decibels: —20 to plus 56dB; Dimensions: 160 x 85 x 70 mm.

SWE-CHECK MODEL 300

Cathode ray tube tester and rejuvenator. Tests each gun separately indicating Shorts, Open Circuits, Emission and Cut-off characteristics. Also removes shorts and rejuvenates low emission tubes. Adaptors available to suit all colour tubes on the Australian market (see below). $253.00 including sales tax.

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SIMPLE 12V TO 22V CONVERTER

Simple voltage doubler powers op-amps and similar circuits from a 12V supply.

WHILE MOST AUTOMOTIVE equipment can be designed to operate on a single +12V supply it sometimes becomes necessary to develop a voltage above 12V, or a negative voltage. This project was initiated when one of our PC boards suppliers wanted to run one of the Philips TV type UHF pre-amplifiers as a booster for his UHF CB rig (receiver only). He needed 20–24V at 35mA. Then almost in the same week a reader came into the office wanting a circuit which will allow him to charge a 12 volt pack of Nicads at 150mA from the car battery.

While the obvious choice is an inverter the relative low power requirement weighed against the cost, complexity and noise generated by such a device made us look to an alternative design. With this unit we simply generate a square wave and then voltage double it to give 22V or, with a slight reconnection of the rectifier circuit, −10V. If both rectifiers are used both +22V and −10V (total 32V) is obtainable.

The circuit however is not limited to 12V and is useful over the 6–15V range. The output voltage is approximately twice the input less 2 volts.

Construction

As this project is very simple any construction method may be used. However the PC board described makes the assembly very easy. The only point to watch is in the handling of the IC which is CMOS – avoid contact with the pins, and solder the power supply pins (7 & 14) first.

SPECIFICATION – ETI 248

Input voltage	6 – 15V
Output voltage	twice input, less 2V
Output impedance	≈ 15 ohms
Maximum load	125 ohms
Maximum output current	
6V input	75mA
8V input	105mA
10V input	130mA
12V input	165mA
14V input	190mA
15V input	210mA
Idle current	
@ 12V input	21mA
Efficiency	
@ 165mA, 12V input	75%

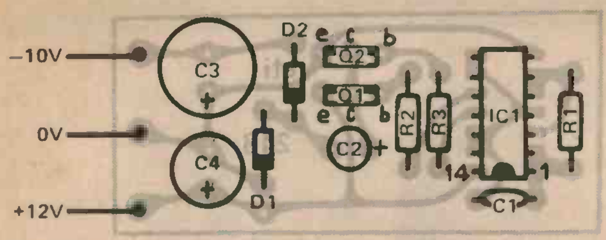

Fig. 1. The component overlay of the −10 V version.

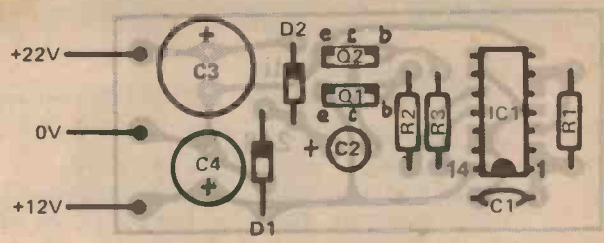

Fig. 2. The component overlay of the +22 V version.

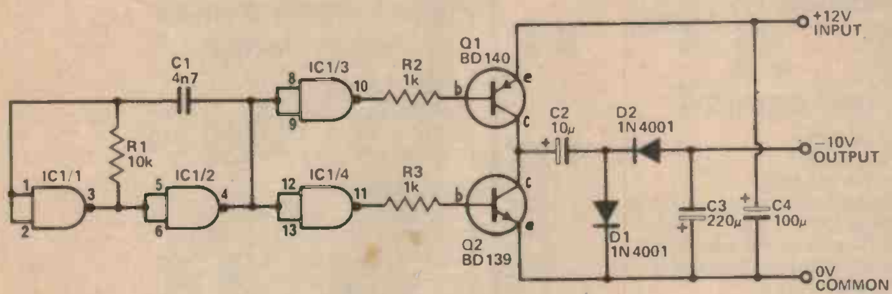

Fig. 3. The circuit diagram of the −10 V version.

PARTS LIST – ETI 248

Resistors all ½W 5%
- R1 . . . . . . 10k
- R2, 3 . . . . . 1k

Capacitors
- C1. . . . . . . 4n7 polyester
- C2. . . . . . . 10μ 25V electro
- C3. . . . . . . 220μ 35V electro
- C4. . . . . . . 100μ 25V electro

Semiconductors
- IC1 . . . . . . 4001B or 4011B (CMOS)
- Q1 . . . . . . BD136 or BD140
- Q2 . . . . . . BD135 or BD139
- D1, 2 . . . . . 1N4001

Miscellaneous
- PC board ETI 248

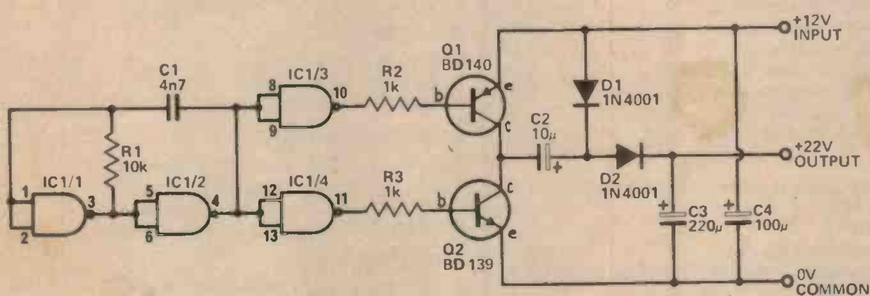

Fig. 4. The circuit diagram of the +22 V version.

HOW IT WORKS – ETI 248

The first two parts of IC1 form a 10kHz square wave oscillator. The frequency is determined by the RC network R1 C1. Reducing either of these causes the frequency to increase and viceversa. The output of the oscillator is buffered by both IC1/3 and IC1/4. These drive Q1 and Q2 via R2 and R3 alternatively turning them on and off i.e. Q1 on Q2 off then Q1 off Q2 on etc. We have used two separate buffers as when the output of IC1/3 goes low, turning on Q1, it is not low enough to ensure Q2 would be turned off if it was driven by the same output.

Note that as the IC is connected as a quad inverter either a NOR (4001) or NAND (4011) can be used. It should however be the buffered (B series) type to ensure that the oscillator section will start.

The output at the collectors of Q1 and Q2 is a square wave between 12V and 0V. This is then voltage doubled by C2, 3 and D1, 2. Due to the natural losses involved in charging and discharging capacitors a maximum efficiency of 75% is obtained and increasing the power beyond the present ratings, while possible, is not practical. If a higher voltage is required voltage tripling or quadrupling is possible.

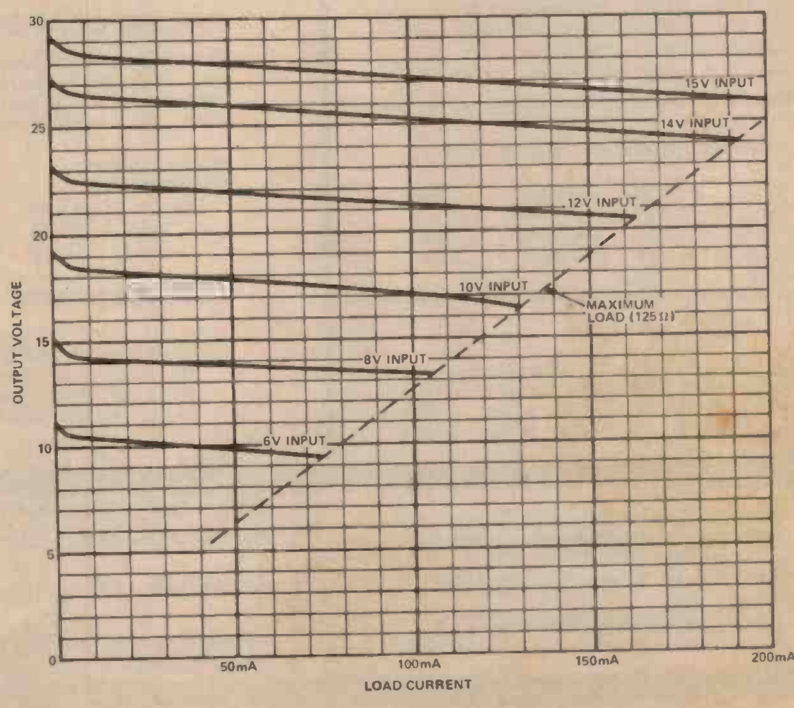

Fig. 5. Graph showing the relationship between the output voltage and load current for various input voltages.

SPECIALS (Offer valid till August 15th 1978 or until stocks are depleted)

741 OP AMPS	5 for $1.50	14 pin solder sockets	10 for $2.20
555 TIMERS	5 for $1.50	16 pin solder sockets	10 for $2.60
BC547/548/549 TRANSISTORS	5 for $0.75	6800 CPU (plastic)	$17.50 each
BC557/558/559 TRANSISTORS	5 for $0.75	8080A CPU (plastic)	$14.50 each

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74LS00	.32	74LS109	.55
74LS01	.32	74LS112	.55
74LS02	.32	74LS113	.55
74LS03	.32	74LS114	.55
74LS04	.35	74LS123	1.75
74LS05	.35	74LS132	1.55
74LS08	.35	74LS138	1.50
74LS09	.35	74LS151	1.20
74LS10	.35	74LS154	2.50
74LS11	.35	74LS157	.90
74LS12	.35	74LS161	2.55
74LS13	.85	74LS162	2.55
74LS14	1.55	74LS163	1.75
74LS15	.40	74LS164	1.55
74LS20	.35	74LS165	2.15
74LS21	.35	74LS174	1.45
74LS27	.35	74LS175	1.45
74LS28	.42	74LS190	2.50
74LS30	.35	74LS191	2.50
74LS32	.35	74LS192	2.50
74LS37	.46	74LS193	2.50
74LS38	.46	74LS194	2.50
74LS40	.35	74LS195	2.50
74LS42	1.25	74LS196	2.00
75LS51	.40	74LS221	1.50
74LS73	.65	74LS240	2.70
74LS74	.65	74LS241	2.70
74LS76	.60	74LS243	2.65
74LS78	.55	74LS244	2.70
74LS85	1.50	74LS245	2.70
74LS86	.55	74LS253	1.95
74LS90	1.20	74LS279	1.00
74LS92	1.20	74LS365	1.00
74LS93	1.20	74LS366	1.00
74LS95	1.60	74LS367	1.00
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8080A	$15.75	SC/MP II	16.75
6800	19.50	Z80	35.00
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3882 Z80 counter timer circuit	15.50
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DM8131 6 bit address comparator	6.25
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DM8553 8 bit addressable latch	4.25

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1602 UART	7.50
5740 keyboard encoder	19.75
57109 number cruncher with data	19.75
2101 256 x 4 static RAM	3.75
2112 256 x 4 static RAM	3.75
2114 1K x 4 static RAM	14.25

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CCD103	125 pads 0.150" O.D.
CCD138	125 pads 0.187" O.D.
CCD139	125 pads 0.200" O.D.
CCD141	125 pads 0.25" O.D.

DUAL IN LINE $1.55

CCD6014	16 only 14 pin
CCD6004	16 only 16 pin
CCD5020	2 strips 80 pads 0.1"

EDGE CONNECTORS $1.55

CC6701	80 contacts 0.10" centres
CC6705	80 contacts 0.125" centres
CC6794	80 contacts 0.15" centres
CC6709	80 contacts 0.156" centres

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(dropout blue 0.1" high stability grid)

CC1489	8.5" x 11" sheet	.55
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1 Mc/s	7.95	10 Mc/s	7.95
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SOCKETS

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14 pin solder	.30	24 pin solder	.80
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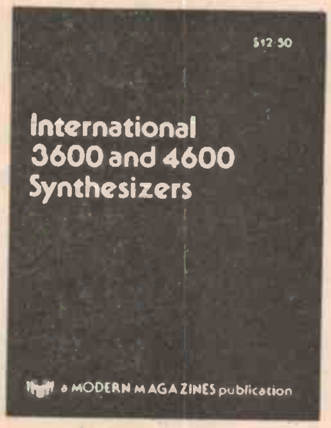
ETI PROJECTS

Reprints of many of our most popular projects are available in book form. Top Projects Vols 3 and 4 and our Test Gear book are available from most newsagents or directly from us. Our address is:— Electronics Today International, 15 Boundary Street, Rushcutters Bay, NSW. 2011. The Synthesizer book is available only from us and a limited number of specialist suppliers — it is not sold by newsagents.

TOP PROJECTS VOL 3
Published in October 1976. Projects include FM Tuner. 25 Watt Amplifier, Active Cross-over. Crossover Amplifier, Booster Amplifier, 50 Watt Power Module, 400 Speaker System, Audio Noise Generator, Dual Beam Adaptor, Tone Burst Generator, Digital Display, ETI Utiliboard, Linear IC Tester.
$2.50 plus 40 cents postage and packing.

TOP PROJECTS VOL 4
Published in June 1977. Projects include Audio Expander/Compressor, 50-100 Watt Amp Modules, Stereo Amplifier, Dynamic Noise Filter, Audio Phaser, Audio Limiter, TV Game, Swimming Pool Alarm, Train Controller, Car 'Scope Testing. Temperature Alarm, Active Antenna, GSR Monitor.
$3.00 plus 40 cents post and packing.



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$3.00 plus 40 cents post and packing.

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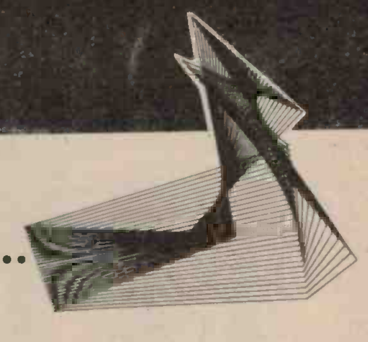
ETI's COMPUTER SECTION



NEWS

New Pocket Terminal

The G. R. Electronics Pocket Terminal is a hand-held device capable of sending and receiving data in 8 bit serial ASCII code. It has a 40-key positive tactile response keyboard comprising two single function and 38 multi-function keys which give internal control of the unit and allow transmission of all 128 ASCII codes, with a maximum rate repeat facility.

The terminal has a simultaneous display capacity of eight characters in line on 16-segment 'starburst' LEDs which can generate all 64 ASCII upper case alphanumerics and symbols clearly and legibly.

An internal memory is provided, with capacity for the last 30 characters received. These may be assessed for display in blocks of eight adjacent characters.

Two versions of the Pocket Terminal are available; interface for operation with 20mA current loop or at V24/RS232 levels. As standard the unit is fitted with an internal 'bleeper' which provides an audible response to reception of the 'BEL' code.

A removable panel on the rear of the unit gives access to a switch set allowing a number of operating options to be selected which include single or dual stop bits, parity and 300/110 Baud transmission rate.

The pocket terminal can be used for microprocessor programming, production data entry, warehousing, mobile data collection, training and education.

The unit operates off a single DC 5 volt supply drawing 450mA.

For further details contact: *The Dindima Group Pty. Ltd. P.O. Box 113, Balwyn, Vic. 3103.*

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. 356 6176.

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.

DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N4733	5.1v	1 W Zener	.25
1N753A	6.2v	500 mW Zener	.25
1N758A	10v	"	.25
1N759A	12v	"	.25
1N5243	13v	"	.25
1N5244B	14v	"	.25
1N5245B	15v	"	.25

SOCKETS/BRIDGES

8-pin	pcb	.20	ww	.35
14-pin	pcb	.20	ww	.40
16-pin	pcb	.20	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.35	ww	.95
24-pin	pcb	.35	ww	.95
28-pin	pcb	.45	ww	1.25
40-pin	pcb	.50	ww	1.25

Molex pins .01 — To-3 Sockets .25
2 Amp Bridge — 100-prv .95
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TRANSISTORS, LEDS, etc.

2N2222	NPN	(2N2222 Plastic .10)	.15
2N2907	PNP		.15
2N3906	PNP	(Plastic - Unmarked)	.10
2N3904	NPN	(Plastic - Unmarked)	.10
2N3054	NPN		.35
2N3055	NPN	15A 60v	.50
T1P125	PNP	Darlington	.35
LED Green, Red, Clear, Yellow			.15
D.L.747		7 seg 5/8" High com-anode	1.95
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FND359		7 seg com-cathode (Red)	1.25

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4000	.15
4001	.15
4002	.20
4004	3.95
4006	.95
4007	.20
4008	.75
4009	.35
4010	.35
4011	.20
4012	.20
4013	.40
4014	.75
4015	.75
4016	.35
4017	.75
4018	.75
4019	.35
4020	.85
4021	.75
4022	.75
4023	.20
4024	.75
4025	.20
4026	1.95
4027	.35
4028	.75
4030	.35
4033	1.50
4034	2.45
4035	.75
4040	.75
4041	.69
4042	.65
4043	.50
4044	.65
4046	1.25
4049	.45
4050	.45
4066	.55
4069/74C04	.25
4071	.25
4081	.30
4082	.30
MC 14409	14.50
MC 14419	4.85
4511	.95
74C151	1.90

— T T L —

7400	.10
7401	.15
7402	.15
7403	.15
7404	.10
7405	.25
7406	.25
7407	.55
7408	.15
7409	.15
7410	.15
7411	.25
7412	.25
7413	.25
7414	.75
7416	.25
7417	.40
7420	.15
7426	.25
7427	.25
7430	.15
7432	.20
7437	.20
7438	.20
7440	.20
7441	1.15
7442	.45
7443	.45
7444	.45
7445	.65
7446	.70
7447	.70
7448	.50
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.30
7475	.35
7476	.40
7480	.55
7481	.75
7483	.75
7485	.55
7486	.25
7489	1.05
7490	.45
7491	.70
7492	.45
7493	.35
7494	.75
7495	.60
7496	.80
74100	1.15
74107	.25
74121	.35
74122	.55
74123	.35
74125	.45
74126	.35
74132	.75
74141	.90
74150	.85
74151	.65
74153	.75
74154	.95
74156	.70
74157	.65
74161	.55
74163	.85
74164	.60
74165	1.10
74166	1.25
74175	.80

74176	.85
74180	.55
74181	2.25
74182	.75
74190	1.25
74191	.95
74192	.75
74193	.85
74194	.95
74195	.95
74196	.95
74197	.95
74198	1.45
74221	1.00
74367	.75
75108A	.35
75491	.50
75492	.50
74H00	.15
74H01	.20
74H04	.20
74H05	.20
74H08	.35
74H10	.35
74H11	.25
74H15	.45
74H20	.25
74H21	.25
74H22	.40
74H30	.20
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.20

74H72	.35
74H101	.75
74H103	.55
74H106	.95
74L00	.25
74L02	.20
74L03	.25
74L04	.30
74L10	.20
74L20	.35
74L30	.45
74L47	1.95
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74L74	.45
74L75	.55
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74L123	.85
74S00	.35
74S02	.35
74S03	.25
74S04	.25
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.25
74S40	.20
74S50	.20
74S51	.25
74S64	.15
74S74	.35
74S112	.60
74S114	.65

74S133	.40
74S140	.55
74S151	.30
74S153	.35
74S157	.75
74S158	.30
74S194	1.05
74S257 (8123)	1.05
74LS00	.20
74LS01	.20
74LS02	.20
74LS04	.20
74LS05	.25
74LS08	.25
74LS09	.25
74LS10	.25
74LS11	.25
74LS20	.20
74LS21	.25
74LS22	.25
74LS32	.25
74LS37	.25
74LS38	.35
74LS40	.30
74LS42	.65
74LS51	.35
74LS74	.35
74LS86	.35
74LS90	.55
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LM320K12	1.65

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LM320T12	1.65
LM320T15	1.65
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LM340T18	.95
LM340T24	.95
LM340K12	1.25

LM340K15	1.25
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Remote Controller

A new domestic remote controller from Mountain Hardware Inc. operates by sending 50 kHz control signals over the mains wiring. The Introl system, which at present operates on 110 V only, has controllers for S100 or Apple II buses, while the power control modules, which plug into mains outlets, can each control two independent 500 W channels. The central controller can turn up to 64 units on or off, and can poll remote units asking for the status of each device.

4K CMOS RAM

A new 4K static CMOS RAM, developed by Hitachi, has a standard access time of 43 ns. The gate length on the chip has been shortened from 6 microns to 3 microns, thus halving the parasitic capacitance and doubling the speed.

Albion Microcomputer Group

A very active group is running in Queensland, with monthly meetings on the second Friday of each month at Windsor State School, Harris Street, Windsor and an attendance of about 60 people at each meeting. The Group is now incorporated as an interest group under the IREE.

Apart from regular monthly meetings a series of ten week courses have been arranged with the Technical and Further Education Department. The second ten week course in the series is now under way; this is split into four groups, two of beginner's standard, one advanced standard and one on microcomputer programming. The courses are attended by just over 100 people.

Note that the phone number for the Group has changed to 356-6176 and the old number is disconnected.

9440 for S100

There's a rumour going round that Fairchild are developing a set of three cards for the S100 bus, which will carry a 9440 16-bit processor and 16 Kbytes of memory. As the 9440 (see last month's Printout) executes the instruction set of the Data General Nova minicomputer, this would make available a large amount of software for use in S100-based computers, particularly in business applications.

Sydney Auction Night

Check right now in your social diary to see if you are free on the evening of Monday, 17 July. If you are, then a trip to the Microcomputer Enthusiasts' Group meeting at the WIA Hall, 14 Atchison Street, St Leonards, would be well worth your while. Take some money with you, and if you've any spare microcomputer gear that you want to get rid of, take that along also, as the evening's programme is an Auction Night. There's always the chance of a great bargain!

The Sord M222 is a business model from the M200 series.

EPROM/ROM Compatibility

A new booklet from Intel Corp gives information on pin and signal compatibility of their EPROMs and mask-programmed ROMs. The booklet covers the 2758, 2716, and 2732 EPROMs, and the 2332 and 2364 mask-programmed ROMs; it also gives information on address decoding schemes.

Also new from Intel is the latest version of the 8085A, the 8085A-2, which Intel claim to be 'the highest performance 8-bit microcomputer available today'. This 5 MHz version of the 8085A features a 0.8 μs instruction cycle yet maintains a memory access time of 350 ns – which is not unduly fast. Further information may be obtained from local Intel distributors, Warburton Franki or A J Ferguson.

Sord Computers

Several interesting products in the Sord line of microcomputers are now available from Abacus EDP Services of 66-68 Albert Road, South Melbourne, Vic 3205. Sord Computer Systems, Inc. was founded in April 1970 by a group of ex-DEC engineers in Japan, and now boasts a broad line of microcomputers.

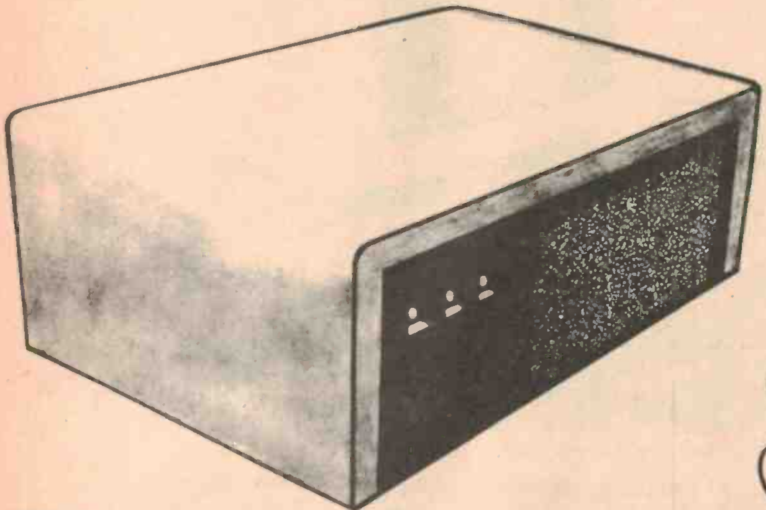
Top of that line is the Model 8050, a Z-80 based small business computer which can run RPG II and multi-user BASIC as well as FORTRAN-80. An impressive range of peripherals is available, including a CRT unit, both hard and floppy disks, a range of printers, cassette and tape drives, card reader, paper tape punch and reader, intelligent keyboard and communications interface. The 8050 is modular in design, using mini-computer style mechanical construction, and utilising LSI for high reliability.

Perhaps of more interest to the hobbyist is the Sord M200 series of Z-80 based microcomputers. These are similar in construction to the Commodore PET, or a SOL with a built in monitor, and utilise the S100 bus for expansion. Various different models are available, for business, lab or home use, including one with a built-in cash drawer. Both hardware and software are very advanced; for example, two 64 Kbyte memory areas are available, one for system software and the other for user code. Major software for the M200 series is a very advanced extended BASIC; FORTRAN IV will soon be released. As for the Model 8050, a wide range of hardware/peripheral options is available.

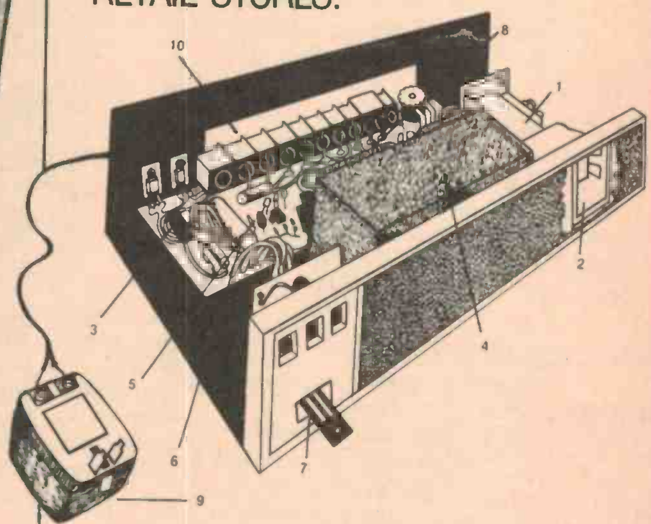
A lower-cost system, the M100, is specifically designed for home use. The Z-80 based M100 has 16 Kbytes of RAM as standard and runs an 8K BASIC. It provides a 64 x 24 display on a standard TV set, uses the S100 bus, and incorporates some interesting features such as an audio speaker, journal printer interface, and an 8-bit 2-channel A/D converter with joystick.

Abacus are also agents for Century Computers, and Soroc, whose IQ120 CRT terminal is extremely popular with computer hobbyists in the US. Further information on any of these products is available from Abacus EDP Services.

Reader Offer — MIDEX SYSTEM 55



FOR USE IN HOMES, MEDICAL/DENTAL OFFICES, SMALL RETAIL STORES.



1. Gunn diode transceiver
2. Antenna
3. Process electronics
4. Four-hour standby battery (rechargeable)
5. Timing circuits
6. Automatic reset
7. Coded electronic switching
8. Sweep siren and amplifier
9. Stepdown transformer adaptor (to Aust. pattern)
10. Inputs for additional external circuits.

SPECIFICATIONS:

OPEN SPACE RANGE: (main axis) 50 foot maximum
RANGE CONTROL: Single turn potentiometer. Range adjustment from zero to full.
SENSITIVITY: 1-2 steps within set range. Self-adjusting for constant (background) motion.
PROTECTION PATTERN: Single lobe 50 foot maximum length, 20 foot maximum width.
EXIT TIMER: 30 seconds
ENTRY TIMER: 20 seconds
RECHARGEABLE STANDBY BATTERY: 4 hours standby
POWER CONSUMPTION: 8W maximum
ALARM CYCLE TIMER: 1 minute
SIREN ALARM: (Active during alarm cycle) 5W into 8 ohm speaker (or into any combination of speakers not resulting in less than 4 ohms)
AUXILIARY SENSOR INPUTS: Normally closed contact
ELECTRONIC KEY SWITCH: OFF (Test light active for walk test purposes). ON (timers activated. Until operational).

Until recent times intruder alarm systems were generally designed to sound an alarm if one or more external doors or windows were opened.

Such systems offer adequate protection for homes and offices with few external entry points but are less than adequate where there are large door or window areas. Installation can also be a major and costly business often involving hundreds of metres of easily damaged cable and a large number of switches and connections.

Because of this there is a growing trend toward self-contained systems which detect the movement of an intruder. The best of these use microwave energy: a Gunn diode projects a very high frequency (10.5 GHz) stable peardrop shaped radiation pattern into the area to be protected.

Objects within the radiation area partially reflect the energy to the transceiver. If all objects within range are stationary the reflected waves will be at the original transmitted frequency. If they strike a moving object the movement will cause a (Doppler) frequency shift and the waves return at a slightly higher or lower frequency. The transmitted and received frequencies are compared and any difference is amplified and used to trip the alarm.

The radiation pattern is almost impossible for an intruder to detect and is not affected by air currents, noise, light, sound, temperature or humidity.

Maximum detection range is approximately 15 metres — controls are provided to reduce sensitivity if required.

The Midex unit contains a powerful amplifier siren circuit which should be used in conjunction with the blast horn type speaker specified. The blast horn supplied (or equivalent) has such volume and penetration as to cause pain within 15 seconds of exposure. It is almost impossible for an intruder to stay within the area.

The Midex unit is 'armed' and 'disarmed' by a special coded electronic key. An inbuilt timing circuit allows 30 seconds to leave the building and 20 seconds to re-enter before the alarm is activated.

Also included as standard are connections for additional external closed loop circuitry (i.e. door and window sensors) and 'panic switches'.

The Caldor Corporation Pty Ltd has arranged to offer these units directly to our readers at $299.95 (plus $5 postage and handling). The recommended heavy duty blast horns are also offered at $49.95 each (plus $5.00 each post and packing). For total protection two such horns should be used. A lighter version is also available for $29.95, (plus $5.00 post and packing). This version is adequate for protecting small areas.

This magazine has inspected and tested the products offered and can thoroughly recommend them. They are properly engineered intruder alarms from one of the USA's leading and most respected manufacturers in this field (Midex Corp, Mountain View, Calif.).

NOTE: This offer is made by the Caldor Corporation, and this magazine is acting as a clearing office for orders only. Cheques should be made out to 'Midex Offer' and sent together with the order form to 'Midex Offer' Electronics Today International, 15 Boundary St, Rushcutters Bay, NSW 2011.

ETI will process orders and send them on to Caldor who will then send out the goods by certified mail. Please allow approximately four weeks for delivery.

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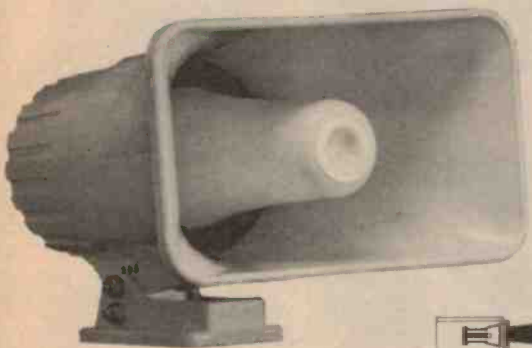
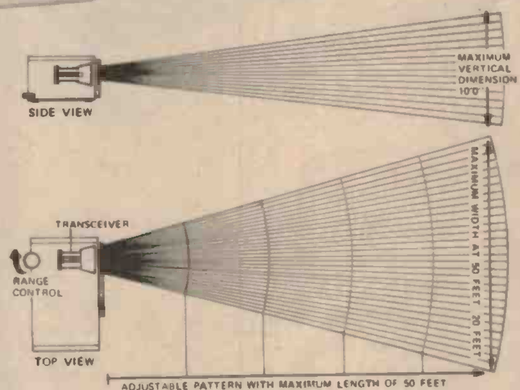


RADIATION PATTERN



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- [ ] Large Blast Horn/s at $49.95 each $.................................
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Postage and packing $5 per unit $.................................

Total $.................................

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M100

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SPECIFICATIONS:

CPU
Using a Z-80 microcomputer chip.

ROM
Up to 8K bytes capacity.

RAM
16K bytes (M110) or 32K bytes (M120).

KEYBOARD
Full ASCII keyboard and 20- BASIC command keys.

CONTROLLERS
Audio cassette 2-channel. CRT monitor controller.

INTERFACES
Modern Interface (RS232C) with edge connector. 8-bit digital input output. Journal printer interface. 8-bit 2-channel AD converter and joystick.

SPEAKER
2 octave output speaker.

S100
Bus signal edge connector.

CLOCK
Provided.

OPTIONAL UNITS
- Power Supply: Input 230 V 50 Hz, output5 V, 4 A and 12 V, 0.5 A for M100 CPU.
- Colour graphic (256 x 192 dots) display controller.
- Black & white TV monitor (24 lines of 64 characters).
- SNO100 Bus extension cabinet.
- 8 outlet power control box.

THE M200 SERIES FAMILY

- *M220 Standard Model with optional dual mini-floppy disk drive.*

- *M230 Laboratory Model and printer.*

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ROM: Mask programmable variety.
RAM: 48K bytes capacity. Accessed by Z-80 through CRT display priority.
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KEYBOARD: Easy-to-operate, multi-purpose, intelligent-type 124-key system, 26 designated keys with four commands for frequently used characters in BASIC. Four mode and five shift keys. LEDs prevent operational errors. Normal-Reverse mode. Special keyboard arrangements available on request.
CRT DISPLAY: Built-in l2-inch flat face braun tube. 24 lines of 80 characters. 186 different alphanumerics and signals for aa total of 1920 characters by means of dot matrix. Normal-Reverse mode. Graphics on a character-by-character base.
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I/O SERIAL PORT: 2 RS 232C serial ports for MODEM, Teletype, and a switch selectable additional audio cassette interface.
SOFTWARE: SORD Extended BASIC Plus.
OPTIONAL UNITS: A to D, D to A converters, high speed line printer, DI/DO, IEEE 488 Interface Bus (HP-IB) MODEM. Typewriter keyboard on M222.

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8080 Educational/Prototyping Interface

This paper by Dr Paul F Goldsborough, of Canberra College of Advanced Education, describes an interface board for the 8080 which allows debugging of both software and hardware. It also allows educational experiments based on the 'Bugbooks'.

FOR THE ELECTRONIC ENGINEER, technician or OEM'er working in his small to medium scale electronics laboratory, the college or university professor wanting to effectively teach microcomputers, or for the hobbyist who would like a cheap flexible microcomputer system, the present microcomputer market presents some real problems. Two of the major problems for the user are which microprocessor (8080A, 6800, 2650, SC/MP etc.) to use?; and what type of development system or evaluation kit to commence with? A further problem relates to the required background knowledge. Since an understanding of assembly language programming and microcomputer interfacing is necessary to use microcomputers, the evaluation or development kit chosen should, ideally, be suitable for easily leading the user through these fundamentals before going on to more advanced experimental work. In other words, the user should be able to learn the fundamentals with his development system before going on to more advanced experiments and prototyping work.

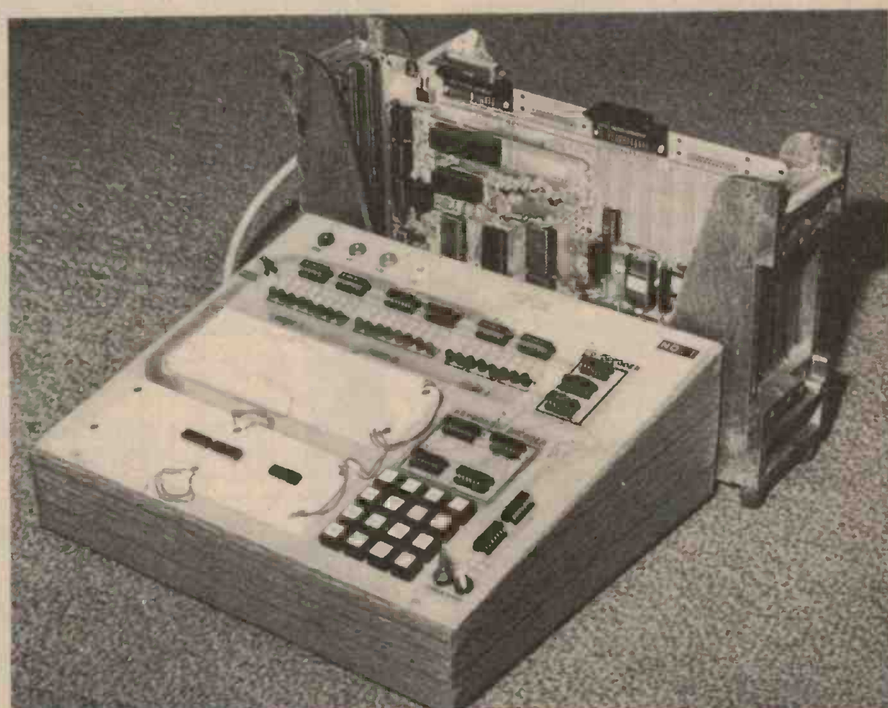

Fig.1. A prototype of the educational/prototyping microcomputer. The SKD-80 (at rear) is connected to the MMD-1 educational interface via the 43 pin P-1 edge connector and the 25 pin J-1 edge connector.

The problem with the microcomputer market at the moment, however, is that there is really no product which is useful as *both* an educational microcomputer and also as a prototyping/development system. On the one hand, several teaching microcomputers of varying effectiveness and cost are available. These include the Intel Prompt 80 system, E & L Instruments' Mini Micro Designer (MMD-1) and Bug Books, and the ISIAS Company's "Computer in a Book". These educational systems are usually characterised by built-in educational interfaces in the form of key boards, LED displays, etc., which are so necessary for teaching microcomputer principles. Because of their built-in educational interfaces. These systems are usually unsuitable both physically and functionally as software and hardware prototyping/development systems. On the other hand, systems which are designed specifically for prototyping/development work are available and some of these have been described in this magazine. These systems range in complexity and cost from small evaluation kits through to the large effective, but expensive, microcomputer development systems. These, in general, are unsatisfactory for direct use as educational microcomputers because they lack an educational interface and effective teaching literature.

The educational/prototyping microcomputer described in this article was designed by the author to provide an instrument which is useful as both an educational microcomputer, *and* as a prototyping/development system. The development work was carried out at the Virginia Polytechnic Institute and State University with Dr. Peter Rony, Mr. David Larsen, and Mr. John Titus, the authors of the popular Bug Book Series. The prototype system which was developed is shown in Figure 1. The educational interface used in this system is that of the Mini Micro Designer microcomputer for which two educational, self-teaching books [1] on digital electronics and

Project 634

8080A programming and interfacing had already been written. This material has been tested with students and professional groups and found to be extremely effective for teaching microcomputer fundamentals. [4] Hence, because of this and the popularity of the Intel 8080A microprocessor in the U.S.A., the educational interface of the MMD-1 was retained and interfaced to the commercially available Intel SDK-80 prototyping microcomputer.

The system then can be used initially for educational and/or self teaching work. Assembly language programming is facilitated by key board data entry, which provides rapid data entry while still allowing the user to maintain close contact with the microcomputer. The SK-10 solderless bread-boarding socket which contains the data, address, control lines and 24 PPI lines, facilitiates interfacing experiments which can be done in conjunction with Bug Books 5 and 6. In addition, hardware single step (single machine cycle) facilities, and a bus monitor are included in the educational interface as additional self-teaching aids. Keyboard data and command entry are controlled by a small monitor program known as KEX — the keyboard executive program.

For prototyping and advanced experimental work, the SDK-80 has facilities for teletype and VDU data entry, vectored interrupts, parallel data entry and I/O device configuration under program control via the 8255 programmable peripheral interface. During prototype system development, software and hardware system aids are necessary for program and system debugging. These aids can be 'added to' a stand alone prototype microcomputer system as is done for example, with the Intel In Circuit Emulator (ICE) and microcomputer development system. As a cheaper alternative, an effective software development aid, D-BUG, which was written by Dr. Chris Titus, of Tychon, Inc., Blacksburg, Virginia, has been incorporated in the system to be described, as an integral part of what is effectively the final stand alone microcomputer. In addition to the usual teletype monitor facilities for manual program entry, memory examination and program initiation, D-BUG has facilities for inputting and outputting programs to paper tape, thus avoiding the need for time consuming repetitive hand entry of programs; as well as a most effective break point and single-step feature for program debugging. The advantage of this 1K program is that when a break point is set and hit during program execution, the contents of

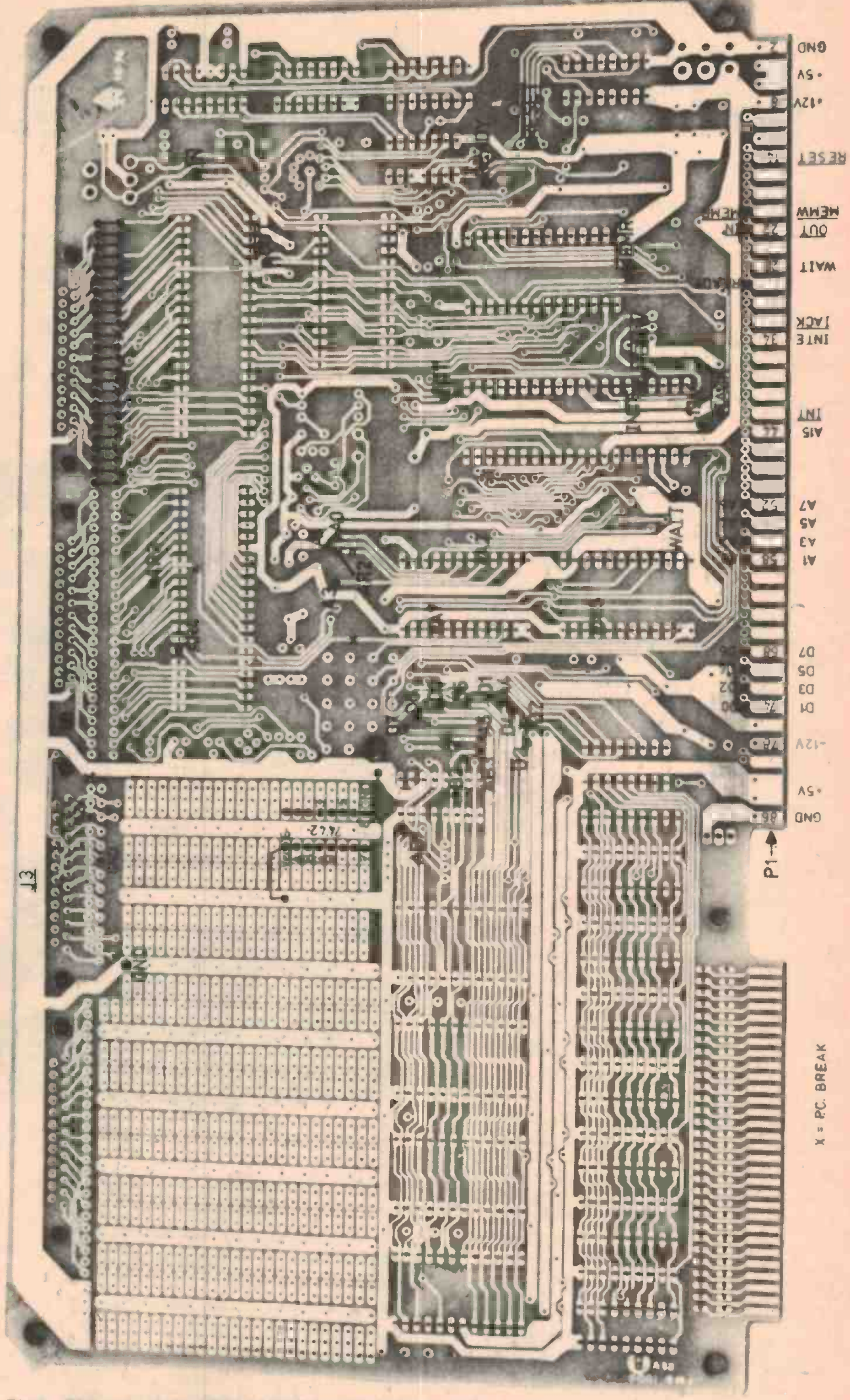

Fig.2. The rear of the SDK-80 PCB board showing the P-1 edge connector pin assignments. The positions from which the address, data and control signals are to be wired to P-1 are indicated with dots.

registers A, B, C, D, E, H, and L, the contents of the memory location addressed by register pair H, the stack pointer and the last two entries on the stack are automatically printed out, avoiding the need for manual examination. The program may then be single stepped (by pressing the S key) and at each step, all the above data is output, allowing full examination of program execution. Alternatively, another break point may be set and program execution moderate cost ($286 plus tax – the cheapest in the Intel range), and the simplicity and generality of its layout. The kit is supplied with a 1K EPROM or ROM for the system monitor, a spare 1K EPROM, 256 words of RAM, and a PPI and USART making it excellent value. Also supplied is a users guide [(2)], which provides clear directions for construction and check-out of the microcomputer. I estimate construction time at 4-5 hours. The jumper wiring of optional features is summarised in Table 2.

The SDK-80 board is physically compatible with the Intel MDS system and so has two base edge connectors P-1 and P-2. On other Intel systems, the address, data and control signals are brought down to the P-1 edge connector. However, this is not done on the SDK-80 although plated-through holes are provided at each edge connector pin to permit user wiring. Hence, once you have assembled the SDK-80 (and verified that it is operating using the supplied system monitor and a teletype if one is available), the next step is to bring the address lines (A0-A7, A15), data lines (D0-D7) and control signals ($\overline{IN}$, $\overline{OUT}$, $\overline{MEMR}$, $\overline{MEMW}$, $\overline{INT}$, INTE,

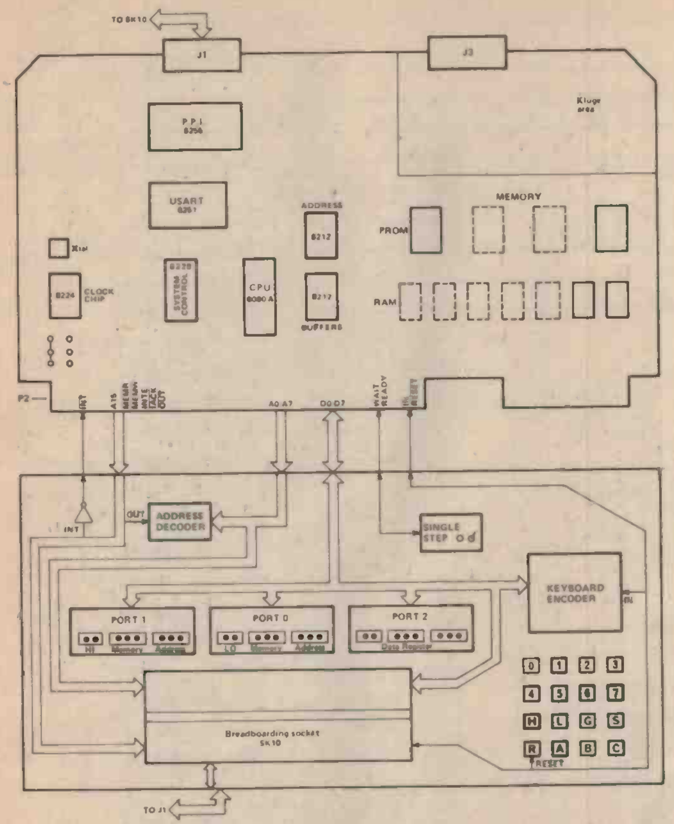

Fig.3. Block diagram of the Educational/Prototyping microcomputer showing the SDK-80 (top) and educational interface (bottom).

continued. These features of DBUG are illustrated in Table 1.

Hardware debugging is aided by the hardware single step circuit, and the easy availability of the data, address, and control lines at the SK-10 socket for monitoring. Once the software and hardware for the stand alone application have been developed and tested, an identical system is constructed omitting the educational interface, KEX and DBUG. A PROM, which contains the program developed in RAM and which has been tested in the educational/prototyping microcomputer to run at the origin, is used to drive the new stand alone system. Program initiation is then by a system reset.

The system described here was used by the author in England during April, May, and June of 1977 for the development of a stand alone data logger for a natural gamma spectrometer. It was found to be most effective indeed for programs up to several hundred bytes With memory expansion, a 6K resident editor-assembler can also be added to further speed the development cycle.

The SDK-80 Prototyping Microcomputer

The SDK-80 was chosen as the prototyping microcomputer because of its

TABLE 1

```
        TYCHON EDITOR-ASSEMBLER V-2                          PAGE 01-001
                    /THIS PROGRAM IS USED TO ILLUSTRATE THE FEATURES
                    /OF PROGRAM "DBUG"
                              *020 000
020 000 061                   LXISP
020 001 000                   000
020 002 024                   024
020 003 001                   LXIB
020 004 001                   001
020 005 002                   002
020 006 021                   LXID
020 007 003                   003
020 010 004                   004
020 011 306     LOOP,         ADI
020 012 004                   004
020 013 003                   INXB
020 014 303                   JMP
020 015 011                   LOOP
020 016 020                   0
-----------------------------------------------------------------------
      020 003 B
      020 000 G
      020 003
      SZ I P 2  A   B   C   D   E   H   L   M   S P   C S
      01000110 000 002 001 000 000 000 000 303 024 000 377 377

      S 020 006
      01000110 000 002 001 004 003 000 000 303 024 000 377 377

      S 020 011
      00000010 004 002 001 004 003 000 000 303 024 000 377 377

      S 020 013
      00000010 004 002 002 004 003 000 000 303 024 000 377 377

      020 011 B
      C
      020 011
      00000010 010 002 002 004 003 000 000 303 024 000 377 377
```

Software diagnostic provided by DBUG for the above program.

IACK, WAIT and READY) down to the P-1 edge connector. Figure 2 shows the SDK-80 PCB board layout, P-1 edge connector pin assignments and the positions on the board from which the address, data and control lines are wired down to P-1. To provide buffering and line drive for the address data and control lines, all lines are wired to the edge connector from the I/O side of the 8212's and the 8228 system controller.

Educational Interface

The MMD-1 educational interface was modularised and wired to the SDK-80 via a 43 pin socket which matches the SDK-80 P-1 edge connector. Figure 3 is a functional block diagram of the assembled microcomputer showing the data, control and address lines paths. Figure 4 shows a circuit diagram of the educational interface. The construction of this circuit should not present any problems. The operation of the major part of the circuit was described in the May to July, 1976 issues of *Radio Electronics.* The main circuit features, however, can be summarised as follows:

- Data/command entry is via key switches and two 74148 priority encoders. The 74148's, together with 4 NAND gates and the EO output of the second 74148 are used to generate a 5 bit coded word which is buffered on to the data bus lines D0-D3 and D7 via an 8095 tri-state buffer.
- Debouncing of the KEY switches is done by software.
- Three 8 bit LED displays (O/P ports 0-2) are wired to the data bus using 7475 latches and LED's.
- Device select, latching pulses for O/P ports 0-2 are generated by uniquely decoding the device codes 000_8, 001_8 and 002_8 using a 74L42 and five inverters, and NOR'ing the resulting device select pulses with OUT.
- *Hardware single stepping* is achieved by raising the READY line of the 8224 clock chip on the SDK-80 using a 7474 flip flop which is then reset ≈500 ns later by the 8080 'WAIT' line going "low". The single step clocking pulse to the 7474 is optionally provided by either a debounced press button switch or an external single stepping clock.
- During normal operation of the MMD-1 educational interface, output port 1 is used to display the high memory address byte (A8-A15). Since this byte rarely if ever changes during teaching, port 1 has been used as a *bus monitor* by tying the enable inputs (pins 4 and 13) of the 7475's to a logic one through a single-pole, single-throw switch. With the enable inputs at 'one' (switch closed), the outputs of the 7475's follow their inputs and the Port acts as a bus monitor. With the enable input lines 'low' (switch open), data is latched.
- An active low signal (INT) is required by the SDK-80 for interrupts. However, as the chapters on interrupts in Bugbook 6 uses an active high signal INT, an inverter has been used in the interface to invert INT for input to the SDK-80.

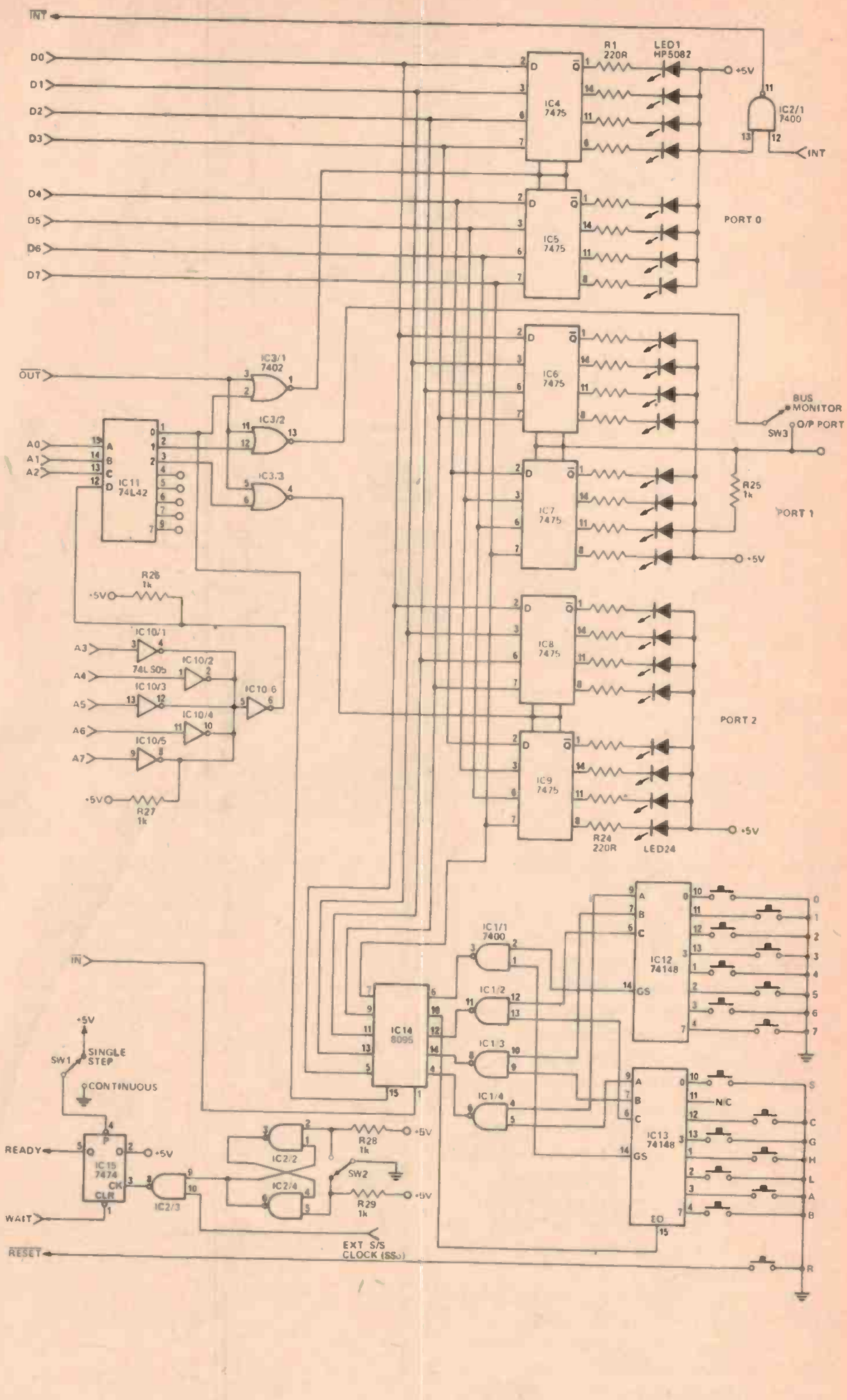

Fig.4. Educational interface circuit diagram.

Software Control and Device Code Considerations

Referring to Figure 5 which shows a memory map of the SDK-80, it can be seen that the first 4K words of memory are allocated in 1K blocks to ROM or EPROM. The fifth 1K block of memory is allocated to RAM in 4, 256 word segments. Since the kit supplied, resident, SDK-80 monitor required the top 30 words of RAM for stack and temporary storage, the 256 words of RAM supplied with the kit were located at address 023_8 000_8.

The educational interface is controlled by a keyboard executive program, called KEX. This must reside in the first 256 words of ROM commencing at address 000_8 000_8 so that a reset key operation always transfers control of the microcomputer to KEX. Because of the SDK-80 ROM memory allocation arrangement, a 1K EPROM must be used to store the program.

A major feature of KEX operation is that it spends most of its time polling Port Ø (the keyboard) in search of user, key entered commands. Hence, it is important to ensure that the Port Ø device code (000_8) and the other educational interface device codes (001_8, 002_8) do not address any or all of the on-board SDK-80 I/O devices. Two important factors concerning SDK-80 electronics must be considered, viz.,

- non-unique, single bit or linear decoding is used to generate device enable pulses for the PPI's and USART and;
- the chip enables for the PPI and USART are *active low*.

Figure 6 shows the combined PPI and USART device code format. Because of the above factors, there is considerable SDK-80 device code redundancy. The educational interface device codes (000_8 through 002_8) represent in fact, the worst case condition in which both PPI's and the USART are *simultaneously* enabled. Clearly, this situation would lead to excessive loading of all the I/O devices. However, the educational interface device codes must be retained as they are used throughout Bugbook 6. Hence, to ensure satisfactory computer operation, either the PPI and USART must be removed from the SDK-80 or their device codes must be changed and/or uniquely decoded. For initial system checkout described below, I suggest that you simply remove the USART and PPI. A permanent solution is presented later.

TABLE 2

SDK-80 Jumper Wiring

Function	Action
To disable "HOLD"	J5-2 to J5-3
To connect 8224 & 8080A "READY" lines	J5-7 to J5-8
To permanently "ENABLE" bus lines	J5-4 to J5-5
For 110 Baud	PADS 29 to 37, 4 to 5
For Teletype "20 mA current loop" operation	PADS 1 to 2, 7 to 8, 10 to 11, 13 to 14, 15 to 16, 18 to 19, 21 to 22, 23 to 26, A to B

Next month we shall conclude this project with full constructional details and application information. Owing to space limitations, we are unable to provide printed circuit board drawings for this project, but boards will be available from the usual suppliers (e.g. RCS Radio, Applied Technology, etc.). If you wish to make your own, positives or negatives (please state which) are available from Nebula Electronics, 15 Boundary Street, Rushcutters Bay, NSW 2011, for $6 per set.

For similar reasons, it is impossible for us to include listings of the Keyboard Executive Program, KEX or tape dump program HTAPE in the magazine. However, photocopies of the listings with some documentation are available directly from ETI at a charge of $2.50 to cover costs.

Concluded next month

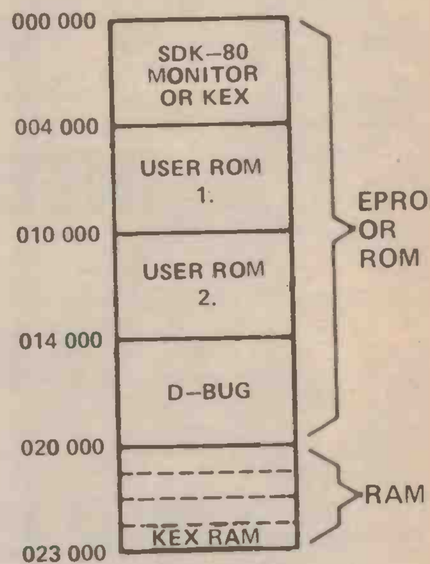

Fig.5. SDK-80 memory map.

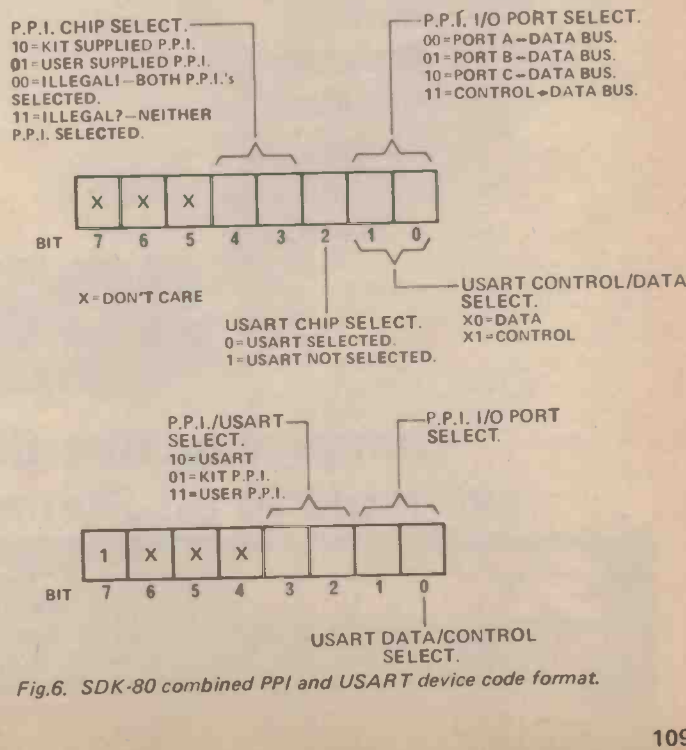

Fig.6. SDK-80 combined PPI and USART device code format.


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propagation a closer look

Roger Harrison concludes, in part III, his introductory essay on radio propagation and explores the inner meaning of those prediction curves.

LONG DISTANCE propagation on the HF bands is not all by means of multi-hop reflections between the ionosphere and the earth. Considerable distance can be covered, or paths not supposed to be 'open' can be worked – often well beyond the MUF – by means of a variety of "anomalous propagation" modes.

The ionosphere is not an homogenous medium. The cream is not mixed in with the milk, so to speak. It is a curious mixture of 'thick' patches and 'thin' patches, bulges and tilts – all the time on the move under the influence of a variety of forces. Some of which have already been explained.

"Chordal Hop" Propagation

The base of the ionosphere is not 'flat', nor parallel to the earth's surface in many places. This characteristic gives rise to 'tilts' in the base of the ionosphere which can be exploited to provide multiple reflections from the ionosphere *without intermediate ground reflections*.

This is now commonly referred to as "chordal hop" propagation. The concept is illustrated in Figure 12.

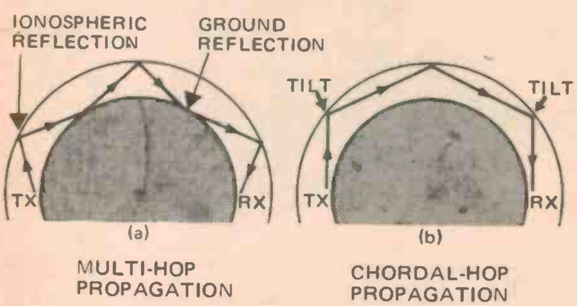

Fig.12.

When tilts occur at suitable points along a path, particularly at the ionospheric reflection point nearest each terminal of a path (the 'control point'), then chordal hop propagation often results. If a signal arrives at a tilt at a suitably low angle, then the ionosphere will support propagation well above the 'predicted' MUF and will also provide extremely strong signals on lower frequencies as the signal will spend less time travelling through the D-layer together with the decreased loss through successive ground reflections.

Chordal hop propagation has been exploited by amateurs working from Britain to Australia on several of the lower HF bands. Tilts occur in the base of the ionosphere at the 'sunset' zone and at regions either side of the geomagnetic equator. Using the tilt south of the geomagnetic equator in the Indian ocean area, and the sunset tilt over the Mediterranean, British and West Australian amateurs have been able to make contact on the 3.5 and 7 MHz bands at times when they would normally be 'closed'.

Low angle radiation from the antenna is necessary to exploit these modes but due to the ionosphere "focussing" the signal rays, and the low angle of incidence on the ionosphere, very little power is necessary to produce surprising signal strengths.

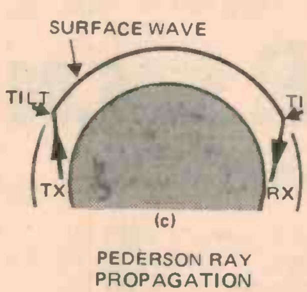

Fig.13.

"Pederson Rays"

Anomalies in the electron distribution well within the F-layer can entrap signals so that a sort of total internal reflection phenomena occurs.

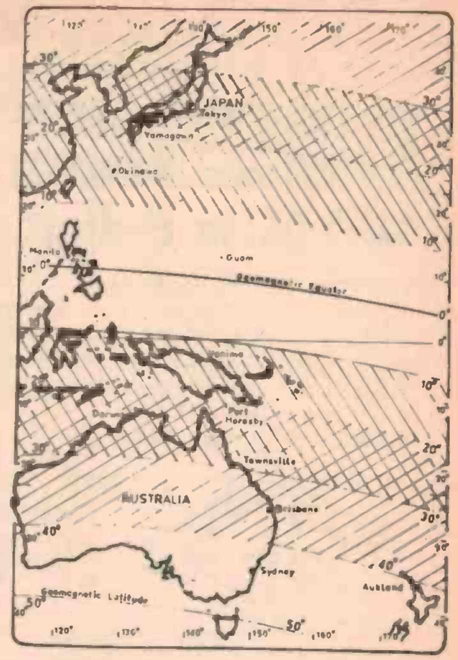

Fig.14. Australasian sector of the world showing terminal zones for class I TEP (20° to 40° geomagnetic latitude) and class II TEP (10° to 30° geomagnetic latitude).

A signal trapped in such a manner can travel surprising distances, again without intermediate ground reflections, and re-emerge from the ionosphere via another anomaly or tilt.

Signals travelling through the ionosphere in this manner are referred to as Pederson Rays after the man who first described them. The phenomenon is illustrated in Figure 13.

A Pederson Ray generally travels through the ionosphere at considerable heights and experiences more "loss" than chordal hop signals. However, it is often experienced where high radiation angles occur from an antenna so that the signals enter the ionospheric anomalies at a favourable angle.

Transequatorial Propagation

This mode of propagation was discovered by radio amateurs in 1947. Confirmed contacts on the 50 MHz band between amateurs in the USA and South America exploited certain characteristics of the equatorial ionosphere unknown at that time and which have taken some 30 years of research to explain – and it's not finished yet!

There are two types of TEP known as "afternoon-type", or class 1, and "evening-type" or class 2.

Afternoon-type TEP is a true chordal hop propagation mode and occurs generally between 1200 hours and 1900 hours local mean time. Stations situated in the zone between about 20° and 40° geomagnetic latitude are able to contact stations in a similar zone on the opposite side of the geomagnetic equator. Figure 14 shows the

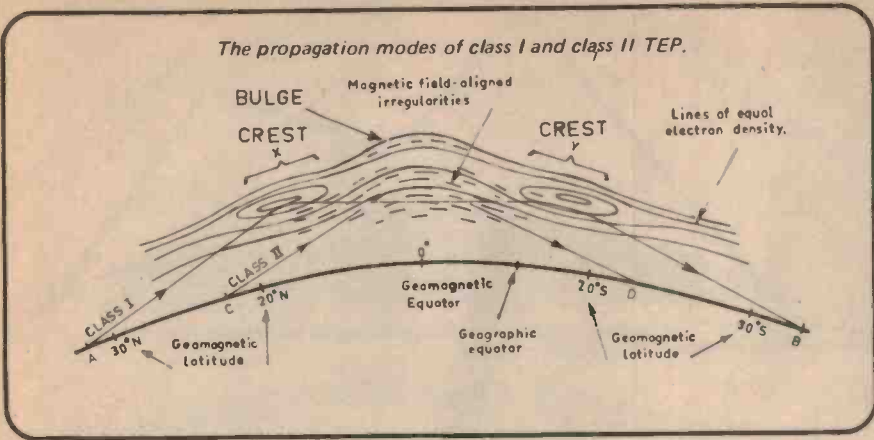

Fig.15. The Propagation modes of class I and class II TEP.

Australasian sector of the world with the class 1 zones cross-hatched thus: ////.

Evening type TEP is generally experienced between 2000 hours and 2300 hours local mean time and stations located in the area between 10° and 30° geomagnetic latitude (cross-hatched \\\\ in Fig. 14) can contact stations in the similar zone on the opposite side of the geomagnetic equator.

Transequatorial propagation is predominantly an equinoctial occurrence, peaking in the months March-April and September-October but it can occur over many more months around the equinoxes (21 March and 21 September), particularly during high sunspot activity.

The propagation modes for both classes of TEP are illustrated in Figure 15. The afternoon-type mode is generally called a "supermode". The signal is reflected from two dense 'bulges' in the ionosphere located either side of the geomagnetic equator. The density of these bulges, and the tilts associated with them, cause 'ray focussing' which gives rise to the surprising signal strengths observed on afternoon-type TEP signals. Fading on these signals is small; propagation distortion experienced on 'normal' ionospheric modes is absent giving rise to good quality signals as well.

Signals up to 65-70 MHz may be propagated by class 1 TEP, which represents a considerable extension of the conventional MUF for these paths. Occurrences will increase in coming years as the sunspot activity increases.

The best paths for class 1 TEP are those which cross the geomagnetic equator at angles close to 90°. Even so, paths which have considerable obliquity — such as USA to Australia — are occasionally bridged during good conditions.

Evening-type TEP is a "field-guided" mode. The equatorial bulges (X and Y in Fig. 15) that exist during the afternoon in the equatorial region of the ionosphere break up after sunset and the ionosphere over the geomagnetic equator develops dense 'slabs' of ionisation which align themselves with the earth's magnetic field. If a signal is sent towards this area of the ionosphere so that it arrives more or less at a tangent to the magnetic field then it may become 'trapped' between the 'slabs' of dense ionisation and conducted across the equator by successive reflection from a series of these irregularities.

Again, signals will be quite strong on evening-type TEP but considerable 'flutter' fading is generally experienced — generally at a rate between 5 and 15 Hz.

Evening-type TEP will support signals of much higher frequencies than for afternoon type. Until recently, it was thought that the limit was in the vicinity of 100 MHz, but recent contacts between Australian and Japanese amateurs, as well as Puerto Rican and Argentinian amateurs, on the 144 MHz band clearly indicate that there is more to be learned about this mode of propagation.

Evening-type TEP is much more tolerant of path obliquity than afternoon-type. However, the paths are generally shorter.

The zones for each class of TEP shown in Fig. 14 are calculated from the geometry of the propagation mechanism and don't necessarily indicate the limits. Amateurs from Sydney right down to Hobart have worked into Japan on the six metre band on many occasions, via class 1 TEP.

Class 2 TEP rarely reaches as far south as Brisbane though. Extensions of the paths can occur if 'Sporadic E' propagation is available in suitable areas.

The propagation mechanism of evening-type TEP has only recently been explained. Research by scientists of the Australian Ionospheric Prediction Service has led to confirmation and explanation of class 2 TEP.

Complex "Mixed" Modes

Many propagation paths can experience complex propagation modes involving both the F-layer and E-layer, particularly Sporadic-E. These modes are common on equatorial paths and can involve multiple reflections from the F and E layers both with and without intermediate ground reflection. These complex modes can give rise to extension of the MUF or disturb communications into particular areas.

Three types of complex modes are illustrated in figures 16, 17 and 18.

Using the Prediction Charts

The ionospheric prediction charts published regularly in ETI show the frequency range which can be used over a particular path for a particular month (for the month ahead) and the variation over a 24 hour period.

The monthly predictions for each path show the maximum usable frequencies for less than 50% of the days of the month on the uppermost curve. This is the optimistic prediction. The curve below this indicates the predicted MUF for between 50% and 90% of the days of the month — a more reliable prediction. The absorption limiting frequency, the ALF, is indicated by the lower curve. Propagation over the path is not possible at times shown for the frequencies lower than the curve.

Paths

The Australian Ionospheric Prediction Service provides ETI with computer printouts of monthly predictions for a total of 36 paths, but only the predictions for the common and/or most interesting paths will be reproduced each month. We have chosen the terminals of these paths so that the predictions will serve the widest range of reader's interest, both amateur and shortwave listener.

Path Terminals

Four Australian terminals, serving the major population centres, have been chosen. These are as follows:

EAST COAST
NORTH EAST
SOUTH CENTRAL
WEST COAST

These are more or less self-explanatory as regards the general area. The EAST COAST predictions serve the area from southern QLD to Tasmania. The NORTH EAST predictions serve northern QLD and to a large extent the Northern Territory.

The SOUTH CENTRAL predictions serve South Australia and the south area of the Northern Territory.

The WEST COAST terminal serves for Western Australia.

Continued from p.113

As the paths are quite long, the only differences that will be noted by widely separated stations in the terminal service areas will be a slight time shift. From the published predictions it will also be noticed that several Australian terminal areas may be served by one path prediction. The similarity between predictions is so close that separate predictions are not warranted in these cases.

Consequently, although only 18 predictions may be published, as many as 28 paths may be covered by predictions.

There are nine overseas terminals chosen to provide predictions for major population centres or areas of particular interest. These are as follows:

JAPANESE ARCHIPELAGO
SOUTH PACIFIC
NORTH AMERICA
SOUTH AMERICA
NORTH AFRICA
SOUTH AFRICA
CENTRAL USSR
EUROPE-SHORT PATH
EUROPE-LONG PATH

Predictions for the JAPANESE ARCHIPELAGO (labelled "JAPAN" on the graphs) will serve for Japan, Korea, south east Russia, Hong Kong etc, including the island chains near Japan. As this is a very good TEP circuit, watch for the predictions to exceed 40 MHz and signals up to 60 MHz or more may be experienced on Transequatorial Propagation.

The SOUTH PACIFIC predictions are centred on the Tuomoto Archipelago and serve the Gilbert and Ellice island group, Cook Islands etc.

The NORTH AMERICA predictions are centred on Colorado in the USA and should prove useful for USA, Mexico and Canada. The SOUTH AMERICA charts are centred on Bolivia and should prove useful for most South American countries as well as Central America and the Bahamas.

The NORTH AFRICA chart is centred on Chad and should serve well for all of North Africa and the Mediterranean region. Predictions for SOUTH AFRICA are centred on Johannesburg and will serve south to central African countries.

The CENTRAL USSR prediction chart will serve the South Georgia, Novisibirsk to North India region.

Two prediction charts can be provided for EUROPE, "long path" and "short path". At present, the short path predictions are far and away the best, the long route suffering from severe absorption and is not 'open' at any times different to that for the short path.

If you are interested in a particular frequency band then the times it will be 'open' for propagation between the terminals given can be found from the graphs.

Project a line from the particular frequency band of interest across the graph. Where this line crosses the MUF curve will indicate the times the path will be open for that frequency. Project lines down to the hours axis along the bottom of the prediction chart to read off the times.

The upper MUF curve will indicate that the path will be open for longer hours, but for fewer than half the days of the month. The lower MUF curve will show the band to be open on that path for fewer hours on most days of the month.

This is illustrated in figure 19 for the 28 MHz band. Note that 'Universal Time' (UT — better known as GMT) is used and you'll have to convert for your time zone. For the Australian East Coast, add 10 hours, for the Central Zone, add 9½ hours, for the West Coast add 8 hours.

Don't forget that in summer some states introduce daylight saving and an appropriate adjustment should be made.

Any enquiries about the predictions published in ETI should be directed to the magazine, not to the Ionospheric Prediction Service.

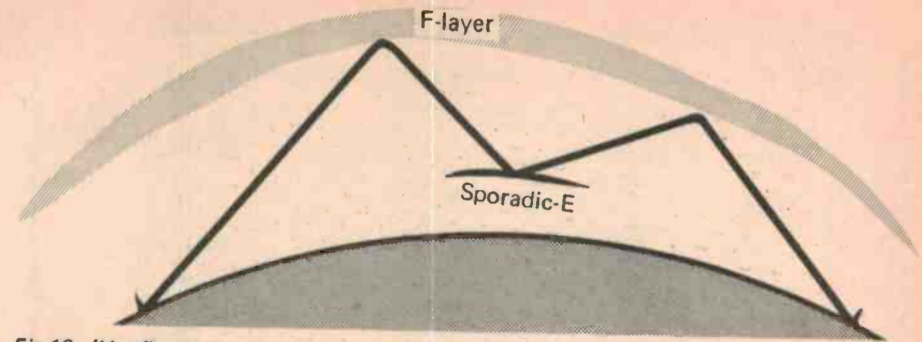

Fig.16. 'M-reflection' - a complex propagation mode involving reflections from the F-layer and E-layer without intermediate ground reflection.

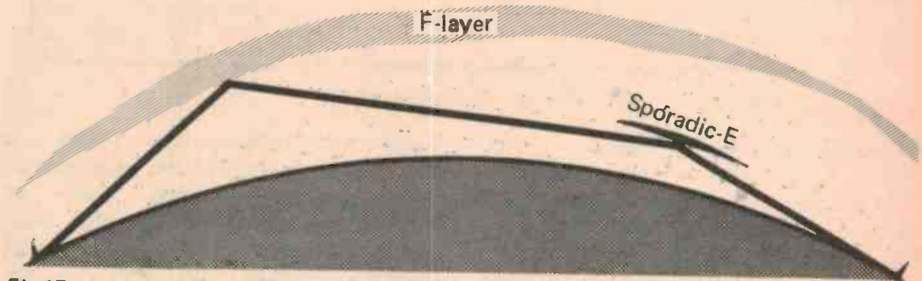

Fig.17. A complex chordal hop mode involving reflections from the F-layer and E-layer without intermediate ground reflection.

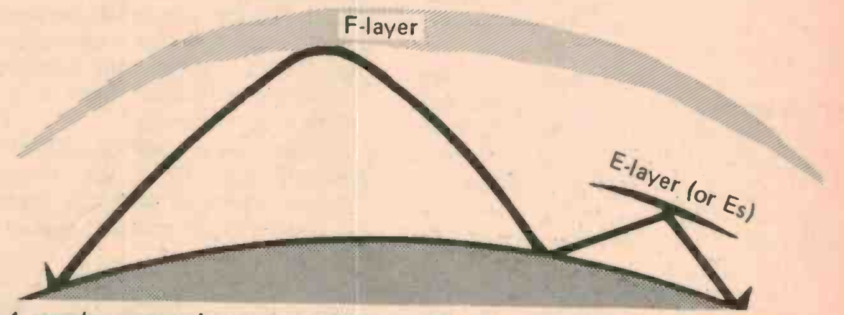

Fig.18. A complex propagation mode involving one F-layer hop and one E-layer hop. Sometimes referred to as "N-reflection".

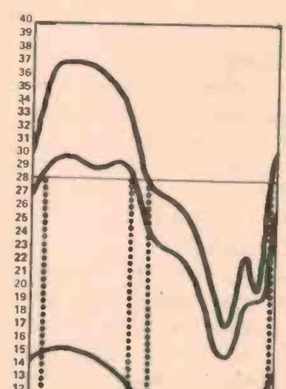

Fig.19. Using the prediction graphs.

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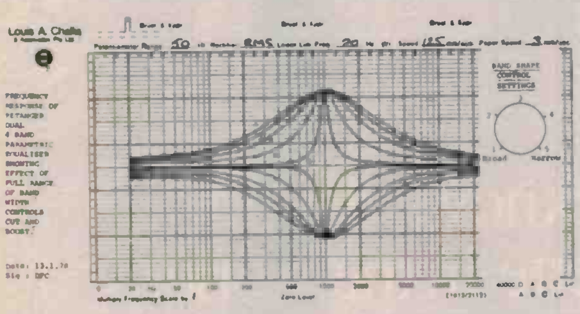

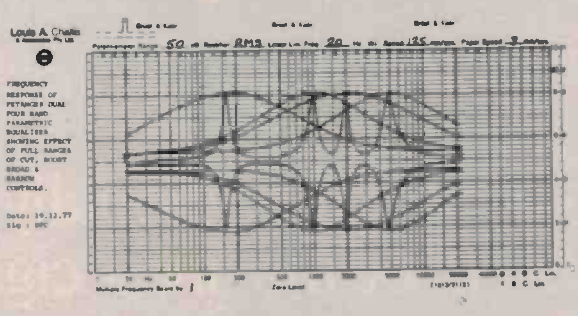

Actual unretouched frequency sweeps

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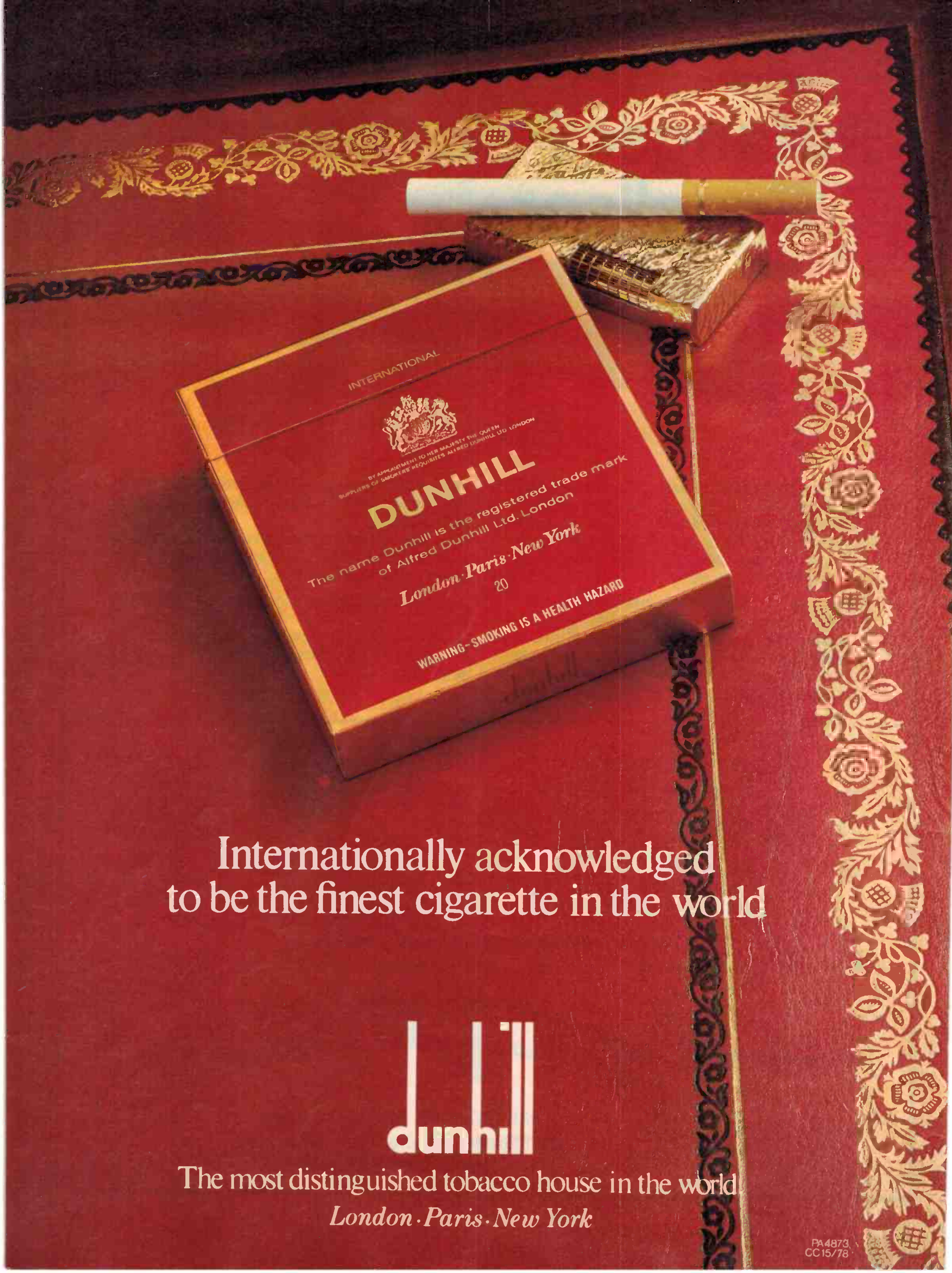
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send your ad to —
ETI MiniMart,
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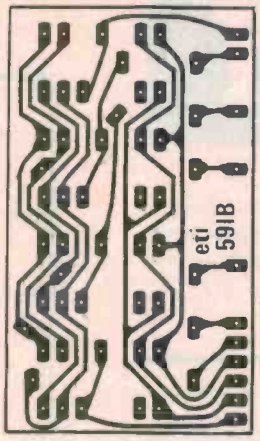
Using ETI PCB Artwork

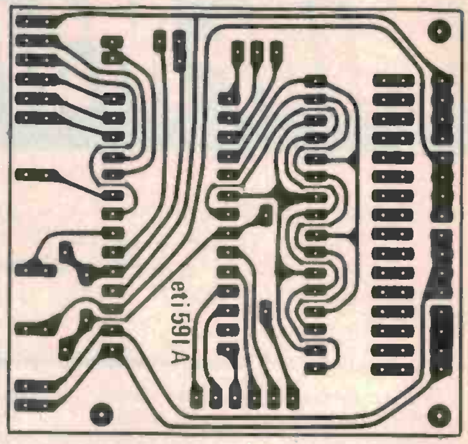
This method can be used to make negatives of ETI artwork from October 1977 on, provided the reverse of the page is printed in blue. The film used is Scotchcal 8007 which is UV sensitive and can be used under normal subdued light.

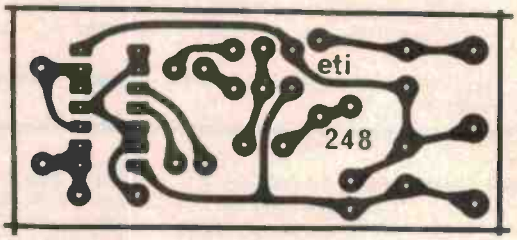
Cut a piece of film a little larger than the PC board and expose it to UV light through the magazine page. The non emulsion side should be in contact with the page. This surface can be detected by picking the film up by one corner - it will curl towards the non emulsion side. Exposures of about 20 minutes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

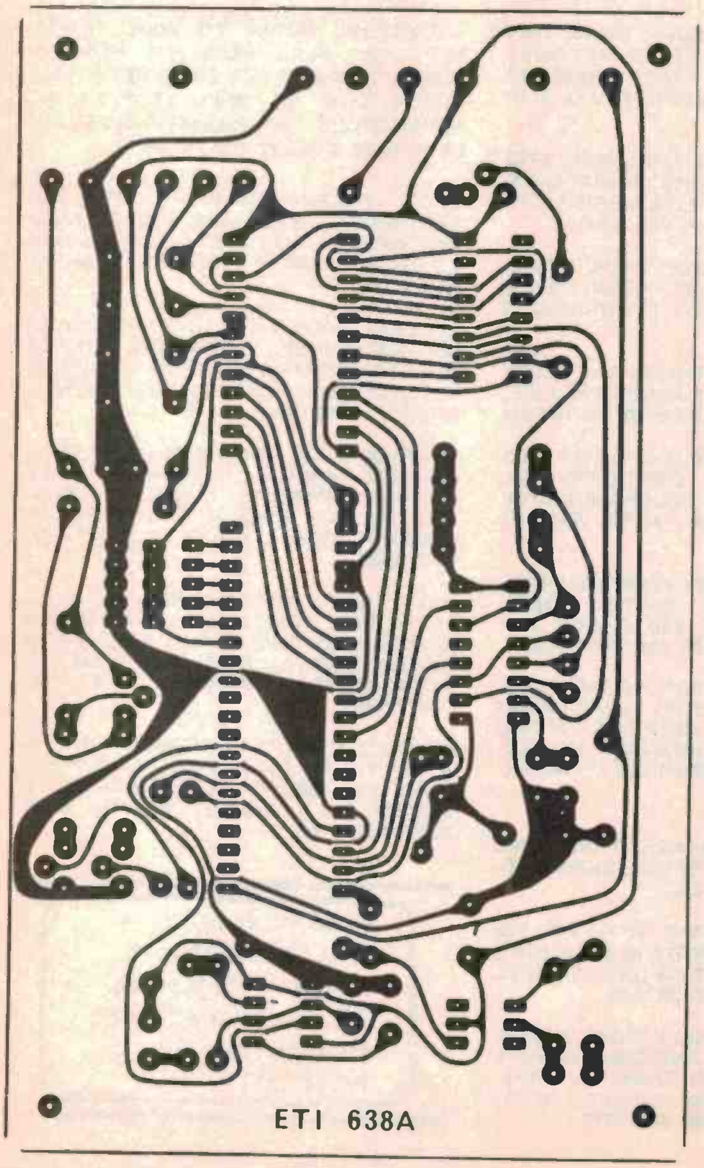
The film can now be developed by placing it emulsion side up on a table, pouring some Scotchcal 8500 developer on the surface and rubbing it with a clean tissue.

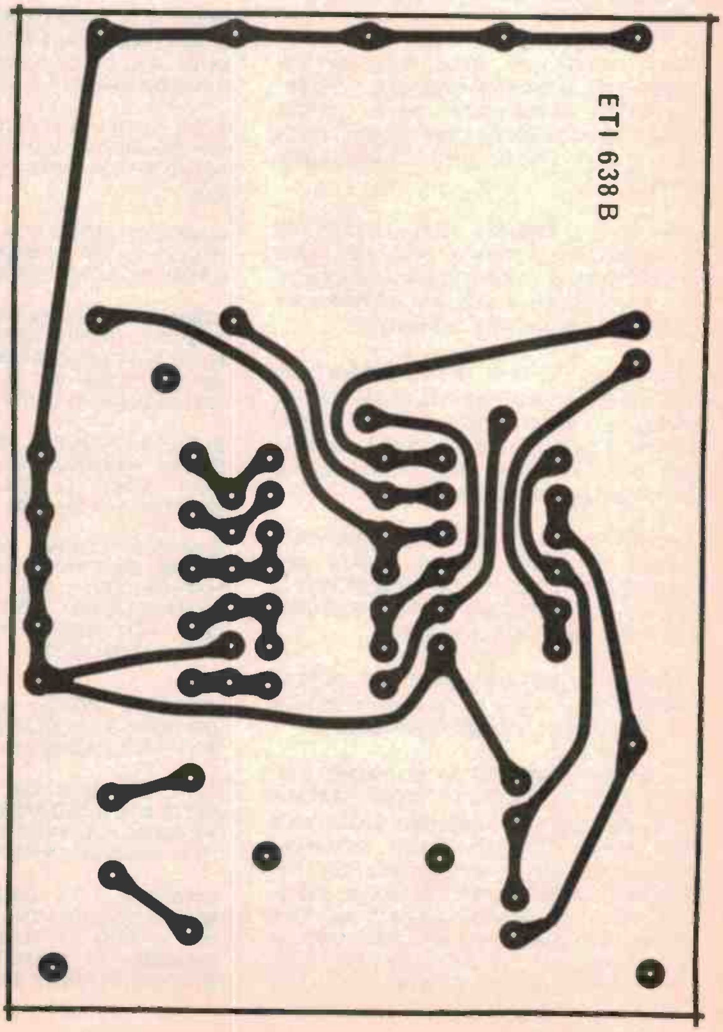
Further information on Scotchcal and PCB manufacture can be found in the September and December 1977 issues of ETI. Please note also, that occasionally pressure on space may unfortunately prohibit the printing of blue type behind all PCB's, in which case the reader must resort to more conventional photographic techniques for PCB manufacture.



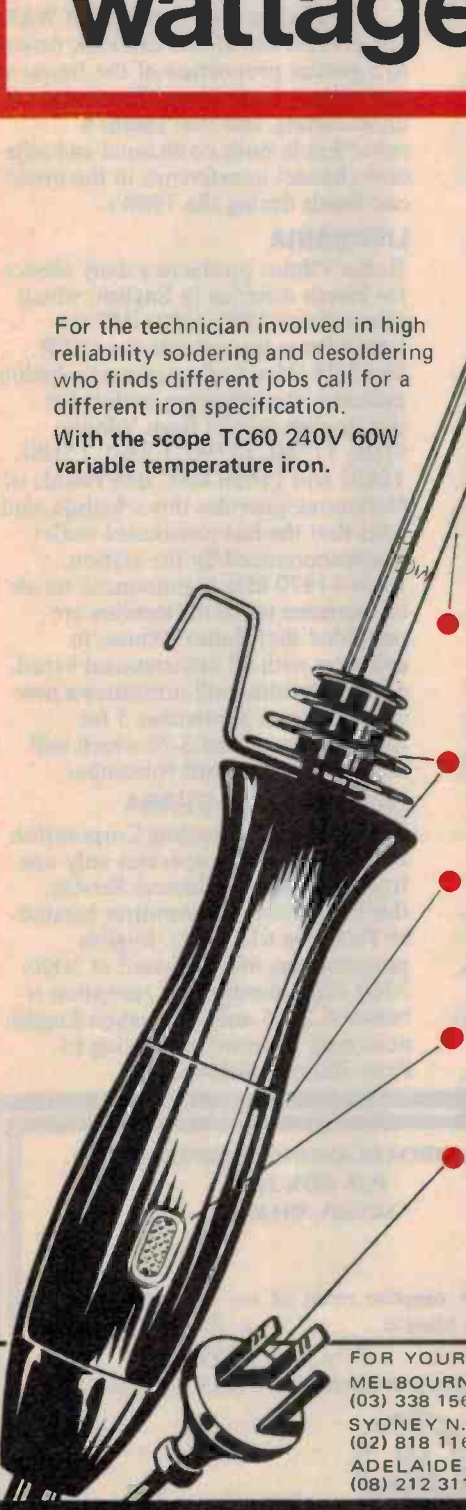








A professional iron with adjustable temperature – wattage and tip size...



For the technician involved in high reliability soldering and desoldering who finds different jobs call for a different iron specification.

With the scope TC60 240V 60W variable temperature iron.

You specify exact temperature required without changing tip.
Dial any intermediate temperature 200°–400°C and make adjustment while soldering. This will be controlled with unusual accuracy ± 2% of set temp. You no longer need to invest in a range of tips just to vary temperature.

You specify exact tip profile required without affecting temperature.
Screw on any one of 14 tip shape and weight combinations from 0.8 mm to 6.4 mm all iron plated for long life. No need to buy up to 3 irons to span this tip range.

You specify that the desired wattage range lies between 10W–60W.
Then let actual wattage required for the job be determined by the iron's simple mechanical sensing and control system. Consisting of expansion rod and micro switch in the handle.

PROTECTION
Component protection is aided by earthed tip and barrel. Critical components & operator can then be earthed to common point.

COOLER FINGER GRIP
Cooling fins keep your finger tips comfortable handle shape aids good balance and feel.

TEMPERATURE KEY
Is inserted into handle 40°C variation per quarter turn. Key is removable to discourage unwanted alteration to setting.

NEON
Indicates when power is being applied to element – monitors control system.

50V, 24V VERSIONS
Are available with 50W elements.

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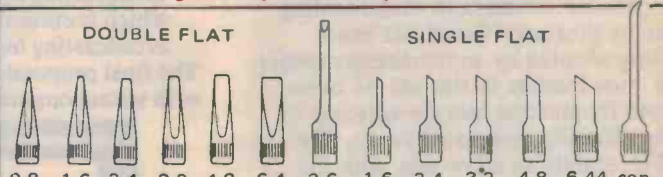
Long life tips for Scope TC60 iron.



DOUBLE FLAT						SINGLE FLAT						
0.8 mm	1.6 mm	2.4 mm	3.2 mm	4.8 mm	6.4 mm	2.6 mm	1.6 mm	2.4 mm	3.2* mm	4.8 mm	6.44 mm	con-corde

Iron plated screw-on pre tinned. *This tip is fitted as standard.

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SWL COMMUNICATIONS

Compiled by Peter Bunn,
on behalf of the Australian Radio DX Club (ARDXC).

WORLD ADMINISTRATIVE RADIO CONFERENCE 1979

In October 1979, in Geneva, the International Telecommunications Union (ITU) convenes the first World Administrative Radio Conference in 20 years.

WARC-79 is of vital importance for both international shortwave broadcasters and DXers as it is expected to determine the structure and the size of the shortwave broadcasting bands (i.e. that part of the frequency spectrum reserved for commercial shortwave broadcasting) for the remainder of this century.

Since the previous conference in 1959, there has been a tremendous increase in the number of broadcasting stations using shortwave, as well as an accelerating "power race" by major broadcasters who now use 250 kilowatt and even 500 kilowatt transmitters.

The consequent over-crowding of the frequency spectrum reserved for shortwave broadcasting has led some stations, such as Radio Sweden and the Swiss Broadcasting Corporation, to try experiments with single side band (SSB) transmissions. SSB transmissions narrow the bandwidth of the signal and make more effective use of transmitted power by eliminating the carrier which is present in normal AM signals. Such experiments have not been altogether successful, not least because many potential listeners use inexpensive receivers which lack the BFO (beat frequency oscillator) necessary to resolve SSB signals.

Another solution to overcrowding on the shortwave broadcast bands being adopted by an increasing number of broadcasters is the use of out-of band frequencies, usually adjacent to the officially designated bands. The ITU regulations allow this, with the proviso that no interference is caused to the great variety of other facilities using the frequency spectrum. Frequencies immediately adjacent to most of the shortwave broadcast bands are generally reserved at present for international fixed services, mainly radio-telephone, radio-teletype and other such point-to-point services. With the growing use of satellites for these fixed services, these channels have been left vacant to a greater extent, thus providing frequencies for commercial shortwave broadcasting. This has led to a practical (though unofficial) expansion of many of the shortwave broadcast bands, and examples of this are just below the 49 metre band (5950 - 5900 kHz), just above the 41 metre band (7300 - 7400 kHz), and above the 25 metre band from 11975 to 12100 kHz.
and examples of this are just below the 49 metre band (5950-5900 kHz), just above the 41 metre band (7300-7400 kHz), and above the 25 metre band from 11975 to 12100 kHz.

Two long term solutions to the problem of over-crowding of the shortwave broadcast bands certain to be considered are the expansion of the existing broadcasting bands, and secondly, the creation of new broadcasting bands.

Proposals for band changes were made at a meeting earlier this year of representatives of 14 international broadcasting organizations and a number of telecommunications authorities from western countries, including Australia. The major points of interest for DXers in the proposals of this meeting in Vienna are:

- Expansion of all present SW broadcasting bands (except the little-used 11 metre band) into adjacent channels eg: the lower limit of the 49 metre band would move down to 5740 kHz from the present 5950 kHz.
- Creation of a new band reserved for international broadcasting, from 13600 to 14000 kHz.
- Removal of amateur operators from the 41 metre band.
- Introduction of international SW broadcasting into the 60 metre band, which is currently reserved for local broadcasting in tropical regions.

The final proposal is certain to meet with strong opposition from Third World countries at the World Administrative Radio Conference in October next year.

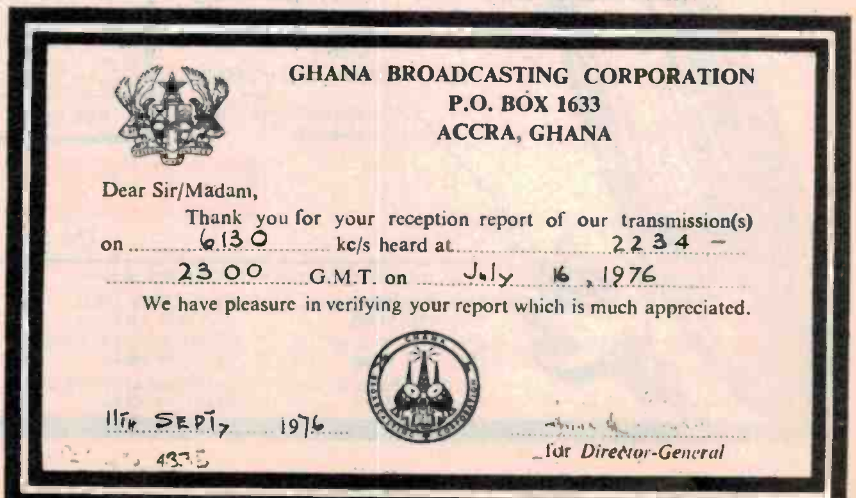
But whatever the outcome of WARC '79, it is certain DXers can look forward to a greater proportion of the frequency spectrum being reserved for shortwave broadcasting, and that means a reduction in both co-channel and adjacent channel interference in the broadcast bands during the 1980's.

LITHUANIA

Radio Vilnius produces a daily service for North America in English, which is broadcast 2300-2330 GMT via transmitters throughout the USSR. The J-78 (May to September) schedule indicates the following outlets for this English service from Vilnius: 9600, 11780, 11790, 12060, 15180, 15405 and 11690 kHz. Bob Padula of Melbourne provides this schedule, and adds that the last mentioned outlet is not announced by the station, while 11870 kHz is announced on air but remains unheard. Readers are reminded that Radio Vilnius, in common with all international broadcasting stations, will introduce a new schedule from September 3 for transmission period S-78 which will remain in effect until November.

ENGLISH FROM GHANA

The Ghana Broadcasting Corporation at Accra currently operates only one frequency for its Overseas Service, this being from a transmitter located at Tema, on 6130 kHz. English programming may be heard at 2000-2300 daily, though best reception is between 2245 and 2300 when English news may be heard, according to Peter Bunn in Melbourne.


GHANA BROADCASTING CORPORATION
P.O. BOX 1633
ACCRA, GHANA

Dear Sir/Madam,

Thank you for your reception report of our transmission(s) on 6130 kc/s heard at 2234 - 2300 G.M.T. on July 16, 1976

We have pleasure in verifying your report which is much appreciated.

11th Sept, 1976

for Director-General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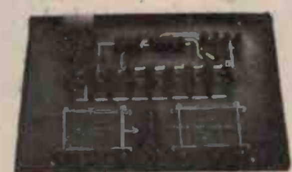
FRONT PANEL DISPLAY

Designed for 8080 but will suit most systems. Input lines are 16 ADD Lines, 8 Data lines, 2 x 8 Bit prog, output port, status flags etc. All inputs buffered, flat cable interface. HEX DISPLAY with ½" high 7 seg. Led display for Address & Data bus. 4 Displays for address bus and 2 displays for data bus. 10" x 8" board size.
WITH HEX DISPLAY — KIT PRICE $105.00.

NUMBER CRUNCHER

MM57109 Number Cruncher. Buffered I/O will suit 8080, 6800, SCAMP, etc. Will perform floating point and scientific calculations under software control. Full data and software support.
KIT PRICE $54.00
BUILT AND TESTED $72.00

PAPER TAPE READER



Manual operation, self-contained in case 160 x 110 x 50. Flat cable interface to I/O port. Handshake logic, Status LEDS, Data and software supplied. Simple to use on all systems 8080, 6800 etc.
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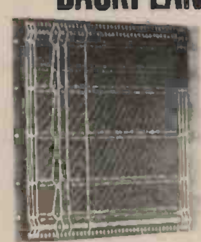

Quality fibreglass boards, 5 sockets per board with wide spacing, provision for linking boards together, even different types.
8" x 8" 6800 board with wide centres — $26.50.
12" x 6" 8080 board with provision for both sockets — $27.50.

GOLD PLATED SOCKETS
To suit 8080 & 6800. 43 way double sided, $9.50 or 5 for $45.00.

U.V. EPROM ERASER
Erase up to 4 eproms at once, such as 2708 etc in 15/30 mins. 240 V operation, small size 3" x 4" x 8" Assembled and tested only. $47.50.

SINGLE STEP CONTROL for 8080
Push button single step mode. Auto step low speed (Variable speed) mode, Interrupt facilty. Run mode LED, will suit other systems, works off wait, & ready, lines. Panel mount. **KIT PRICE $23.00.**

All Boards double sided with ground plane.

ALL PARTS POST FREE
See advt Jan 78 EA for digital tacho, stop watches, tran. ignition system, burglar alarm, etc.

Built & Tested prices and Tax Free prices on application.

S.M. ELECTRONICS
10 Stafford Court, Doncaster East, 3109.
Box 19, Doncaster East, 3109. (03) 842-3950.

A TV GAME KIT FOR THRILLS & SPILLS

MOTOR CYCLE STUNT GAME

COMPLETE KIT
$29.50
Cat. K-3474 ▲
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REQUIRES 6xAA battteries
Cat. S-3003 15c each.

What an incredible way to spend the cold winter nights! With this latest video game you can pit your skills against the latest in IC technology, in the form of motor cycle games. The games are complex enough to give many hours of pleasure and excitement but the construction is extremely simple, even for the raw beginner. There are two stages of skill (pro and amateur) and four games – Motorcross, Enduro, Drag and Stunt. Plug into your TV set and enjoy all of the thrills and spills of motor cycling from the comfort of your own armchair.

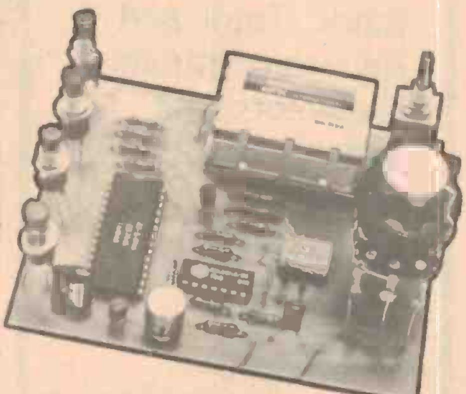
* Similar to the games costing over $1,000 found in many hotels.
* See Electronics Today June 1978 issue for article.
* Computer IC contains 1000's of transistors and complex circuitry.
* Crystal controlled and exclusive pre-built modulator - absolutely no tuning required.
* Professional unit designed especially for the beginner.
* Fully pre-punched and pre-drilled front panel, for the professional look.
* Simply plug into your TV aerial socket.
* In-built speaker and on screen scoring.

THE HEART OF THE GAME.

The printed circuit board showing how simple the construction is - with the kit you get full easy to follow instructions.

SPARE PARTS CORNER

PC Board (only)	H-8615	$3.85
RF Modulator	K-6040	$3.00
AY-3-8760 IC	Z-6854	$19.50
3.58MHz crystal	K-6031	$3.00



SPECIAL OFFERS- YOU CAN'T LOSE

7 DAY INSPECTION OFFER.

Buy the kit, take it home and have a good look at it. If you feel that it is beyond your capabilities then return it to us in its original packing and condition and we will refund your money.

'SORRY DICK IT DOESN'T WORK' OFFER.

The Dick Smith kit is so complete and easy to build that even a complete novice will have no trouble building it with complete success. However even in the unlikely event that you can't get yours to work, don't worry! Every kit contains a "Sorry Dick it doesn't work" coupon. You send in your TV game, the coupon and for a service fee we'll fix it for you. The service fee covers everything except replacement of the IC, should this be necessary.

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324ET78

LATIN AMERICAN ROUND-UP

Radio Luz y Vida at Loja, Ecuador, has been logged in Melbourne by Peter Bunn on the new outlet of 4850 kHz, having moved from 4830 kHz. Reception was fair with Spanish station identification at 1145. Sign-on time for Radio Luz y Vida is 1045 GMT.

Radio America at Lima, Peru, now appears to be running to a 24 hour schedule, with much US pop music. Reception in Melbourne is very good between 0600 and 0900 GMT on 6010 kHz.

Radio-television Dominicana at Santo Domingo in the Dominican Republic currently provides good reception in our evenings from 1000 GMT until past 1100 GMT. The station varies nightly in its operating frequency, as both 5970 kHz and the adjacent 5975 kHz have been noted on separate occasions.

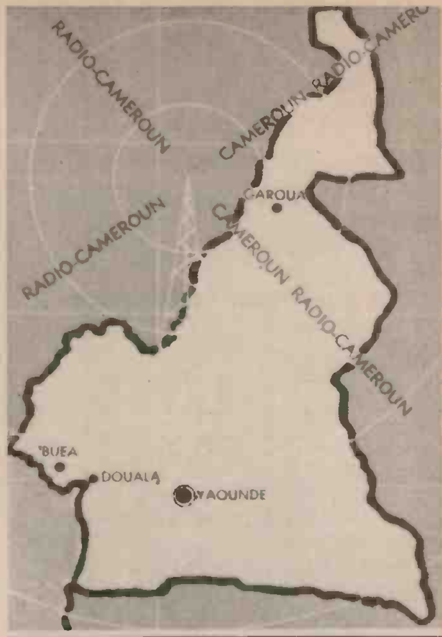
ECUADOR

The voice of the Andes, HCJB at Quito, has introduced a new frequency for daily broadcasts to Europe. In line with the current trend to higher frequencies due to greater sunspot activity and the European winter, HCJB now uses 21490 kHz between 1500-2100 GMT. English program segments are aired at 1530-1800 and 1900-2030 GMT on this new outlet.

AFRICAN SIGNALS

Our early mornings are the best time to tune to Africa. Two of the strongest signals are currently observed from Bangui in the Central African Empire on 5038 kHz until station close at 2300 GMT, and from Radio Garoua in Cameroon on 5010 kHz. Garoua closes transmission daily at 2200 GMT. Another station providing particularly good reception at the moment is Radio Ghana on 4915 kHz, which may be heard until sign-off at 2305 GMT. This is the Home Service program, and is separate from the Overseas service mentioned earlier. This outlet is easily found on the dial, as it is just below the strong signal put out by the ABC Brisbane regional service on 4920 kHz.

Meanwhile, Radio Nacional de Angola at Luanda may now be heard on the new outlet of 4790 kHz, replacing 4820 kHz. Bob Padula notes good signals between 2000 and 2300 GMT.



The Australian Radio DX Club is a non-profit body with headquarters in Melbourne. For further information on shortwave radio, and on the activities of the ARDXC, please write to the General Secretary, PO Box 67, Highett, Vic. 3190, enclosing a 30c. stamp for return postage.

AMATEUR COMMUNICATIONS

Trio-Kenwood Expansion

Trio-Kenwood (Australia) Pty Ltd was established in August 1977 and commenced operations in October 1977 to distribute the Hi-Fi products of its parent company, Trio-Kenwood Corporation of Japan.

More recently (and more importantly), Trio-Kenwood Communications Division was registered as a subsidiary of the Australian company with the dedicated objective of providing 'professional facilities to amateur radio operators'.

Administration and Accounts will be handled through the main Australian company (TKA) at 30 Whiting Street, Artarmon, NSW, but the communications company has its own premises, including warehouse, showroom, offices, service department and spare parts store, across the street at 31 Whiting Street, Artarmon. Any questions? Phone: 439-4322.

Begonia Award

The Ballarat Amateur Radio Group, Victoria, has initiated the "Begonia Award" Certificate which is available to amateur operators or SWL's who can show confirmation of working or hearing Ballarat amateurs.

As from 1 January 1978, the requirements for issue of the certificate are:-

1. **DX stations or SWL's.**
   Work or hear 5 Ballarat amateur stations. Any band, any mode. Cost 8 IRC's.

2. **VK stations or SWL's.**
   Work or hear 10 Ballarat amateur stations. Any band, any mode. Cost $2.00.

   LOGS:
   Send a list of stations worked stating callsign, name, date, band, mode and time in Zulu. Do not send QSL cards.

   SEND LIST TO:
   Award Manager, R E Barker, 22 Pauls Crescent, Wendouree, Victoria, Australia, 3355.

CB COMMUNICATIONS

Ah so – Asahi

The Asahi brand name has been closely associated with CB products since before . . . well, since before most current CBers remember.

Asahi antennas are well known by the 'old hands' of CB and a new Asahi antenna release is obvioulsy worth some scrutiny.

The 'Million CW7' is a top-loaded, cowl mount mobile antenna that is reputedly tops amongst European CBers.

It mounts in the ordinary car radio antenna hole on a vehicle cowl or fender and, for this reason, the CW7 includes an adjustable ball and locking screw.

This allows the antenna to be adjusted to a vertical position, regardless of the slope of the car body panel on which it is mounted.

Over-all length is 1.4 metres and the antenna is supplied with a coax cable including connectors on each end.

The Million CW7 is distributed through Imark Pty Ltd, 66 Banfield St, Ararat, Vic., 3377, (053) 52-2697.

Tallest legal base antenna?

A new design threequarterwave base antenna has just been released on to the market by Dick Pullem's Electric Bug – Adelaide's "biggest little CB shop".

They claim their design has the highest performance as tested against other leading half and five-eighth wave base antennas.

We'd like to test one – especially since reading what all the theory books have to say about 3/4 – wave antennas!

The antenna is constructed using cadmimum-plated steel for the base, stainless steel in the driven element support, PTFE insulator (polytetrafluorethylene – to the chemists, and that's what you call a proper insulator) and all joints are bolted right through (no self-tappers!).

If you want to try one of these out you'll have to crack the piggy banks for all of $69.86 and trundle down to Dick Pullem's Electric Bug at 264 Torrens Rd, Croydon, SA. 5008. Phone 46-3019.

Dick in Grace Bros.

Dick Smith has taken over the electronic equipment concessions previously held by Audio Shack in Grace Bros' Sydney suburban stores.

The Dick Smith Electronics departments at Grace Bros stock most of the products sold in Dick's eight electronics enthusiasts' shops around Australia.

There is special emphasis on electronic products for the home handyman, car buff and hi-fi enthusiast.

Many of these products are imported directly by Dick Smith and are exclusive to his electronics departments at Grace Bros and his own retail outlets.

New Mura SWR meter

The latest SWR meter from Mura, their CBT-35, is a deluxe unit featuring separate meters for simultaneous measurement of SWR and RF power.

It includes an antenna tuner for precise antenna-feedline system tuning.

Like its little brothers (or is that sisters?), the CBT-15 and CBT-25, the new model has backlit meter scales and includes an integral 610 mm coax lead and PL259 connector – no "jumpers" necessary.

The CBT-35 has two power ranges: 10 watts and 100 watts, and indicates percentage modulation as well.

Two special brackets are included for easy attachment of the instrument above or below your transceiver or whatever you want to mount it on.

The matcher is claimed to match impedance between 25 and 140 ohms down to the required 50 ohms.

The CBT-35 is a handy 160 mm by 54 mm by 70 mm, and makes good use of the two relatively large meter scales.

The Mura CBT-35 is distributed in Australia by President Electronics, 15 Boundary St, Rushcutters Bay 2011, (02) 33-3727 – with dealers all over.

In Melbourne, try Just CB of 546 Whitehorse Rd, Mitcham, Vic, 3132 (03) 873-2673.

Sawtron UHF from Imark

Owen Smart of Imark, Victorian CB supplier from Ararat, returned from Japan recently with news that he will be releasing a range of UHF CB rigs under the Sawtron brand name between June and August this year.

There are to be three rigs in the range; an economy mobile, a deluxe mobile and a deluxe base station.

The two mobile rigs will have control consoles which can be separated from the transceiver portion of the rig. This allows the transceiver section to be mounted in any safe, convenient position away from the controls – and possible rig snatchers – in the vehicle boot, under a seat etc, in the same fashion as "hide away" HF rigs.

The deluxe mobile will feature a "selective calling" facility. This allows communications only between stations fitted with the appropriate electronic circuitry that adds a special 'tone-burst' signal to the transmission that opens the other station's mute.

The deluxe base staion features a control panel that looks more like a desk-top calculator than a CB console. It has no conventional knobs. There is a keyboard entry for the selective calling feature (selecall) a built-in base-type microphone, push button channel change and slide controls for squelch, volume control etc.

There are two LED digital readouts, one for the channel number, the other for the selecall.

The big advantage with the base station is that the transceiver section can be situated up to 200 metres away from the control console. Thus, it can be located close to the antenna, minimising the length of coax feedline necessary (saving money on expensive low-loss coax!) and reducing the amount of power and signal lost in the coax. This allows top performance to be obtained.

Naturally, everybody's asking about price. The economy mobile will retail for around $300 to $350. The deluxe mobile for about $350 to $400. The deluxe base station will sell for a very competitive $450 – $500.

Imark will also be making a range of antennas available for the UHF CB band for both mobile and base applications.

Want to know more about what CB radio is coming to? – contact Imark at 66 Banfield St, Ararat, Vic., 3377 (053) 52-2697.

RB14 - ho, hum delayed again!

The revised RB14, which has been promised to us since ... um, ah, jeez, it's so long I've forgotten, has been delayed again.

More red tape it seems. Nobody can be satisfied with all the proposals in the draft - and the first thing we're likely to see will only be a draft anyway - so why can't it be released, warts and all, for everyone to comment and then thrash it out from there?

If you want to know what might be in the all-new singing-dancing, virginal white, lemon-fresh RB14 then get a copy of the June issue of CB Australia from your local newsagent.

Do we get to see it before Christmas? – said the Bishop to the actress!

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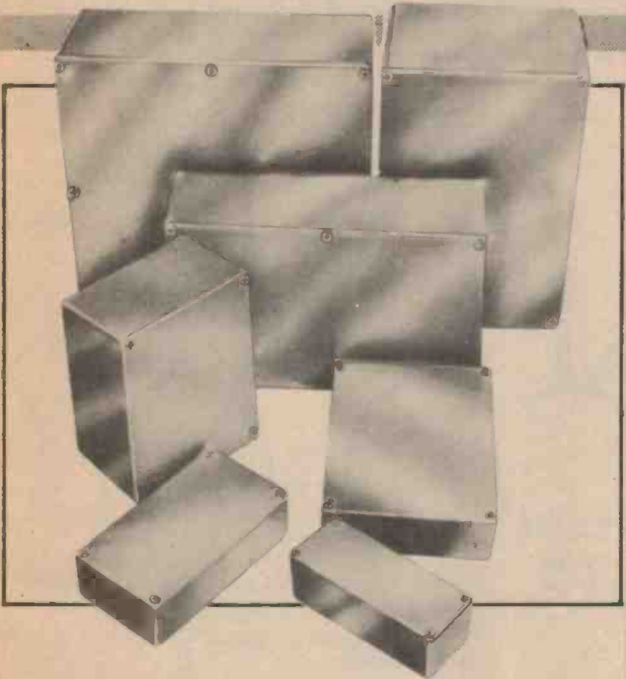

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predictions

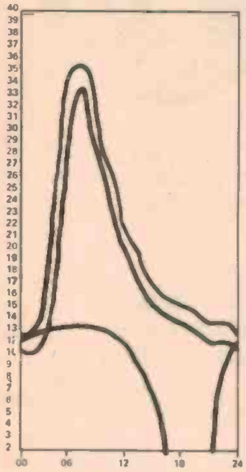
Ionospheric Predictions for the month of August

THESE PREDICTION GRAPHS have been prepared courtesy of the Ionospheric Prediction Service Division of the Department of Science.

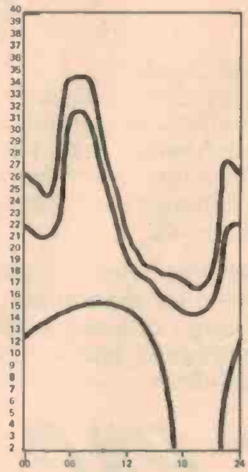
Any enquiries about these predictions should be directed to ETI, not to the Ionospheric Prediction Service.

The graphs indicate the maximum usable frequency (MUF) on HF circuits between various centres in Australia and selected points overseas.

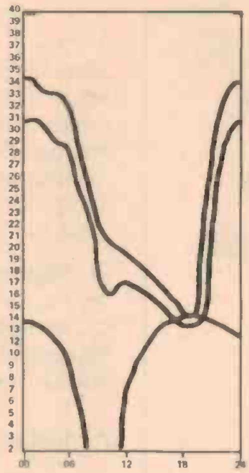
For less than 50% of the days of the month the highest frequencies propagated will be at least as high as the uppermost curve. Between 50% and 90% of the days of the month the MUF will be at least as high as the curve beneath the upper curve. The absorption limiting frequency (ALF), which affects the lowest frequencies that will be propagated, is indicated by the lower curves on the graphs.



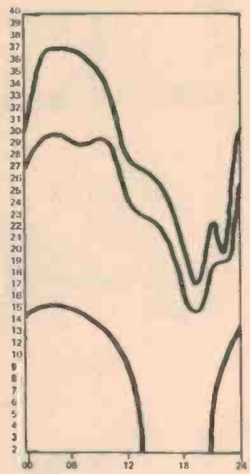
East Coast — South Africa (also serves South Central)



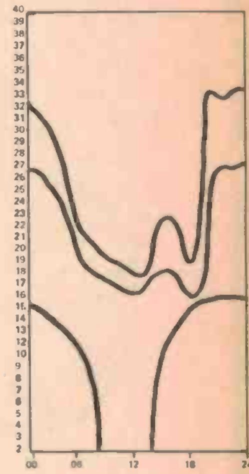
East Coast — North Africa (also serves South Central)



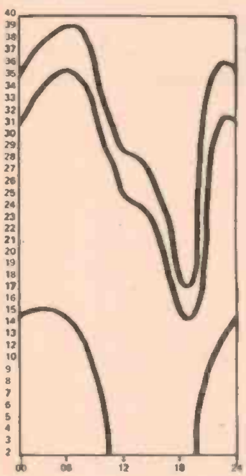
East Coast — South America (also serves South Central)



East Coast — Central USSR (also serves South Central)



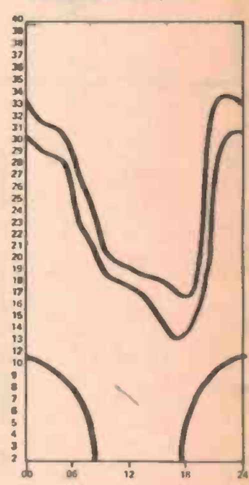
East Coast — North America (also NE and South Central)



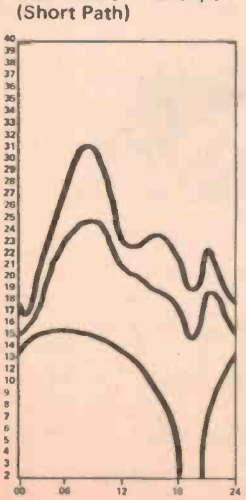
East Coast — Japan (also serves NE and South Central)

SWL and AMATEUR COMMUNICATIONS

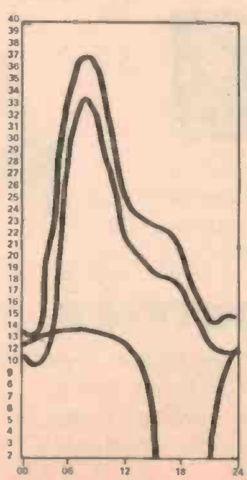
East Coast — South Pacific



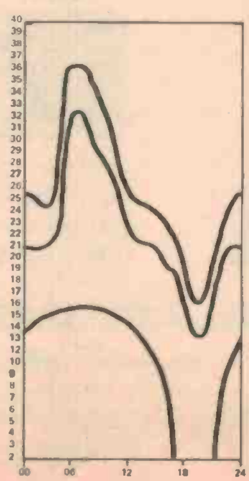
East Coast — Europe (Short Path)



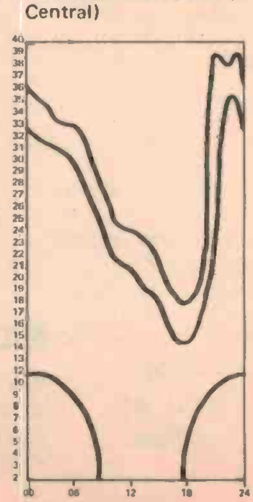
North East — South Africa



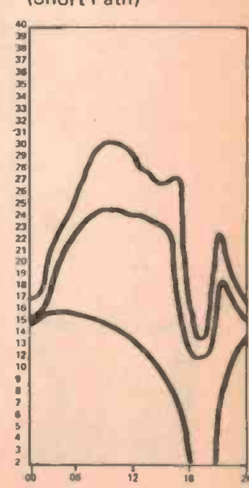
North East — North Africa



North East — South Pacific (also serves South Central)

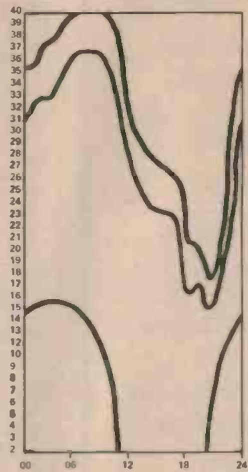


North East — Europe (Short Path)

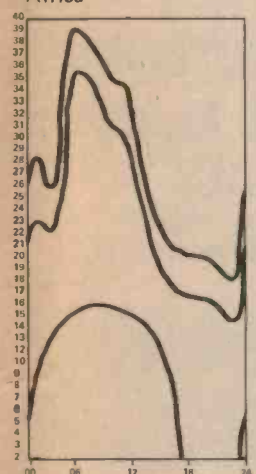


South Central — Europe (Short Path)(also West Coast)

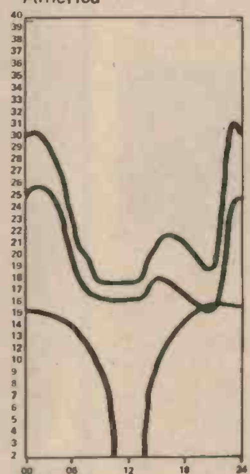
West Coast — Japan



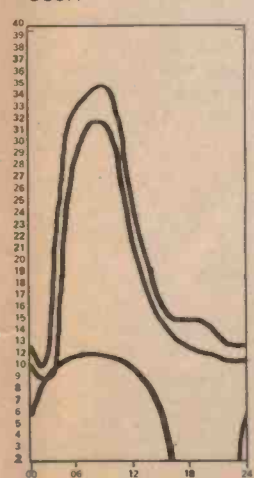
West Coast — North Africa



West Coast — North America



West Coast — Central USSR



West Coast — South Africa

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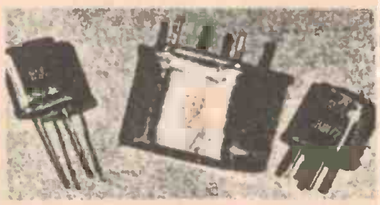

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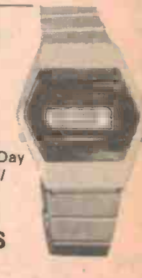

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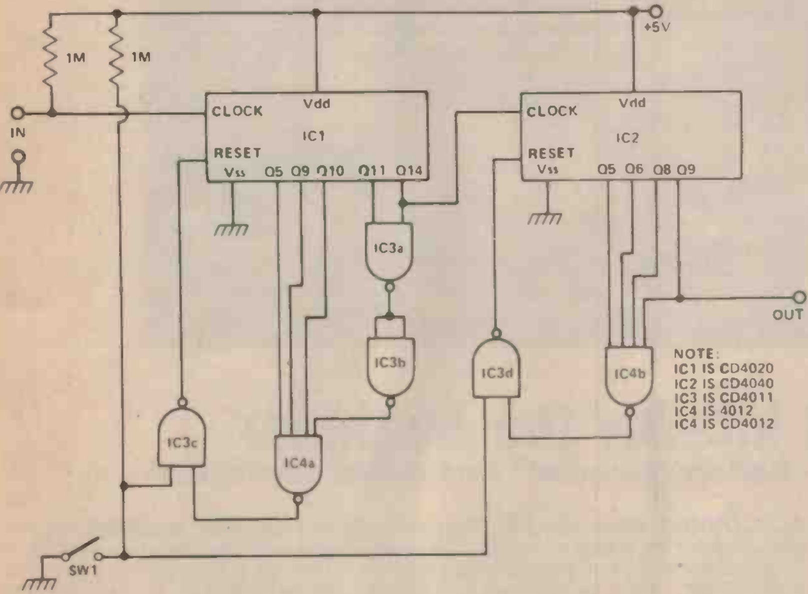
Ideas for experimenters

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.



Divide by 4,320,000 Counter

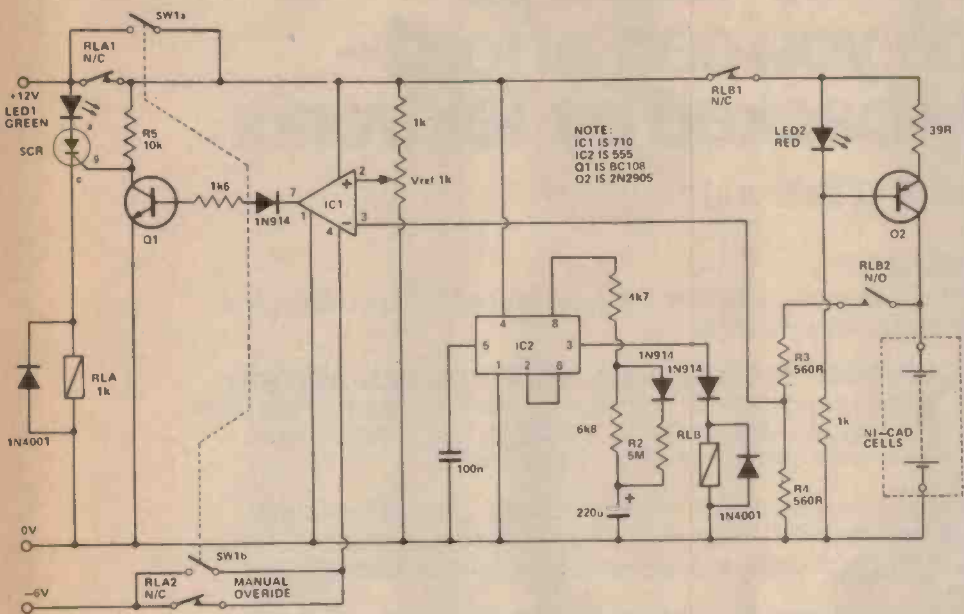
So what is a 4320000 counter good for? Well, 50x60x60x24 = 4320000 so that if you feed in 50 Hz at the input the counter will give 1 pulse per 24 hours, e.g. it can form the basis of an extremely accurate 24 hour alarm. Such an alarm never requires setting once the counter has been reset to zero at the required time of day and will thereafter give the alarm at exactly the same time every day. It can thus be used for instance to wake oneself up every morning without fail.

Such a circuit is very easily built using just 4 cheap CMOS chips, IC1, a 14 stage binary counter is set to divide by 10000 (binary 10011100010000) by reseting to 0 on the count of 10000. Similarly IC2, a 12 stage binary counter divides by 432 (binary 110110000). IC3 and IC4 provide the necessary decoding to reset the counters (which are reset by a logic '1' unlike TTL where a logic 'O' is usually required). Additionally the gating allows the counter to be reset to 0 by SW1.

Automatic Nicad Charger

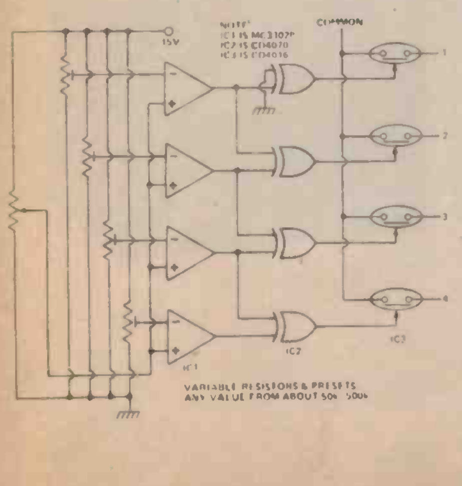
The problem of ensuring that expensive Nicad cells are not damaged in the recharging process is twofold. First, as the cells have a low internal resistance, they are susceptible to damage by excessive charging currents. Second, damage will also occur if the charging process is carried out for too long a period.

The first problem may be overcome by charging at a constant current. The second problem may be overcome by the use of an automatic sensing comparator circuit, which compares the voltage from the cells with a preset voltage, related to the fully charged value. In practical terms, the circuit appears as shown in Fig. 1. A red LED supplies the voltage drop to ensure that Q1 passes a constant current of about 25 mA to the cells under charge. This charging current may be adjusted, if



desired, by changing the value of R1. The 555 runs in the astable mode. However, the duty cycle is adjusted to be *less* than 50%, by incorporating a diode and resistor in parallel with R2. How this is accomplished may be easily understood if one remembers that charging of the capacitor takes place through these paralleled components, whereas, due to the blocking diode, discharging current only flows through R2. The 'off' time is around 15 mins. and the 'on' time less than 0.5s. The relay coil RLB, thus receives a positive pulse of short duration every 15 mins. Contact RLB1 opens, disconnecting the charging supply and contact RLB2 closes. A sample of the total voltage across R3 and R4 is applied to the variable input of the 710 comparator. This input voltage is compared to the preset reference voltage and if found to be greater, the output will drop to –0V5 (from +3V2). The inverting action of Q2 causes the gate of the thyrister to undergo a positive transition, via R5. The gate causes the device to conduct, causing the contacts RLA 1 & 2 to open and disconnect the supply from the rest of the circuitry. The green LED is illuminated, indicating the termination of the charging period.

This circuit may be used to charge a total of six 1V5 cells. Of course V_{ref} may need adjustment so as to be commensurate with the voltage across R4. A manual override switch is also provided.



Slide Switch

One of the disadvantages of slide pots is the unavailability of matching slide switches, as with rotary switches and pots, but slide pots can be given switching action by the use of this circuit.

Each analogue switch is only turned on when the comparators driving the respective EX-OR gate are in opposite states, i.e. when the voltage on the slider wiper is between the appropriate two preset voltages.

The example is a 4-way, 1-pole switch with off but any-way, any-pole switches can be made, using 741s as comparators if economic. A little mechanical ingenuity can provide click stops, if required.

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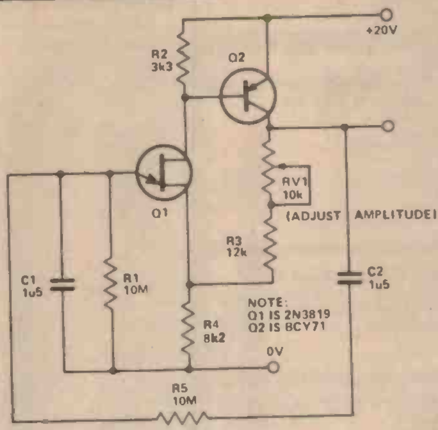
TK11

Ideas for experimenters

VLF Sine Generator

Generating very low frequency sine waves (i.e. less than 0.1 Hz) presents several problems, Timing capacitors usually have to be large valve electrolytics, any amplifier used must be D.C. coupled, and the amplifier's input impedance must be very high. One standard method is to first generate low frequency square waves, and then to shape these into an approximation of a sine wave by the use of several non linear devices, such as diodes. The circuit shown in Fig. 1 is a relatively simple approach based on the familiar wien bridge. An n-channel FET and a pnp transistor are arranged in a DC coupled circuit and the voltage gain is determined by the negative feedback R3 and R4. The gain need only be about three, thus if the bias required by the FET is 3V the output level will be approximately half the supply voltage.

Since R1 can be a high value resistor the value of the capacitor is only 1u5 for sine wave outputs of 0.01 Hz. This capacitor is available in polycarbonate. The amplitude of the output can be adjusted by RV1 to give low harmonic distortion and to be about 10V peak to peak. As expected, with this wien bridge circuit, frequency stability is good with changes in both supply voltage and temperature.

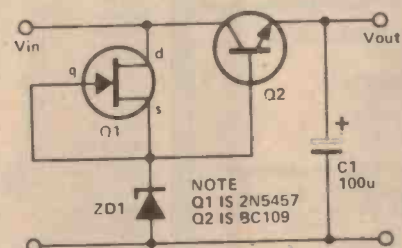


Voltage Stabiliser

Here is a voltage stabiliser with good performance and low component count which will operate well, even when $V_{in}-V_{out}$ drops to 2 V. Only a few milliamps are dissipated through the zener, making it suitable for battery operated equipment.

Most circuits of this type (but with the FET replaced by a resistor) suffer from zener saturation when V_{in} is getting low, or in excessive zener current when V_{in} is high.

Actual component values can be varied to suit individual applications.



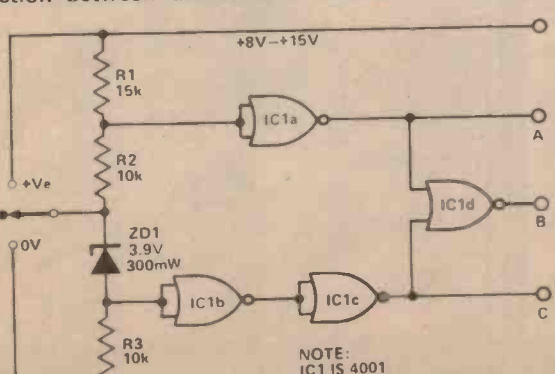
3-way CMOS switch

When the input is switched positive the voltage across the zener is sufficient to bias the junction between R3 and the zener high, producing a high output at C.

With the input unconnected, the junction between R1 and R2 is high while the junction between the zener and R3 is low. This will produce a high output at B.

Connectin the input to 0V causes output A to go high.

The circuit was primarily designed to be used with quad CMOS switches (i.e. 4016, 4066) for audio switching but can be used for a variety of applications.



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