

# electronics today

INTERNATIONAL **SEPTEMBER 1980 60p** ISSN. 0142-7229

## PROJECTS FOR ALL!

**DRILL SPEED CONTROLLER**  
**TV SOUND AMPLIFIER**  
**DIGITAL TEST METER**  
**RIIAA PREAMPLIFIER**  
**ENVELOPE SHAPER**  
**SURVIVAL GAME**  
**VOCODER**



**MAJOR NEW SERIES!**  
**INTRODUCING**  
**MPUS**  
**FIRST PART**  
**INSIDE**

...NEWS...PROJECTS...MICROPROCESSORS...AUDIO...

### 8K ON BOARD MEMORY!

5K RAM 3K ROM or 4K RAM, 4K ROM (link selectable). Kit supplied with 3K RAM, 3K ROM. System expandable for up to 32K memory

### 2 KEYBOARDS!

56 Key alphanumeric keyboard for entering high level language plus 16 key Hex pad for easy entry of machine code

### GRAPHICS!

64 character graphics option — includes transistor symbols! Only £18.20 extra!

### MEMORY MAPPED

high resolution VDU circuitry using discrete TTL for extra flexibility. Has its own 2K memory to give 32 lines for 64 characters

### KANSAS CITY

low error rate tape interface.

**PSI COMP 80**  
**Z80 Based powerful scientific computer design as published in WIRELESS WORLD**



### 2 MICROPROCESSORS

Z80 the powerful CPU with 158 instruction, including all 78 of the 8080, controls the MM57109 number cruncher. Functions include +, -, \*, /, squares, roots, logs, exponentials, trig functions, inverses etc. Range  $10^{-99}$  to  $9 \times 10^{99}$  to 8 figures plus 2 exponent digits

### EFFICIENT OPERATION

Why waste valuable memory on sub routines for numeric processing? The number cruncher handles everything internally!

### RESIDENT BASIC

with extended mathematical capability. Only 2K memory used but more powerful than most 8K Basics!

### 1K MONITOR

resident in EPROM

### SINGLE BOARD DESIGN

Even keyboards and power supply circuitry on the superb quality double sided plated through-hole PCB

**COMPLETE KIT NOW ONLY £225 + VAT**

Cabinet size 19.0" x 15.7" x 3.3" Television not included in price

The kit for this outstandingly practical design by John Adams published in a series of articles in Wireless World really is complete. Included in the PSICOMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board, 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer, 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.

### KIT ALSO AVAILABLE AS SEPARATE PACKS

For those customers who wish to upgrade their purchase or build a personalized system the kit is available as separate packs eg PCB (16" x 12.5") £43.20. Pair of keyboards £34.80. Firmware in EPROMS £30.00. Toroidal transformer and power supply components £17.60. Cabinet (very rugged, made from steel, really beautifully finished) £26.50. P.S. Will greatly enhance any other single board computer including OHIO SUPERBOARD for which it can be readily modified. Other packs listed in our FREE CATALOGUE.

### PSI COMP 80 Memory Expansion System

Expansion up to 32K all inside the computer's own cabinet!

By carefully thought out engineering a mother board with buffers and its own power supply (powered by the computer's transformer) enables up to 3 8K RAM or 8K ROM boards to be fitted neatly inside the computer cabinet. Connections to the mother board from the main board expansion socket is made via a ribbon cable

#### Mother board:

Fibre glass double sided plated through hole P.C.B. 8.7" x 3.0" set of all components including all brackets, fixing parts and ribbon cable with socket to connect to expansion plug **£39.90**

#### 8K Static RAM board

Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" **£12.50**  
Set of components including IC sockets, plug and socket but excluding RAMs **£11.20**  
2114L RAM (16 required) **£5.00**  
Complete set of board components: 16 RAMs **£89.50**

#### 8K ROM board

Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" **£12.40**  
Set of components including IC sockets, plug and socket but excluding ROMs **£10.70**  
2708 ROM (8 required) **£8.00**  
Complete set of board components: 8 ROMs **£78.50**

**OUR CATALOGUE IS FREE! WRITE OR PHONE NOW!**  
**POWERTRAN ELECTRONICS**

PORTWAY INDUSTRIAL ESTATE  
ANDOVER, HANTS SP10 3NM

ANDOVER  
(STD 0264) 64455

**THIS MONTH'S FRONT COVER FEATURE!**  
★ **ETI VOCODER** ★



Panel size 19.0" x 5.25". Depth 12.2".

**14 CHANNELS!**  
**NOISE GENERATOR!**  
**SLEW RATE CONTROL!**

**2 OSCILLATORS!**  
**VOICED/UNVOICED DETECTOR!**  
**LED PPM METERS!**

**COMPLETE KIT ONLY £195 + VAT**

**Kit includes FREE foot control and test oscillator!**

Like all our kits the ETI VOCODER really is complete — fully finished metal work, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc. — even a 13A plug!

**MANY MORE KITS ON PAGE 8**

# POWERTRAN

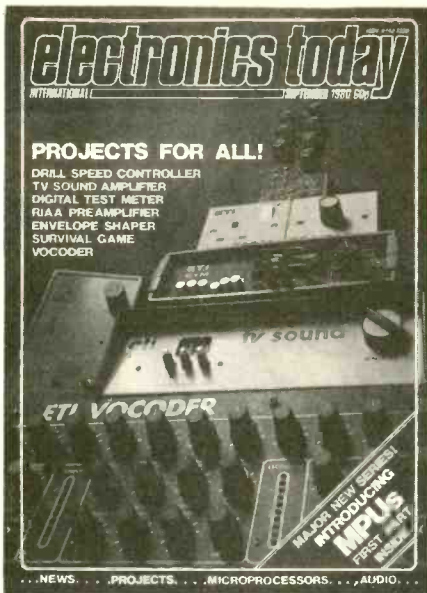
**PRICE STABILITY:** Order with confidence. Irrespective of any price changes we will honour all prices in this advertisement until October 31, 1980, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

**EXPORT ORDERS:** No VAT. Postage charged at actual cost plus £1 handling and documentation.

**U.K. ORDERS:** Subject to 15% surcharge for VAT. No charge is made for carriage, or at current rate if changed.

**SECURICOR DELIVERY:** For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.

**SALES COUNTER:** If you prefer to collect kit from the factory, call at Sales Counter. Open 9 a.m. - 12 noon, 1-4.30 p.m. Monday-Thursday.



# electronics today

SEPTEMBER 1980 VOL 9 No 9 INTERNATIONAL

## FEATURES

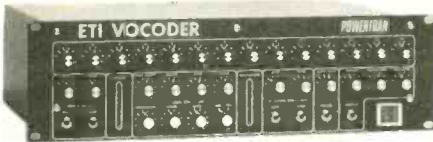
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# Britain's first com computer kit.

## The Sinclair ZX80.

# £79.95

Price breakdown  
ZX80 and manual: £69.52  
VAT: £10.43  
Post and packing FREE



Please note: many kit makers quote VAT-exclusive prices.

You've seen the reviews... you've heard the excitement... now make the kit!

This is the ZX80. 'Personal Computer World' gave it 5 stars for 'excellent value.' Benchmark tests say it's faster than all previous personal computers. And the response from kit enthusiasts has been tremendous.

To help you appreciate its value, the price is shown above with and without VAT. This is so you can compare the ZX80 with competitive kits that don't appear with inclusive prices.

### 'Excellent value' indeed!

For just £79.95 (including VAT and p&p) you get everything you need to build a personal computer at home... PCB, with IC sockets for all ICs; case; leads for direct connection to a cassette recorder and television (black and white or colour); everything!

Yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers at several times the price.

The ZX80 is programmed in BASIC, and you can use it to do quite literally anything from playing chess to managing a business.

The ZX80 is pleasantly straightforward to assemble, using a fine-tipped soldering iron. It immediately proves what a good job you've done; connect it to your TV... link it to an appropriate power source\*... and you're ready to go.

#### Your ZX80 kit contains...

- Printed circuit board, with IC sockets for all ICs.
- Complete components set, including all ICs—all manufactured by selected world-leading suppliers.
- New rugged Sinclair keyboard, touch-sensitive, wipe-clean.
- Ready-moulded case.
- Leads and plugs for connection to domestic TV and cassette recorder. (Programs can be SAVED and LOADED on to a portable cassette recorder.)
- FREE course in BASIC programming and user manual.

#### Optional extras

- Mains adaptor of 600 mA at 9V DC nominal unregulated (available separately—see coupon).
- Additional memory expansion boards allowing up to 16K bytes RAM. (Extra RAM chips also available—see coupon).

\*Use a 600 mA at 9V DC nominal unregulated mains adaptor. Available from Sinclair if desired (see coupon).

### The unique and valuable components of the Sinclair ZX80.

The Sinclair ZX80 is not just another personal computer. Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter; and the Sinclair teach-yourself BASIC manual.

The unique Sinclair BASIC interpreter offers remarkable programming advantages:

- **Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.**
- Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
- Excellent string-handling capability—takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The ZX80 also has string input—to request a line of text when necessary. Strings do not need to be dimensioned.
- Up to 26 single dimension arrays.
- FOR/NEXT loops nested up to 26.
- Variable names of any length.
- BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
- Exceptionally powerful edit facilities, allows modification of existing program lines.
- Randomise function, useful for games and secret codes, as well as more serious applications.
- Timer under program control.
- PEEK and POKE enable entry of machine code instructions.USR causes jump to a user's machine language sub-routine.
- High-resolution graphics with 22 standard graphic symbols
- All characters printable in reverse under program control
- Lines of unlimited length.

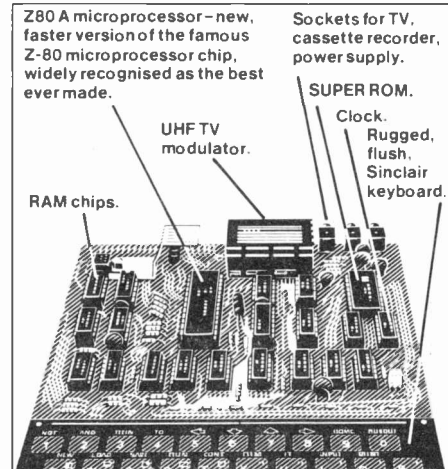
### Fewer chips, compact design, volume production—more power per pound!

The ZX80 owes its remarkable low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the ZX80's 1K byte RAM is roughly equivalent to 4K bytes in a conventional computer—typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines.

And Benchmark tests show that the ZX80 is faster than all other personal computers

No other personal computer offers this unique combination of high capability and low price.



Z80 A microprocessor—new, faster version of the famous Z-80 microprocessor chip, widely recognised as the best ever made.

Sockets for TV, cassette recorder, power supply.

SUPER ROM.  
Clock.  
Rugged, flush, Sinclair keyboard.

UHF TV modulator.

RAM chips.

# plete



## ZX80 software – now available!

See advertisements in Personal Computer World, Electronics Today International, and other journals.

New dedicated software – developed independently of Science of Cambridge – reflects the enormous interest in the ZX80. More software available soon – from leading consultancies and software houses.

### The Sinclair teach-yourself BASIC manual.

If the specifications of the Sinclair ZX80 mean little to you – don't worry. They're all explained in the specially-written 128-page book free with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs. (Available separately – purchase price refunded if you buy a ZX80 later.) A hardware manual is also included with every kit.

### The Sinclair ZX80. Kit: £79.95. Assembled: £99.95. Complete!

The ZX80 kit costs a mere £79.95. Can't wait to have a ZX80 up and running? No problem! It's also available, ready assembled and complete with mains adaptor, for only £99.95.

Demand for the ZX80 is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. We'll acknowledge each order by return, and tell you exactly when your ZX80 will be delivered. If you choose not to wait, you can cancel your order immediately, and your money will be refunded at once. Again, of course, you may return your ZX80 as received within 14 days for a full refund. We want you to be satisfied beyond all doubt – and we have no doubt that you will be.

**sinclair**  
**ZX80**  
Science of Cambridge Ltd  
6 Kings Parade, Cambridge, Cambs., CB2 1SN.  
Tel: 0223 311488.

ETI SEPTEMBER 1980

### ORDER FORM

To: Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.  
Remember: all prices shown include VAT, postage and packing. No hidden extras.  
Please send me:

Quantity	Item	Item price £	Total £
	Sinclair ZX80 Personal Computer kit(s) Price includes ZX80 BASIC manual, excludes mains adaptor	£79.95	
	Ready-assembled Sinclair ZX80 Personal Computer(s) Price includes ZX80 BASIC manual and mains adaptor	£99.95	
	Mains Adaptor(s) (600 mA at 9 VDC nominal unregulated)	8.95	
	Memory Expansion Board(s) (each one takes up to 3K bytes)	12.00	
	RAM Memory chips – standard 1K bytes capacity	16.00	
	Sinclair ZX80 Manual(s) (manual free with every ZX80 kit or ready-made computer)	5.00	

NB. Your Sinclair ZX80 may qualify as a business expense.

**TOTAL £**

I enclose a cheque/postal order payable to Science of Cambridge Ltd for £ \_\_\_\_\_

Please print

Name. Mr/Mrs/Miss \_\_\_\_\_

Address \_\_\_\_\_

ETI/9/80



# DIGEST

## Booking Up

**B**ernard Babani (Publishing) Ltd of The Grampians, Shepherds Bush Road, London W6 7NF have brought out a brand new catalogue of Radio and Electronics books which they publish. They cover such subjects as Electronics, Semiconductors, Computers, Television, Radio, Hi-fi, etc. Whether you are a hobbyist, engineer, designer or student, they have something for you. The catalogue is free, just send them a reasonably large stamped addressed envelope and you will receive your copy by return.

## Power Cuts On The Way

**I**n 1968 your 20 inch colour telly using 90° deflection would have consumed over 200 W. Now, the figure is around 65 W. A new development from Finland will further reduce that to about 40 W.

The system, which results in a reduction of about 40% in power consumption, has been incorporated in the Salora G Series of portable colour sets. The design is basically a 90% efficient couple between the power supply and picture tube using an induction transfer system. The resultant cool running improves reliability and extends operational life.



The G Series, with its 16, 20 and 22 inch models, will operate from a standard 60A/hour 12 V battery for 15 hours, or from mains for as long as you pay your bills.

All the models feature automatic electronic tuning, fine

tuning and memory plus add-on options for remotec control, 12 V battery and video frequency interface unit.

Salora products are available in the UK from Salora (UK) Ltd, 25A Techno Trading Estate, Swindon SN2 6EZ.

## Computer Aided Yacht Race

**T**his year the 1980 Observer Single Handed Transatlantic Yacht Race is being aided by a computer-based system. Known as the Argos system, each of the yachts involved in the race has an on-board transmitter which emits a signal picked up by two satellites regularly crossing the Atlantic. These signals are then rebounded to earth for decoding and processing. The information is fed via Toulouse in France to a CII Honeywell Bull computer in Paris and then is further processed by a Micral Computer in the Paris offices of Europe 1 radio sta-

tion. A Benson drafting machine on line to this computer is then able to give a graphic representation of the yachts' positions. This information is used by the radio station for its coverage of the race and also allows the race organisers to keep a constant eye on the progress of each yacht. This means increased safety for the race, as Coastguards can be immediately notified if they are in difficulty. After the disasters which occurred during last year's Fastnet race, this system will hopefully increase the safety factor in open sea racing.

## Powering Down

**E**very piece of electrical and electronic equipment needs a power supply of some sort. Larsen Sweeney's latest forecast of the use of power supplies in Europe up to 1986 reports a general downtrend. Not only is the general power supply business slowing down, but, in particular, newer supply systems, eg switching regulated and switched mode, are also feeling the pinch. This is largely a result of a slowdown in new product design and development.

The report warns that British power supply designers are at a distinct disadvantage in this marketplace and many will not

survive the recession. Their competitors in West Germany, France, Sweden and Japan are supported financially by their respective governments, but the British companies are on their own.

The 243 page Larsen Sweeney report covers 16 European countries and 34 power supply product groups, including sections on marketing, the industry, the end user and distributors. Every home should have one. You'll have to raid the piggy bank, though. 'Power Supply In Europe To 1986' will set you back £695. Beat the rush... send your life savings now to Larsen Sweeney Publications Ltd, P O Box 36, Maidstone, Kent.

## EMP — The Govt. Speaks

Your Ref.

HOME OFFICE,

QUEEN ANNE'S GATE,

LONDON, SW1H 9AT

Our Ref.

2 7. 1980

The Under Secretary of State desires to acknowledge the receipt of your letter of the 27. 6. 80 which is receiving attention.

This is the entire text of the replies we have received to date from the vast machinery of the British government. Receiving attention? We shall keep plugging away though, and report any sensible answers we do manage to obtain. Meanwhile what are your views on the subject of EMP? Let's hear about them.

## Vetting VDUs

**I**f your work involves reading data from a telly screen (operating a computer terminal, for instance) you may occasionally wonder if it affects your eyesight, especially if you go home every night with a splitting headache.

The twin evils of radiation and eyestrain have attracted some attention with respect to VDU usage. For this reason the VDU Eye Test (VET) Advisory Group was set up to devise a test package for VDU users. Their final report has now been published as a 12 page booklet.

The Group found 'that no significant hazard from X-ray, ultra-violet, visible or RF radiation has been detected' in modern VDU design. Moreover, the

Group found no evidence that VDU use could cause eyestrain. We consulted a practising Ophthalmic Optician who told us that normal use of the eyes cannot cause damage.

The report did, however, list several factors that could cause discomfort, which the layman might call eyestrain. These included the posture of the VDU user and the working environment.

The Group concluded that VDUs can be used safely, if designed and intalled with proper attention to the user's ergonomic requirements. Where there is intensive use of VDUs, the user's eyesight should be checked with the test recommended in the report.

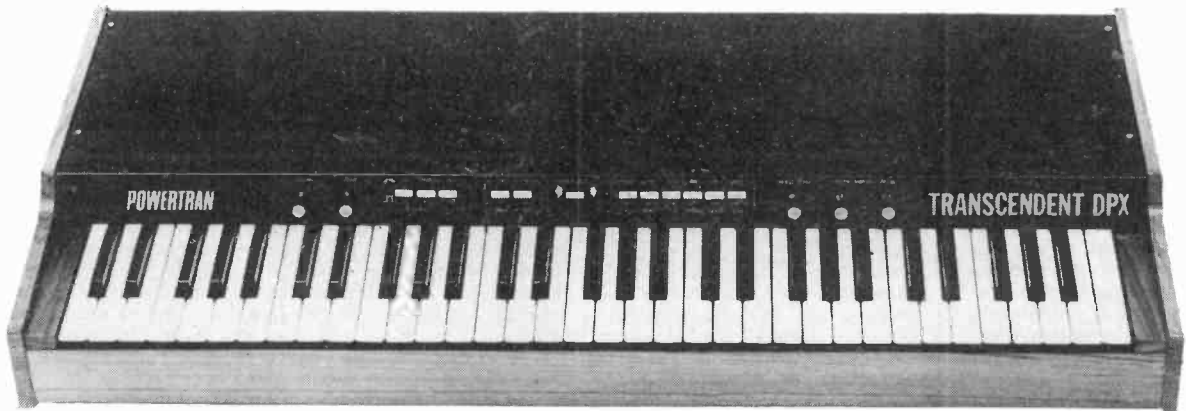
If you would like a copy of the VET Advisory Group's report, write to Tom Stewart, Butler Cox & Partners Ltd, Morley House, 26-30 Holborn Viaduct, London EC1A 2BF.

# TRANSCENDENT DPX

**DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER**

**Another superb design by synthesizer expert Tim Orr — published in Electronics Today International**

The Transcendent DPX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic, i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.



Cabinet size 36.3" x 15.0" x 5.0" (rear) 3.3" (front)

## COMPLETE KIT ONLY £299 + VAT

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects. As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing, etc., etc.)

Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet. The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug!

# POWERTRAN

**MANY MORE KITS ON PAGE 110 MORE KITS AND ORDERING INFORMATION ON INSIDE FRONT COVER**

## TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

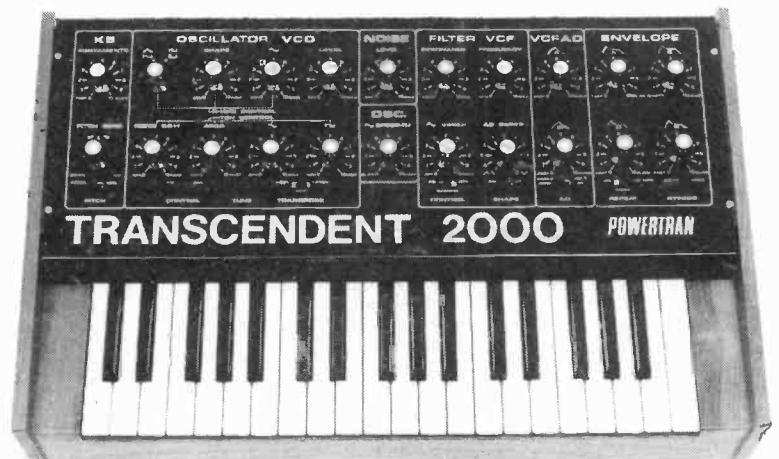
**LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN ELECTRONICS TODAY INTERNATIONAL.**

The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an effective 7 octave range. There is portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or 1/2% metal film) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready-built units selling for many times the price.

**COMPLETE KIT  
ONLY  
£168.50 + VAT!**

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more elaborate than a multi-meter and a pair of ears!



Cabinet size 24.6" x 15.7" x 4.8" (rear) 3.4" (front)





## Metering Your Multis

The Alpha V is the latest and smallest hand-held digital multimeter from Gould Instruments. It has a 3½-digit liquid crystal display with 25 measuring ranges covering the five basic functions of DC voltage, AC voltage, DC current, AC current and resistance. It has a maximum reading of 1999 and maximum resolution of 100 µV. Range and function selection is by two rotary switches on the clearly coded front panel. The multimeter is powered by a 9 V carbon zinc or alkaline battery (PP3 or equivalent), the latter giving a typical life of 200 hours. There is a battery low indicator provided by the display, which shows 'BAT' when less than 10% of useful battery life remains. The case is of high-impact ABS plastic and the display is shock mounted behind a polycarbonate plastic window. Accessories supplied with the basic instrument include standard red and black test leads, battery and handbook. The cost is £85.00 (plus VAT) from Gould Instruments Division, Roebuck Road, Haina

## Anti Car Theft

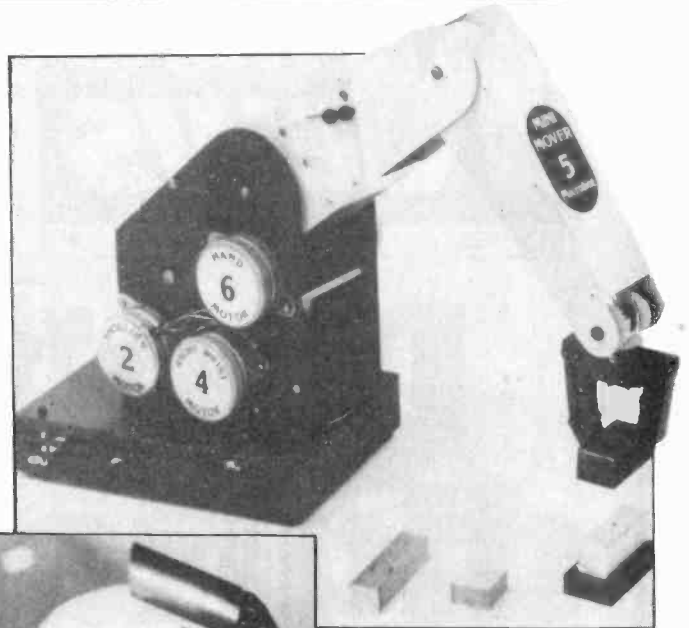
Maywood Security Services Ltd. is marketing a method of deterring vehicle thieves. A mobile service is offered which involves abrading the vehicle registration number on every window of a car, caravan, commercial vehicle or boat. This means that in order to mask the identity of a stolen car the thieves must replace all of its windows. The abrading process takes about five minutes at a cost of about £5 per vehicle (quantity discounts may be given). Maywood Security Services Ltd are operating as a franchise for Safecar and they will quite happily call at your place of work or home. This method has received the support of police crime prevention officers throughout the country who have to deal with some 350,000 vehicle thefts a year. The address is Maywood Security Services Ltd, Peake House, 232 High Street, Harlington, Hayes, Middlesex, UB3 5DS. They cover North West, West and South West London.

## Status Symbols

Raindirk of Downham Market Norfolk are now supplying the Status range of audio equipment. Their Status 500 power amplifier delivers 250 W per channel into 8R, using power MOSFET output stages. The Status 20 Stereo Control Unit is a rack-mounting system with a modular disc replay amplifier that can be remotely located, three band equaliser with continuously variable turn-over frequencies, built-in headphone amplifiers and external mains power supply. The range will soon also include a parametric equaliser. You can get more information on the Status 500 and the rest of the Status range from Raindirk Ltd, Downham Market, Norfolk.

## Sharp Shapes

Sharp Corporation are now marketing an alternative to conventional tubular LEDs. They are designed for flush fitting to front panels and are currently offered in the form of round 'point' indicators, equilateral and isosceles triangles, square and flat sections, all in three different sizes, (3, 4, and 5 mm) and three different colours — red, yellow and green. The shapes make good function indicators and the 'squares and flats' can be stacked to form bar graphs. For 1,000 pieces the price is between 5p and 10p each depending on the size, shape and colour. They are available from CRP Electronics Ltd, 13 Hazelbury Crescent, Luton, LU1 1DF.



Defence Ministries and may become an industry standard.

Aimed at managers, engineers and programmers, ICS's 'Computerised Robots' course will pinpoint where the new breed of 'intelligent' robots can be used to increase productivity and streamline production.

Japan is currently the major employer of robot labour with 6,000 in use (40,000 if you include the simplest automata). The USA has 3,500 while Europe has only 2,000. If computer companies enter the robotics market, it is estimated that there could be 200,000 robots in use by 1990 in the USA alone with over 35% of all production in robot 'hands' by the turn of the century. As the increasing use of robot labour changes the face of society, all we will need is a machine that enjoys living in it.

You can get more information on the course programme from Dr David C Collins, ICS Publishing Co Ltd, Pebblecoombe, Tadworth, Surrey.

## Robot School

Integrated Computer Systems Inc. have announced details of their new courses in 'ADA' and 'Computerised Robots'. 'ADA', a new high level computer language, has been developed by the US Department of Defence in co-ordination with European

## Small is Beautiful

A miniature hi-fi system is now available from Mitsubishi Electric, called 'System 4'. It delivers 50 W per channel, both channels driven into 8R and it measures 27W x 42.4H x 27cmD. The four units consist of the M-A04 Power-amp, M-P04 pre-amplifier, M-F04 AM/FM Tuner and the M-T04 front-loading Cassette Deck which is metal tape compatible. Their latest speaker system is also available. A 50 W 8R two way infinite baffle speaker, the SS 630E, retails at £115.00 for the pair. Frequency response is 60 Hz to 22 kHz and dimensions are 305W x 544H x 257mmD.



## SPECIAL REPORT

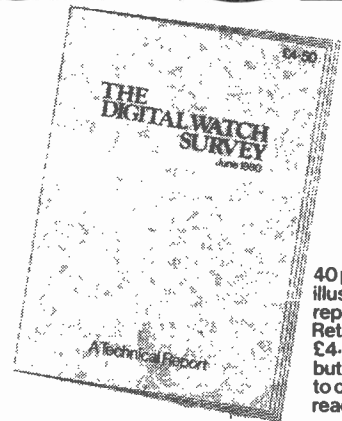
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by Trevor Raven.  
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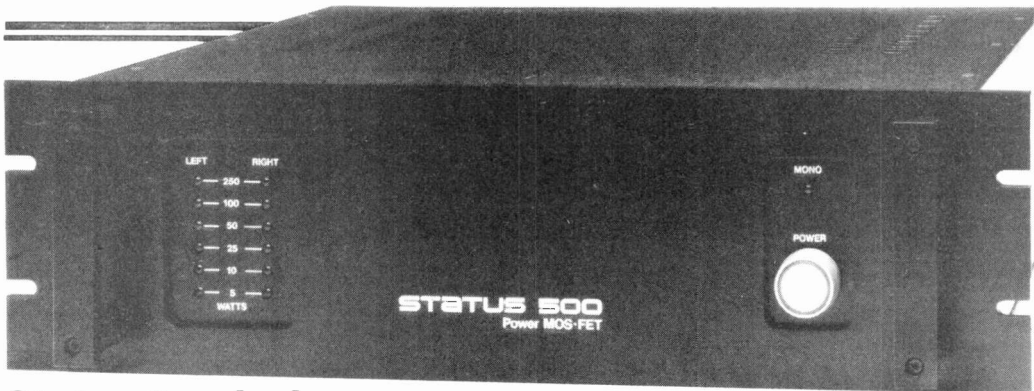
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## Status Symbols

**R**aindirk of Downham Market Norfolk are now supplying the Status range of audio equipment. Their Status 500 power amplifier delivers 250 W per channel into 8R, using power MOSFET output stages. This Status 20 Stereo Con-

trol Unit is a rack-mounting system with a modular disc replay amplifier that can be remotely located, three band equaliser with continuously variable turn-over frequencies, built-in headphone amplifiers and external mains

power supply. The range will soon also include a parametric equaliser. You can get more information on the Status 500 and the rest of the Status range from Raindirk Ltd, Downham Market, Norfolk.

## 100 W Power Amp (August)

In Fig.7 on page 67, C1, 2 and 4 are shown the wrong way round. However, they are shown correctly on the component overlay.

In the Power Amplifier Board Parts List on page 68, R15 should be 10R 1W and R16 should be 10R 2W. In the DC Sensing Board Parts List on the same page R7 should be 4k7, R20, 23 are 82k, R18 is 1k0, R26 is 91k and R27 is 5k6. C1,2 and 11 should be 22u 16 V electrolytic and C9, 10 should be carbonate types.

The component overlays on page 69 are correct.

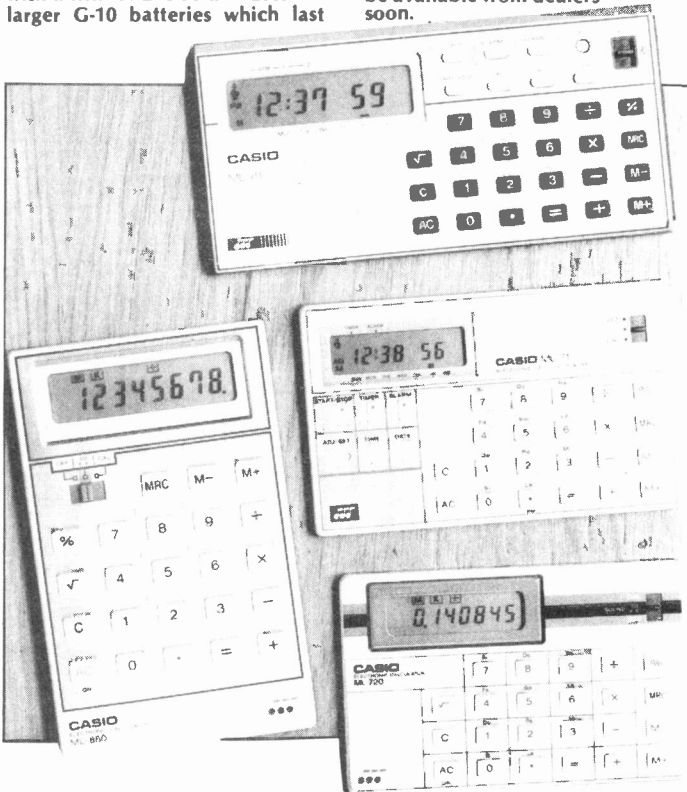
## Music To Your Ears

**C**asio have brought out four new calculators to follow in the footsteps of their Melody Card M-80. They all have eight digits calculating capacity in four functions, with full percent and independent memory. Sliding the mode switch to 'music' converts them to an 11 note instrument for the user to play tunes on the numerals (0-9) and decimal keys.

The ML-720 is credit-card sized and is priced at £17.95. It is powered by two G-8 size batteries which last for 700 hours continuous calculating use. This is extended by an automatic power off function with full memory retention. The ML-860 is slightly bigger with a RRP of £16.95 and uses the larger G-10 batteries which last

almost twice as long as the G-8 type.

For £25.95 you have the choice of the ML-71 and the ML-81 which both tell the time as well. The ML-71 is credit-card size and keeps continuous track of time, with running second display and date and includes a one-tenth second stopwatch feature. It also has an alarm for any preset time of day as well as a countdown timer. The G-10 batteries last about a year. The ML-81 is larger again with the same facilities as the ML-71 plus an independent alarm. The two G-12 batteries last for 14 months continuous operation. All these calculators should be available from dealers soon.



ETI SEPTEMBER 1980

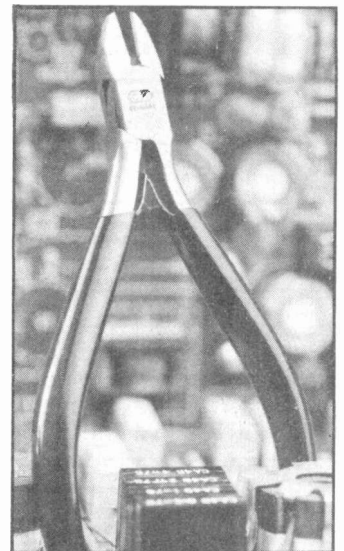
## Black Hole (May 1980)

**R**21, R83 and C10 should be 1k0, 18k and 10nF respectively. A 39k resistor should be connected in series with C40. Cut the appropriate PCB track and solder the resistor across the break. A 1N4148 diode should be connected across each SAD512D input (soldered to the underside of the PCB). Later issue PCBs from Powertran will be suitably modified.

## Kit News

**T**K Electronics' contribution to making legs obsolete should be available in September. It's a touch-controlled light dimmer with single alternate action touch plate. Nothing strange in that, you say. Well, TK have married their touch dimmer with an infra-red remote control system. So, you needn't leave your water bed, with infra-red light controller in one hand and ultrasonic TV controller in the other (and the two will not interfere with each other). TK's TDR300K 300 W Remote Controlled Lightdimmer will probably cost around £10. Watch their adverts in ETI for latest details. Meanwhile TK can supply an infra-red on/off light controller for £12 plus VAT (order model RC500K). A multi-channel infra-red remote control system for models, hi-fi, etc is also available separately.

Aura Sounds, who pioneered the introduction of Wersi organ kits in the UK, have been appointed marketing agents for Heathkit Electronics. Both companies and you and I come out on top — Heathkit broadens its sales representation, Aura Sounds expands its kit business and Heathkit products are a little more widely available to the likes of you and me.



## Hard Wire Side Cutter

**A** new specialist side cutter for use in the electronics and electrical industries is now available from CeKa. Its hard wearing tungsten carbide tipped cutting edges provide the tool with long working life and cutting capacities of, for example, 0.6 mm on piano wire and 1.6 mm on hard electrode wire. The cutter is 4½" in size and is box jointed for exact location, flush cutting and the prevention of cutting edge overlap. A smooth and controlled action while cutting in sensitive or confined situations is achieved by double leaf return springs. The cutter handles are covered by moulded black PVC grips. In addition to cutting hard wires, CeKa states that use of the side cutters continually on ordinary soft wire will make its working life almost indefinite. The RRP of the CK Precision Side Cutter is £19.40 plus VAT. The address is CeKa Works Ltd, Pwllheli, Gwynedd, North Wales.





# ETI NEXT MONTH

October issue on sale September 6th - Don't miss out order your copy today.

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## FM Radio Control

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In the course of the past year you've seen all the others produce radio control projects. You've also seen them make a right mess of the idea!

Next month ETI presents the definitive FM, easy-to-build, every-home-should-have-one, radio control. We won't spin it out over 10000 issues either, our circuit is sufficiently refined for us to be able to present full details in one issue!

If you're at all intrigued by controlling things at a distance ETI October is *the* place to be.

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## Fuzz Sustain

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Brilliantly innovative project to please all of the guitarists, all of the time. This nifty little box can provide a really rich fuzz sound and/or a *true* sustain. We stress the 'true' because there have been some attempts to pass off things which are decidedly second-rate before now. As usual ETI gets it right! Inexpensive, ingenious and simply magnificent are words which could well apply to this our latest musicians project!

Don't miss it lest your plectrum gets lonely!

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## Circuits Circuits And More Circuits

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Spot Designs is our new 'tried and tested' circuits features. All the ideas presented have been built and proven — so it is not surprising that this is already a popular new addition to ETI. Next month we're presenting six pages of this top-class ideas material, in response to the many requests to increase the size of the feature.

This is a 'special' one-time only offer so don't get left out circuitless!

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## Universal Cassette Interface

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Into micros? Then ETI has something a little bit special for you next month — a tape interface with switchable baud rate and flexible I/O. It can be run with any system and any tape machine (within reason) and offers all the benefits of being able to save programs on tape at a ridiculous price! Miss this and your fingers will undoubtedly drop off typing!

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## Einstein Relatives

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Yep. The feature you said we would *never* do. A clear easily understood explanation of the Special Theory of Relativity. This is the topic that those smug little physicists are always telling us humans we can never hope to comprehend. Well we can. Just read ETI next month and see for yourself.

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## Also Appearing . . . . .

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Taking part in next month's production we also have: a Bench Amp for the experimenter; a review for the HP-41C alpha-numeric calculator; an audio signal generator; a flash trigger for quick-off-the-mark photographers plus, of course, all our usual brilliant regulars. It's got to be worth the mere 60p we ask in exchange!

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Articles mentioned herein are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

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# HEAD AMPLIFIER DESIGN

If you've taken the plunge into moving coil cartridges and you're looking around for a head amplifier, Andy Sykes of Videotone explains how you can design your own.



For those of you not yet smitten by the all consuming Hi-Fi bug, a 'Head Amplifier' is *not* the latest tool for psychologists. The term is borrowed from the telecommunications industry where a preamplifier sited at the mast head is sometimes used to boost the received RF signal in areas of poor signal strength.

Over the past five years there has been a tremendous upsurge of interest in new methods of extracting the musical information from the depths of the record groove. Along with this has come a re-appraisal of the relative merits of the moving coil and moving magnet pickup cartridges. Each has a great deal to recommend it and we should start by comparing the two, albeit briefly.

The principle of operation is the same, ie a current is induced in a coil by a (relatively) moving magnetic field. In the moving magnet type it is, as the name suggests, the magnet that moves because it is mounted on the opposite end of the cantilever to the stylus.

## Mass Tendencies

This system works well, but the mass of the magnet/stylus assembly has a nasty tendency to resonate within or just above the audio band. With careful design this effect can be minimised, but some colouration of the sound still occurs. Another problem is that the high impedance of the cartridge, due to the high number of turns required to achieve a usable output, also causes matching problems, lending to high fre-

quency losses in the signal lead capacitance.

Despite all this, excellent results are achievable for a moderate cost and it worth noting that the most competitive area for moving magnet cartridges is between £15 and £25.

## Role Playing

Recent developments in technology, however, have made possible an effective reversal of the roles of magnet and coil, neatly overcoming the problems just mentioned, as it is now the coil which moves, inside a static magnetic field. (It is only fair to mention at this point that Ortofon have been producing very underated moving coil cartridges for many years and are generally considered to be the pioneers of the field). The coil can be made very light, reducing the resonance problem and the output impedance is low due to the small number of turns used, which cures the lead losses.

All is not quite sweetness and light, however, as the system brings its own set of problems, which can be summarised as:

1. Low output — 150uV nominal
2. Very low source impedance
3. Expensive to manufacture

These problems *can* be overcome at a price, however, and if it is perfection for which you strive, the moving coil cartridge can be considered the best method of transferring data from the record to your ears at present. It is interesting to note that most of the current batch of professional Hi-Fi reviewers use a moving coil cartridge against which others are judged. ➔

## Coming Up in the World

A step up device is required to match the low output impedance of the cartridge and to raise its meagre output to a point comparable with the universal moving magnet input or amplifier at approximately 5 mV. One way to achieve this is by the use of a matching transformer similar to those used with low impedance microphones. This solution, however, brings in problems such as secondary load matching, third harmonic distortion, frequency response limitations and hum pickup, all of which require careful and thus expensive design to overcome successfully. An active amplifier is a more cost effective (the watchword of the eighties) solution and has the added advantage of being within the design capabilities of the home constructor.

## Design Criteria

The criteria to be considered in the design of such a preamplifier are primarily noise, frequency response and distortion.

If we consider a general MC (Moving Coil) cartridge with an output of 150 mV, source impedance of 10 R, and frequency response of 20 Hz to 25 kHz, a matching head amp would have to have at least the following characteristics to achieve Hi-Fi standards:

1. Gain x30 for nominal 4.5 mV output into 47k
2. Signal to noise ratio better than 60 dB
3. Distortion less than 0.05%
4. Overload factor better than 40 dB
5. Frequency bandwidth better than 20 Hz to 20 kHz

The input impedance should theoretically be the same as the cartridge source impedance for maximum power transfer, but it has been argued that MC cartridges work best into loads somewhat higher than this, as it reduces the power dissipation in the (cartridge) coil. Manufacturers differ widely in their recommendations for input impedance, but values between 100R and 470R are most commonly quoted. These values are normally determined by audition, but in my experience strict adherence to the recommended value is by no means as important as one is lead to believe, the differences in sound being more likely due to circuit variation than to mismatch. A good general purpose design *should*, therefore, be suitable for all MC cartridges.

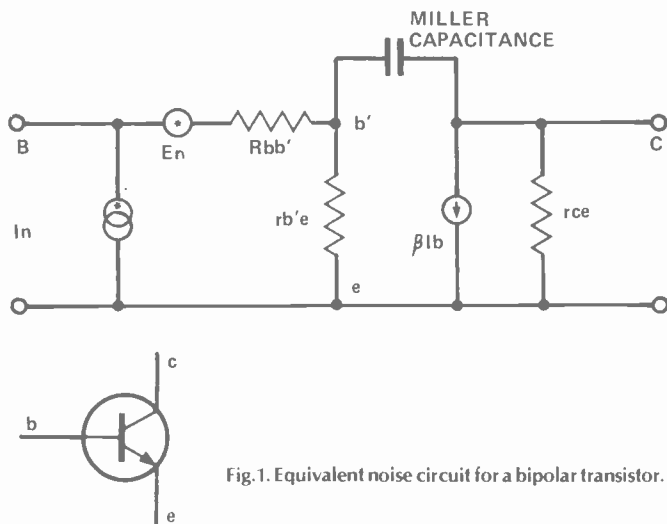


Fig. 1. Equivalent noise circuit for a bipolar transistor.

## Noise Model

Noise can be thought of as an additional voltage appearing at the input of an amplifier, the ratio between this voltage and the input signal voltage being the measured signal to noise ratio. It is assumed in this model that all noise introduced by the amplifier is added to this input noise voltage and that subsequent amplification of both signal and noise takes place equally and noiselessly. If we wish to achieve a signal to noise ratio of better than 60 dB, this implies an equivalent input noise voltage of around 150 nV. As a comparison, a moving magnet input stage with a signal to noise ratio of 80 dB would have an input noise level of 450 nV and only the very best amplifiers ever achieve anything like this kind of noise figure.

There are three main sources of noise in a transistor amplifier; thermal noise, flicker noise and shot noise. The first two are common to all electronic components, both active and passive, whereas the last is produced in active devices only. Without getting too bogged down in semiconductor physics, shot noise is caused by random fluctuations in the diffusion of minority carriers at the base/emitter junction of the transistor and also by recombination effects within the base region.

Suffice it to say that this type of noise is proportional to the emitter current flowing through the transistor (or diode) and is broadband. Flicker noise is present in semiconductors, resistors and thin metal films, and is produced by skin effects in the surface of the conducting regions of the device. The noise level depends upon the material, but is typically proportional to  $I^2/F$ , where  $I$  is the current flowing, and is thus often called  $1/f$  noise. Thermal noise is, as the name suggests, produced by thermal agitation within the component material and is again broadband in character and proportional to the temperature of the device. The level of noise can be calculated from the equation

$$e^2 = 4KTBR$$

where  $e$  = generated noise voltage  
 $K$  = Boltzman's constant  
 $B$  = frequency bandwidth over which to noise is measured  
 $T$  = temperature in degrees Kelvin  
 $R$  = the resistance value

Armed with this knowledge, the potential noise generated by any component used in our proposed head amp can be measured and steps taken to reduce its contribution to the total noise produced by the circuit.

In general there are four ground rules which should be followed to help achieve good performance.

1. Choose low noise components
2. Pay careful attention to transistor biasing arrangements
3. Keep resistor values as low as possible
4. Pay careful attention to avoid the pickup of external noise sources

Couldn't be simpler could it?

Low noise types of resistors are metal oxide, close tolerance metal glaze, or thick film. Avoid the use of large electrolytics as the (inevitable) leakage currents generate noise. Tantalum or polycarbonate types are best for the higher capacitance values and polystyrene or silver mica the best cost/size/noise level compromise for lower values. PTFE is the best of all, however, but tends to be on the expensive side. The noise levels produced by transistors are normally obtained from the manufacturer's data and there are several factors to be considered.



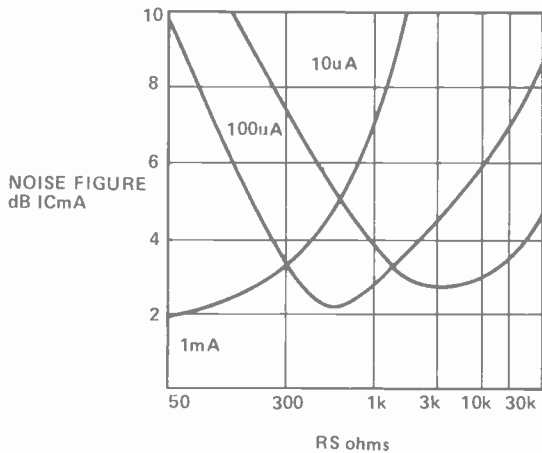


Fig.2. Noise curves for the BC413.

## Equivalent Thinking

If we refer to the equivalent circuit for a transistor in common emitter configuration shown in Fig.1, and then consider the various noise sources contained within this circuit, a mathematical expression for the total noise generated can be derived. The exact form of this equation requires far too much deep thought for us to deal with it in detail here, but note that both noise voltage and noise current terms would be involved. It is also immaterial because transistor manufacturers are kind enough to measure it for us and provide noise versus frequency, and noise versus source resistance plots which take the general form shown in Fig.2.

The overall noise level is dependent upon the collector current flowing and for the lowest noise there is an optimum source resistance.

For use in our head amplifier this should ideally be the same as the source impedance of a moving coil cartridge, about 10 R, but due to the need to optimise other parameters it is more likely to be between 1k and 10k for a typical audio low noise transistor. This is because the vast majority of uses for these devices involve higher source impedances, ie 47k and the manufacturers do not see sufficient market to justify the production of a special low noise, low source resistance type, except, that is, for the ever-industrious Japanese.

A Nipponese semiconductor firm recently introduced the answer to the head amp designers dreams with a range of low noise transistors with optimum source resistances as low as 2R!

This ability to cobble up a special device to order, where no standard model is adequate, is one reason why the Japanese rule the audio kingdom.

## Phenomenal

All is not yet lost, however, as there are two phenomena which may be used to advantage when designing a low noise amplifier with standard components. The first is that some medium power transistors exhibit better noise figures when driven from a low source resistance than normal low noise, low level types. This is mainly due to the need to keep  $r_{bb}$  low (see Fig.1) in order to obtain good  $h_{fe}$  figures when operating at relatively high collector currents (values between 1 mA and 10 mA are common), which tends to rule out battery operation.

This brings the additional problem of the mains supply, of which more later. Suitable transistors for this type of use are 2N4405 or BC361, both of which have been successfully used in commercial designs.

The second possible answer is the use of a parallel transistor stage. This is where several transistors are wired in parallel, obvious really isn't it? The main advantage of which lies in the fact that in common emitter mode the base/emitter junctions are in parallel and thus the noise currents and voltages produced by each transistor are summed together, see Fig.3. The basic rule for Communications Engineers considering the noise levels of their systems is that noise signals from several separate sources, feeding into a common input, add by power.

Therefore, the total noise voltage for our parallel stage will be given by the equation  $E_{nt} = E_n/N$  where N is the number of transistors. Similarly the total noise current will be given by  $I_{nt} = NI_n$ . Now the best noise source resistance for a transistor is given by  $R_o = E_n/I_n$  and so for our parallel stage this is  $R_{ot} = E_{nt}/I_{nt} = R_o/N$ .  $R_{ot}$  is thus dependent upon the number of transistors used in parallel, the greater the number used the lower the best source resistance becomes.

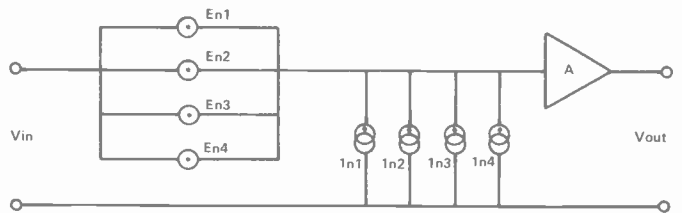
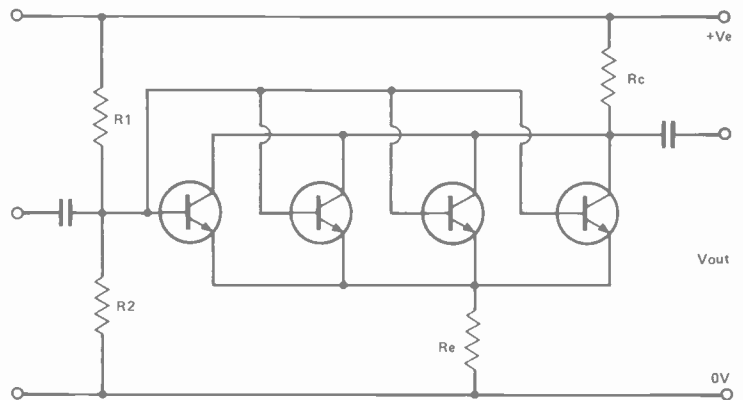


Fig.3. Noise model of parallel stage.

Let us now consider a typical low noise transistor with a best source resistance of 2k to be used with an MC of source impedance 10R. The number of parallel transistors required for the best match is given by  $2000/10 = 200$ . This is clearly impractical for reasons of cost, the physical space required and, more important, the high value of Miller capacitance that would result. As can be seen from Fig.1, the Miller capacitance introduces feedback between the collector and base of the transistor and is the factor which limits the high frequency response. It would be a major problem if this many transistors were used. In practice eight transistors seems to be the best compromise and is the number most commonly used. Even so it is important to choose a transistor with both a low best source resistance and a good  $F_t$  if good results are to be obtained. The  $F_t$  of a transistor is the frequency at which the gain becomes unity and should be in the region of 200 MHz. Suitable types for this type of use are BC413, BC415, BC337, 2N4148.

## Circuit Options

So much for the theory, we come now to consider the options open to us, in terms of the circuit configurations, which may achieve the required specifications for our Head Amplifier. Something to remember here is that any biasing components used will also add to the noise. Take a standard common emitter circuit, for example, with feedback to counteract thermal changes as shown in Fig.4. The noise voltages produced by R1, R2 and R3 all contribute to the overall noise of the stage. The base bias resistors are particularly important as their noise voltages are effectively in parallel with the input signal and will be amplified by such. The contributions of these biasing components can be reduced by decoupling as shown in Fig.5. The biasing under DC conditions remains the same, but the equivalent noise circuit is as shown.

Note that only the noise associated with R3 will contribute to the input noise and this may be made low in value reducing the thermal noise from this component.

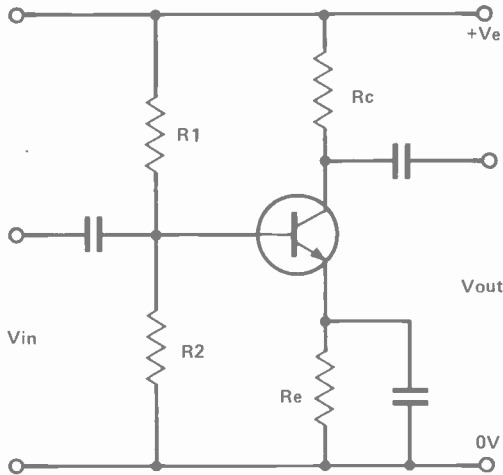


Fig.4. A standard common emitter circuit.

These examples serve to illustrate the principle because a single stage circuit is unsuitable for use as a high quality Head Amp. The main reasons for this are the variations in gain due to the spread of  $H_{fe}$  values in any transistor type and the relatively high values of distortion which are produced. Some form of feedback is required to stabilise and reduce both these parameters and, in general, at least a two stage circuit must be used to produce an acceptable performance.

## Controversial Distortion

There is no "best" circuit but there are, as always, some points to bear in mind. In order to reduce the distortion to an acceptably low level, a fair amount of feedback is required and care should be taken to avoid Transient Intermodulation Distortion (TID). This particular form of distortion has proved to be somewhat difficult to define rigorously and there is not an inconsiderable amount of controversy as to exactly what it is and how to avoid it.

Nevertheless it is generally accepted that TID is reduced by ensuring that any amplification stage has a greater gain bandwidth than the stage preceding it. TID also depends on the amount of overall feedback applied around the circuit and careful design of each individual stage to control the amount of harmonic distortion produced will reduce the amount of overall feedback required and hence reduce the circuit susceptibility to TID.

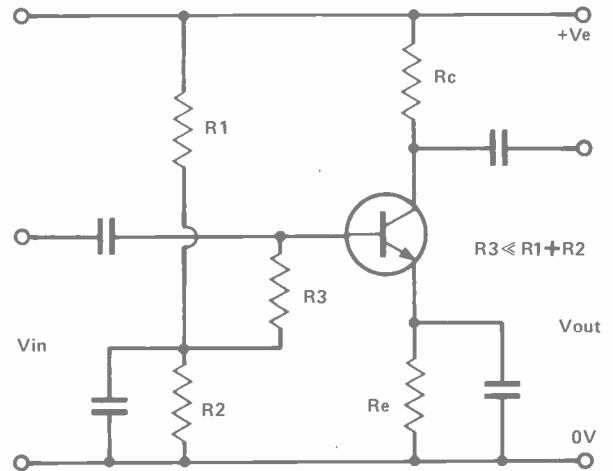


Fig.5. Low noise base bias circuit.

## Breakthrough

The frequency response of the design is also important for two reasons. Apart from the obvious need to keep it wide enough to encompass the whole audio band (traditionally 20 Hz to 20 kHz), it also plays a part in the circuit's susceptibility to Radio Breakthrough. This is a problem because of the high sensitivity of the front end coupled as it is to what is in effect a tuned circuit made up of the cartridge inductance and the input capacitance. My extensive, but completely unintentional, researches into this subject have shown that the two most popular sources of RF interference are Radio 4 at 200 kHz and the local Police/Fire/Ambulance/Taxi Services at anything between 90 and 120 MHz, though the latter is normally only a problem if the offending transmitter is passing close to your Hi-Fi. So, don't put your new moving coil set-up in the front room, folks, if you live on a busy road. The installation of a Mu metal garden gate and front door might also help (for explanation of Mu metal see Hums). Another potential source of RF comes from Citizen's Band transmitters on 27 MHz. But as we all know these are illegal in this country and so nobody really uses them, they just install them in their cars for show.

The offending RF signal is normally received by the first stage acting as a simple diode detector and can be tackled by careful attention to earthing and by the provision of RF filters in the input and supply lines. The input loading capacitor provides good RF decoupling only if a type with good high frequency characteristics is used. Ferrite beads on the input connecting leads can also be used to increase their inductance.

Breakthrough occurring from supply line pickup requires further decoupling to eliminate it. Large electrolytics have a substantial impedance at high frequencies and so should be shunted by a capacitor with better characteristics. A 100n ceramic is suitable here and a small inductor in the supply line is also good practice.

## Passing the Buck

Another method of avoiding breakthrough is to make the bandwidth of the head amp wide enough to include any potentially troublesome frequencies. A bandwidth of, say 10 MHz, would include most national AM stations and any signal picked up would simply be amplified without being detected and passed into the main amplifier. This is known as "passing the buck" in the trade and relies upon the better RF rejection characteristics of the RIAA equalisation stage.

## And so to Details

A typical two stage amplifier is shown in Figs. 6 and 7. These are of the common emitter/emitter follower and common emitter/common emitter types respectively and serve as good examples of typical designs. Both circuits are direct coupled and have overall negative feedback to set the required gain and reduce distortion.

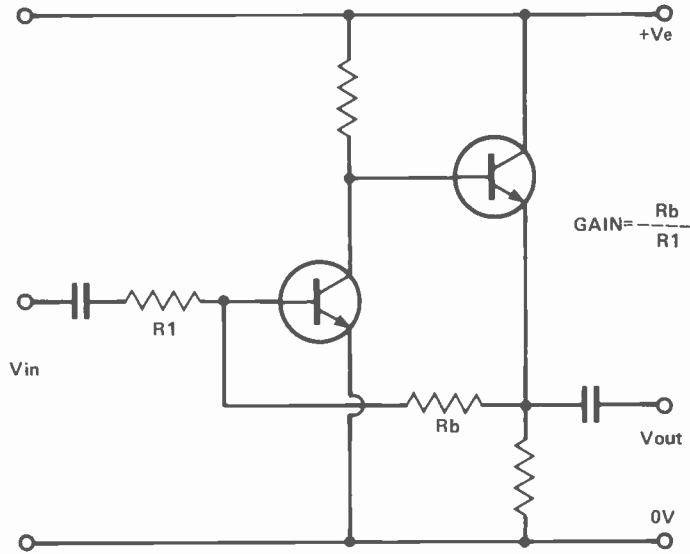


Fig.6. Common emitter/emitter follower amplifier configuration.

The effect of temperature on biasing is also minimised and note that the low noise method of biasing is used in Fig.7. To reduce noise to a minimum the feedback components should be kept as low in value as possible, preferably around the 1-10R mark, though this is only practicable in the latter circuit as R1 in Fig.6 is also the input impedance presented to the cartridge and thus should be somewhere near 100R.

This resistor is in series with the base of the first transistor, however, and as this is probably near to the best source resistance for this stage, assuming the use of parallel transistors, can provide a trade-off with the noise contributed by the relatively high values of the feedback components.

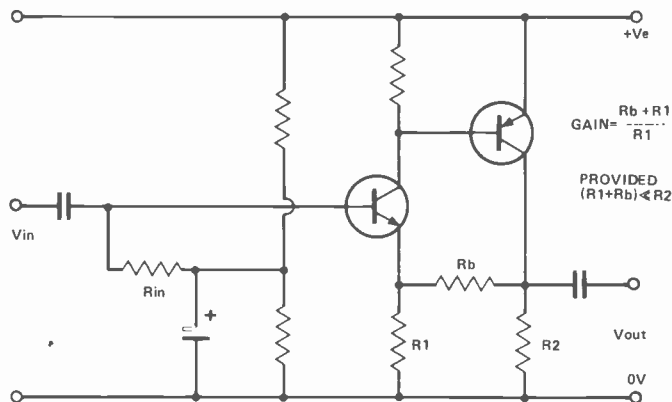


Fig.7. Common emitter/common emitter amplifier configuration.

When using low feedback resistor values make sure that there is sufficient drive capability in the circuit. A feedback resistance of 10R in Fig.7, for example, will require a drive of 100 mA for a 1V swing and would, therefore, require the use of a medium power transistor in the second stage.

This component may also contribute its fair share of noise and some degree of experimentation will be required to reach the best compromise.

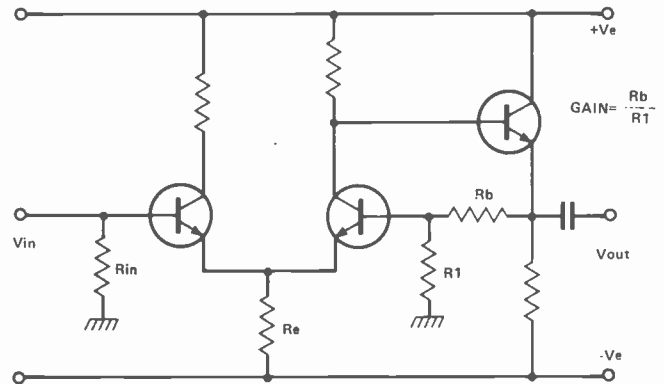


Fig.8. Differential input circuit.

## Redundant Capacitor

A differential input stage as show in Fig.8 may be used to great effect. The input is referenced to signal earth, eliminating the need for an input capacitor. The resistance to supply-borne interference and hum is also greater with this kind of configuration and can be further improved by replacing Re with a constant current generator.

This is just as well because the need for a differential supply makes battery operation expensive and somewhat impractical.

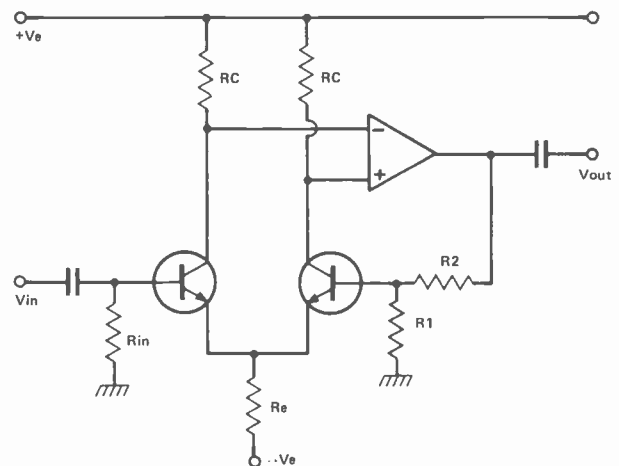


Fig.9. Differential input with op amp.

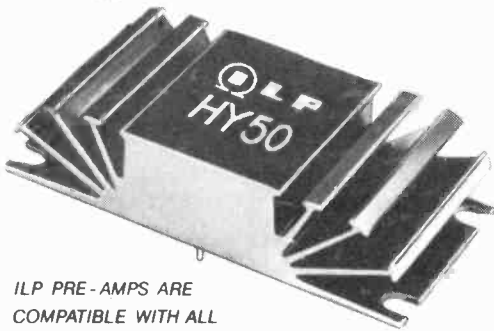
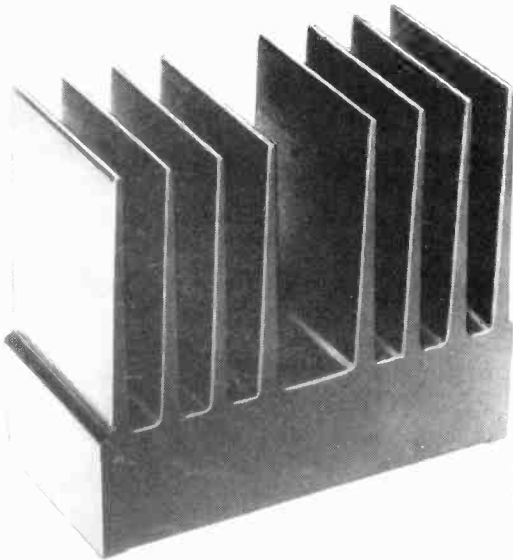
A second gain stage may be added to increase the amount of feedback applied and so reduce distortion. This may be another differential stage or even an operational amplifier (Fig.9).

This latter option may suffer a noise penalty due to the inherent noise output of the op amp but there are some good low noise types now available, such as the TDA1034N and TL071.

Next month we bring Andy Sykes' dissertation to a close with Part 2 of all you need to know about head amplifier design.

ETI

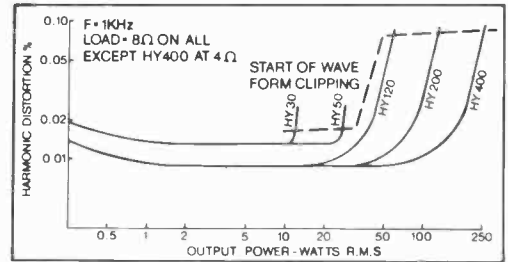
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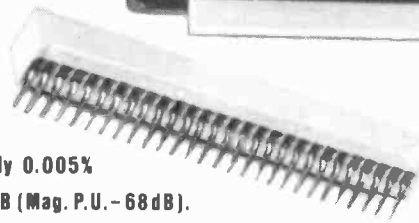
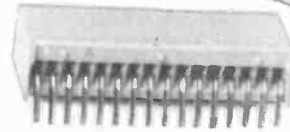
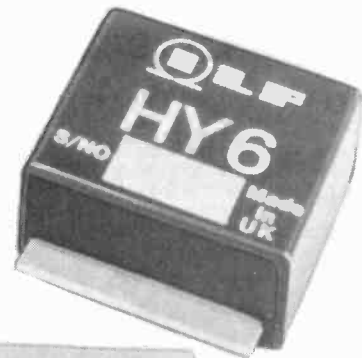
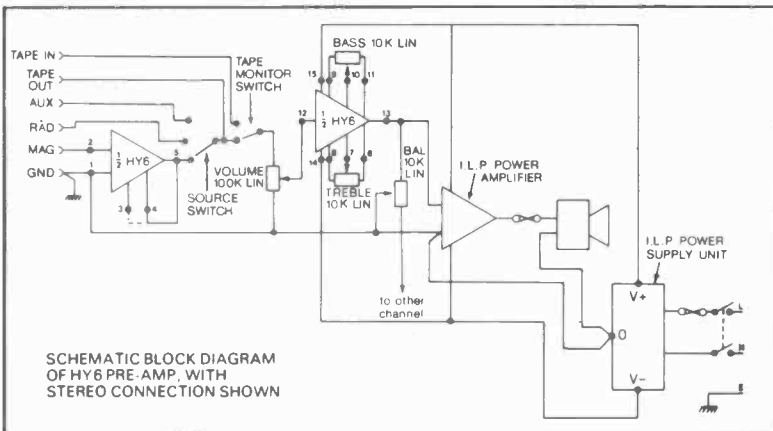
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# CURRENT AFFAIRS

We seem to take for granted that circuits work, but why is it that conductors, semi-conductors and insulators do just what their names imply? A.S. Lipson takes us step by step through the whys and wherefores of atomic structure.

Most of us are reasonably familiar with what electricity is — the movement of electrons through a conductor. But there are some things that we tend to take for granted. For instance, why is it that some materials, like metals, conduct easily, whereas others — insulators — don't, and still others — semiconductors — seem to be somewhere in the middle; conducting, but not as well as metals? In order to find out why, we'll first have to learn something about atomic structure.

## First Theory

Essentially, the atom consists of a central, very small positively-charged lump called the nucleus, surrounded by negatively charged electrons. Many books — particularly old ones — tend to give the impression that the electrons are just like little planets orbiting a sun (the nucleus) and that the atom is like a miniature solar system. This is *wrong*. Electrons do not behave just like little billiard balls, or little solid lumps. It is in fact more accurate (although not quite so simple) to visualise the electrons in an atom as being spread out 'charge clouds' around the nucleus, with most of this charge being concentrated at specific distances from the nucleus. The comparison between the two points of view is made in Fig.1.

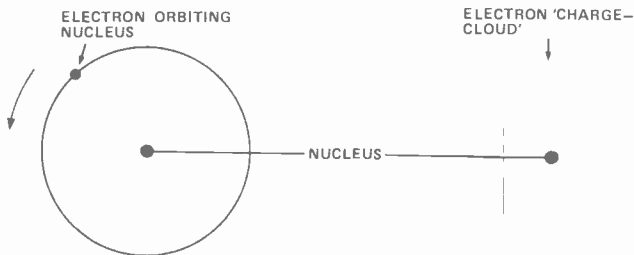


Fig.1. A hydrogen atom according to (a) The 'Solar System' model (b) The 'Charge Cloud' model.

The electrons within an atom can have different energies. If they obtain more than a specified amount of energy (for any particular type of atom), then they can actually break free from the atom. It is clear that the more energy a particular electron has within an atom, the less energy that electron will need to have added to it in order for it to break away from the atom; in other words, the easier it will be for that electron to escape.

## Conduction and Insulation

But what has all this to do with conduction of electricity? In metals, some of the outer electrons present have quite high energies within their atoms and, in a solid lump of metal, one or two electrons from each atom are more or less free of their own atoms, although they are held into the metal as a whole. The positively charged ions left when electrons are removed from atoms are packed closely together and, in between them, the free electrons move about at random, (acting as a sort of 'atomic glue'). This negative charge attracts the remaining positive charge on the ions, and holds the whole thing together. (See Fig. 2.) The charge-clouds of all the free electrons join together, and form what is often known as an 'electron sea'. Because of this structure — the way that they are held together — metals can conduct electricity. Why?

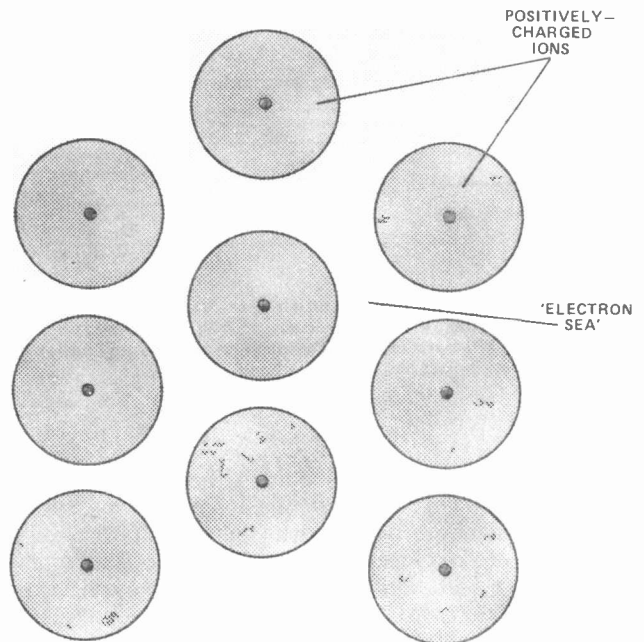


Fig.2. The structure of a metal. Positively charged ions are surrounded by an electron 'Charge Cloud'.

Because of all those free electrons, which aren't held by any particular atom, only by the metal as a whole. They are so loosely attached that if you apply a potential difference across the metal, they can drift along under its influence, and so cause a current to flow. In insulators, on the other hand, the electrons are held much more tightly by the atoms, there is no 'electron sea', and the atoms are bonded together by other means. Consequently, if a potential difference is applied, the electrons are unable to break free from their atoms, and so no current can flow. Our problem is thus solved — we now know how electrical current is conducted in metals, and why it isn't in insulators. Or do we? This theory was widely accepted for some time, and in fact it's still accepted as being broadly true, but there are just one or two things it doesn't explain. Semiconductors, for instance? And why should metals hold their electrons less tightly than non-metals? Our theory is obviously incomplete . . .

## The New Approach

It was the physicists (naturally . . .) to the rescue. So we must once again return to the atom . . .

In the first decades of this century, a startling new branch of physics — Quantum Mechanics — made its debut. This was the work of several men, including Einstein, Heisenberg and Schrodinger. One of the first results Quantum Mechanics produced was embodied in a conclusion that Niels Bohr published in 1913. This was that, contrary to what had previously been assumed, the electrons within an atom could not have just any energy level, but could only exist at certain set energy levels. (See Fig. 3a.) This was a radical departure from what had been believed up until then, but it has been proved and is now unquestioned by physicists.

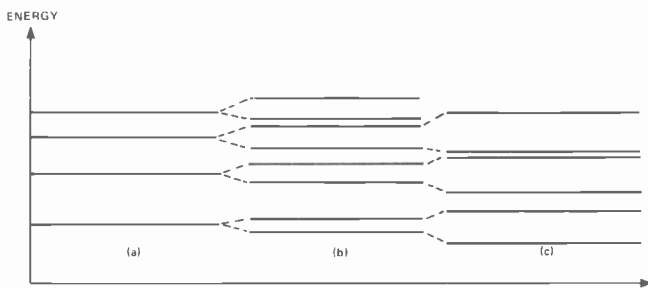


Fig.3a. The electrons within atoms can exist only at set levels. b) When two atoms interact with each other, their energy levels are split. c) In a solid, millions of atoms all interact with each other, and the energy levels are split into so many 'sub-levels' that they behave like continuous bands.

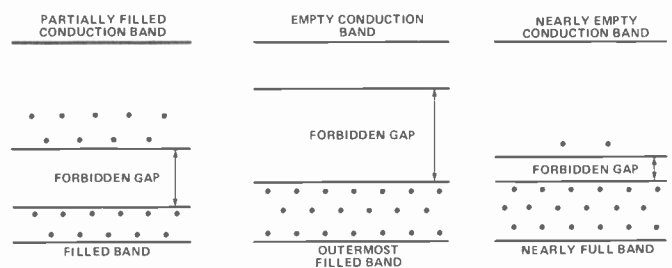
So electrons in atoms can only exist at certain set energy levels. But if you get more than one atom together, the situation changes again — energy levels are split. If, for example, you put two atoms close together, and then look at what has happened to a particular energy level in each atom, you will find that, in one atom, it has shifted up fractionally, in the other atom, it has shifted down slightly. The two atoms act as though the single energy level has been split into two (See Fig. 3b), one very slightly higher than the other. In a solid, where there are millions of atoms all together, the energy levels are split into so many 'sub-levels', all very close in energy, that they act like continuous bands. (Fig. 3c.) In a solid, instead of

there being several separate energy levels at which the electrons can exist there are, instead, several energy 'bands', within which electrons can have a whole range of energy levels. Between these bands however — and this is the important bit — there are still 'forbidden gaps'; energy ranges in which electrons cannot exist because there are no allowable energy levels present. So how does all this help us to understand electrical conduction? Patience . . . We're just coming to that . . .

## Electron Distribution

The way a material behaves electrically, whether it acts as a conductor or an insulator or whatever, depends on the arrangements of its energy bands, and the way that the electrons are distributed within them. The energy bands of a) a conductor, b) an insulator and c) a semiconductor are shown in Fig. 4. Firstly we will deal with the conductor. The energy bands shown in Fig. 4a are fairly typical of a material like copper. As in any material, the lower energy bands tend to fill up with electrons more easily than the higher energy bands, and consequently, they contain all the electrons that they can possibly hold. There is then a 'forbidden gap' of energies, and above this is another band — known as the conduction band. This band, unlike those below it, is not full, but is capable of holding more electrons than it in fact does. An electron in this band is relatively loosely held by this atom and so it requires only a very small amount of energy, which can be obtained from an applied potential difference to raise it to a higher energy *but still within the conduction band*.

It can now drift along within the metal under the influence of the potential difference. Thus, in a metal, which has either a partially-filled conduction band (eg. copper) or an empty conduction band which overlaps a full energy band, (as in magnesium) it is possible for current to flow quite easily. So far, so good. What about insulators? The energy-band theory can also explain the behaviour of non-conducting materials (Fig. 4b). In such substances, there are still full energy bands at the lower energy levels, but the conduction band is empty. In other words in insulators, electrons do not normally exist with enough energy to be in the conduction band. And it is only in this conduction band that electrons are free enough to take part in a flow of electrical current. If it were possible to get the electrons out of the lower energy bands into the conduction band then these materials could conduct electricity, but in order for that to happen electrons would have to cross the forbidden gap, and the energy required to make them do this is much more than can be supplied by a normal potential difference. In terms of eV (the eV, or 'electron-volt', is a measure of energy which atomic physicists find it convenient to work with, 1 eV being the energy picked up by an electron in passing through a potential difference of 1 volt), the forbidden gap in insulators is normally about 5 eV, hence, under normal circumstances, insulators do not carry electricity.





## What About Semiconductors?

Semiconductors are really an 'in-between' case. Like insulators, very pure semiconductors such as silicon or germanium have empty conduction bands when the temperature is 'absolute zero' (about minus 273°C), separated from the other energy bands by a forbidden gap. At normal temperatures the conduction bands are not completely empty. Why? Because in semiconductors the forbidden gap is much smaller than in insulators — about 1 eV. It is so much smaller, in fact, that at normal temperatures, the vibration of the atoms in the semiconductor is sufficient to give enough energy to a few electrons to reach the conduction band. Eventually they fall back to the lower energy bands — but more electrons are entering the conduction band all the time, so eventually a balance is struck, with the number of electrons entering the conduction band in any period of time being equal to the number falling back. At normal temperatures, therefore, there are always just a few electrons in the conduction band of a semiconductor, and so it is able to conduct electricity. Though it conducts less well than a metal, since there are far fewer electrons in the conduction band.

## But That's Not All . . . .

There is, however, another means by which a semiconductor can carry electricity. Every time an electron leaves a lower energy band for the conduction band, it leaves an electrically neutral space where there was previously some negative charge. These neutral spaces, surrounded by negatively-charged electrons, can behave almost like a positively charged particle, and when a potential difference is applied, this 'hole' as it is called travels in the opposite direction to that of the electrons. To understand how this happens, imagine a row of chairs, with someone sitting in each of them except the one at the end. (Fig.5) If the first person in the row moves into the empty chair, the next person moves into the chair left empty by the first person, and so on, the 'space' where no one was sitting appears to move in the opposite direction to the people, and that's exactly how it works with 'holes' in semiconductors. While it appears that the hole is moving in one direction, carrying positive charge, what is really happening is that the electrons in the lower energy bands are travelling in the other direction, carrying negative charge, and are moving into the spaces left by electrons which have gone into the conduction band.

## Conclusion

Therefore, in a semiconductor, there are two types of charge carriers involved in the conduction of electricity; electrons and 'holes'. Various experiments indicate that in germanium, for example, about one third of all the current is carried by the 'holes'!

Fig. 4. Comparison of the forbidden gap position and magnitude in the three basic types of material. Far left: a conducting substance. The lower energy bands are full of electrons and the forbidden gap is easily bridged by sufficiently energetic electrons which then enter the conduction band. Center: insulators. Note the empty conduction band and the wide forbidden gap in which there are no permissible energy levels. On the right: semiconductor materials in which the energy gap is around 1 eV and at room temperature sufficient energy is imparted by heat action to allow some electrons to cross the gap into the conduction band.

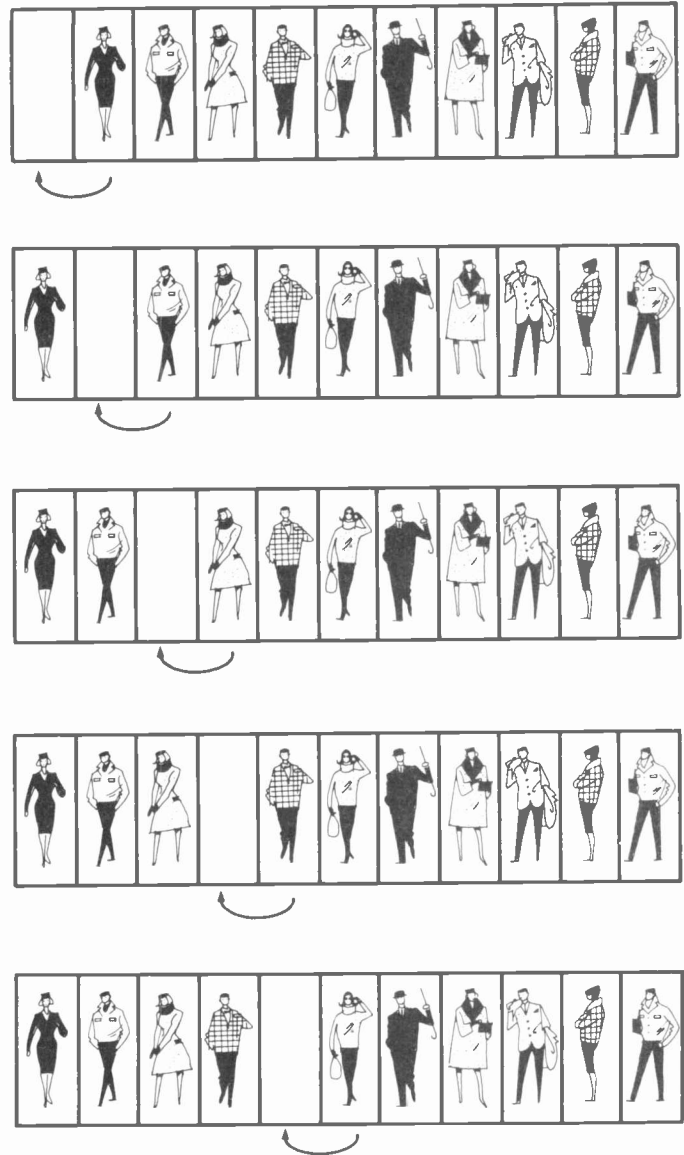
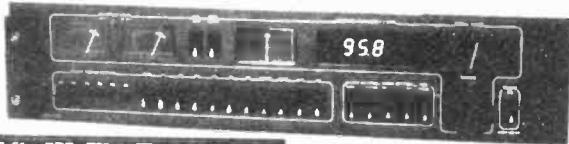


Fig.5. As each person moves into the space next to them, it appears that the gap moves in the other direction. In the conduction band this is an electrically neutral space where there was previously a negative charge. These 'holes' can behave almost like a positively charged particle when a potential difference is applied this 'hole' moves in the opposite direction to the electrons.

You will remember that, in semiconductors, electrons reach the conduction band because of the vibration of the atoms. This fact is quite important. At higher temperatures the atoms vibrate more, and so more electrons (and 'holes') are available for conduction purposes. To the extent that above about 100°C for germanium, and 150°C for silicon, the conduction is no longer really under control, and so devices like transistors, which use semiconductors, have to be kept below these temperatures, if they are to remain reliable during operation. The fact that silicon is useful as a semiconductor at higher temperatures than germanium, was the major reason for the increased use of silicon rather than germanium devices!

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A matching synthesiser unit will be made available later this year, and can be retrofitted to either version. All versions include digital frequency readout/clock, VU deviation meters, 6 preset stations, 10 turn pot manual tuning, toroidal PSU, output level adjustment, 110/240v AC input. Full alignment service available.

### Power Amplifier

Style and performance - with a real 'belt and braces' PSU design.

After a couple of preview comments, it seems that many of you are waiting to hear about the matching HMOSFET power amplifier for the Mk III tuner. Well, it's out at last - complete with twin toroidal PSUs for comfortable 80W RMS per channel, over 100W peak, but limited by thermal shutdown of the HMOS. 10W - 100W log LED output peak indicator, DC offset protection and switch-on pause relay. AC or DC input coupling, direct or relay protected output terminals. The works. Only one version of this item: Complete kit .....£178.25 inc. Carr. £5.

### Preamplifier

More features and facilities, thanks to DC switching and control design

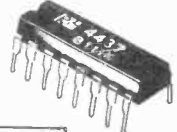
Previewing the most comprehensive audio preamplifier yet..... DC switching of 7 inputs, plus two tape in/outs. 2 low pass, 2 high pass active filters, genuine volume related loudness, 1dB channel matching, with DC volume, balance, bass and treble controls. Suitable for bus/remoted control, tape dubbing, switched monitor etc. 80dB S/N+, THD -75dB or better. Pluggable PU equalization boards, tone control override. Price for complete unit about £149 ex VAT.

## Semiconductors

### Radio/Communications ICs

FOR COMPLETE LISTINGS - SEE OUR NEW PRICELIST

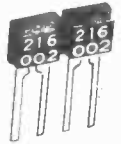
CA3089E	2.11	HA1197	1.61	SD6000	4.31
CA3189E	2.53	CA3123E	1.61	TDA4420	2.59
HA1137W	1.95	TDA1072	3.09	MC1330P	1.38
HA11225	2.47	TBA651	2.53	MC1350P	1.38
HA12412	2.81	TDA1090	3.51	KB4412	2.24
KB4420	1.95	TDA1220	1.61	KB4413	2.24
TBA120S	1.15	TDA1083	2.24	KB4417	2.53
KB4406	0.80	TDA1062	2.24	MC3357P	3.16



### VARICAP DIODES.....

A section from our PL:

BA102	0.35	16:1 ratio AM tuning	
BB204	0.41	KV1215 9v triple	2.93
BB105	0.41	KV1211 9v dual	2.01
BB109	0.31	KV1225 25v triple	3.16
MVAM2	1.93	BB212 9v dual	2.25



### POWER MOSFETS

100W PA's made simple

Since pioneering the 100W complementary MOSFET technique - Hitachi have developed a range of output devices and drivers that ought to revolutionise opinions and attitudes towards the design of all LF amplification systems. We have a new 48 page application note (£1.50 inc) and complete sets of parts, modules and now the new complete PA system (see above).

2SK133 120v N-ch 100W MOSFET £6.33 2SJ48 Pch complement £6.33  
 2SK135 160v N-ch 100W MOSFET £7.29 2SJ50 Pch complement £7.39  
 PA101B Kit for 100W MOSFET PA less Heatsink £16.10. (£23 inc heatsink/bkt)

### ULTRA LOW NOISE PU PREAMPLIFIER

The HA12017 is the last word in PU preamps, and general low noise audio design. It is an SIL IC, with 86dB S/N in RIAA configuration, 10v RMS output capability, 0.002% typ THD at 10v RMS output (imagine the overload margin !!). It comfortably supercedes discrete circuit designs in terms of price/performance, and takes the art beyond the TDA1042's capabilities. (Replaces HA1457) £1.80 each - or an RIAA applications PCB with two ICs for £5.75. Complete with Rs&Cs £9.95.

### Radio Control ICs

We have various RC ICs, including NE544 NE5044, and two new ones from OKI!

KB4445 4 channel dig.prop. FM TX IC. 30mW out (amplifiable) £2.30 inc  
 KB4446 4/5 ch. dig. prop FM RX IC. Suits KB4445 or RCME syst. £2.65.  
 KB4445/6 pair: £4.75. New 8 page data sheet 35p + SAE. More RC ICs in list

### CMOS, LPSNTTL, TTL, MPU: Listings in the new pricelist.

Most CMOS is available in low volume - also LPSN. Standard linears and TTL OK.

Things like ICM7216B, ICL8038, 8080A, 6800P, 2708, NE555, NE556, etc

Coming Soon..... Contain yourselves, RF fans! Not yet ready for a full launch until autumn, but previewed here:

### SSB transceiver system : 10kHz to 1000MHz !!

A modular VLF to UHF SSB TX/RX system at last. With the correct first mixer, the basic PCB covers 10kHz to 1000MHz using LO fed from ext. source (Our 2 IC Mullard synth for instance) and RF PA for TX OP. 0.2uV basic sensitivity in HF. Typ cost for HF synth SSB RX will be less than £200. Add an RF PA for full TRX for another £50. See one in our foyer, and marvel.

CATALOGUES 60p ea., all three for £1.60  
 PRICES SHOWN HERE INCLUDE VAT  
 POST/PACKAGE CHARGE NOW 35p

Please send an SAE with all enquiries. Phone orders by ACCESS but minimum £5. Callers welcome

**ambit**  
INTERNATIONAL

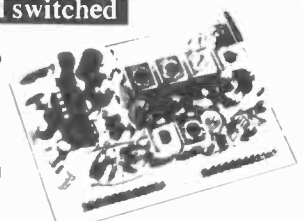
200 North Service Road, Brentwood, Essex

TELEPHONE (STD 0277) 230909 TELEX 995194 AMBIT G POSTCODE CM14 4SG

## Radio/Audio/Communications Modules

### LW-MW-SW-SW DC tuned and switched

91072- All switching of bands by a single pin to gnd. Varicap tuned, with LO output for synth. MW/LW version or MW/LW plus 1 or 2 SW bands  
 MW/LW: £15.58 +1SW £16.73



### VHF Tunerheads

Europe's largest stock range for broadcast and communications. Probably also the world's - details in the catalogues and PL. Specials are also supplied in the region 30-220MHz.

### Pilot Cancel PLL Stereo decoders

944378.2 £26.45

Again, Europe's widest range of stereo decoders including pilot cancel PLL types. The pic shows the 944378 - pilot cancel including post decoder 26/38kHz filtering and muting preamp output



### Switched bandwidth FM IF strips

Broadcast FM IF strips for all occasions, including the new 911225 - with diode switched narrow filter option, ultra linear phase ceramic filters, 84dB S/N, and 0.04% THD (40kHz deviation). Plus usual things like AGC, AFC, dev. mute, level meter drive. £23.95 (supplied in screen can with 0.1 edge connection system) Also the 7230 hyperfi series - as the 911225, but with slope controlled AFC that operates in conjunction with signal level - and an extra IF amp stage for DXing.

### Various digital frequency displays

The World's largest range of receiver DFM's is now joined by the DFM7 (shown) - and L shaped version of the DFM3 with remote display mount connector possibility. 1kHz SW resolution with 455kHz or 10.7MHz offsets, 100Hz res up to 3.9999MHz, and VHF to 299.99 MHz in 10kHz steps : £41.75



## Components

### Crystal Filters

Most popular types are available - ex-stock, and in quantity.

10.7MHz	25kHz Channel spacing 8pole	£16.67
	12½kHz	£17.82
	2.4kHz SSB	£19.78
	Monolithic dual roofing filter	£2.30
34.5MHz	1.3dB loss, 80dB stopband HF first filter in synth. RX	£36.80
RC XTALS	FM pairs (no splits)	£3.74
	AM pairs	£3.57
USB/LSB	Xtals for 10.7SSB filter	£2.88 ea



### Piezo Sounders

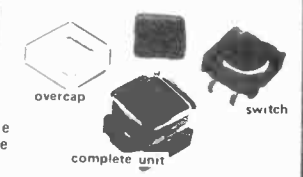
The most efficient warning sounders yet

The latest thing in electro-acoustic efficiency. 1mA of drive from CMOS will give an SPL of 83dB - 10v RMS drive from CMOS uses 3mA for 100dB SPL at 4.8kHz (88dB at 1.65kHz). The data sheets shows various drive circuits, and give full specifications with regard to broadband responses and power consumption etc. 1 off 44p inc. 100 off 28.75p (25p ex vat)



### Keyboard switches and caps

From the world's most widely used switch manufacturers - ALPS - come the biggest and best range of keyswitches, and data entry keyboard switches. The SCM81101 is shown here, with the KT5 2-part cap (with clear top, to enable easy fitting of your chosen legend. Other types are available with built in LED, 90° mounting etc. SCM81101: 17p, KT5: 16p - or 29p/pair



### LCD CLOCKS

Clocks use 1.5v at 15uA only.

### LCD DVM

DVM 9v/1mA

CM161: 7mm LCD 12/24hr, alarms etc £11.44 each  
 CM172: 13mm, 12hr, alarms, timer etc £14.32 each  
 CM174: 13mm, 12hr, min/sec stopwatch £14.32 ea  
 DVM 176: ICM7106 based LCD 3½digit £22.36 each



## WHAT'S NEW at AMBIT

NEW PRICELIST/SHORTFORM:- 28 pages, FOC with A5 SAE pse

Bigger print than our recent one page list - and vastly extended

If you still need convincing to invest £1.60 in the cats, be mean and get this first.

### POWER MOSFET APPLICATIONS HANDBOOK by HITACHI

£1.50 each - or free with pairs of HMOS and the PA101B

Everything you should know about HMOSFET devices theory and applications.

CWD PLEASE Commercial MA terms on application Goods are offered subject to availability prices subject to change - so please phone and check if in doubt

Parts 1-3 AMBIT catalogues 60p ea, or £1.60 the lot.

# 'TUSCAN' FROM TRANSAM



## Take a step up to your next Computer!

### THE CONCEPT

How many ways are there to build an S100 system? Not many, and all expensive. TUSCAN changes all that.

Five S100 boards on one single board — just for starters. Plus five extra slots for future expansion.

What a combination! Z80 and S100 with the TRANSAM total package of system and applications software.

How do we do it? Our prices start at £195 and you can build up in easy stages to a fully CP/M compatible disc based system. Something to think about!

### THE HARDWARE

The first Z80 single board computer with integral S100 expansion. British designed to the new IEEE (8 BIT) S100 specification, the TUSCAN offers total system flexibility. A flexibility available now.

The board holds the equivalent of a Z80 cpu card, 8k ram, 8k rom video and I/O cards with 5 spare S100 expansion slots and offers a price/performance ratio which is hard to beat.

Just compare our price with a commercial S100 ten slot motherboard with this specification.

### THE SOFTWARE

TUSCAN offers the user the choice of system monitor, editor, resident 8k basic, resident Pascal compiler or full CP/M disk operating system. All options are upwards

compatible and fully supported with applications software. Both 5¼" and 8" drives are supported in double density.

### THE PACKAGE

TUSCAN is available in kit form or assembled. With several hardware and software options to suit your requirements and budget. Attractive desk top case also available holds 2 x 5¼" Drives.

# TRANSAM

## NOBODY DOES IT BETTER!

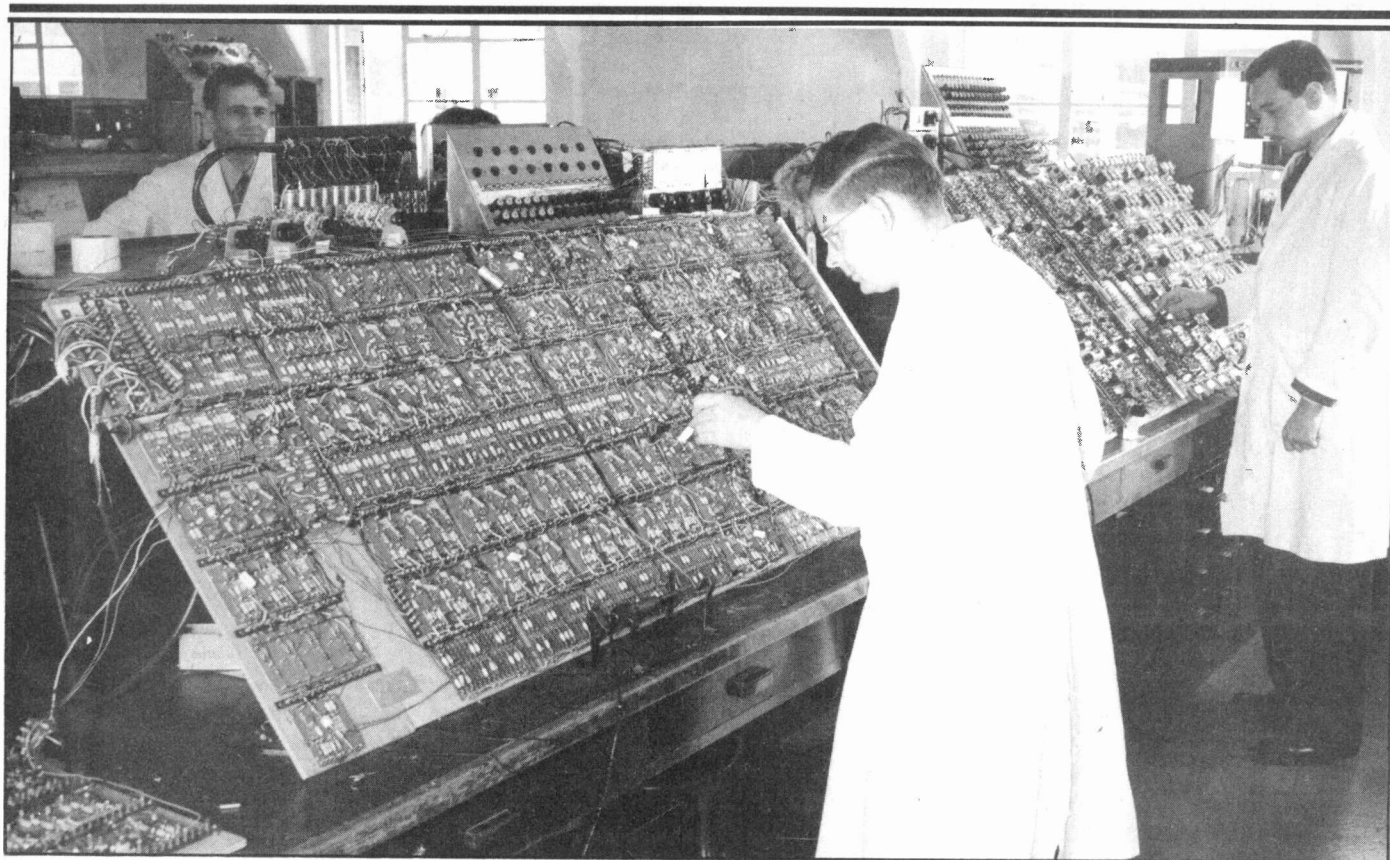
Send to Transam Components Ltd., 59/61 Theobalds Road, London WC1

I am interested in the TUSCAN Z80 based single board computer with S100 expansion and enclose a S.A.E. for further details.

Name \_\_\_\_\_

Address \_\_\_\_\_

Telephone \_\_\_\_\_



# MICROBASICS

Since the demise of Microfile, we felt it was time to initiate another on-going publishing situation computingwise. Henry Budgett kicks off the first instalment of this great new hardware series with a potted history of the technology

**A**lmost without fail we read in some publication or other that the age of computers is upon us. Whilst this statement is unquestionably true it is well worth looking back at the developments that have resulted in this proliferation of computers and computer-based systems. There is a popular temptation to attempt to baffle readers with science and technical terms in articles like this and this has led to an almost 'cult' image being foisted upon the industry, whereas, in reality, we should be trying to do exactly the opposite. It is to this end that I will attempt to define and explain each piece of terminology as it is reached. It is also the reason that I have chosen to begin the series at the beginning rather than to look at just the current darling of the media, the microprocessor.

## Three Wise Men

In taking a look over our shoulders at the names associated with the very early computers we find that three stand out as veritable beacons. Taking them in chronological order, for no better reason than simplicity, we first meet Blaise Pascal. Born in the seventeenth century in France he made a considerable impact on the field of mathematics at that time. His father was a tax collector and the sight of him spending many hours adding figures stimulated Blaise to produce a

mechanical engine that would remove the drudgery. The basic design worked, no mean feat in itself, and enjoyed a limited commercial success. Its main drawbacks were that it could only add or subtract (and only one of those at a time). The Pascaline, as it was called, is still in use today recording the mileage travelled in your car and its improved successor which was capable of multiplication survived until the first electronic calculator sent it to the scrap heap. If you are fortunate enough to have one lying in a corner it is worth the trouble to take its lid off and reveal the guts. Remember as you look that this was invented when the Industrial Revolution was still in the future and there were no facilities for making accurate mechanical parts, a problem that was to cause our next innovator to fail.

## Inventor With A Difference

Charles Babbage began in a similar manner to Pascal. He was also a child prodigy in the field of mathematics and soon began to find fault with the tables of logarithms being published. It was to the end of producing a machine for calculating these tables that Babbage began his life's work. It was fortunate that he was a wealthy man because despite a Government grant of some £17,000 and eleven years work he finally

abandoned his Difference Engine. Despite this failure his thoughts on automated mathematical machines were still active and he conceived the Analytical Engine that was to eventually ruin him. This idea was to incorporate all the essentials of the Difference Engine but with the magic ingredient of being programmable. The original specification of the machine was that it could perform mathematical operations to order on data provided.

At this instant the concept of computers as we know them today was born. The 'Engine' even incorporated most of the elements found in modern electronic machines. However the theory was not matched by the practice. The inability to make precision parts once again spelled doom and Babbage died aged 80 with not much left to his name except a pile of cogs and wheels. His son did manage to put together a working model, which can today be seen in the Science Museum, London.

## Herman The Wise

Less than twenty years later our third individual, Herman Hollerith, forged the final link in the chain of events with his Tabulator. Designed as an entry in a competition to find a system that could analyse the results of the 1890 American census it harnessed the newly developed power source, electricity. Hollerith's machine completed the census in record time and made its inventor a very rich man. Indeed, the company he founded, IBM, is probably the largest mainframe computer producer in the world.

This combination of electricity and advanced mechanics was by no means an ideal solution. In the case of the 'Tabulator', it was designed for one specific job and could not be easily changed. This was not the programmable tool conceived by Babbage. It is interesting to note that, just as Babbage had looked toward the punched cards used by weavers to control their looms, so Hollerith used similar cards to record the census information on. These cards are still in use today in many computer rooms (some things never change!).

## The Electronic Age

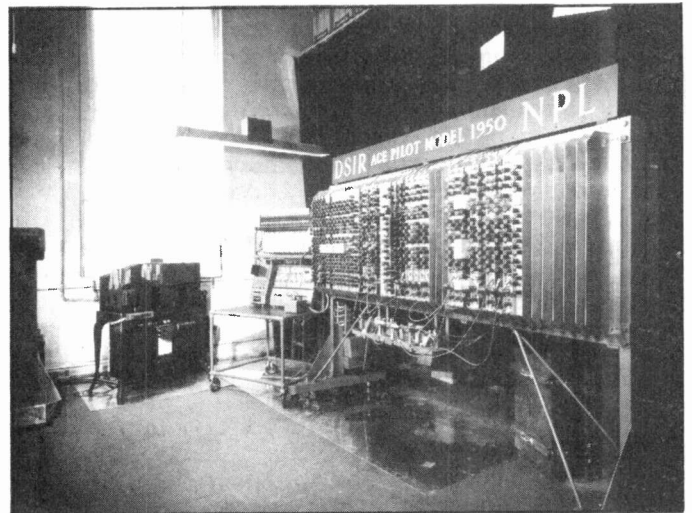
Just as the application of electrical energy brought Hollerith's 'Tabulator' the success it did, so it spurred on the development of the wide variety of electronic circuits based around the thermionic valve. By the time of the second World War there were many potential challengers for the title of the first computer but they all shared one common characteristic. The development of electronic switching had resulted in the universal adoption of the binary number system. The reason is simple, you can easily turn something on or off and hence create a binary code, but it is obviously much harder to turn something off or on in nine discrete steps. If Pascal or Babbage had designed their systems around binary mathematics instead of the conventional decimal they would have simplified their problems ninefold and the world may even have been introduced to the steam powered computer. Having taken the step to binary, computers never looked back and giants such as Collosus, ENIAC and ACE were born. Each of these was the descendent of the 'Analytical Engine' in that it could be programmed to do any logical task, within reason, and consisted of a number of basic elements, as in today's computers.

In much the same way as the transition from mechanical to electrical occurred, these early computers were replaced by pure electronic devices based on the newly invented transistor. The thermionic valve was an unreliable object, slow in operation and costly in terms of power consumption and space. Indeed, the processing capabilities of most of today's microprocessors greatly exceed the facilities offered even thir-

ty years ago. The advent of the transistor produced the 'second generation' of computers. A 'generation' in computer terms is generally defined as a tenfold decrease in size with a tenfold increase in processing throughput at a tenth of the original cost. As the transistor became the descendent of the valve, so the chip or integrated circuit became the descendent of the transistor. In those days, some ten to twelve years ago, the first integrated devices consisted of perhaps a half dozen transistors on a single chip of silicon. Rapid advances were made and soon a new kind of computer was born.

## The Minis

Just as the Mini car revolutionised the way the world looked at motoring so the minicomputer changed the face of computers. Up till the advent of the integrated circuit there had been only 'computers', now there were 'mainframes' and 'minis'. These two were rigidly divided into sectors of operation, the mainframes were used for serious purposes, the minis were 'toys' used in research. Among the names of companies who were to make their fortunes producing minis was DEC, probably still the world leader. Soon the mini was to be found everywhere from research labs to classrooms and their spread was due simply to the fact that they were small, cheap and relatively easy to use. They were even built into pieces of equipment like machine tools. Indeed it is fair to say that the mini paved the way for the micro, although the actual distinctions between them have been rapidly eroded.



The pilot model of the National Physical Laboratory's ACE, one of the first computer giants (Crown copyright).

Firms involved in the business of integrated circuit production tend to follow a natural progression in the devices that they make. First off the production line come the standard logic elements, the AND OR type gates, and once the production of these is running at a profitable level they attempt to squeeze a little more onto the slab of silicon. As soon as this stage is proved they take another leap forward and so on. In the terminology this is a progression from SSI (Small Scale Integration) with about 10-20 actual devices on the 'chip' through MSI (Medium Scale Integration) which has a dozen or so gates (rather than discrete elements) up to LSI (Large Scale Integration) which is taken as being greater than 100 gates on the chip. At this stage of the game we are still talking about complex TTL type packages, the next jump is to VLSI which, believe it or not, stands for Very Large Scale Integration. We are now in the realm of memory devices and microprocessors.



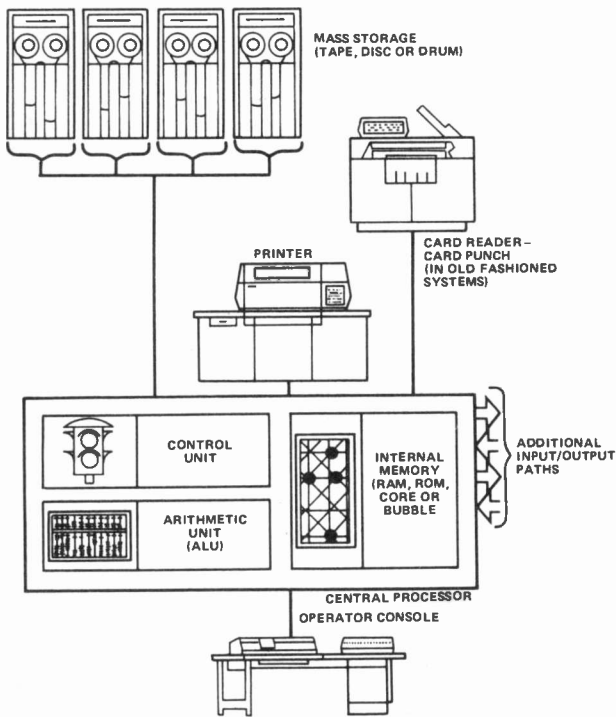


Fig.1. Block diagram of a computer system.

## Common Concept

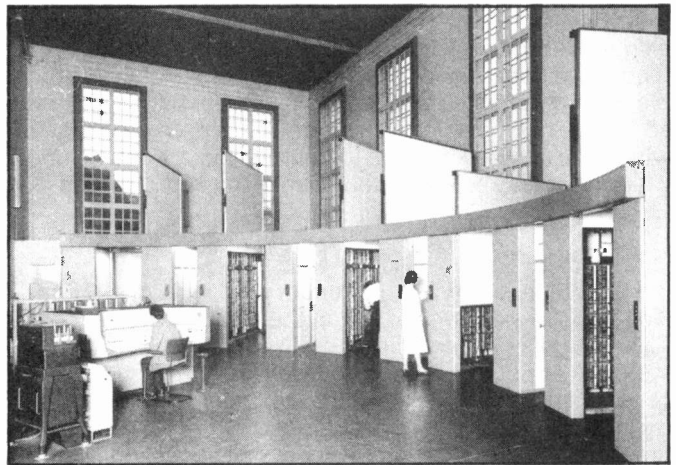
If we take a look at Fig.1 we can see a generalised block diagram of a computer. What kind of computer is not important; they all have the same functional blocks within them, be they micro or mainframe. The common misconception is that the "mighty chip" is a computer, far from it. Your average microprocessor still needs all the memory circuits, control circuits, mass storage devices and other components that even the old valve machines needed; they are merely smaller. The very first microprocessor came about in 1971 simply because it was realised that it would be possible to make a device of that complexity on a single chip. The device was called the 4004 and the company that made it was Intel. More on the micro next month — first some explanation on the basic building blocks of computers.

## Eye Oh

The five fundamental elements of any digital computer are:- the ALU or Arithmetic Logic Unit, the control unit, the store or memory and the input and output devices. Taking these in the reverse order we have the input and output devices, often abbreviated to the I/O. Obviously the machine must be able to communicate with the outside world and vice versa, so the most common form of I/O is the Visual Display Unit or VDU. This has, to a very large degree, replaced the old-fashioned Teletype, a special electric typewriter often called a TTY, and is totally silent in operation, which is a welcome change from the racket the earlier device made. Other forms of I/O device are printers, for producing typed copy, plotters for producing graphical output or in the most esoteric cases digitisers and speech synthesisers.

The function of the I/O was simply to enable the user of the computer to load information for processing into the computer and to be able to get the answers back. Quite apart from this information there is the requirement of the computer programmer who wishes to put in information that will instruct the computer to perform certain operations. This, the program, is stored in the memory and of this vital component

there are two types; general purpose memory and off-line or backing memory. The general purpose memory is made up of a large number of bistable elements manufactured in either magnetic or semiconductor materials. In the context of the micro we often refer to these as the user memory. The backing memory is generally of a mass storage type like magnetic tape in one of several forms or magnetic discs or drums. Whilst the computer may have immediate access to some few thousand



The business end of NPL's ACE computer, used to develop sophisticated mathematical techniques.

storage elements in the user memory, it can often store a few million elements in the backing stores. We will discuss the various types of memory in much greater detail at a later date — only the concept is important at this stage.

The control unit performs the task of making sure that all the various bits of the computer are working in the correct order. It would not be a very efficient machine that had to pause for information because it gave priority to looking after a printer and left the user waiting. The basis of all the control signals is a clock, in fact a very accurate oscillator circuit running at several million cycles per second. This is the heart of the machine and almost without exception all the functions within the computer are locked or synchronised to it.

The one remaining piece of the jigsaw is the ALU. This exists solely to perform arithmetic operations on the elements that are fed to it. Some of these elements are recognised as being instructions, others are simply information which is to be processed according to the previously received instructions. All this takes place at the level of binary signals, that is, each separate piece of information is represented by a pattern of logical ones or logical zeros and this is commonly called 'machine code'. Indeed, at this level of operation the computer is only aware of two groups of patterns — those which correspond to the defined set inside the machine, its "instruction set" in computer parlance, and those patterns which do not match this set which must be data.

## To Pastures New

That's the end of this month's offering. In the next part our concentration will lock on to the microprocessor itself and just what goes on inside that little lump of silicon. Those with a wish to pursue the hardware angle in books, might be interested in the following recommended texts on the subject: Introduction To Digital Computer Design by Woollons, published by McGraw Hill. Consumers Guide to Personal Computing and Microprocessors by Frieberg & Chew, published by Hayden.

ETI

# computing today

What to look for in the October issue  
on sale September 12th.

## FOX AND HOUNDS

CT goes rural again, and not down the pub either. Amid scenes of pink clad men thundering across open country, the sounds of baying hounds, demure ladies in full chase and healthy fresh air we find a curious creature called the fox. No bloodshed here, this must be the only foxhunt where the fox can actually beat his pursuers at their own game. Turn on all your cunning and see how long you last against the hunters.

Once again our reviewers have brought home an exclusive. This time it's an all British machine featuring the first implementation of the new 10K BASIC from Microsoft. How does the machine rate in terms of value against the established favourites like Apples and NASCOMs? Read our exposé in the October issue and make your choice.

## MIGHTY MICRON

## BUSINESS BRAINS

The trend in small business machines these days is to pack all the necessary works into a neat desk-top unit. Are these really computers or just super-intelligent VDUs? Our reviewer grasps the Superbrain, a prime example of the breed, by the horns and attempts to wrestle the facts from within its cool grey exterior.

In the third part of our mammoth survey of computers and equipment we turn our attention to VDUs. Once again we present the facts and figures in clear and concise form to allow you to make the best decision. Don't miss it, it's the only one there is.

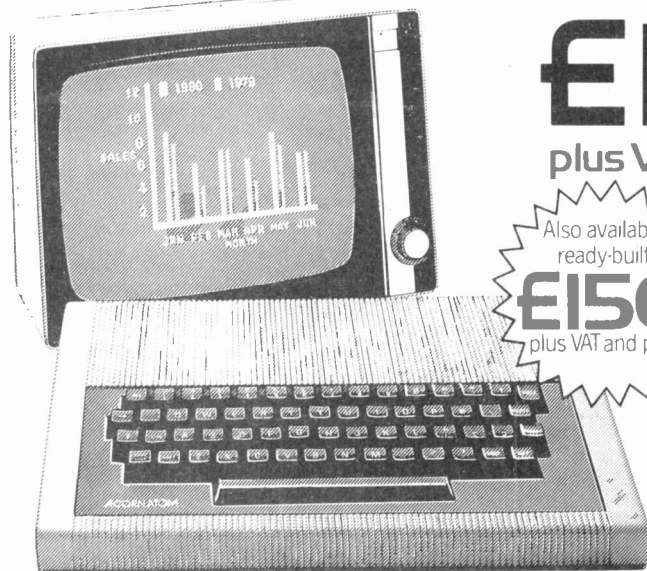
## BUYERS GUIDE

## SPACEWAR

Not just another version of St\*r \*re\* but a real wargame simulation with tactical and strategic positioning. James T might find this a harder match than those Klingons he seems to have so much trouble with.

Unique in concept - the home computer that grows as you do!

# New! - The Acorn Atom



**£120** An outstanding personal computer kit  
plus VAT and p&p.

Also available ready-built  
**£150**  
plus VAT and p&p

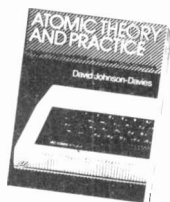
The ATOM - a definitive personal computer. Simple-to-build, simple-to-operate. But a really powerful full-facility computer. And designed on an expandable basis. You can buy a superb expanded package now - tailored to your needs. Or, you can buy just the standard Atom kit, and, as you grow in confidence and knowledge, add more chips. No need to replace your equipment. No need to worry that your investment will be overtaken by new technology. As you need more power, more facilities, you can add them!

\*The picture shown demonstrate mixed graphics and character in three shades of grey provided by the Standard Atom

**The standard ATOM kit includes:**

- Full sized QWERTY keyboard ● Rugged polystyrene case
  - Fibreglass PCB ● 2K RAM ● 8K ROM ● 23 integrated circuits
  - Full assembly instructions including tests for fault-finding.
- (Once built, connect it to any domestic TV and power source)

● Power requirement: 8V at 800 M A. ATOM power unit available. See coupon. PLUS FREE MANUAL written in two sections - teach yourself BASIC and machine code for those with no knowledge of computers, and a reference section giving a complete description of the ATOM's facilities. All sections are fully illustrated with example programs.



**The ATOM concept**

Adding chips into sockets on the PCB allows you to progress in affordable steps to large-scale expansion. You can see from the specifications that the RAM can be increased to 12K allowing high resolution (256 x 192) graphics. Two further ROM chips, e.g. maths functions, can be added directly to the board giving a 16K capacity. In addition to 5 I/O lines partly used by the cassette interface, an optional VIA device can provide varied I/O and timer functions and via a buffer device allow direct printer drive. An optional module provides red, green and blue signals for colour. An in-board connector strip takes the ATOM communications loop interface. Any number of ATOMs may be linked to each other - or to a master system with mass storage/

hard copy facility. Interface with other ACORN cards is simplicity itself. Any one ACORN card may be fitted internally. So you can see there are a vast number of modular options and additions available, expanding with your ability and your budget.

**The ATOM hardware includes:**

- Memory from 2K to 12K RAM on board (up to 35K in case)
- 8K to 16K ROM (two 4K additions) ● 6502 processor ● Video Display allows high resolution (256 x 192) graphics and red, green and blue output ● Cassette Interface - CUTS 300 baud
- Loudspeaker allows tone generation of any frequency
- Channel 36 UHF Modulator Output ● Bus output includes internal connections for Acorn Eurocard.

**The ATOM software includes:**

- 32-bit arithmetic (±2,000,000,000) ● High speed execution
- 43 standard/extended BASIC commands ● Variable length strings (up to 256 characters) ● String manipulation functions
- 27 32-bit integer variables ● 27 additional arrays ● random number function ● PUT and GET byte ● WAIT command for timing ● DO-UNTIL construction ● Logical operators (AND, OR, EX-OR) ● LINK to machine-code routines ● PLOT DRAW and MOVE



4a Market Hill, CAMBRIDGE CB2 3NJ

Your ACORN ATOM may qualify as a business expense. To order complete the coupon below and post to Acorn Computer for delivery within 28 days. Return as received within 14 days for full money refund if not completely satisfied. **All components are guaranteed with full service/repair facility available.**

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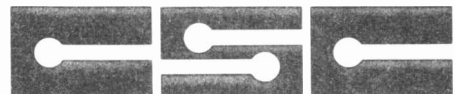


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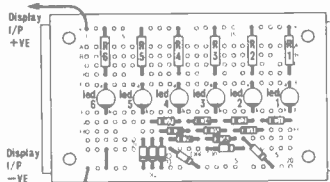
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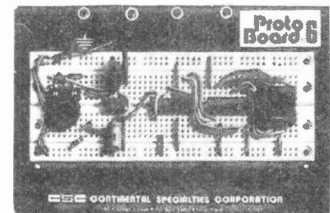
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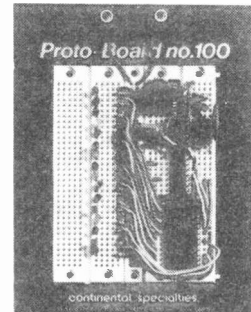
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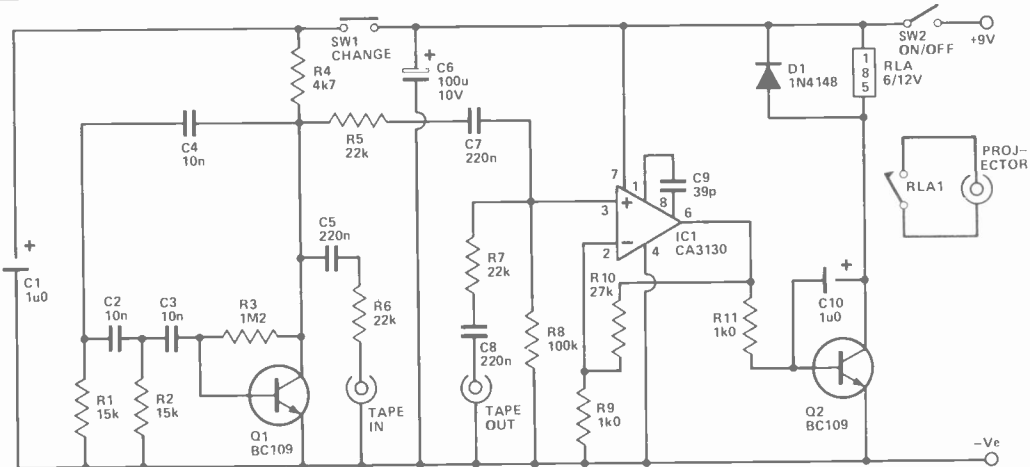
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# SPOT DESIGNS



## Slide/Tape Synchroniser

With the aid of a tape recorder and a slide tape synchroniser it is possible to obtain programmed slide changing with an automatic projector. By using a synchroniser and a stereo tape deck or recorder it is possible to have music and a commentary recorded on one channel and signals to give automatic slide changes at the appropriate points on the other channel.

A slide/tape synchroniser has two sections; a tone generator and an electronic switch. The tone generator is used to record short bursts of tone onto the tape at the points where slide changes are required. The electronic switch is fed with the tone burst output of the tape recorder and closes a pair of relay contacts for the duration of each burst. The relay contacts are, of course, used to control the automatic slide change mechanism of the projector. Usually the output of the tone generator is coupled to the input of the electronic switch, so that operating the tone generator causes the relay contacts to close. This is useful when recording a tape. With the projector loaded with slides, the synchroniser connected to the projector, the output of the tone generator fed to one input of the recorder and the music/commentary signal ready to be fed to the other input, the tape is inserted. Then the music and commentary are recorded and the tone generator is operated at the appropriate times so that the slides are changed and the tone bursts are recorded onto the tape. If the tape is then rewound, the slide magazine is brought back to its starting point and the tone burst output of the tape recorder is fed to the input of the electronic switch, replaying the tape should give the slide show with accompanying sound track and automatic slide changing. The operator only has to start the tape at the beginning of the show and stop it at the end.

A similar technique is used when using the unit as a program-

med slide timer, the only difference being that there is no soundtrack to bother with.

The tone generator uses Q1 in a straightforward phase shift oscillator operating at about 500 Hz, although the exact operating frequency is not of great importance. It is merely necessary to use one at which the recorder is capable of operating reasonably well. The output from the collector of Q1 is coupled to the tape recorder by DC blocking capacitor C5 and resistor R6. The latter attenuates the output. R6 also ensures that the oscillator cannot be so heavily loaded that it ceases functioning. SW1 is a non-locking, push to make switch. It is briefly pressed to connect the supply to the tone generator and produce the tone bursts.

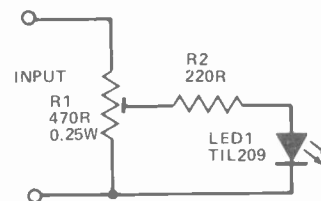
The tone generator is based on operational amplifier IC1, which is used in the non-inverting mode. Its voltage gain is set at about 28 by R9,10 and R8 biases the non-inverting input to the negative supply rail. R5,7 form a simple passive mixer at the input of IC1, so that it can be fed from either the tone generator or from the output of the tape recorder without the need for any changeover switching. The output of IC1 is used to drive common emitter amplifier Q2, which has the relay coil and protective diode D1 as its collector load. Normally IC1's output is low and Q2 is cut off, but in the presence of an input tone the output of IC1 goes strongly positive on positive going half cycles. C10 integrates these pulses so that Q2 is continuously switched on in the presence of an input tone and the relay is energised. The relay contacts then close and operate the slide change mechanism of the projector.

The current consumption of the unit is only about 500  $\mu$ A, but rises to around 40 mA during the brief periods when the relay is activated. The relay can be any type having a 6/12 V coil with a resistance of about 185 $\Omega$  or more, provided it has at least one set of normally open contacts of adequate rating.

## Clipping Monitor

When using an amplifier at virtually its full output power there is a risk of "clipping" occurring. The amplifier is overdriven to the point where output peaks are flattened because the amplifier simply cannot provide a high enough output voltage. The distortion caused by clipping is often quite severe and readily apparent, but this is not always the case. It is not uncommon for the tweeters in loudspeakers to burn out due to overloading caused by clipping producing strong high frequency signals!

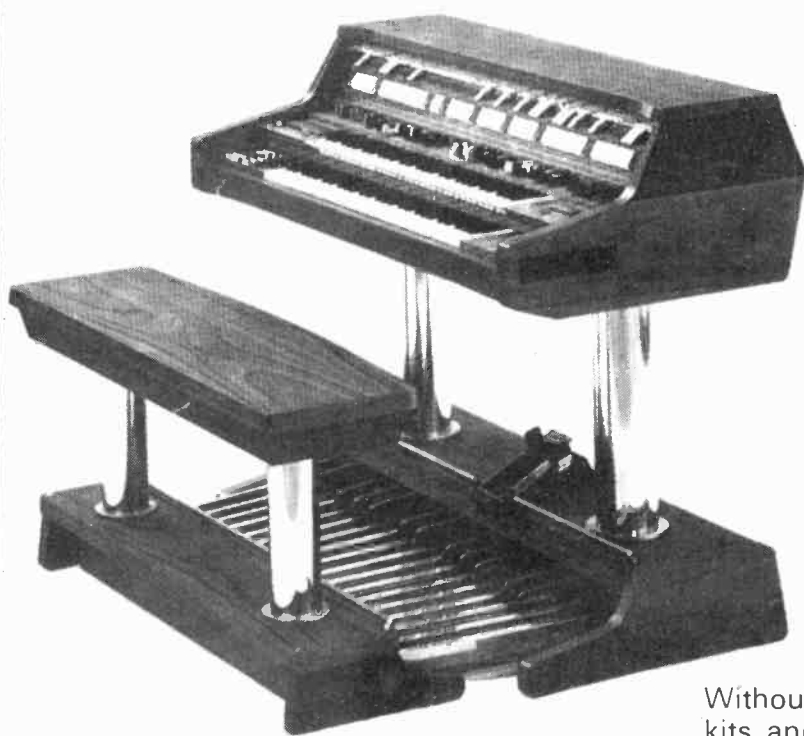
The circuit relies on the fact that with less than about 2 V applied to a LED it will not pass any significant current and will fail to light up. If the voltage applied to the LED is only marginally increased above 2 V, the LED avalanches, a heavy current flows and it glows brightly. R1 is adjusted so that the voltage applied to LED1 via current limiting resistor R2 is just sufficient to cause D1 to glow quite brightly when the amplifier is driven into clipping.



With the amplifier driven just below the clipping threshold there is just enough voltage applied to the circuit to cause LED1 to visibly glow, although it does so at less than full brightness. If the amplifier is driven significantly below the clipping level there will be insufficient voltage fed to D1 to cause it to conduct and it will not light up.



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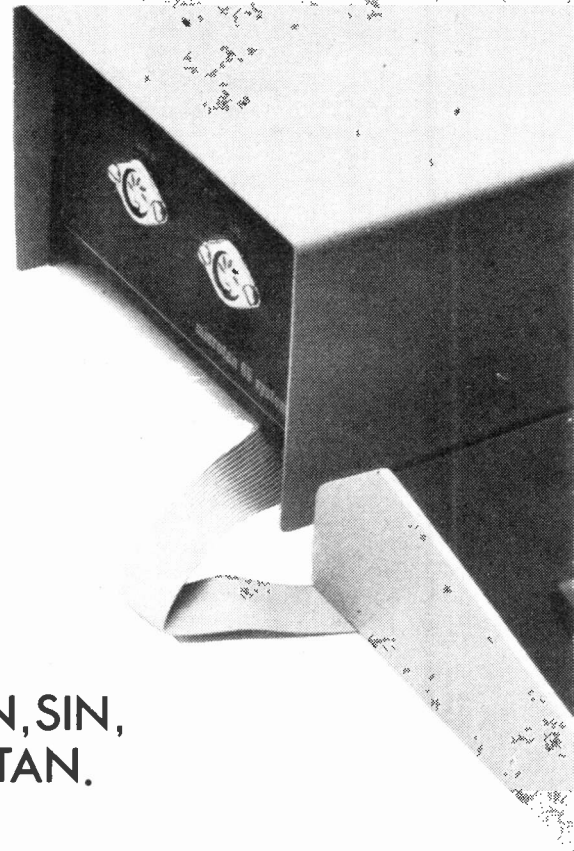
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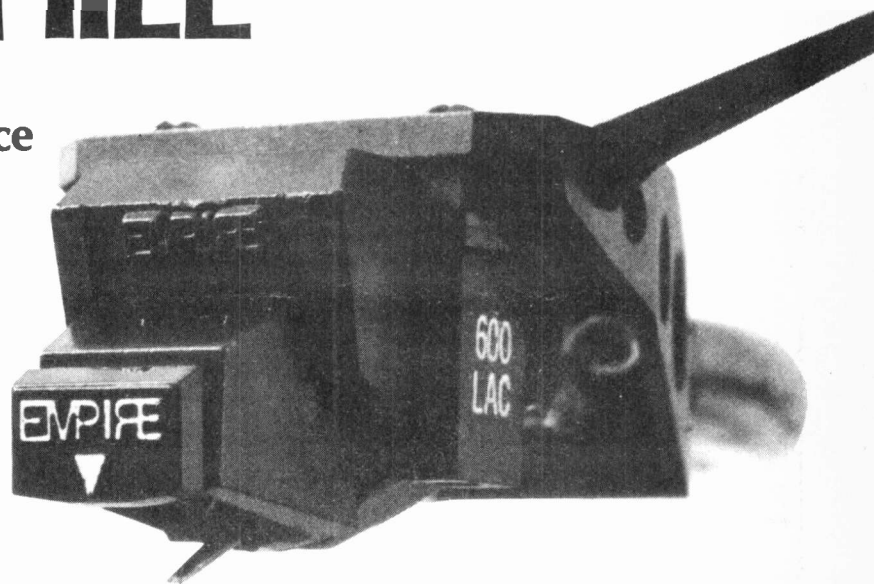
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# AUDIOPHILE

Empire's new Dynamic Interface series comes under scrutiny this month and Ron Harris has some second thoughts on metal tape tests.



After last month's highly physical encounter with the JVC AX9 and its 37lbs of muscle rending weight, I decided to cheat the truss a little longer and return to the realm of the phono cartridge — where weight is measured in grams and a man (and his assets) can feel comfortable in their work.

A friend of mine — yes, even editors have friends — has for some time been muttering darkly about Empire cartridges being the best thing since the Big Bang. But after they managed to ignore my pleas for an EDR-9 when last I lined up the cantilevers I had all but given them up as a figment of his lurid imagination.

However, with the dawning of a new day — and the shuffling arrival of our geriatric postman — was delivered unto me a small brown parcel, containing not one but two Empire cartridges. Once more I am forced to revise my model of the Universe. Wrong again.

Having beaten off my friends grasping, avaricious little paws and refused all offers to kidnap Felicity Kendal in return for the contents of the box, I found myself confronted by the new Dynamic Interface series in the form of its 600LAC and 400TC manifestations.

Right then, into battle, SME raised against the fall of night and the howling of the wolves (i.e. neighbours).

## Empire Strikes Back

These cartridges use a moving-iron principle to generate their millivolts, inherently more linear than the more common moving magnet. The top two in the range, the 600LAC and the 500ID also employ an 'internally dampened' cantilever to overcome the mechanical h.f. resonance at around 18 kHz.

Other innovations include a cantilever composed of an Aluminium alloy with Boron deposited into it, reduced tip mass and 'two position locking' for the stylus assembly to ensure that it is correctly located.

Benefits claimed are flatter frequency response due to close control of resonance, reduced IM distortion, increased trackability (sorry Shure!), good hum rejection and reduced record wear. In fact everything short of the power of regeneration. Maybe that comes with next year's model.

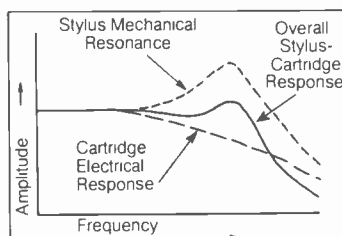
The basic engineering concept of these cartridges differs from the 'norm' in that here the coils and magnets are fixed in place within the body, a hollow iron armature is attached to the cantilever and generates the output in the coils by moving within the field from the three magnets situated next to them.

Unusual is Empire's use of two 'front' magnets to linearise the field through the pole pieces and coils, which also act to reduce hum pickup. Field strength is effectively concentrated in the gap where the armature is in motion. Empire say this also reduces microphonics (susceptibility to outside vibration).

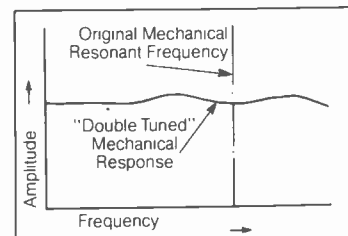
## Inside Story

The 600LAC features the inertially dampened tuned stylus (IDTS) system, Empire's scheme to defeat h.f. resonance. This employs an assembly INSIDE the cantilever, consisting of elastomer ring and iron piecework, which provides an antiphase resonance at the critical point to produce a much flatter "twin peak" overall response around resonance.

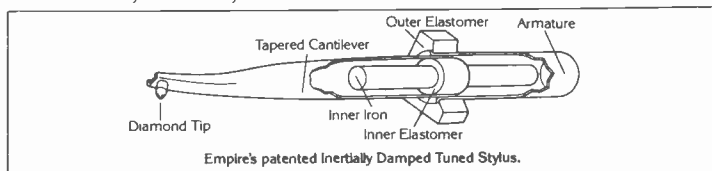
The diagrams explain this better than any combination of letters and spaces.



Frequency response of a conventional stylus assembly.

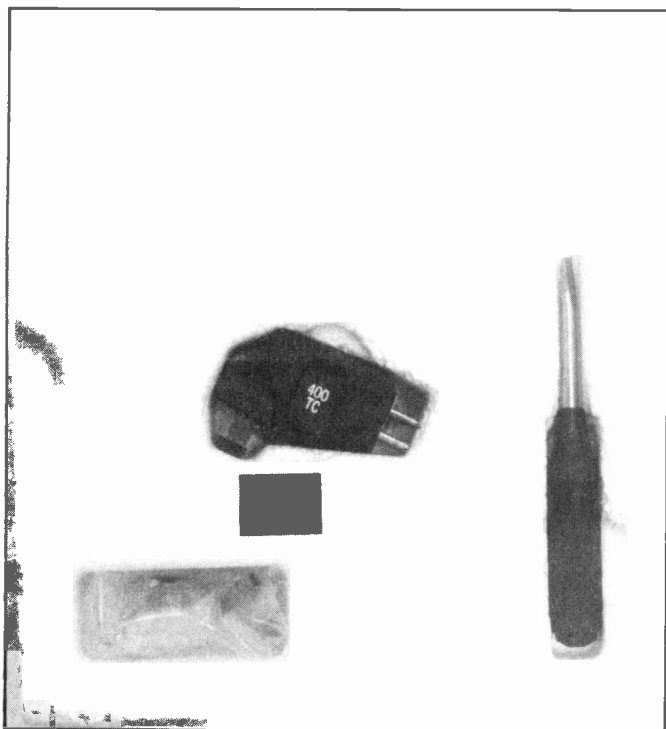


Frequency response using Empire's patented Inertially Damped Tuned Stylus.



Empire's patented Inertially Damped Tuned Stylus.

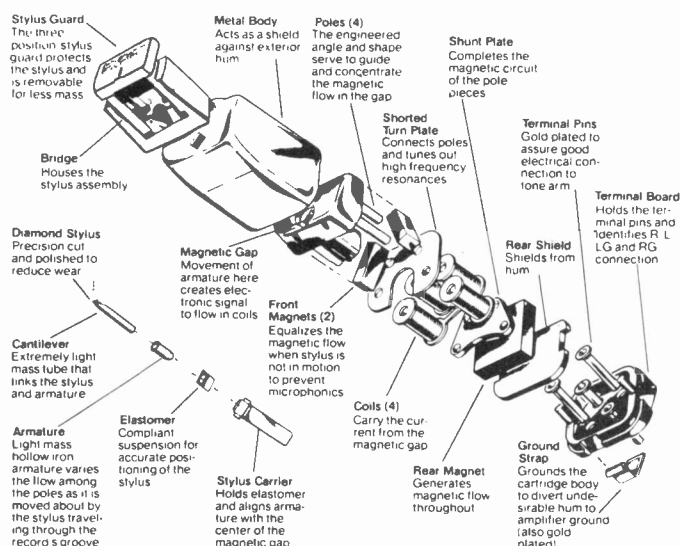
Says it all better than words — Empire's IDTS system.



The 400TC pickup reclining in its box awaiting the moment of truth and the SME. All the DI range are physically similar and are distinguished by the colour of the stylus carriers. In the case of the 400TC this is an extremely lurid red.

LAC stands for 'Large Area of Contact' and implies that lower record wear should be expected from the 600LAC than from a normal elliptical or spherical point. Under high-power magnification a very high order of finish was revealed on our sample, confirming the manufacturer's claim of having paid special attention to stylus polish. Such care would manifest itself in better preservation of those irreparable grooves and lower surface noise.

The 400TC has the tapered cantilever of its more expensive brethren, and a lower tip mass than most units in this price range. The 400TC retails at around £30 and the 600LAC at



An exploded view of an Empire cartridge. Note the use of two small magnets ahead of the main assembly. This is to concentrate and linearise field strength in the region around the moving iron element.

about £75 — both in very competitive areas indeed. Good performance is not a bonus here, merely a basic requirement for (commercial) survival.

## Packet In?

One immediate disappointment must be the presentation of the cartridges. Both arrive wedged into a block of polystyrene, along with fixing hardware and mandatory screwdriver. Outer packaging is a simple cardboard sleeve. Whilst one can applaud the avoidance of expensive trappings that do nothing to enhance performance, surely this is going a little too far — especially at the £80 or so of the 600LAC?

Indeed, the overall appearance of the cartridges themselves does not manifest the overtly confident engineering that one gets from something like a Shure or an Ortofon. Not that they are anything but well made — please don't go thinking that Audiophile is casting needless aspersions! The company offer a two year guarantee on all the range as proof of their confidence in the product. It is certainly not misplaced, I think.

## Sound Evidence

After the measurements had been taken and the lab stool vacated for a more comfortable armchair, the 600LAC was auditioned mounted in the inevitable SME series III pickup arm — still the Rolls Royce of its field. Comparison was drawn against the Ortofon/SME 30 H and Coral MC81 (moving coil) units.

Whatever the criteria the 600LAC is a good cartridge. Its sound is characterised by a solid bass and a forward presentation. Treble is very well extended and smooth. Resonances are well controlled, so that damping is certainly effective audibly. The Empire works well with any type of music, but undeniably adds a certain amount of 'life' of its own that is most exciting with rock.

At times I could detect a slight 'edge' on difficult, heavily modulated passages although tracking was always impeccable and the 600LAC was never tricked into mistracking. It has a great deal of the sparkle and transparency of the best cartridges around, but loses out in the mid-range where it is a little veiled when judged absolutely. Nonetheless all hi-fi is a compromise of some sort or other, and this pickup gives away less to perfection than most. Good value, I thought.

On to the 400TC, which was compared against the Shure M97EJ and Goldring G900 IGC reference. In a straight A-B comparison the Empire betters the Shure, but falls short of the more refined G900 IGC. It does offer very good returns on the £30 investment required to secure its services, however.

Like the 600LAC, the sound is forward in nature and projects the music outwards from the loudspeakers. Presentation is confident with a good low frequency performance and very smooth top end. As long as speakers are chosen to complement the distinctive style this Empire would be a worthy addition to any system in the £400-£600 price range.

In fact the 400TC is close enough to the 600LAC to make me wonder what place exists for the 500ID, a model that sells for £45 and sits between the two in the Empire range.

## Conclusions

Overall then, two good units well placed to succeed and which should be added to shortlists for audition at the friendly neighbourhood dealers. Good features common to both were an insensitivity to surface noise, extended bass and smooth treble. Well worth a listen.

I can see Empire gathering quite a following for this new



## Tape Measures

Up-cock on the measurement front it seems. Many moons ago I reviewed the TCK 55 II from Sony and in doing so apparently discovered that said machine would not function to the best of its considerable ability with Sony tapes. Metal variety, anyway. Since then Sony have made a valiant effort to completely bury me in cassettes, on the principle that the one I had was a bad sample and all others will work.

After clambering out from under the little plastic boxes and clearing a space to work, I sat down to do a retest with some other examples of their metallic machinations. Lo and behold. Better frequency response and improved linearity. Suspicious editorial mind begins to dream up fiendish Japanese plots to "fix" results. Is Audiophile having its statistics interfered with?

A strong desire for impartiality, together with a fair helping of cowardice led me to pack off the TCK 55 II and all its little metal ammunition for independent testing once more. I neglected to tell the engineer concerned about the initial discrepancy on a particular tape type, just to see if he'd turn it up independently. Come to think of it, those Samurai warriors polishing their swords outside my door may have slipped my mind too — still I probably imagined it . . .

It would appear from a consideration of both our results that there was something wrong with the tape rather than the machine, after all. That probably clears Sony Tape Recorders Ltd off my back, but enrages Sony Cassette Production 1921 Ltd, or some other such edifice.

(Maybe it is no coincidence that everyone in my train compartment this morning was of oriental extraction and carried a long and curved thin brown paper parcel. Anyone know the Japanese for: "Me given up reviewing hi-fi, taken up knitting instead"?)

ETI

Model	600LAC	400TC
1 Frequency Response Bandwidth	6Hz - 50,000Hz	7Hz - 34,000Hz
2 Frequency Response	20Hz - 28,000Hz ± 1¼ dB	20Hz - 20,000Hz ± 2 dB
3 Tracking Force Range	1 to 2 grams	¾ to 2 grams
4 Recommended Tracking Force	1½ grams	1¼ grams
5 Separation @ 200Hz	21 dB	20 dB
@ 1kHz	30 dB	28 dB
@ 5kHz	20 dB	20 dB
@ 12.5kHz	17 dB	16 dB
6 I.M. Distortion @ 3.54 cm/sec	0.1%	0.15%
@ 14.5 cm/sec	0.4%	0.5%
7 Stylus Shape and Size	LAC	0.2 x 0.7 mil bi-radial
8 Cantilever	Boron vapored, inertially damped, tapered Aluminum alloy	Tapered Aluminum alloy
9 Effective Tip Mass	0.6 mg	0.6 mg
10 Compliance (Dynamic)	20 x 10 <sup>-6</sup> cm/dyne	20 x 10 <sup>-6</sup> cm/dyne
(Static)	28.5 x 10 <sup>-6</sup> cm/dyne	23 x 10 <sup>-6</sup> cm/dyne
11 Tracking Ability @ 300Hz	17.9 cm/sec	17.9 cm/sec
@ 1kHz	38 cm/sec	32 cm/sec
12 Channel Balance	within 1.0 dB	within 1.0 dB
13 Vertical Tracking Angle	20°	20°
14 Output @ 1kHz @ 3.54 cm/sec	4.0 mV	3.8 mV
15 Number and Type of Magnets	2 Samarium Cobalt, 1 Indox V	2 Samarium Cobalt, 1 Indox V
16 Load Resistance	47k Ohms	47k Ohms
17 Capacitance	150 pF	150 pF to 400 pF (350 pF optimum)
18 Hum Sensitivity @ 60Hz	0.34 µV/A/m	0.5 µV/A/m
19 Total Weight	5.3 grams	5.3 grams
20 Stylus Replacement No. & Color	S600LAC (Black)	S400TC (Red)

How about this for a set of specs? Empire are certainly unafraid to lay it all out in black and white. On test no significant differences were discovered. Hum susceptibility was not tested — you'll note that they have specified this at 60 Hz. Damn colonials again is it not? Tracking weight ranges are sensibly specified and I found that the lower values worked well.

range of cartridges without too much difficulty, and I can think of no higher praise than to comment that while auditioning the 600LAC I was in no hurry to return to the familiar tones of my reference unit.

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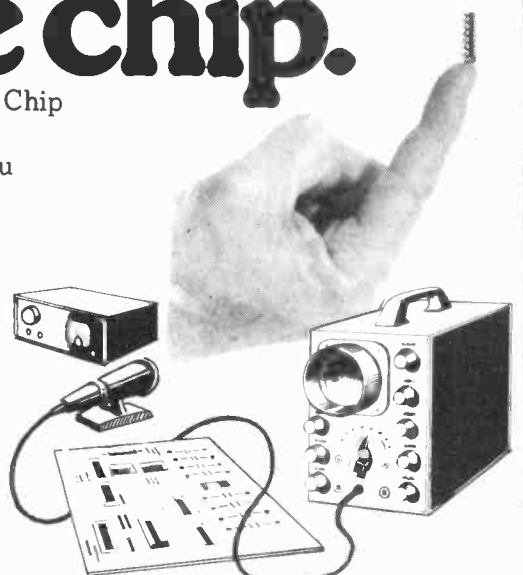
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# RAVEN ON

Dave Raven of Metac Electronics chats about chips that answer back and discusses display developments.

Speech synthesis and voice recognition are techniques which are rapidly changing the interface between humans and their machines. Until now we have been content to read from a visual display or listen to pre-recorded non-intelligent voices which merely pass on information.

Today, however, it is possible to incorporate a human voice which is not a recording and can appear intelligent by varying its responses to the inputs received from humans or data produced by a machine. If, in the past, a colleague was seen listening or talking to a car, calculator, microwave oven or television set, he would most likely be advised to visit a psychiatrist at the earliest opportunity. But now thanks to new devices and computer software technologies, behaviour such as this will become commonplace.

## Speak & Spell

The first consumer product which truly contains speech synthesis and which is on the market is Speak & Spell, developed by Texas Instruments. Working with a pair of 128-kilobyte read-only memories and a special version of TI's TMS1000 8-bit microcomputer, the silicon chip can produce a total of 200S of sound for a vocabulary of over 200 words. However, it is capable of accessing up to 2.1 megabytes of memory. Since the speech generator uses memory at a maximum rate of only 1200 bits per second, it could be designed to speak for as long as 30 minutes. The novelty value of Speak & Spell does not wear off quickly as may be imagined and from the reactions of my own young children, it was a clear favourite over other electronic games they have been shown. The word games and spelling tests produced a new angle for creating an interest from children in learning and I also found it quite compulsive myself.

Prior to the breakthrough by Texas Instruments in speech synthesis, earlier products which have surfaced over the last decade have been quite cumbersome and certainly more expensive. Now, with rapid advances taking place in large scale integrated circuits — both analogue and digital — and developments in signal processing, it is realistic to expect a flood of new consumer and industrialised products entering the markets.

## Vocal Chips

The techniques used to design speech synthesis circuits are split into three different methods — formant synthesis, linear predictive coding and waveform digitisation with compression. Linear predictive coding is the technique chosen by Texas Instruments for their Speak & Spell Game. The chips which are incorporated represent an integrated circuit model of the vocal tract. Basic to the model is the linear predictive coding technique (LPC) which provides feedback values or coefficients for a digital lattice filter on the synthesiser chip. This linear filter mimics the major resonant modes of the vocal cavity in the human vocal tract. A microprocessor then performs the calculations to derive the filter coefficients. The third chip is a word-storage read-only memory that holds the speech parts broken into four parameters — voicing, pitch, amplitude and frequency. From this information a complex software algorithm manipulates the sound parameters to create the speech synthesis.

## Swings And Roundabouts

There are advantages and disadvantages with each of the three speech synthesis techniques mentioned here since they can vary considerably in the quality of speech provided, the amount of data required to achieve acceptable quality and the cost of memory for storing speech data. The technique that is normally chosen depends upon the application for which it is required.

Products using formant synthesis are currently being included in a number of hobbyist computers, among them the TRS80 home computer and PET, as well as in medical and business applications.

During recent years probably one of the most misunderstood pieces of consumer electronic technology has been the liquid crystal display. I well remember an article appearing in ETI which quoted some very out of date information on the life of liquid crystal displays (LCD), and for years after, I experienced worried customers quoting this article back to me about the unreliable life-time of the display.

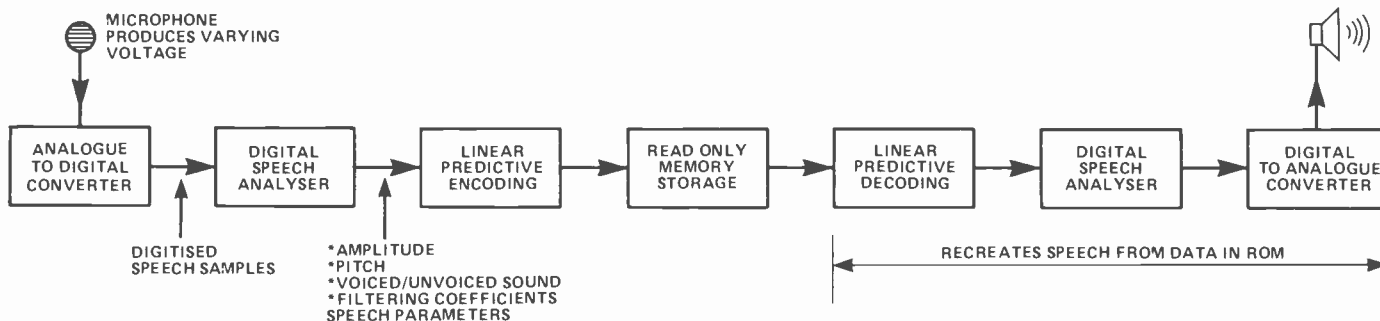


Fig.1. A block diagram showing the elements of a speech synthesiser chip.

They were of course referring to displays which appeared back in history during the very early seventies and it has been my experience that the LCD is probably one of the most reliable display forms currently available. I stuck my neck out in 1976 in an article published in ETI predicting that LCD would win the day over LED, (Light Emitting Diode) remember, and I propounded the reliability of this technique back in those dark days. Well, they say that the good always win and there is little doubt that LCDs have stood the test of time.

## Physical Contact

Recent advances in the synthesis (that word keeps appearing this month) of new liquid crystalline materials have made it possible to manufacture plastic sealed LCDs having very long operating lives. This new technique permits economical production of large area displays and at the same time improves the performance of multiplexed addressing. Thus, these new displays are capable of handling an ever-increasing amount of information in alphanumeric or quasi-analogue form. One of the major problems facing designers in their attempts to increase the amount of information which can be displayed, is how to make physical contact with each segment of the display. This is also a problem for chip designers who are restricted by the amount of space for lead-outs. One solution which is getting around this difficulty is by reducing the number of outside contacts to a display, especially when the display has more than 40 separately addressable segments. This can be achieved by means of a technique known as time-multiplexed addressing, in which appropriate segments are connected together to form a group and are sequentially addressed by means of a

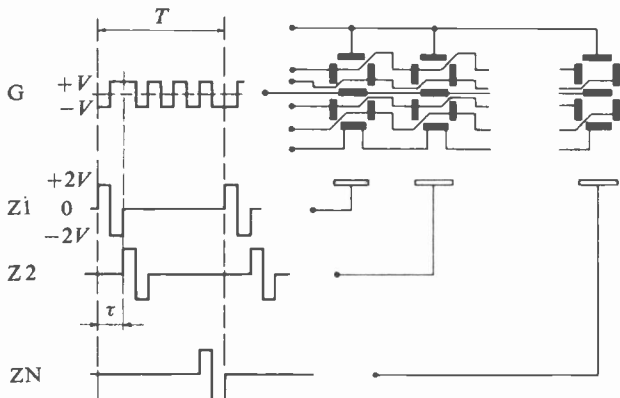


Fig.2. The principle of time-multiplexed operation. The selection interval for each digit, Z1 to ZN, is cyclically repeated at intervals of T. Only the driving signal for segment G is shown.

rear electrode consisting of several parts. Direct addressing of the LCD is presently employed in most watches and other measuring instruments which means there is a direct connection between each display element and a corresponding contact in the driving electronics, which is usually an integrated circuit. This addressing technique, whilst resulting in lots of connections, does have its advantages, since it affords much more freedom with respect to driving voltages and operating temperatures than do other addressing systems. For a directly addressing display it is easy to increase the driving voltage to obtain a display which is readable over a wide range of viewing angles.

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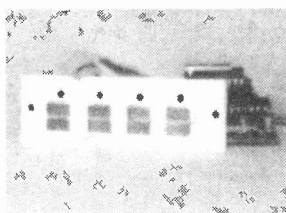
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# DESIGNER'S NOTEBOOK

ETI project editor Ray Marston devotes this month's 'Notebook' to the rather unglamorous but vital subject of passive attenuators.

One of the most important types of artillery in the design engineer's armoury of 'vital weapons' is the apparently simple passive circuit known as the 'attenuator'. Naturally, these apparently simple weapons are full of nasty little surprises and have a tendency to explode in the face of the unwary designer. This month's 'Notebook' is devoted to a brief discussion of the subject.

## Attenuators

Attenuators are used to reduce an awkward value input or output signal to a lower and more convenient level. The simplest example of a practical attenuator is the 'pot' circuit of Fig.1, which may be used as a volume control in an audio system or as an output level control in a simple audio generator, etc.

The input signal to the pot attenuator is connected across the total resistance chain and the output is taken from the pot slider. Note that the pot effectively comprises an upper (R1) and a lower (R2) resistive arm, thus forming a basic 'L'-type attenuator and that the degree of attenuation is determined by the ratio of lower arm resistance divided by the total resistance.

The precise amount of attenuation provided by a pot is generally of little importance and the control is usually left uncalibrated. If a precise amount of attenuation is required, a simple switched potential divider network of the type shown in Fig.2 may be used. It is important to note, however, that this circuit is designed to feed into an *infinite* impedance, or at least one that is very large compared to the total resistance of the divider chain.

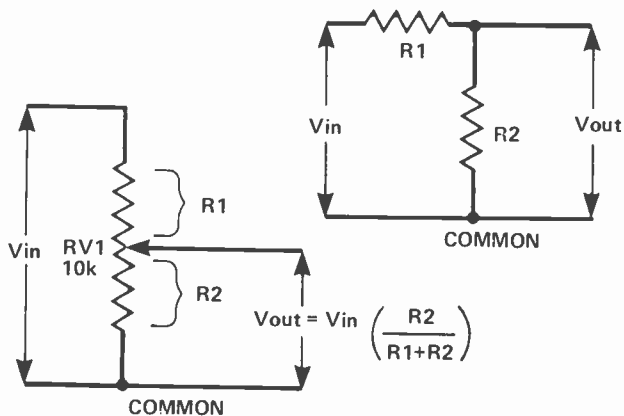


Fig.1 A simple 'pot' attenuator, as used for a volume control or an uncalibrated output level control (left) is a common version of the 'L' attenuator (right).

## Design Tips

The first step in designing an attenuator of the Fig.2 type is to decide what its input impedance or total resistance is to be. Next, the values of the individual resistors are determined. Here the design is carried out in a simple sequence of logical steps, there being as many steps as there are attenuator switched positions. In each of these steps, the circuit is considered to consist of an upper and a lower half only. An example will help clarify matters.

Assume (as in our example) that the total resistance is to be 10k and that two attenuation positions (excluding unity) are required and are  $\div 10$  and  $\div 100$ . The values for the greatest amount of attenuation are always determined first, so for  $\div 100$  the lowest arm must contain 1/100th of the total resistance, or 100R. This gives the value for R3 and leaves the remaining 9900R in the 'upper' (R1 + R2) arm.

The values for the  $\div 10$  position are next calculated and it is found that 1k $\Omega$  is needed for the 'lower' arm. In this case, however, the 'lower' arm consists of R2 + R3, but as R3 is already known to be 100R, R2 must be 1k $\Omega$  - 100R = 900R. The upper arm, R1, must obviously contain the remaining 9k $\Omega$  of the 10k chain.

This simple design procedure may be expanded up to give as many attenuator steps as are required for a particular application.

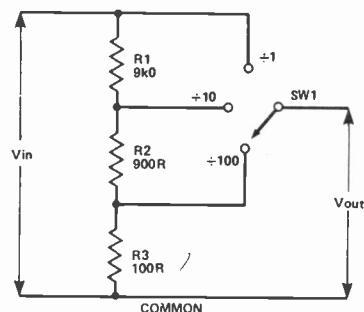


Fig.2 The method of designing this simple switched attenuator is explained in the text.

It should be noted that the simple attenuator circuit of Fig.2 is only accurate at low frequencies or when moderately low values of resistance are used. At high frequencies, stray capacitance will shunt the values of all resistors and may significantly reduce their values and thus the accuracy of the attenuator. This effect is particularly acute when high value resistors are used: a mere 2pF of stray capacitance represents a reactance of about 800k at 100 kHz and will have a very significant shunting effect on any resistor with a value greater than a few tens of kilohms.



## Compensation

This problem can readily be overcome by shunting all resistors with correctly chosen values of capacitance, as shown in Fig.3.

Here, each resistor of the chain is shunted with a fixed capacitor, the reactance values of capacitance being in the same ratios as the resistive arms of the attenuator. The highest reactance (smallest capacitance) is connected to the largest resistor and typically has a value in the range 15 to 50pF, the value being large enough to 'swamp' strays but small enough to present an acceptably high impedance to input signals.

This 'compensated' type of attenuator is invariably used in 'scopes and various other types of high frequency test gear, as shown in the typical circuits of Figs.4 and 5. Once again, note that the compensated attenuator is intended to feed into a high impedance load.

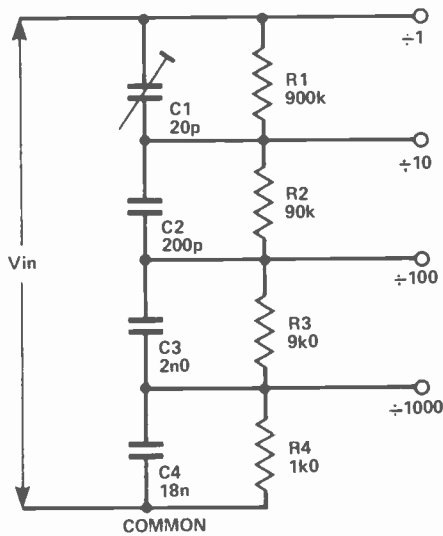


Fig.3 A method of providing frequency compensation (to give a wide frequency response) to a simple attenuator network.

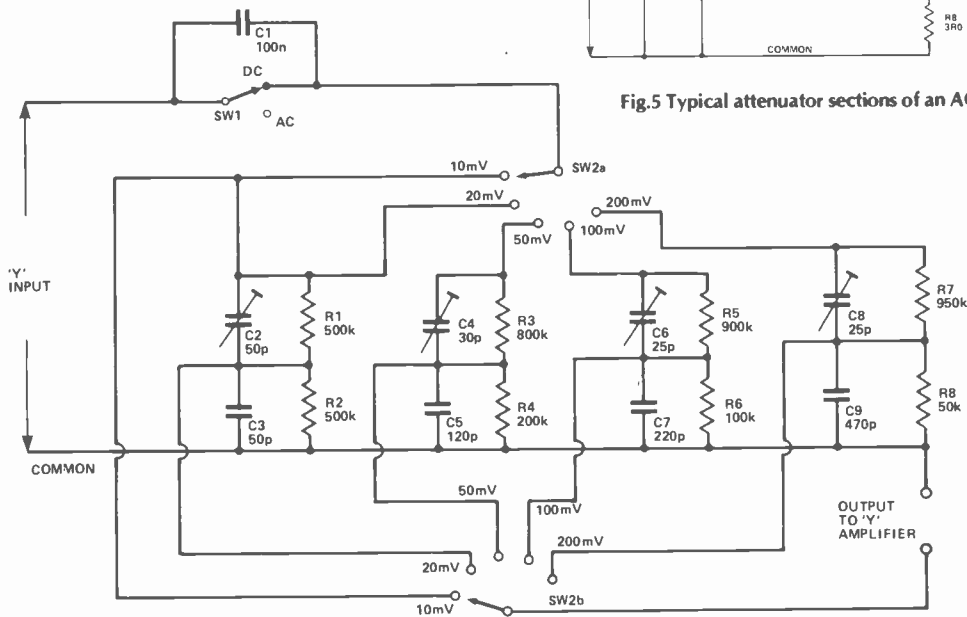


Fig.4 Section of a typical 'scope' Y amplifier attenuator.

## Pot Pitfalls

At this point in our discussion it may have dawned on you that, because of the effects of stray capacitance, there can be certain pitfalls in using pots in some types of circuit. Suppose, for example, that you have designed an audio amplifier with a beautifully flat frequency response but have, in a moment of madness, fitted it with a 500k volume control. You will (hopefully) not be unduly surprised to consequently find that, at low volume settings, stray capacitance of a few picofarads across the upper arm of the pot causes the amplifiers treble response to be boosted by several dB at 12 kHz or so!

Again, suppose that you have designed a superb LF sine/square generator which produces square waves with rise and fall times of a mere 50 nS or so, but have fitted the beast with a simple 10k pot as an output level control. Naturally, you will not be surprised to find that the few picofarads of strays across the upper arm of the pot acts as a reactance of only a couple of thousand ohms to your fast rise and fall time signals and consequently causes your square waves to appear incredibly 'spiky' at low amplitude settings.

Both of the above problems can be solved or minimised by using pots with sensible low resistance values, bearing in mind the effects of strays at the operating frequencies in question.

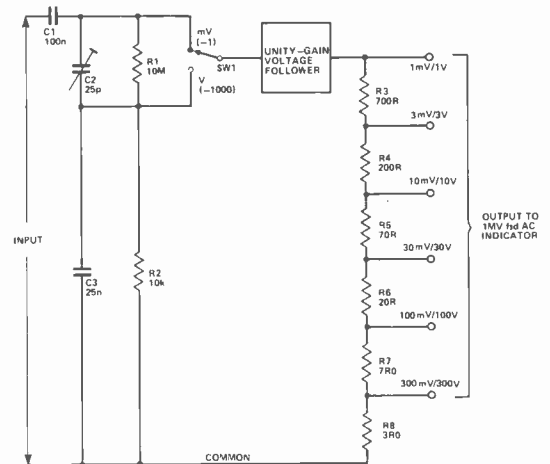


Fig.5 Typical attenuator sections of an AC millivoltmeter;

## Matched-Resistance Attenuators

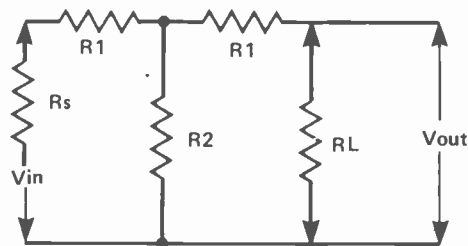
Often, an attenuator is needed to feed into and/or from a fixed load of some kind, in which case the simple potential divider types of circuit discussed above are of little use. Instead, one of the many versions of the so-called matched-resistance attenuator must be used. Two of the most popular attenuators of this type are shown in Fig.6, together with their basic design formulae. Note that these formulae are valid only when the attenuators are correctly terminated at each end.

The 'T'-type attenuator is a perfectly simple design and several sections can readily be cascaded to form variable attenuator networks, as shown in the practical circuit of Fig.7. Here, the attenuation can be varied from 0 dB to 60 dB in 20 dB steps by switching individual sections into or out of the circuit.

The  $\pi$  attenuator sections cannot be directly cascaded, as is made clear in Fig.8. Nevertheless, sections can be cascaded in modified form to produce a ladder attenuator network, the most popular of all attenuator types.

Looking at Fig.8, you can see that if three individual  $\pi$  sections are wired in cascade (Fig.8a) their adjacent R2 sections connect in parallel to give an impedance of P/2 (Fig.8b) while the two R2 end sections have impedances of P. If an external load, RL, is simply switched to the different outputs of the cascaded  $\pi$  attenuator sections (Fig.8c) the load will clearly see impedances of roughly half of the correct value and so be severely mismatched. To put things right, the formula for the component values of the ladder network of Fig.8c are re-jigged as shown.

The ladder attenuator of Fig.8c is very widely used in AF and RF signal generators. Figure 9 shows the practical circuit of a fully variable 600R attenuator that can be used in sine/square generators, etc.. The odd resistor values (correct within 2%) can be made up by wiring pairs of resistors in series or parallel.



COMMON  
'T' - TYPE ATTENUATOR  
 $R1 = R \left( \frac{n-1}{n+1} \right)$   $R2 = R \left( \frac{2n}{n^2-1} \right)$

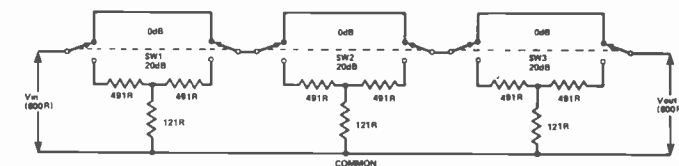


Fig.7 Three identical 20 dB 600R 'T' attenuators cascaded to make a 0-60 dB switched attenuator unit.

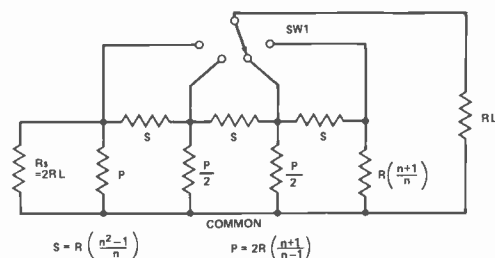
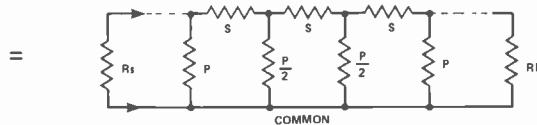
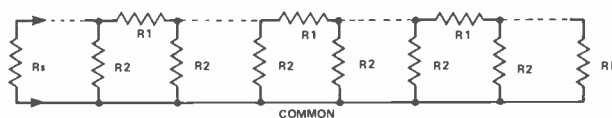
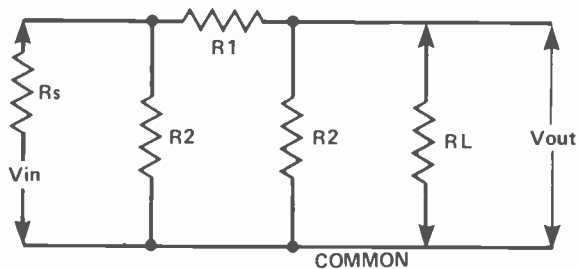


Fig.8 The ladder attenuator (c) is a development of the basic  $\pi$  attenuator (a and b).

Fig.6 Two popular types of matched-resistance attenuator.



COMMON  
' $\pi$ ' - TYPE ATTENUATOR  
 $R1 = R \left( \frac{n^2-1}{2n} \right)$   $R2 = R \left( \frac{n+1}{n-1} \right)$

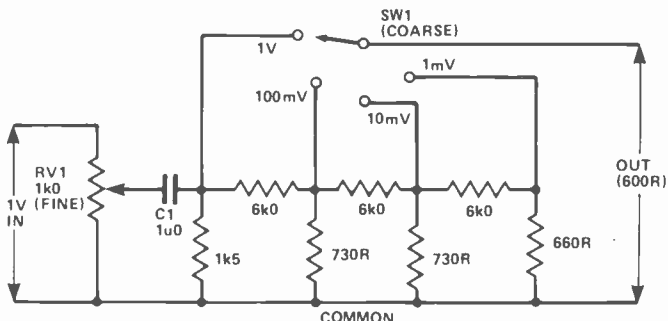


Fig.9 Practical 600R output attenuator network for a modern sine/square generator. RV1 gives fine control. SW2 gives coarse control.



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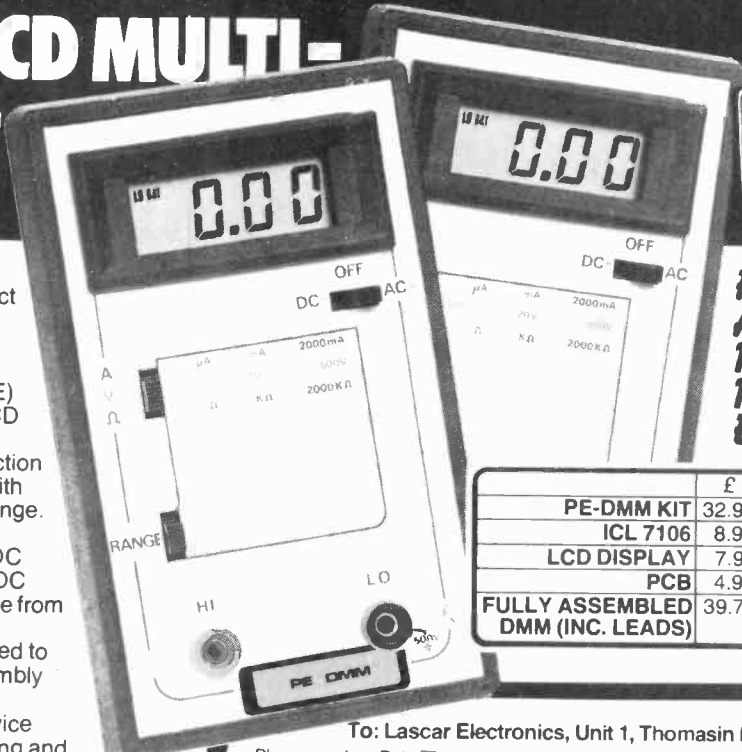
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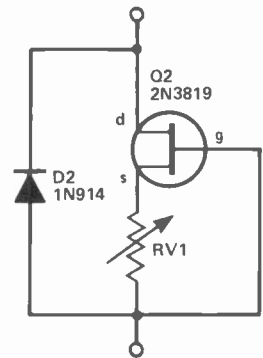
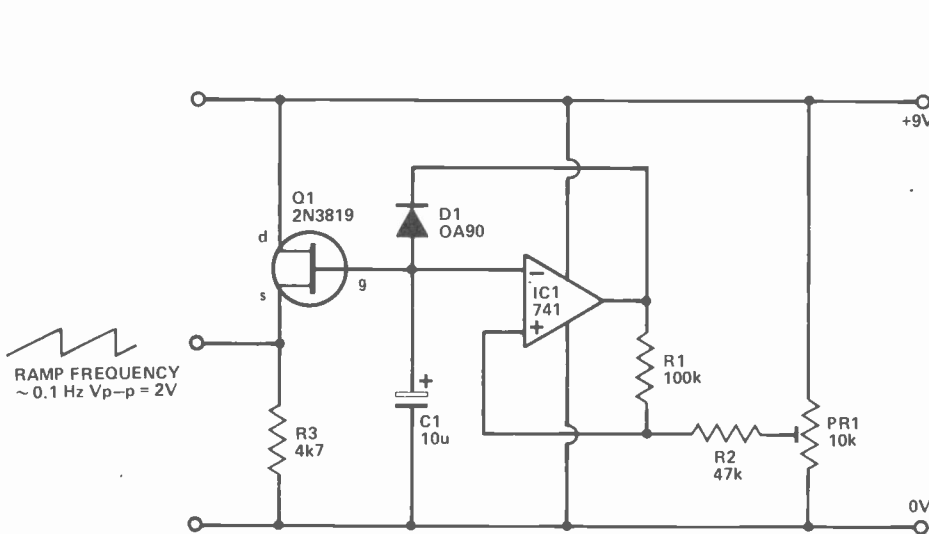


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# TECH TIPS



## VLF Ramp Generator

C. Malloy, Whitby.

It is always satisfying to exploit the otherwise unwanted property of a device — the reverse bias current of a leaky germanium diode, in this circuit. This reverse saturation current is typically a few microamps for the OA90 and is relatively constant over 2-10 V. This constant current is used to linearly charge the capacitor in the relaxation oscillator built around the 741.

When the diode becomes forward biased the capacitor is rapidly discharged by the limited output current of the op-amp. Frequencies below 0.01 Hz are possible, though measures may have to be taken to improve the linearity of the ramp.

PR1 allows some degree of DC offset of the ramp and the source follower (Q1) reduces the loading on the capacitor which tends to degrade the ramp's linearity. For the same reason tantalum (ie low leakage) types should be used for large values of C3. Linearity can be further improved by the use of a FET input op-amp such as the 3140.

The frequency can be made variable by using the FET constant current generator shown in Fig. 2, which should replace the diode, D1. With RV1 at 100k the current will be about 30 uA and roughly inversely proportional to RV1. This constant current generator needs a voltage of about 3 V to function well. This may require an increased power supply. However, the resulting linearity is excellent, especially with the suggested FET input op-amp.

## Car Radio Suppressor

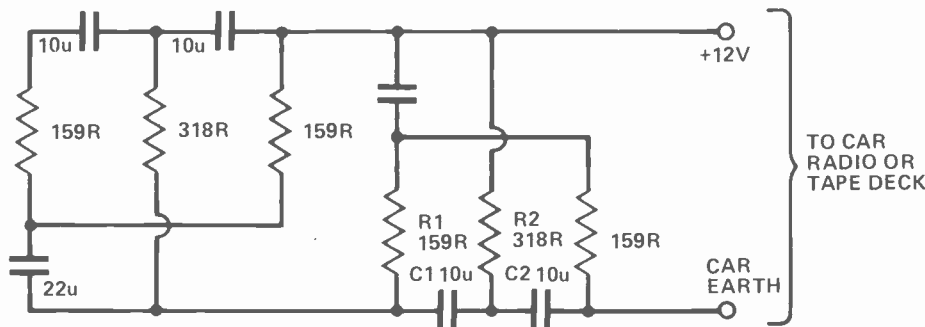
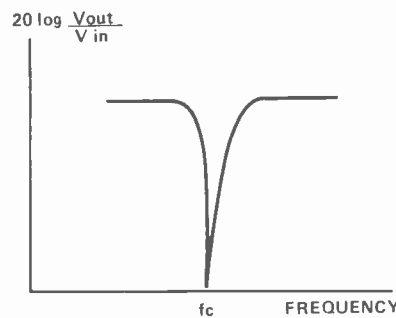
L. Marks, Lancs.

This circuit will suppress mains-borne interference every time the car drives over a buried power line. It may also be used for suppressing ignition HT by a modification to the following equation:

$$f_c = \frac{1}{2\pi R_1 C_1}$$

where  $R_1 = \frac{1}{2}R_2$ ,  $C_1 = \frac{1}{2}C_2$ .

The circuit works as a band reject notch filter.



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## Parametric Equaliser

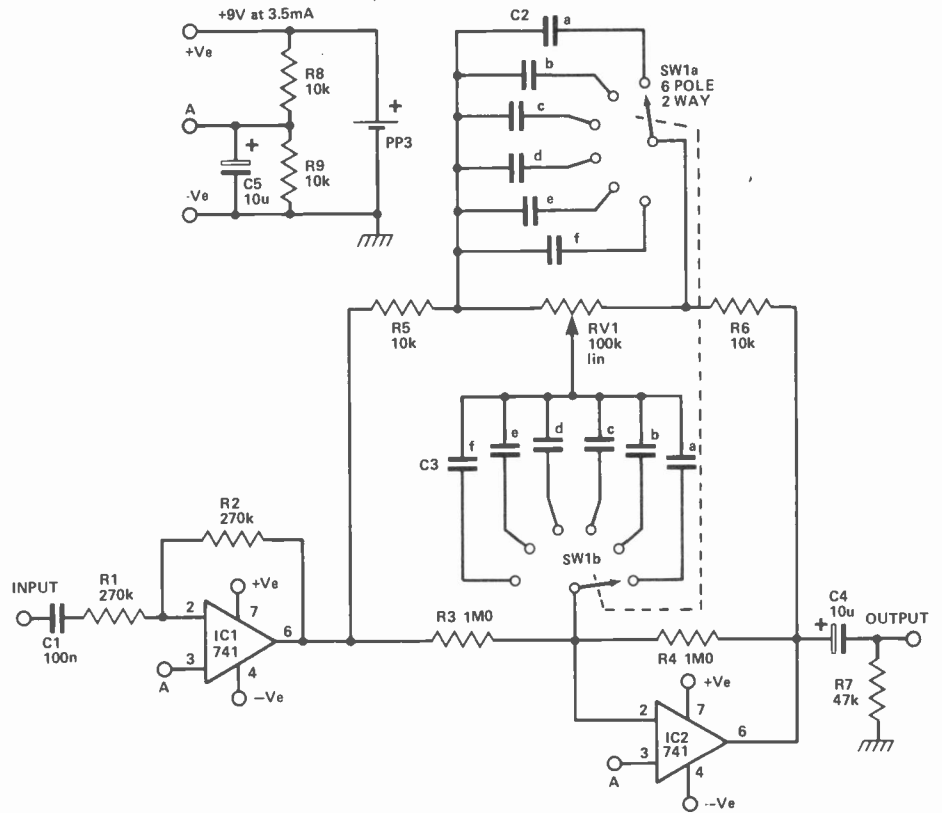
C.E. Read, Norwich

The parametric equaliser offers six bands of tone control separated by an octave in frequency, each frequency band being selected by the six position rotary switch.

Potentiometer RV1 permits the selected frequency band to be boosted or cut by 12 dB. The filter is particularly ideal for use with a guitar to modify and enhance the tonal qualities of the instrument.

For example, the 500 Hz setting with cut gives a hollow funky sound, whilst the 500 Hz setting with boost gives an overdriven valve amplifier, the raunchy sound favoured by many rock guitarists, but without the unpleasant muddy, harsh sound resulting from boosting the entire audio frequency spectrum.

	FREQ (Hz)	C2 (pF)	C3 (pF)
a	125	47000	4700
b	250	22000	2200
c	500	12000	1200
d	1k	5600	560
e	2k	2700	270
f	4k	1500	150



## PCBs From Film

I. Parker, Bath.

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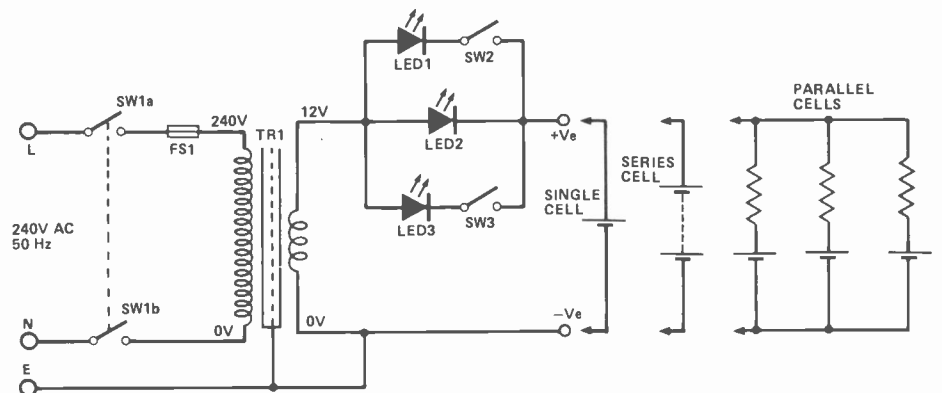
printers and ask them to make an overhead transparency copy of it. This looks like an ordinary photocopy but instead of being printed onto paper the image appears on transparent film. Lay this on top of a piece of presensitised PCB (obtainable from most electronic retailers), use bulldog clips or adhesive tape to make sure of good contact. Then expose to sunlight for about half an hour, spray the board with the developer (following instructions carefully) and then etch the board in a normal solution of Ferric Chloride.

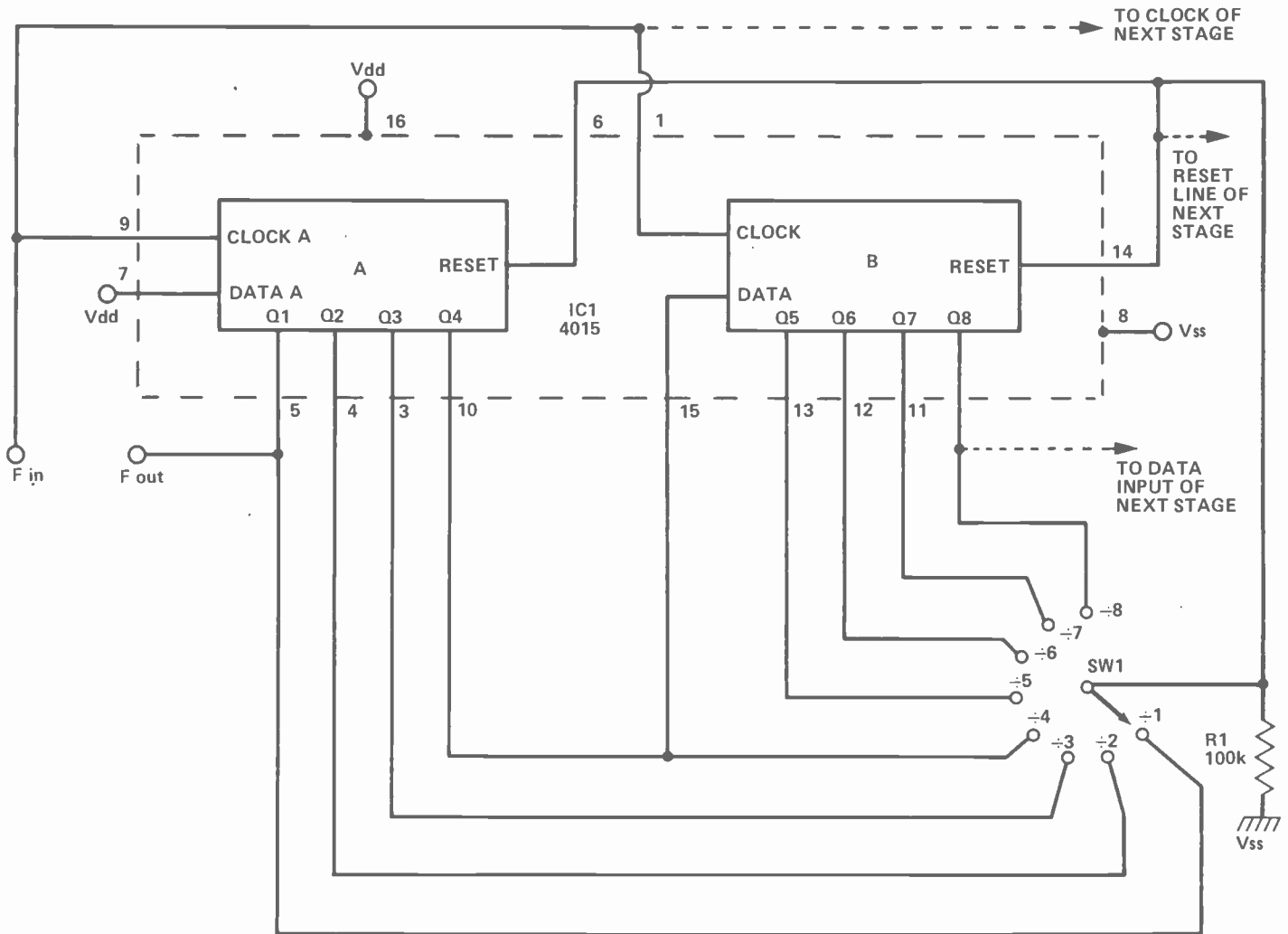
## Ni-Cad Charger

J. Grainger, Rugby

This circuit makes use of the new constant current LEDs which are now available for about 50p (Radio spares). These devices pass a constant current of about 15 mA for applied voltages in the range 2-18 V and will also block up to 18 V peak in the reverse direction. Furthermore, they may be paralleled directly to give any multiple of 15 mA and, of course, they light up to give an indication that they are working.

The circuit shown will charge a single cell at 15, 30 or 45 mA, or cells in series up to the supply voltage limit (about 14 V). If it is desired to charge cells at less than 15 mA, several cells may be paralleled using suitable sharing resistors, which should drop about 10 V at the cell current. The LEDs will be damaged if the peak voltage of the supply exceeds 18 V (13 V RMS).





## Burglar Alarm

P.N. Durrant, Chester.

The original circuit was developed as a car burglar alarm, but it could be used as a digital combination lock or, with slight modifications — removing counter 2 — a home burglar alarm.

A suitable 4 or 5 digit code is selected and, via a BCD switch wired to the appropriate latches of the 74118. Unused numbers commoned to the reset latch. Switch common is earthed through a push-button. Each is selected and entered by pressing the "enter" button. An incorrect number resets the latch. If the code is right then the unit is all reset and the relay is pulled in. The alarm is now disarmed.

If the code latch is reset a "0" appears at point A, counter 1 starts to count until it reaches eight, which sets the first RS latch, arming the

detector latch.

A digital "0" from the detector switches resets the latch and starts counter 2, which allows a set time to elapse before RLA drops out and the alarm sounds.

Since originally designed for cars without external reset, the final delay was included to allow the owner to enter and reset before the alarm was activated. Therefore the oscillator is set to the fastest time the code can be set.

To arm the unit a noncode number is set in. This leaves enough time to leave the car before the unit is armed. I used an illuminated push-button and connected it to show when the counter had reached its reset point. This also has the advantage of showing the thief that your system is all go.

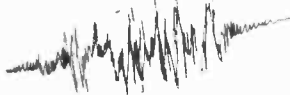
The power supply must be quite heavily smoothed as the unit was found to be quite sensitive to the noise found in car electrics. The coding switch was a thumbwheel type, since it fitted the holes already in the vehicle it was designed to be used in. A touch type keyboard could be substituted, but an enter button must also be fitted.

The whole unit can be built using CMOS, especially if it is required to run from a separate supply from the main battery. The relay is a reed type holding in a larger multicontact relay with its many enabling and disabling uses in a car. It will also operate many anti-theft devices in the home. A slow code input and 5 S clock acts as a reaction timer, which could be embarrassing after a "liquid lunch".



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## MUSIC

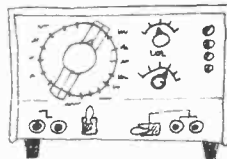
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## AUDIO

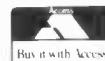
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# VOCODER

Change sex or orchestrate yourself (same thing, really) with the ETI Vocoder, designed by Richard Becker of Powertran.



A vocoder could be simply defined as a device which will, in real time, superimpose the spectral characteristics of one signal upon another. To leave it at that, however, would result in many a yawn and a few skipped pages. In fact vocoders are anything but boring! Put speech and the output of an instrument into a vocoder and the instrument, not the operator, appears to be doing the talking or singing! Use the internal excitation oscillators, change the frequency and the speaker suddenly changes sex. Use the noise generator and there is whispering in the breeze. Use the output of a cassette deck and the London Symphony Orchestra recites the Karma Sutra! Just a few of the possibilities!

Human speech is built up from two basic components — the sound from the vocal chords which buzz when air is passed over them and the sound of air rushing past the teeth. These sounds are used to produce voiced and unvoiced speech respectively. By opening and closing the mouth and the nasal cavity, and by moving the tongue, thereby adjusting the resonances, the basic sounds are modified in amplitude and harmonic content. If the variations in amplitude and harmonic content can be analysed and applied to suitable electronic control circuitry then the basic sounds of speech can be substituted for by almost anything and this is just what a vocoder does.

The first part of a vocoder is a spectrum analyser producing control signals which are a measure of the strength of the speech signal in each of the frequency bands (14 in this design). The substitution (excitation) signal is also split into a number of frequency bands (using identical filters to those used for analysis) and each of these signals is passed through a voltage controlled amplifier whose gain is determined by the control signals. The sum of the outputs of these amplifiers is the vocoder output.

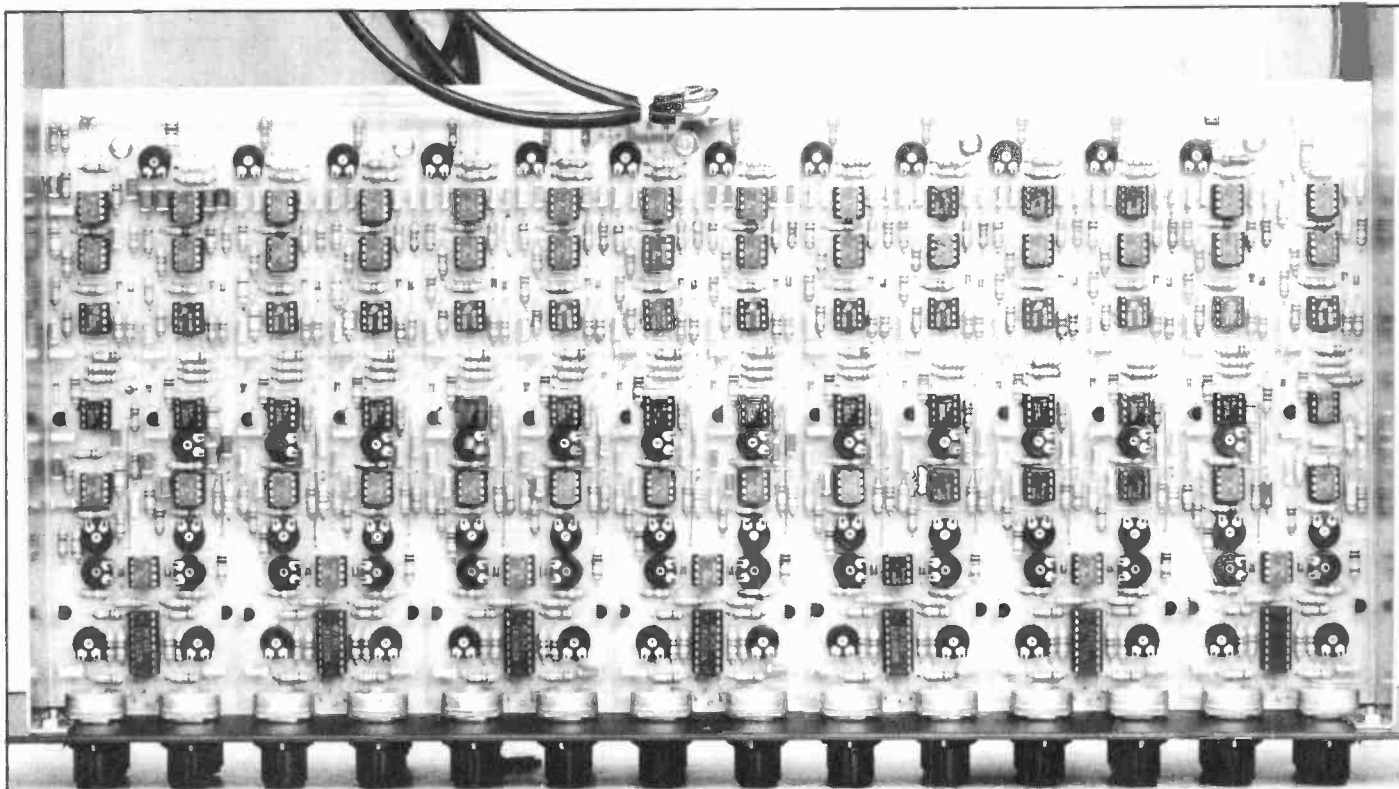
## The system

The speech signal, after passing through the pre-amplifier and tone control stages, is separated into 14 bands by bandpass filters, a low pass filter and a high pass filter. The bandpass filters are double tuned that is to say each of the two stages has a slightly different resonant frequency. The effect of this is to broaden the band of accepted frequencies and give the response curve a flattened top. A high Q makes the filters cut off rapidly out of the pass bands.

The envelope followers consist of an active full wave rectifier and a low pass filter, the output of which is the control signal for the synthesiser section. The control signal passes through a sample and hold stage which is used to freeze the music, by means of a footswitch, at any required point of articulation. The stage is also used for slewing rate control which smooths out the control signals for slower and smoother changes in spectral balance and amplitude resulting in speech being changed into singing or chanting.

## Holy Responses

In the synthesis section there is a filter bank identical to that of the analysis section. Voltage controlled amplifiers modulate the outputs of these with the control signals from the analysis section. The outputs are then summed to produce the output signal. Alternate channel outputs are inverted since there is a change in phase as a signal is swept through the resonant frequency of the filter. Therefore, at the midpoint between adjacent bands phase cancellation will occur producing deep holes in the overall frequency response. By having adjacent channels outputs inverted with respect to each other there is addition instead of subtraction at the midpoints.



The analysis/synthesis board occupies the front half of the case. All the potentiometers are PCB mounting for ease of construction. The Power Supply Unit (to be described next month) is a respectable distance away, mounted on the rear panel.

## SPECIFICATION

14 channel: Filters — 4th order with bandpass filters at  $\frac{1}{3}$  octave spacing.

LED Bar Display PPMs for both speech and excitation.

Speech input: amplifier:

mic input: sensitivity 1 mV

mic input: impedance 100k

line input: sensitivity 500 mV

line input: impedance 10k

tone control:  $\pm 6$  dB Treble boost — Bass cut/Bass Boost - Treble cut.

excitation input amplifier:

low input: sensitivity 10 mV

low input: impedance 100k

high input: sensitivity 500 mV

high input: impedance 10k

tone control:  $\pm 6$  dB Treble boost-Bass cut/Bass boost-Treble cut

Internal excitation:

pseudo-random counter noise generator

2 oscillators — range: 15 Hz-250 Hz

pulse width: fully variable

Slew rate control: 100:1 range. FREEZE by footswitch

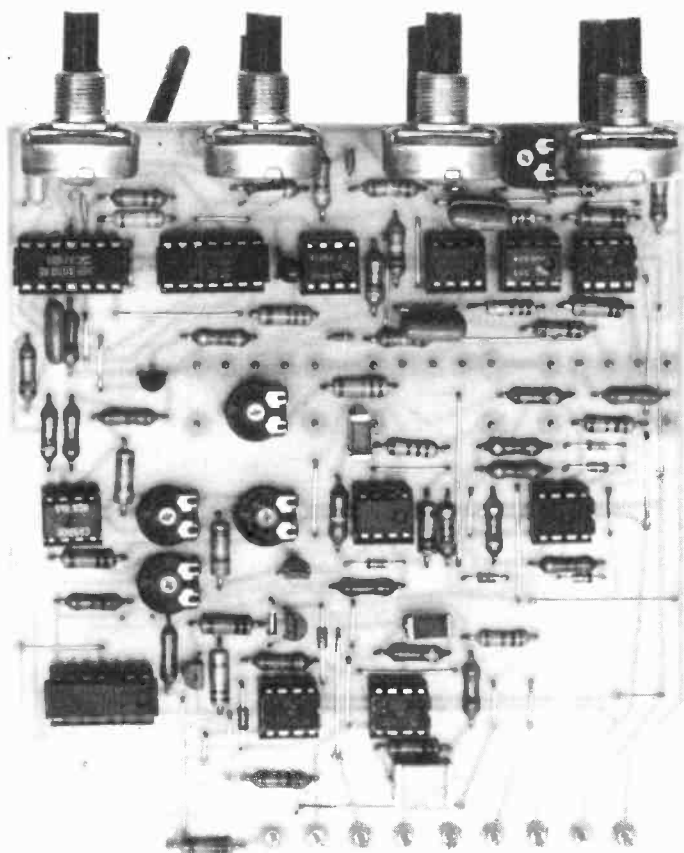
Voice/unvoiced detector:

AGC on noise generator to follow excitation signal

Output amplifier:

mixing controls for vocoder, speech bypass and external excitation bypass

Output level: 1V



The internal excitation board.

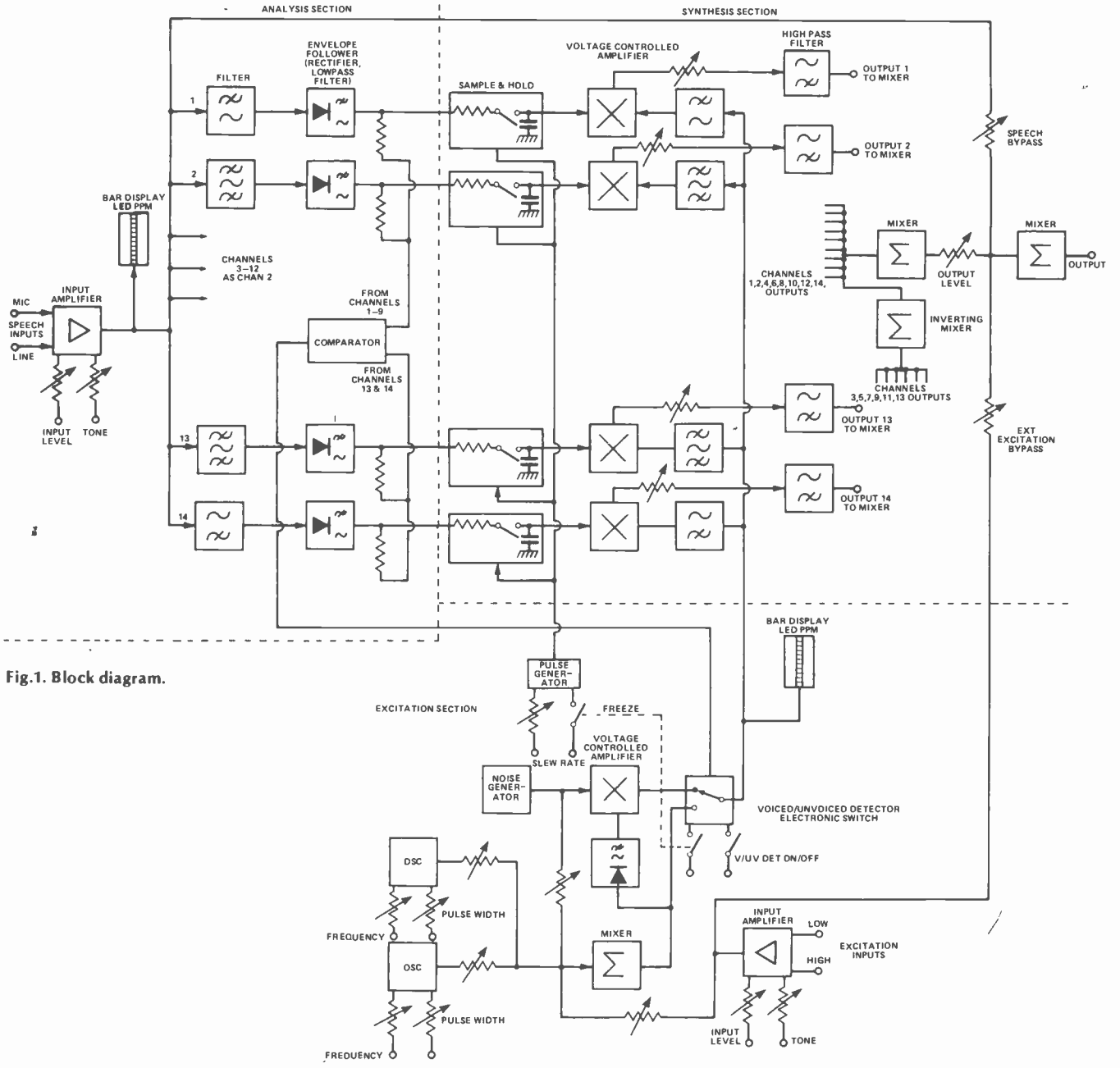
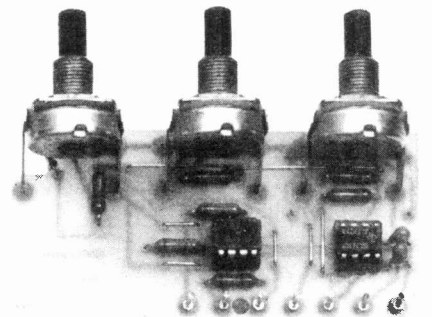
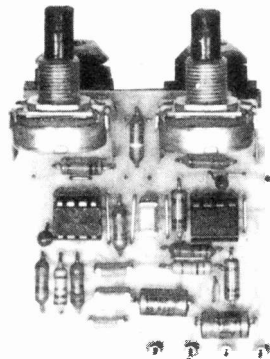
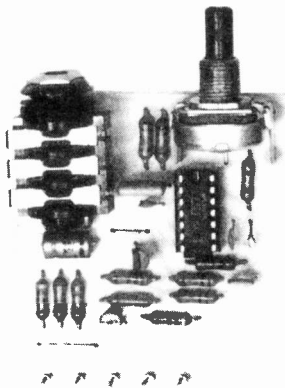


Fig.1. Block diagram.



Details of the smaller boards devoted to slew rate control (left), input amplifier (middle) and output amplifier (right) will be given in the concluding part of the Vocoder project next month.

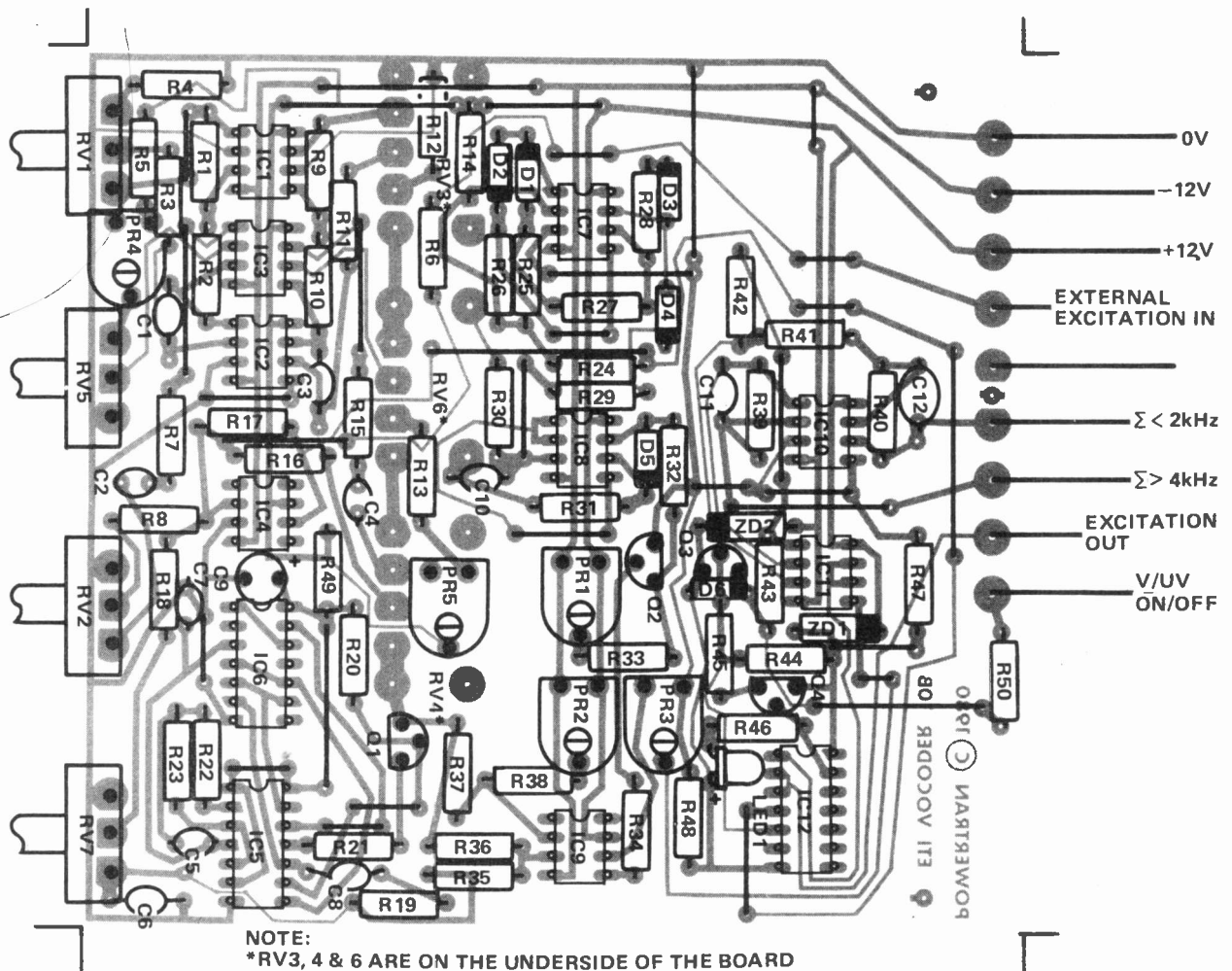


Fig.2. Component overlay of the internal excitation board.

## PARTS LIST

### RESISTORS — ALL 2% METAL OXIDE

R1,9,29,34,40,44,45,50	10k
R2,10	5k6
R3,11	18k
R4,12	560R
R5,13	11k
R6,8,16,18,35,39,43	47k
R7,15	150k
R14,30,42	1M
R17	100k
R19	15k
R20,24,25,26,27,28	4k7
R21,32	22k
R22	330k
R23	27k
R31	3k9
R33,38	470k
R36,37,46	1k5
R41,47,48	1k
R49	3k3

### POTENTIOMETERS

RV1,2,5,7	10k logarithmic
RV3,4,6	10k logarithmic
PR1,2	100k preset
PR3	220k preset
PR4,5	2k2 preset

### CAPACITORS

C1,3	100n polyester
C2,4	10n ceramic
C5	220p ceramic
C6	33n polyester
C7	100p ceramic
C8	10n polyester
C9	10u 16V tantalum
C10	100n polycarbonate
C11	220n polycarbonate
C12	1u0 polycarbonate

### SEMICONDUCTORS

IC1,2,7,10,11	1458
IC3,8	TL082 or LF353
IC4	741
IC5	4006
IC6	4030
IC9	CA3080
IC12	4016
Q1,3	BC182L
Q2,4	BC212L
ZD1,2	5V1 Zener
D1-D6	1N4148
LED 1	TIL209

### MISCELLANEOUS

9 way connector and pins, IC sockets, terminal pins, rotary on/off switch.

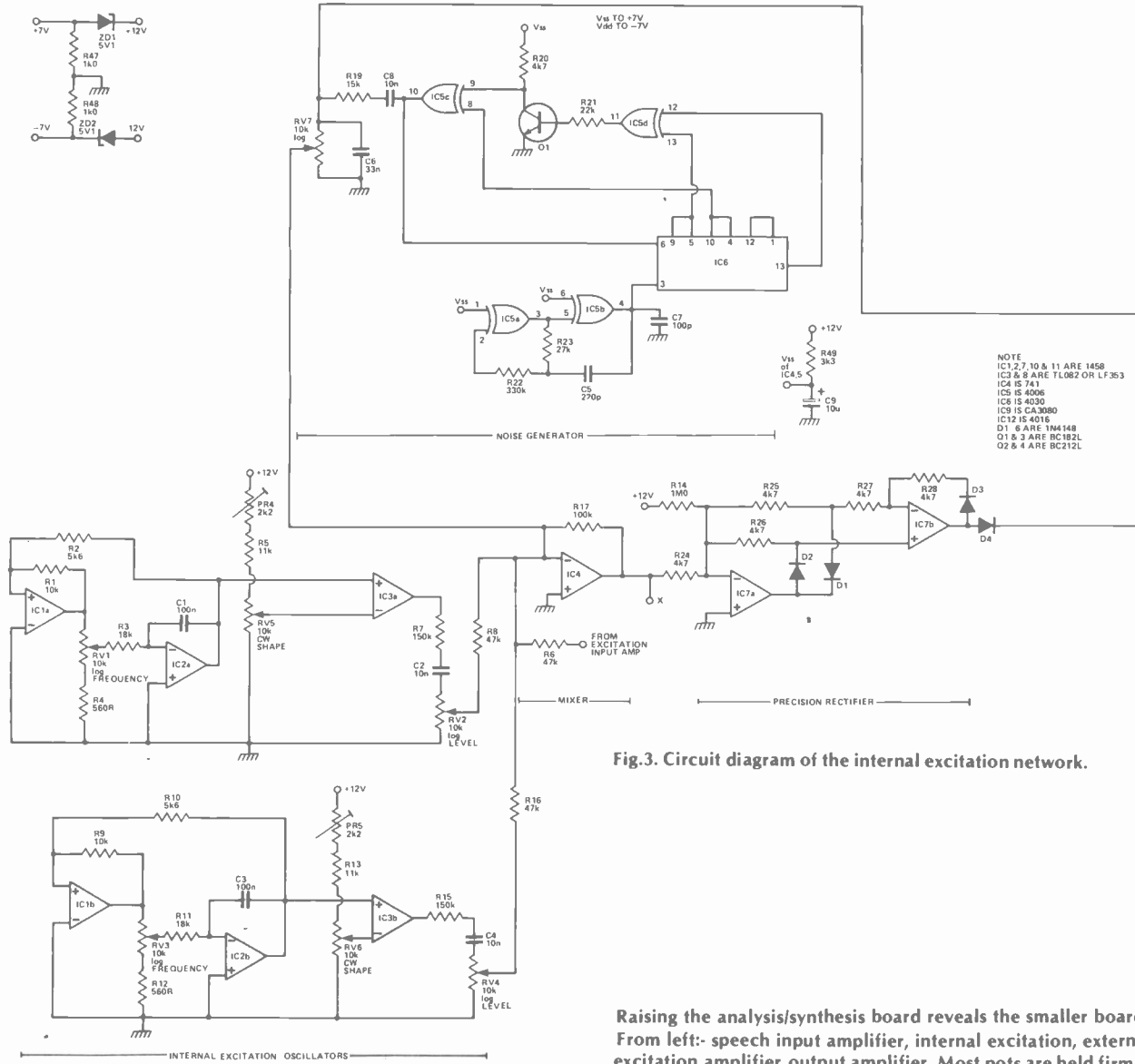
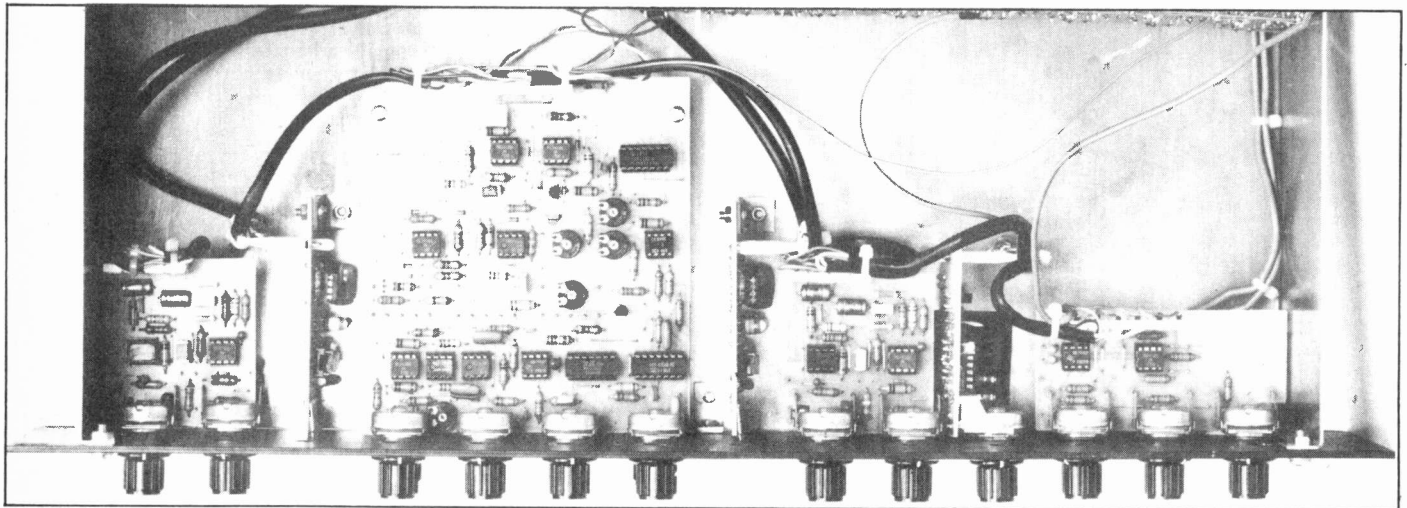


Fig.3. Circuit diagram of the internal excitation network.

Raising the analysis/synthesis board reveals the smaller boards. From left- speech input amplifier, internal excitation, external excitation amplifier, output amplifier. Most pots are held firmly on their PCBs by pot mounting frames.



## HOW IT WORKS

IC1, 2 form a pair of relaxation oscillators. IC2 is an integrator driven by the output of IC1. C1 is charged until it reaches about one third of the supply line voltage when the Schmidt trigger (IC1) changes state and C1 starts discharging until it reaches about one third of the supply line voltage in the opposite direction, making IC1 change state again. The output of IC2 is a triangular waveform which is compared with an adjustable DC voltage by IC3 to produce a pulse output of adjustable mark/space ratio. The outputs of the two oscillators are mixed with the external excitation and the noise by IC4.

The noise generator is a pseudo-random counter. IC5a,b form an oscillator operator at about 40 kHz. This clocks IC6, which is an 18 stage shift register with feedback applied round it via IC5c, d and Q1. The output of IC5c is a complex pulse train, which, when filtered by C8, R19, C6 has the characteristics of random noise with a very even frequency response.

The key part of the voiced/unvoiced detector is the comparator IC11a, which compares the levels of the speech components over 4 kHz with those below 2 kHz. It is not necessary to use separate filters for this purpose as the control signals at the outputs of IC3 of the analysis section contain the necessary information and these are summed by IC10a, b before comparison. When voiced speech is present IC11a goes low, Q3 turns off, its collector goes high and the analogue switch IC12b is opened allowing the output of IC4 to pass to the synthesis section. To match the noise level to that of the excitation from IC4 there is AGC. IC7a is a full wave rectifier peak detector which is buffered by IC8a. IC8b and Q2 are a voltage to current converter to provide a control current for the OTA IC9 through which the noise is passed.

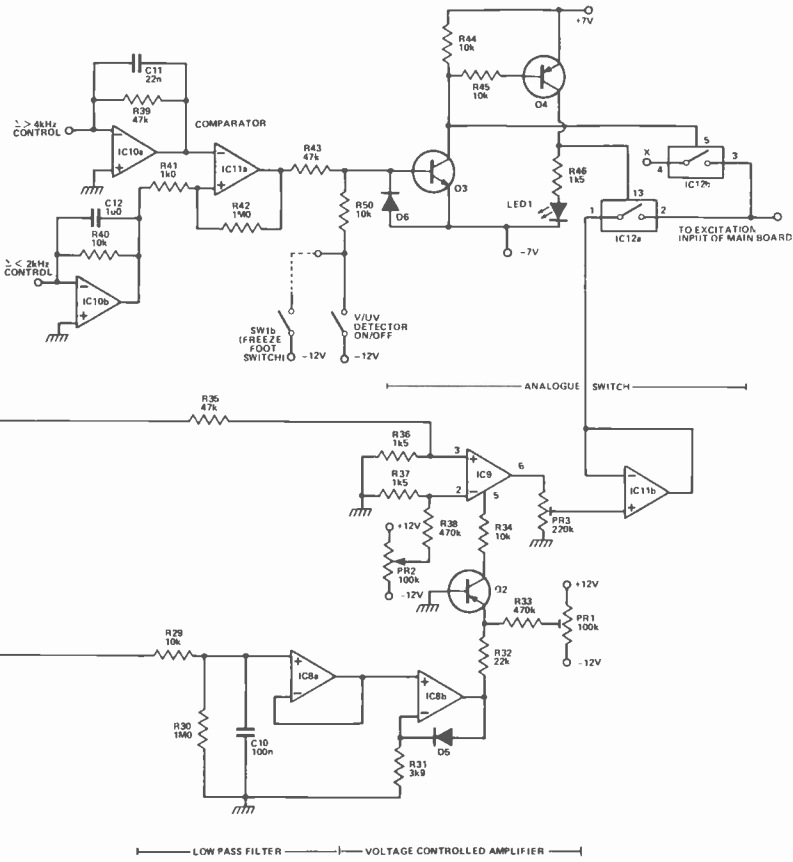
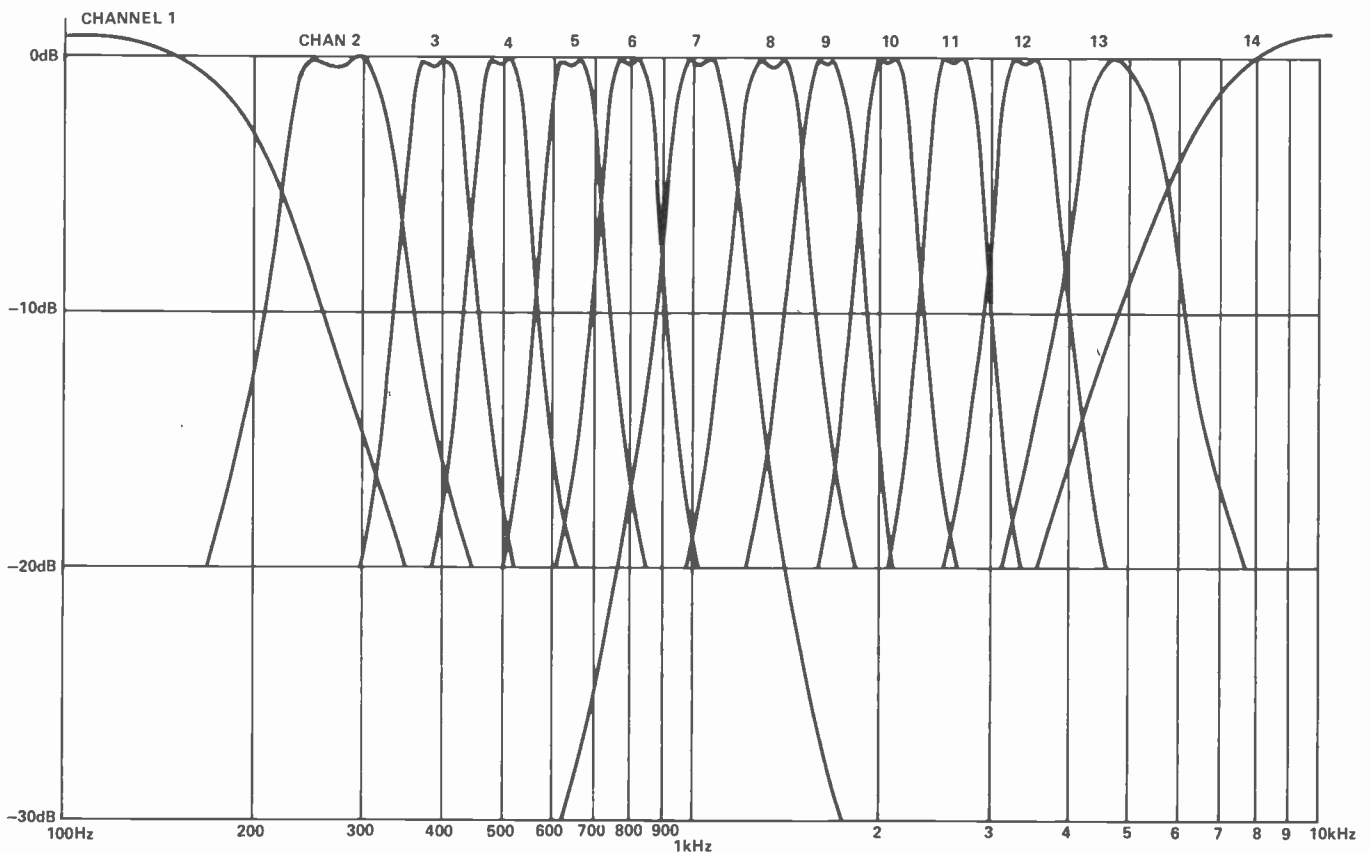
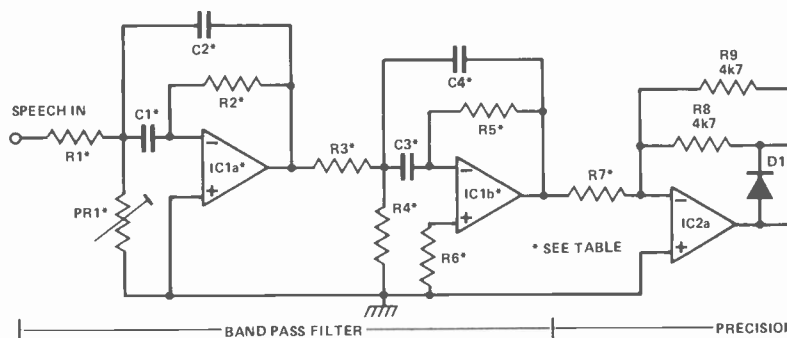


Fig.4.(below) Filter frequency response curves.



For external excitation, there is a pre-amplifier and tone control circuit similar to that used for speech. The output of this stage is mixed with the two oscillators (which generate pulses of variable width and frequency) and also with the output of the noise generator. The noise also passes through an AGC circuit to match its level to the excitation signals. This noise is then used to substitute for the other excitation signals by the voiced/unvoiced detector electronic switch when unvoiced speech is detected by the comparator which determines whether the majority of the energy in the speech is at low frequencies (2 kHz — voiced) or at high frequencies (4 kHz — unvoiced).



## BUYLINES

Powertran Electronics, Portway Industrial Estate, Andover, Hampshire, are supplying a complete kit of parts for this project at £195.00 plus 15% VAT. Delivery by Securicor is £2.50 extra. Everything is included in the kit down to the last nut and bolt. They even give you a 'freeze' footswitch and a test oscillator for setting it up!

Next month we conclude the Vocoder project with constructional details of the remaining boards and power supply, with notes on setting up and use.

## HOW IT WORKS

IC1 in channels 2-13 is the analysis bandpass active filter. PR1 adjusts the first section in relation to the second. When correctly set up there is an overall voltage gain of 10. In channels 1, 14 IC1 is a low pass filter and a high pass filter respectively. IC2 rectifies the signal to demodulate it to convert it into a control signal for the VCA. IC3 is an active low pass filter with a cut off frequency of 200 Hz or one fifth of the frequency of the bandpass filter, whichever is the higher.

R14 takes the output of IC3 out for analysis by the voiced/unvoiced detector. IC4 is the slewing rate controller, Q1 and R15 acting as a variable resistor which, in conjunction with C7, forms an RC network adjusting the slewing rate controller, Q1 and R15 acting as a variable resistor, which, in conjunction with C7, forms an RC network adjusting the slewing rate of the stage. Being a FET Q1 could, on its own, be used as a variable resistor by simply varying the V<sub>GS</sub>, but there are 14 of them to control simultaneously and without careful selection they would not track together. To deal with this Q1 is used instead as a switch which is turned on and off by a 1 kHz pulse signal of variable width. C7 is then charged and discharged at a rate dependent on the duty cycle of the pulse

signal and R15. During the ON period V<sub>GS</sub> is maintained at 0 by the feedback via R17.

IC5 and Q2 form a voltage to current converter, the gain of which is set by PR2 to compensate for variations in gain in IC6. For correct operation IC5's input must never go negative. To ensure that it doesn't, a bias voltage is applied via R15. This voltage together with the combined offset voltages of IC1-5 is nulled out by PR3.

IC6 is an OTA (operational transconductance amplifier), which could have been our old friend the CA3080, but a better device, the LM13600 is now available. It achieves very low distortion by having linearising diodes at the input. Bias current for these is supplied by R28. The gain is controlled by the current supplied to pin 1. The output of the OTA is taken to a volume control RV1 from where it goes back into IC6 to a buffer stage before being taken out via C12 and R30 to a virtual earth mixer. C12 and R30 serve as a high pass filter to remove breakthrough of the control signal. The excitation or music signal is applied to the OTA via IC7 which is a filter identical to that of IC1.

CHAN	PR1,5	R1,21	R2,22	R3,23	R4,24	R5,25	R6,26	R7	R12,13	C1,3,8,10	C2,4,9,11	C12	IC1,7
1	—	10k	10k	2k0	220R	10k	10k	4k7	68k	47n	150n	220n	TL082/LF353
2	2k2	2k0	82k	24k	910R	110k	110k	4k7	47k	68n	68n	47n	1458
3	1k0	6k2	180k	47k	560R	220k	220k	4k7	30k	39n	39n	33n	1458
4	1k0	6k2	180k	47k	430R	220k	220k	4k7	24k	33n	33n	27n	1458
5	1k0	6k2	180k	47k	430R	220k	220k	3k6	18k	27n	27n	22n	1458
6	1k0	6k2	180k	47k	430R	220k	220k	3k0	15k	22n	22n	18n	1458
7	1k0	6k2	180k	47k	560R	220k	220k	2k4	12k	15n	15n	15n	1458
8	1k0	6k2	180k	47k	560R	220k	220k	1k8	12k	12n	12n	12n	1458
9	1k0	6k2	180k	47k	510R	220k	220k	1k5	12k	10n	10n	10n	1458
10	1k0	6k2	180k	47k	470R	220k	WIRELINK	1k2	12k	8n2	8n2	8n2	TL082/LF353
11	1k0	6k2	180k	47k	430R	220k	WIRELINK	1k2	12k	6n8	6n8	6n8	TL082/LF353
12	1k0	6k2	180k	47k	560R	220k	WIRELINK	1k2	12k	4n7	4n7	4n7	TL082/LF353
13	2k2	2k0	82k	24k	1k1	110k	110k	1k2	12k	3n3	3n3	4n7	1458
14	—	13k	43k	2k0	220R	43k	13k	1k2	12k	1n0	1n0	4n7	1458

Table 1. Component values for the 14 channels of the analysis/synthesis section.



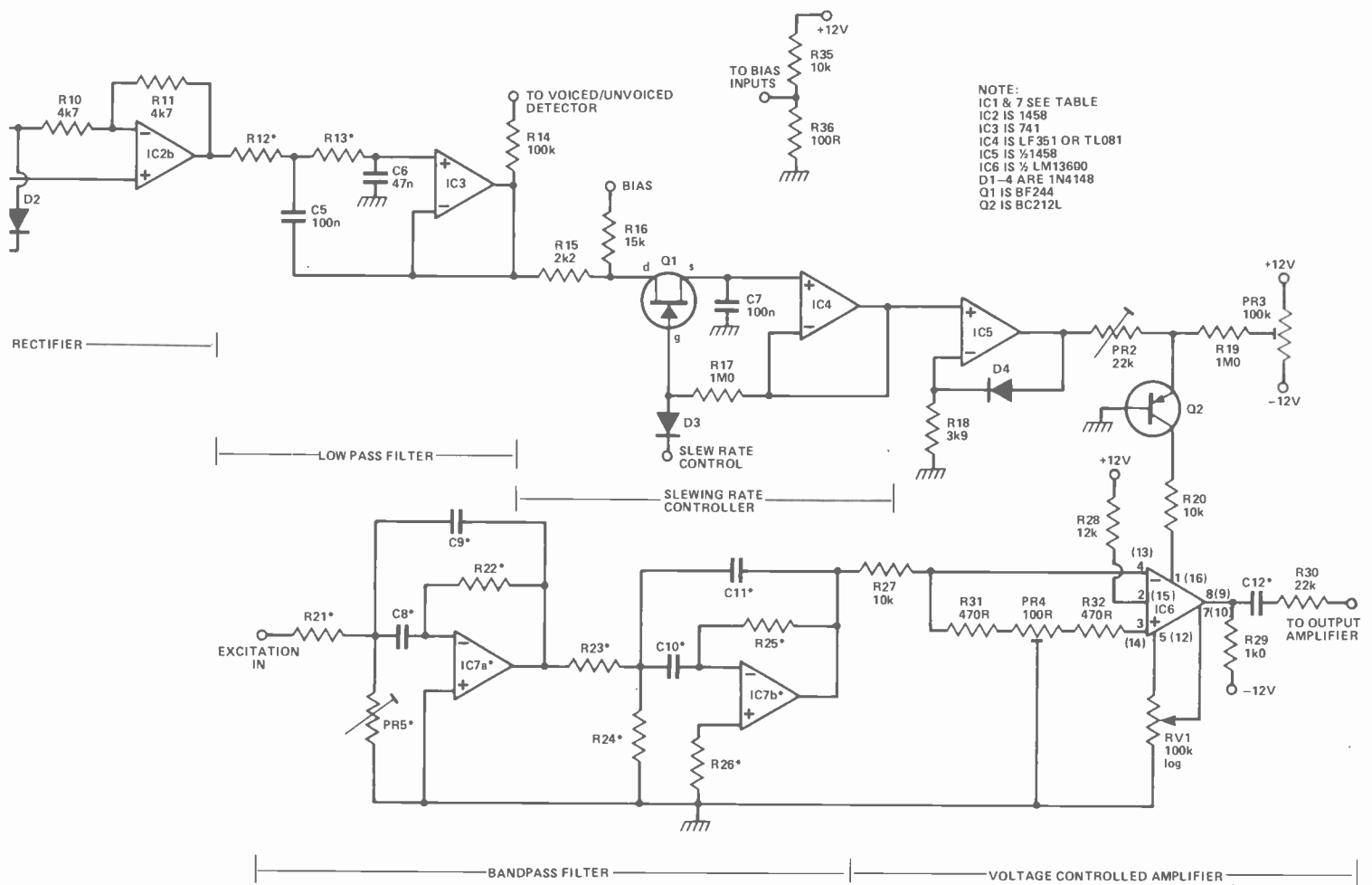


Fig.5a(above). Circuit diagram of analysis/synthesis section.

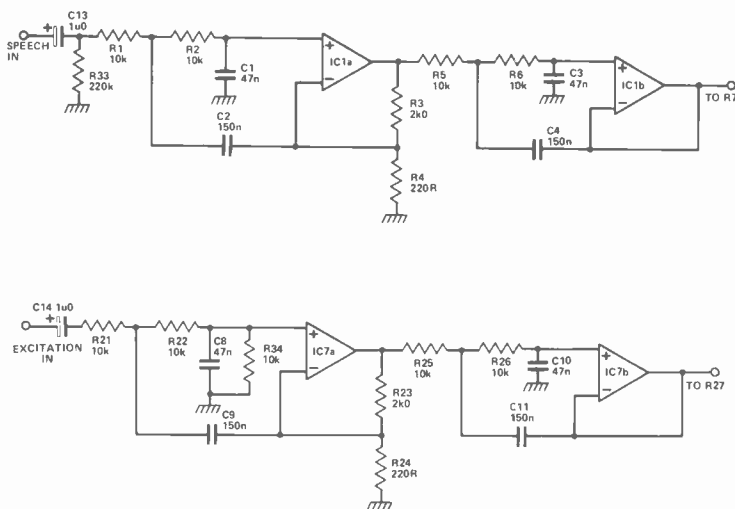


Fig.5b. In channel 1 band pass filters are replaced by the low pass filters shown above.

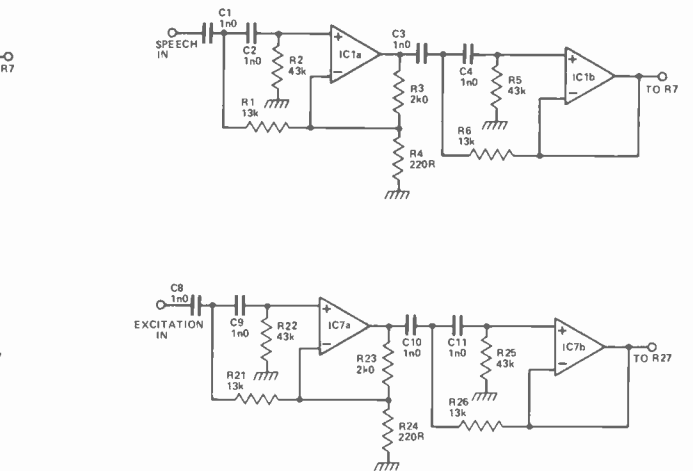


Fig.5c. In channel 14 band pass filters are replaced by the high pass filters above.

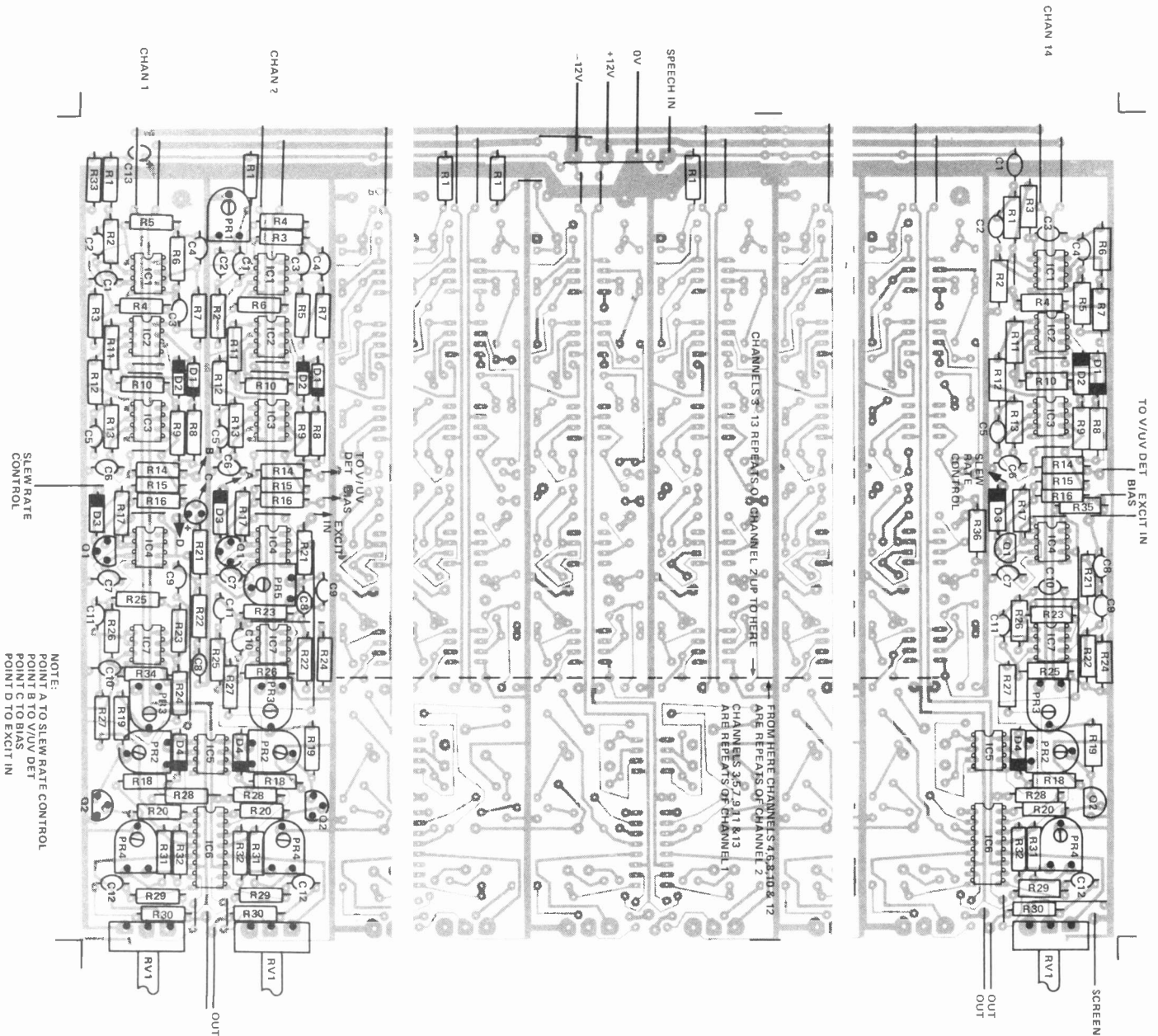


Fig. 6. Component overlay of the analysis/synthesis section. We haven't shown the whole board, as the channels are very similar. The three parts of the board (above) show channels 1, 2 and 14 and the power connections in the middle.

## PARTS LIST

### PARTS COMMON TO ALL CHANNELS

#### RESISTORS ALL 2% METAL OXIDE

R1-7, 21-26	see Table 1
R8,9,10,11	4k7
R12,13	see Table 1
R14	100k
R15	2k2
R16	15k
R17,19	1M
R18	3k9
R20,27	10k
R28	12k
R29	1k
R30	22k
R31,32	470R

#### POTENTIOMETERS

RV1	100k logarithmic
PR1,5	see Table 1
PR2	22k preset
PR3	100k preset
PR4	100R preset

#### CAPACITORS

C1-4,8-12	see Table 1
C5,7	100n polycarbonate
C6	47n polycarbonate

#### SEMICONDUCTORS

IC1,7	see Table 1
IC2,5*	1458
IC3	741
IC4	TL081 or LF351
IC6*	LM13600

D1-4	1N4148
Q1	BF233C
Q2	BC212L
*only 1/2 of IC used in each channel	

#### PARTS SPECIFIC TO CHANNEL 1

R33,34	220k
C13,14	1u0 tantalum

#### PARTS SPECIFIC TO CHANNEL 14

R35	10k
-----	-----

#### PARTS SPECIFIC TO CHANNEL 13

R36	100R
-----	------

#### MISCELLANEOUS

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# DRILL SPEED CONTROLLER

Keep your electric drill under control with this handy circuit... cheap and simple.

This circuit enables you to control the speed of any appliance that uses a 'universal' motor-drills, sanders, polishers, etc. Only a few components are required and this circuit is just about the simplest that can be built from discrete components. Don't let that put you off though! You get full-wave control from zero to full speed. Who could ask for more?

## Construction

We built our unit on its PCB into a standard plastic switch-box and fitted the speed control onto a plastic blanking plate. No heatsink was used on the prototype and one will probably not be required for intermittent use.

## Warning

Remember that when running an appliance at low speeds, the efficiency of the cooling fan normally built onto the motor-shaft will be severely reduced. This may result in your motor burning out, so remember to allow the windings to cool when running for an extended period or simply run the appliance at full speed off-load for a short while.

There are no special points to watch with this circuit. A PCB design is given, though any method of construction may be employed. Note that 400 V polypropylene capacitors were used in the prototype as these are better able to withstand connection to the AC mains. Despite its simplicity, this circuit will provide a smooth, wide-range control and amply repays the little effort involved in its construction.

## BUYLINES

All the necessary components should be readily available from your usual suppliers. See mail order suppliers advertising in this issue. The polypropylene capacitors are available from Electrovalve Ltd, 28 St Judes Road, Englefield Green, Surrey TW20 0BH.

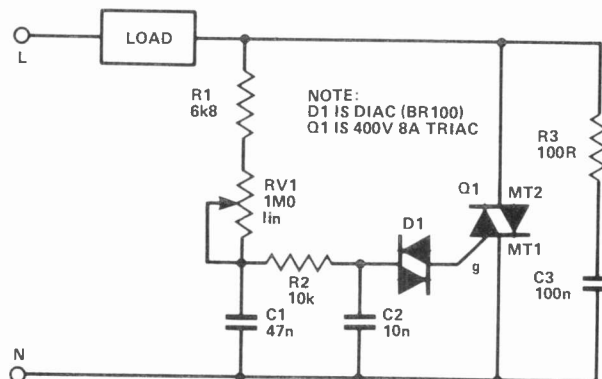
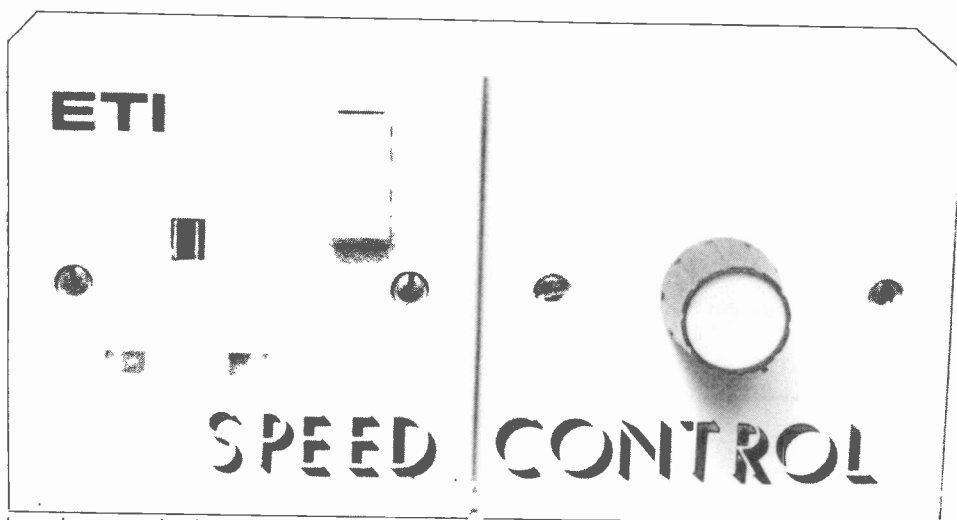


Fig.1. Circuit diagram.

## HOW IT WORKS

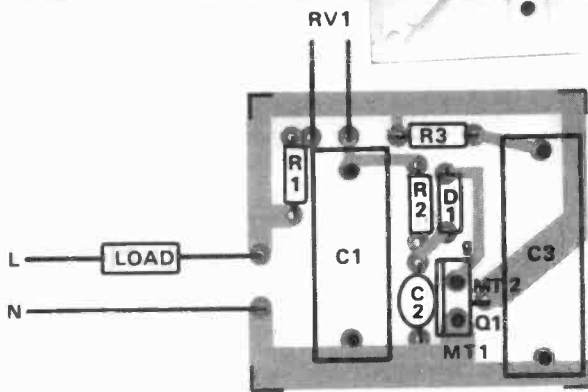
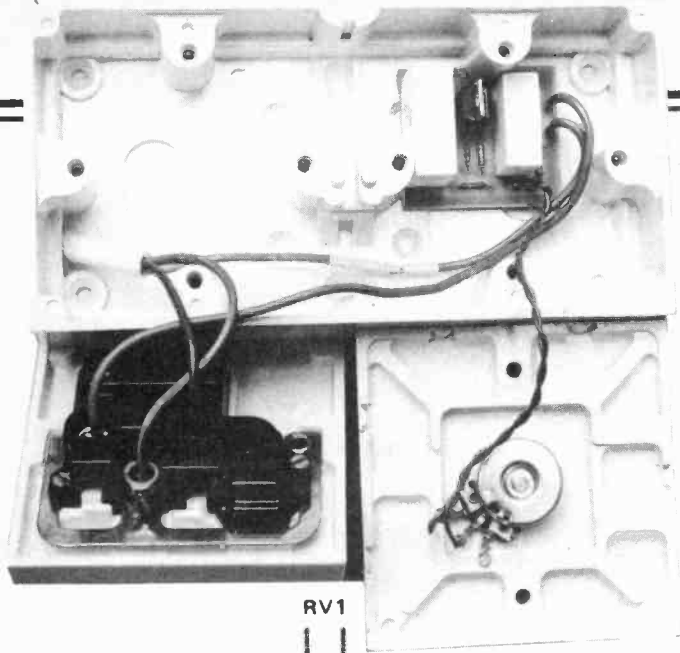
The essential feature of the circuit is triac Q1. This bi-directional electronic switch controls power flow through the load. This can be any 'universal' motor as may be found powering an electric drill, polisher, etc. The resistor-capacitor combination R3, C3 comprise a snubber network which prevents spurious switching effects in the triac. The triac is turned on when the current flow in its gate — MT1 junction exceeds a certain value. Direction of current flow is unimportant, though there will be a small difference in the sensitivity of the triac, and the device will switch on for both cycles of the alternating mains waveform.

The resistor-capacitor network built with R1, 2, RV1, C1, 2 cause an alternating waveform at mains frequency to appear at the 'hot' end of C2. Adjustment of RV1 controls the phase of this signal with respect to the mains input. When the voltage across C2 exceeds about 30 V, current will flow in the gate circuit of the triac, turning it on. It remains on until the applied mains voltage falls to zero. It then remains off until re-triggered. Dissipation in the triac is low as it is only ever either fully on or fully off and a heatsink is unlikely to be required.

# PROJECT: Drill Speed Controller

(Left) The PCB fits snugly into a standard plastic switch box and the speed control is mounted on a plastic blanking plate. A switched power socket completes the picture.

Fig.2 (bottom left). Component overlay



## PARTS LIST

<b>Resistors</b>	
R1	6k8
R2	10k
R3	100R
<b>Potentiometer</b>	
RV1	1M0 linear
<b>Capacitors</b>	
C1	47n 400 V AC polypropylene
C2	10n polyester
C3	100n 400 V AC polypropylene
<b>Semiconductors</b>	
Q1	8 A 400 V triac
D1	Diac (BR100 or equiv.)
<b>Miscellaneous</b>	
Case, PCB, Power Outlet, etc.	

ETI

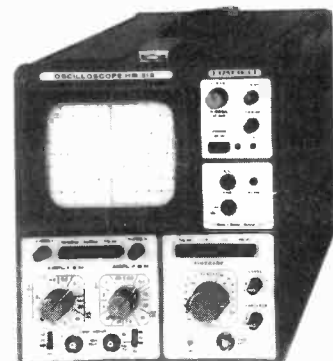
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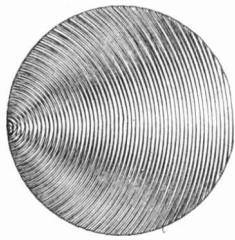
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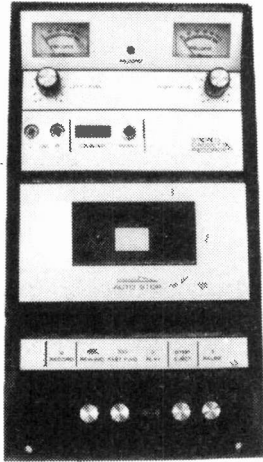
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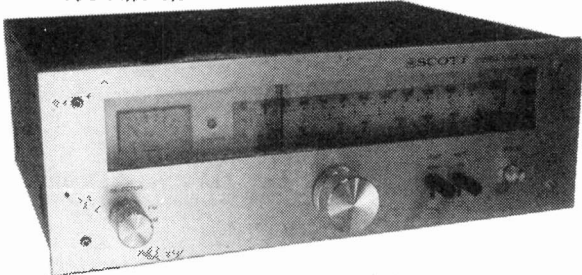
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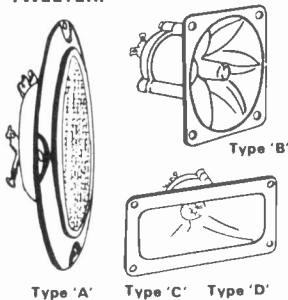
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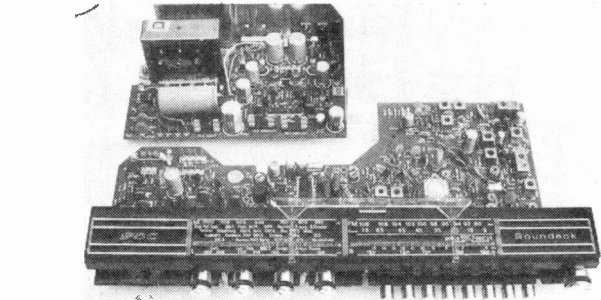
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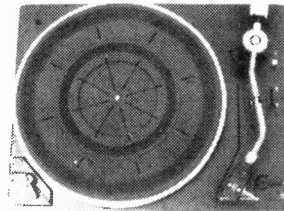
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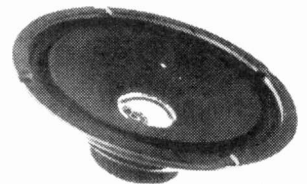
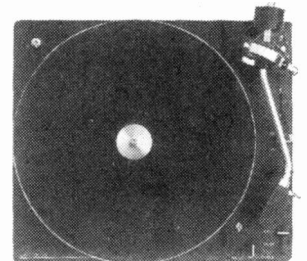
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# TV SOUND TUNER

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The BBC frequently 'simulcasts' the sound channel of some of its television music presentations. As well as providing stereo, this gives a dramatic improvement in sound quality. In fact TV sound is transmitted with frequency modulation and can provide good quality (though in mono). The weak link in the system is the TV audio stage and small loudspeaker.

This unit enables you to feed a high quality TV audio signal into your hi-fi; so you will not have to chip your speakers from their concrete columns or mount the TV in the fireplace (even though the chimney does provide an excellent ventilating system!) Use of ready built and aligned modules makes the project very easy to build and it is not expensive!

## Tuner Control

An ELC1043 varicap tuner and IF board are bought separately (see 'buylines') and assembled. A handful of other components mount on our PCB and provide power supplies and an optional monitor amp. The varicap tuner is controlled by a single tuning voltage of 0-30 V. We used a surplus push-button station selector unit but any source of a stable voltage may be pressed into service. If you are really up to date, you can even tune the system with your home computer.

## Construction

The tuner mounts directly on the IF board. All the holes are there, as well as quite a few spares, though you will need to enlarge the holes for the screening can lugs. Two resistors set the AGC voltage and a capacitor filters the tuning voltage. Be

careful when dealing with the IF board not to disturb any of the adjustments. Remember the units are pre-aligned.

## To The Manor Borne

We had our board running within an hour but then it failed mysteriously. Manor quickly sorted us out and sent us away with strict warnings about playing football with the board! Remember that the TV signal comes in on a wing and a prayer at a few hundred MHz and even the IF operates at 38 MHz so show it some respect.

Construction of the PSU and amplifier PCB is straightforward. Take special care to connect the screening braids as shown to avoid hum pick-up. When the unit is assembled into its case, with an aerial connected, a station should be tuned in. A slight buzz may be present. This can be nulled out by adjusting the tuning control whilst making slight adjustments to the quad coil. This is preadjusted and should not need to be moved more than a turn to compensate for the effects of added stray capacitance from the case, etc.

## Home Programming

Two versions of the tuner front-end are available. They are interchangeable. Our prototype used the cheaper GI device and we were unable to make any comparison with the more expensive Mullard unit. You pay your money and you takes your choice. Whichever you choose, this project will reward you with quality TV sound. We cannot help with the programmes ...

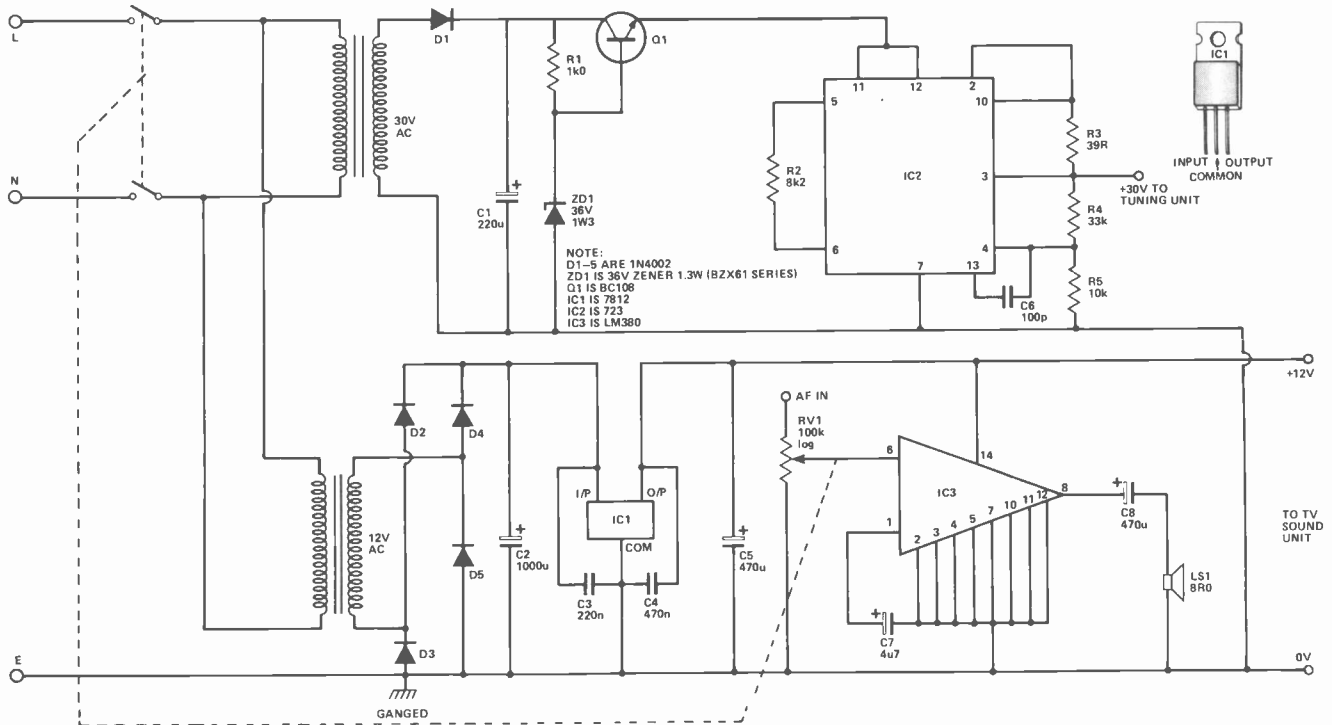


Fig.1. Circuit diagram.

## HOW IT WORKS

The TV signal is converted from its UHF carrier frequency down to a more manageable 38 MHz intermediate frequency (IF) by the varicap tuner module ELC1043. 'Varicap' refers to the variable capacitance diodes which replace mechanical tuning capacitors in the front end. The capacitance of the diodes varies according to the reverse bias voltage applied to them. All diodes exhibit this effect but varicap diodes are optimised for operation as capacitors. A relatively high voltage is required and an extra 30 V supply is generated (channels 21 to 34 can be tuned with 0 to 12 V supply).

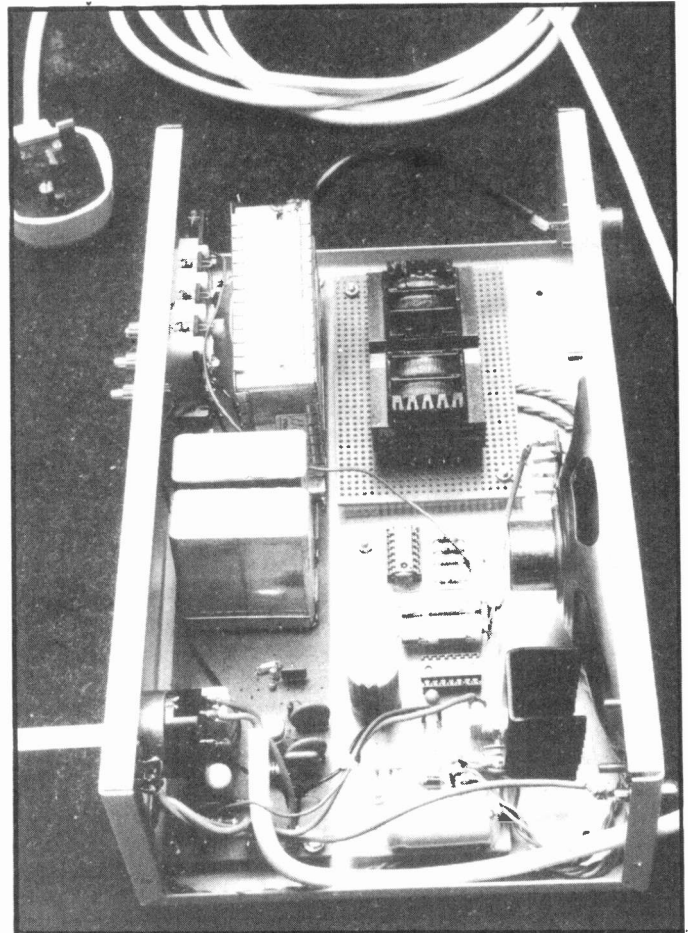
The output from the tuner module is coupled to the IF stage via a 1n0 capacitor. Our unit came with the capacitor mounted in place — a small disc ceramic is fine. The two cans on the IF sub-assembly are Philips G8 colour receiver modules. Their output is coupled to the TAA570 detector via a 6 MHz ceramic filter which removes the video signal but passes the 6 MHz FM sound carrier. Keep your wiring away from this area of the board. If you touch a finger to the ceramic filter you will hear a variety of AM broadcast stations come booming through! The audio output is coupled via a 1µF electrolytic capacitor.

Note that a video signal is available from the IF board. Although it has a reasonable level — around 1V0 peak-to-peak — you will need to buffer the signal before attempting to use it. Refer to the G8 service manual for suitable circuitry.

Both the tuner and IF board are supplied pre-aligned. A 100nF capacitor is added to the board to filter any track noise from the tuning control and two resistors are used to preset the AGC for optimum gain. A TAA570 detects the sound signal and produces an AF output of a volt or so. This signal will drive your hi-fi directly or via a resistive divider if the amplitude is too high. We incorporated a simple monitor amplifier in our design.

The power supply is quite conventional. A 30 V AC winding is half wave rectified producing a DC voltage of about 43 V. This is pre-regulated by the circuitry around Q1 to reduce the supply below the 40 V absolute maximum required by IC2. This is a 723 regulator chip connected to provide a stable nominal 30 V supply for the station control unit which feeds the tuning voltage to the TV front end.

Output current is limited to about 20 mA though in normal operation only about 1 mA or 2 mA will be drawn. A 12 V AC winding is rectified and regulated with a 7812 IC regulator. This supplies the IF board (about 100 mA) and an on-board monitor amplifier — the LM380. If you do not require an amplifier then omit RV1, IC3, C7,8 and the loudspeaker. Note that IC1 runs rather warm and should have a small heatsink fitted. Although we used a surplus TV station selector unit, any multiturn pot(s) may be pressed into service. 100k units work well.



The ready-built IF sub-assembly fits along the front of the case, with our monitor amp behind.

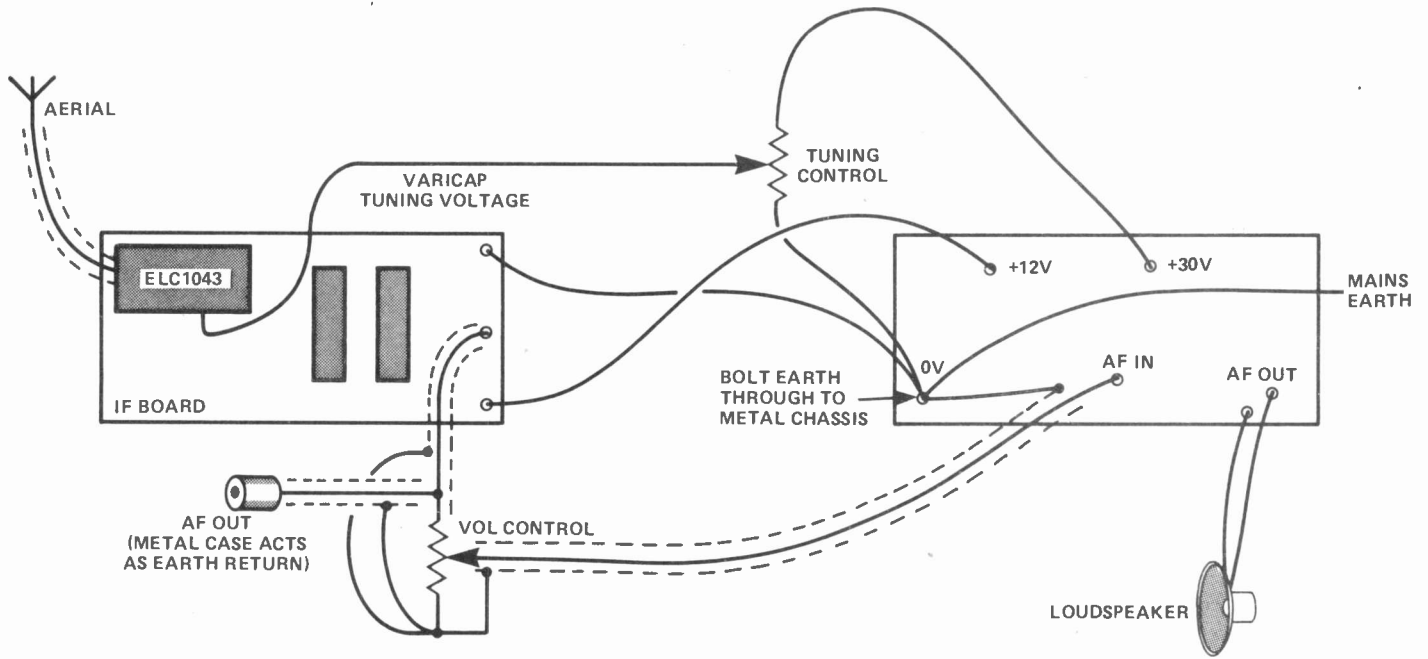


Fig. 2. Connections between our amplifier and the ready-made IF board.

## PARTS LIST

Resistors All 1/4W 5%

R1	1k0
R2	8k2
R3	39R
R4	33k
R5	10k

one 6k8 and one 2k2 resistor are required to set the AGC level.

Potentiometer

RV1	100k log.
-----	-----------

Capacitors

C1	220u 63V electrolytic
C2	1000u 25V electrolytic
C3	220n polyester
C4	470n polyester
C5,8	470u 25V electrolytic
C6	100p ceramic
C7	4u7 tantalum

one 100n capacitor is required to filter the tuning voltage.

Semiconductors

IC1	7812
IC2	723
IC3	LM380
Q1	BC108
D1-5	1N4002
ZD1	36V zener 1.3W (BZX61)

Miscellaneous

12V transformer, 30V transformer, heatsink, loudspeaker, varicap tuner, IF board, case.

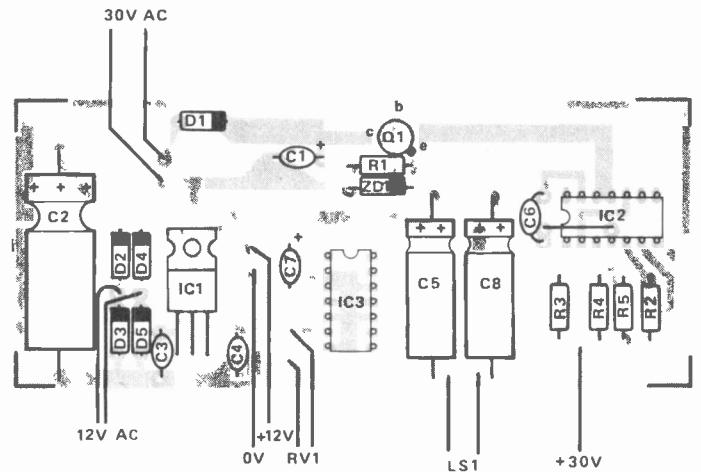
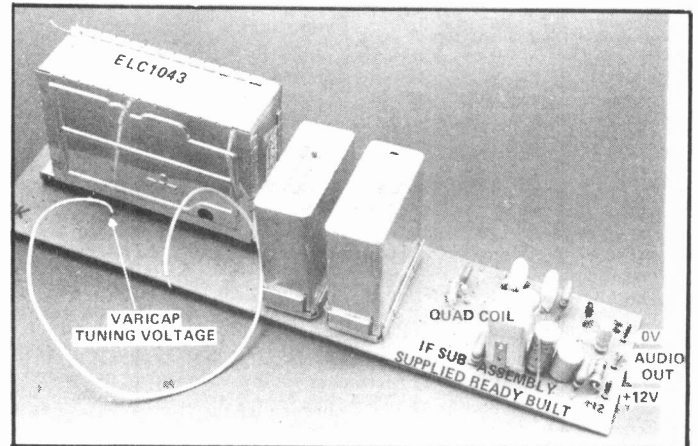


Fig. 3. Component overlay.

## BUYLINES

The ELC1043 varicap UHF tuner and IF sub-assembly are available from: Manor Supplies, 172 West End Lane, London NW6. Tel: 01-794 8751. They can also supply a suitable push-button station control unit.



The UHF tuner mounted on the IF sub-assembly.

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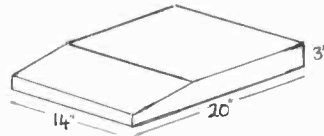
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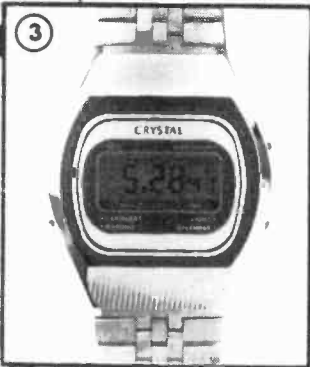
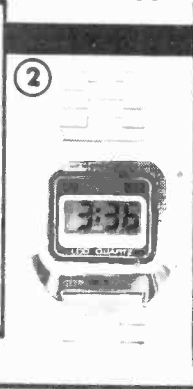
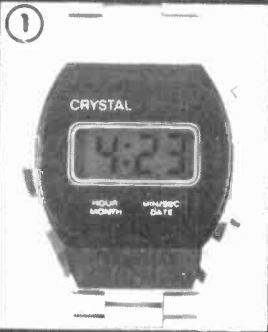
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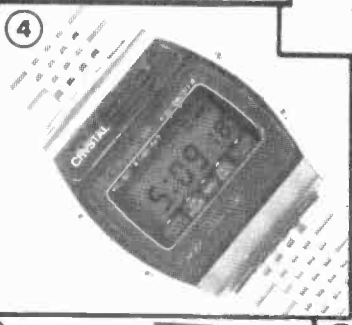


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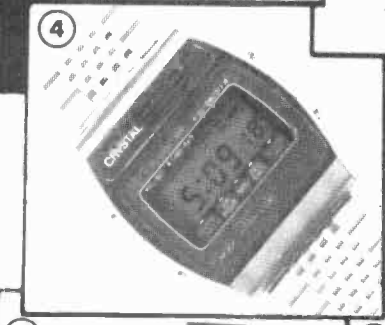
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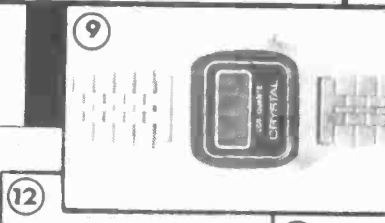
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# DIGITAL TEST METER

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Two of the most useful pieces of modern electronic test gear are the Digital Multimeter (DMM) and the Digital Frequency Meter (DFM). These instruments are highly accurate, rugged and can be used in any attitude (vertical, horizontal, upside down, etc). Trouble is, they tend to be a bit expensive; a decent pair of such instruments costs about £200.

We have overcome the price by producing a unique 30-range digital instrument that acts as a combined 25-range DMM and 5-range DFM. We've decided to call this new instrument a Digital Test Meter, or DTM. Our DTM is designed around the very latest 3½ digit liquid crystal digital voltmeter module (thereby simplifying construction), is powered from two 6 V battery supplies and typically gives several months of operation from a single battery set.

The AV (alternating voltage) ranges of the DTM are frequency compensated; they are typical responses that are flat within 1% to 40 Hz or to within 1 dB to 120 kHz.

The resistance indicating section of the DTM uses a ratiometric measurement technique and a test voltage of about 300 mV maximum, thereby enabling in-circuit resistance measurements (such as a resistor in parallel with a semiconductor junction) to be made without forward biasing in-circuit junctions. The DTM is provided with an independent facility (via a specific test terminal) for testing semiconductor junctions.

The frequency meter section of the unit can be used to measure frequencies in the range 10 Hz to 1.999 MHz. The input impedance of the section is roughly 200 kΩ and signal levels in the approximate range 10 mV to 100 V can be accepted.

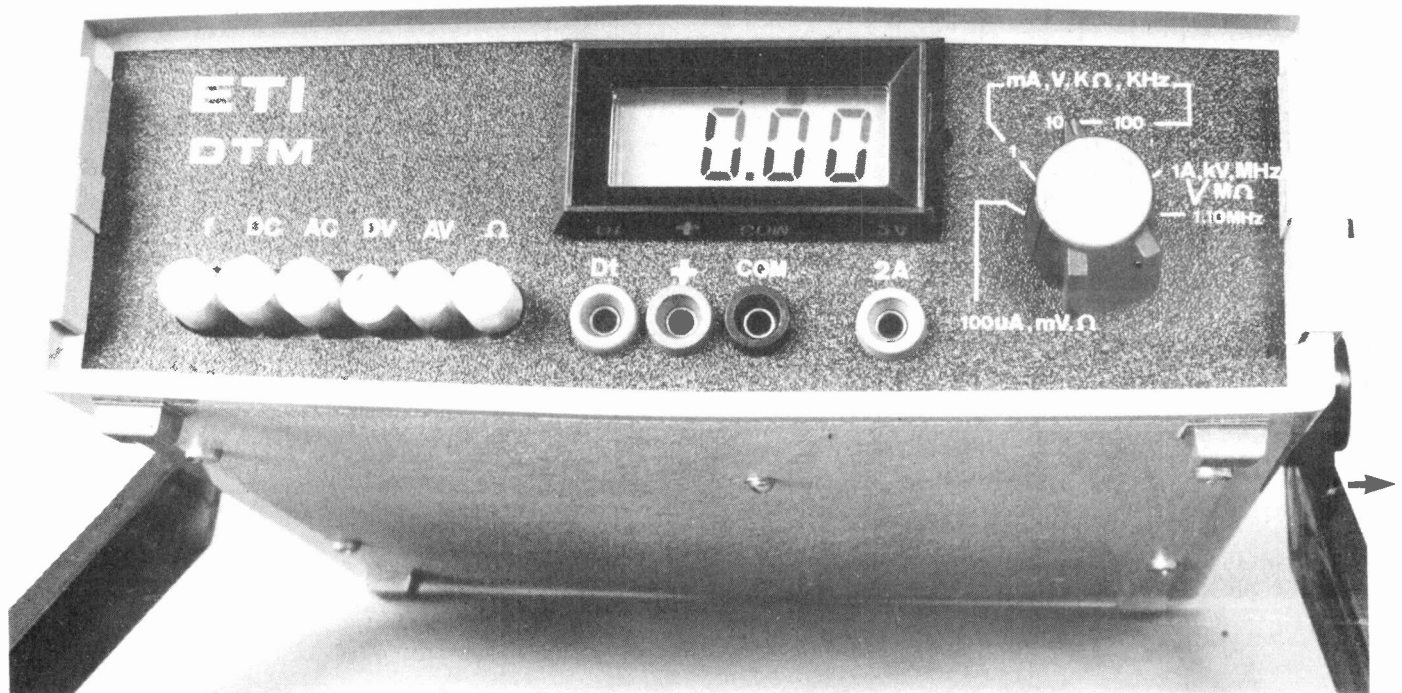
The DTM is provided with a built-in precision 1V2 DC reference, which can be used for basic calibration of the DC and DV ranges. Resistance calibration is automatically established by built-in standard resistors. The instrument must be compared with external standards to calibrate the basic AC, AV and frequency ranges.

## Accuracy

The basic 3½ digit DVM module used in the DTM is intended to read 100 mV full scale, with 100% over-range capability (giving a maximum reading of 199.9mV). The basic module is capable of reading with an accuracy that is within 0.1% (one digit, or 100 uV) of full scale, once it has been initially calibrated against a suitable reference standard.

In practice, all other ranges of the DTM are obtained by feeding inputs to the DVM module via resistive potential dividers, current ranging resistors and resistance standards.

In our prototype DTM we've used 1% resistors in all pertinent positions, thus giving the completed instrument an overall accuracy of 1% which we consider to be adequate for most practical purposes. If you want higher accuracy,



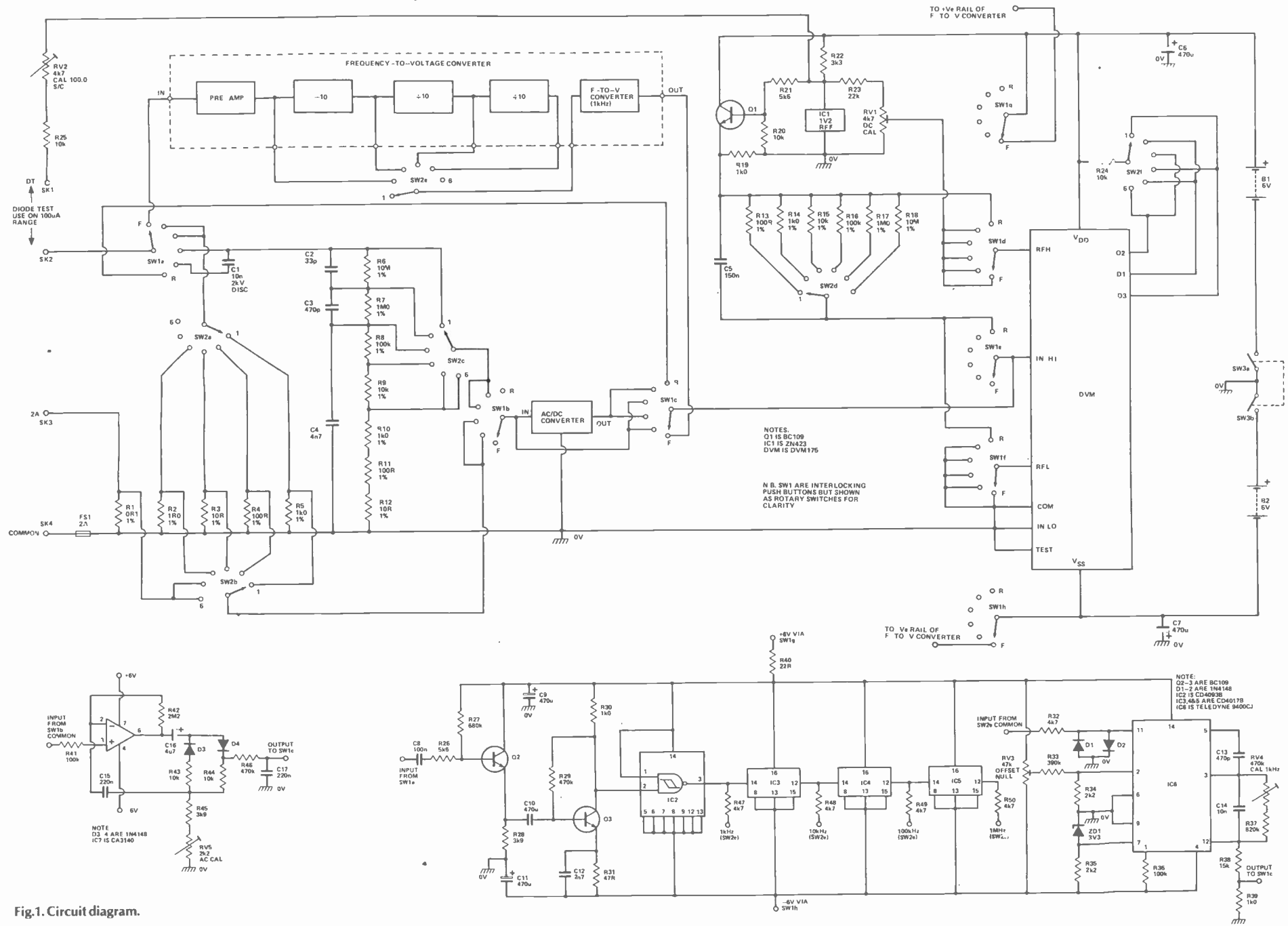


Fig. 1. Circuit diagram.



## HOW IT WORKS

SW2 RANGES	SW1 'MODE' SETTINGS					
	f	DC	AC	DV	AV	R
1	—	100uA	100uA	100mV	100mV	100R
2	1kHz	1mA	1mA	1V	1V	1kΩ
3	10kHz	10mA	10mA	10V	10V	10k
4	100kHz	100mA	100mA	100V	100V	100k
5	1MHz	1A	1A	1kV	1kV	1MΩ
6	—	1A	1A	1kV	1kV	10M

Table 1. SW2 range details for the six meter functions.

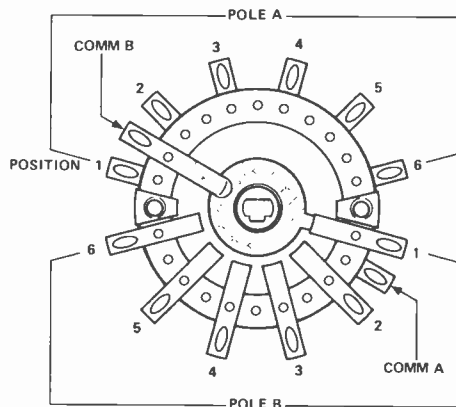


Fig.2. The wiring of SW2 (above) can become a veritable jungle if you're not careful. Lock yourself away from all distractions for half an hour and work round each pole in turn.

The heart of the DTM is a DVM 176M Rev C 3½ digit liquid crystal DVM module, available from Ambit International. This module has a built-in voltage reference and is intended to be powered from a single 9V battery. The complete module (including the readout) typically draws only 1 mA of current and is intended to read 100 mV DC full scale with 100% over-range capability (giving a maximum reading of 199.9 mV).

In our particular application we need, for various reasons, to power the module from a split 12 V (6-0-6) battery supply, which makes it necessary to ignore the module's built-in voltage reference, and supply it with a reference voltage from an external source. IC1 and the RV1-R23 divider are used for this purpose.

In the completed DTM, voltage ranging is obtained by feeding inputs to the DVM module via the R6-R12 potential divider network. AC voltage ranging is obtained by feeding inputs to the DVM module via the same potential divider (which is frequency compensated via C2-C3 and C4) and via a precision AC/DC converter (designed around IC7).

Current ranging is obtained by feeding the test current through the appropriate one of the R1 to R5 ranging resistors and monitoring the voltages that they generate. In the DC mode, the generated voltages are fed directly to the input of the DVM module. In the AC mode, they are fed to the module via the AC/DC converter.

Frequency indication is obtained by feeding input signals to the DVM module via a precision frequency-to-voltage converter. The f-to-v converter has a basic range of 10 Hz to 1,999 kHz and frequency ranging is achieved by feeding input signals to the converter via switch-selected decade divider networks.

Resistance measurements are made by disconnecting the external reference from the DVM module and connecting the test resistor in series with the appropriate one of the R13 to R18 ranging resistors and powering the combination with a few hundred millivolts DC (via the IC1-Q1 network). The voltage of the ranging resistor is monitored at the reference-input terminals of the DVM module and the voltage of the unknown resistor is monitored at the module's signal input terminals. The DVM module compares the ratios of the two voltages (and thus the ratios of the resistors) and gives a readout that is interpreted directly in terms of resistance.

This 'ratiometric' system of resistance measurement has two distinct advantages. First, maximum test voltages of only a few

you'll have to locate a source of supply of ultra-precision resistors.

Construction of the unit presents a bit of a challenge, due to the complexity of the interwiring. Construction needs to be tackled in a methodical manner, with the unit being given a functional check at the end of each building stage. The following building sequence is recommended.

## DV Ranges & AV Ranges

Gather all hardware together (switches, battery pack, sockets, fuse holder and the DVM module and bezel) and secure them in their final positions in the instrument case. On our prototype, we've used a bank of push-button switches for SW1 (mode selection) and a rotary switch for SW2 (range selection). On/off switch SW3 is mounted on the rear of the instrument. SW1 is mounted on a small PCB and fixed, via

hundred millivolts are applied to the unknown resistor, thereby enabling in-circuit resistance measurements to be made without causing semiconductor junctions to become forward biased. Second, the accuracy of measurement is independent of the energising voltage and is determined solely by the accuracy of the ranging resistors, thus eliminating calibration problems. Our circuit measures resistances of 0R1 to 19.99M in six ranges.

In the DTM, multi-pole switch SW1 is used to select the mode of operation and SW2 is used for range selection. SW2 sets the decimal point of the display to a position appropriate for the selected range.

The DTM has a facility for testing semiconductor junctions. To use this facility, the unit is switched to the 100uA range in the DC mode and the test device is connected between the DT+ and + terminals of the instrument. The DT+ terminal is energised from the built-in 1V2 source via RV2 and R25 and the resulting device current is read out by the DVM module. Open circuit devices give a reading of zero. Short circuit devices give a reading of 100.0. Good silicon junctions give a forward reading of roughly 60.0.

The AC/DC converter section of the instrument is designed around IC7, which is connected as a precision rectifier. The gain of the circuit can be pre-set, for calibration purposes, via RV5. The output of the converter is integrated by the R46, C17 network and by an additional network that is incorporated in the DVM module.

Frequency to voltage conversion input test signals are fed to high-impedance (roughly 200k) input buffer Q2 via safety resistor R26 and are then amplified by Q3 and converted to square waves at the input frequency via IC2. The resulting square waves are then divided down by decade dividers IC3 to IC5.

The heart of the converter is IC6 which, quite simply, is a dedicated precision frequency-to-voltage converter chip, in which the input signal is fed to pin 11 via R32 and a proportional analogue voltage appears at the junction of R38-R39. In our application, the IC is configured to cover the basic range of 10 Hz to 1,999 kHz. Frequency calibration can be set via RV4 and offset nulling (zero output for zero input) can be achieved via RV3.

Frequency ranging of the complete converter circuit is obtained by feeding the input of IC6 from an appropriate point in the IC2-IC5 network via SW2e. Thus, on the 1kHz range IC6 is fed directly from the output of IC2; on the 1MHz range, IC6 is fed from the output of IC5.

self-tapping screws and ¼ inch spacers into studs moulded into the base of the case.

Make up PCB A as shown in the overlay, taking special care over the construction. Note that 1% resistors are used in the range-determining positions. Fit Veropins in all appropriate positions on the board, to facilitate wiring interconnections. Make up the power supply (+6 V, 0 V and -6 V) connections to the board via SW3.

Make up the following interconnections to the DVM module, noting that the module is a MOS device and can be damaged by static charges; VSS to -6 V and VDD to +6 V on PCB A. Connect COM, IN LO and TEST together and connect to the 0 V power supply line. Connect the 0 V line to the instrument's common input terminal via FS1. Connect RFL to the common terminal of SW1f. Connect RFH to the common terminal of SW1d. Connect IN HI to the common terminals of SW1c and SW1e.

Refer to the main circuit diagram and make the following connections. Wire up SW1d and make the connection to RV1 slider on PCB A. Wire up SW1f and make the connection to COM terminal on the DVM module. Trace the DV (direct voltage) path through the circuit and make the appropriate connections as follows. From SK2 to SW1a common; from SW1a DV to R6 and from the R6-R12 chain to the 1 to 6 pins of SK2c; from SW2c common to SW1b DV/AV; from SW1b common to SW1c DV and AC; from SW1c common to SW1e common and to the IN HI terminal of the DVM module.

With all the above connections made, double check the wiring and then switch the unit on. Short the instrument's input terminals and check that the DTM reads 000 on all ranges in the DV mode. Switch to the 1 V range, connect the unit's input terminal (SK2) to SK1 and trim RV1 to obtain a reading of 1V2 (1200). The unit is now approximately calibrated (within 5%) on all DV ranges. Remove the connection from SK1 and check that the unit is functional on all DV ranges.

If you have access to a precision DV source or to an accurate DMM, you can precisely calibrate the DTM by switching it to the 100 mV DV range, connecting a known input test voltage (100-199 mV) and adjusting RV1 for a correct reading.

## Decimal Pointing

Refer to the main circuit diagram and make the connections from +6 V to SW2f common via R24 and from the SW2f range pins to the D1, D2 and D3 terminals on the DVM module. Switch the DTM on, on the DV ranges, and check that the decimal point appears in sensible positions on each range (eg 100 mV reads 100.0 on the 100 mV range or 100 on the 1 V range).

Refer to the main circuit diagram and trace the AV (alternating voltage) path, making additional connections as appropriate, as follows. From SK2 to the top of R6 via SW1a and C1; from the output of the R6-R12 chain to SW1b via SW2c; from SW1b common to R41 of the AC/DC converter on PCB A and to the DV and DC pins of SW1c; from R46 of the converter on PCB A and to the DV and DC pins of SW1c common to IN HI on the DVM module.

When the above connections are complete, set the unit to the 100 mV AV range, connect a 1 kHz sine wave of known amplitude (100-199 mV) to the input of the DTM and adjust RV5 for a correct reading. Switch the unit to the 1 V range, increase the input signal to a sensible value and check the frequency response of the instrument. The response should be virtually flat from 20 Hz to 40 Hz; if necessary, the value of C2 can be padded up slightly to obtain the required response. Check that the unit is functional on all other AV ranges.

## DC Ranges & AC Ranges

Refer to the main circuit diagram, trace the DC (direct current) circuit path (via R1-R5), add all appropriate switching connections and then give the unit a functional check on all DC ranges.

Refer to the main circuit diagram, trace the AC (alternating current) circuit path, add any appropriate switching connections and give the unit a functional check on all AC ranges.

## Resistance Ranges

Refer to the main diagram again, trace the resistance measuring circuit (via R13-R18 and SW2d, SW1d-SW1e-SW1f and from the IN HI pin of the DVM module to SK2 via SW1c

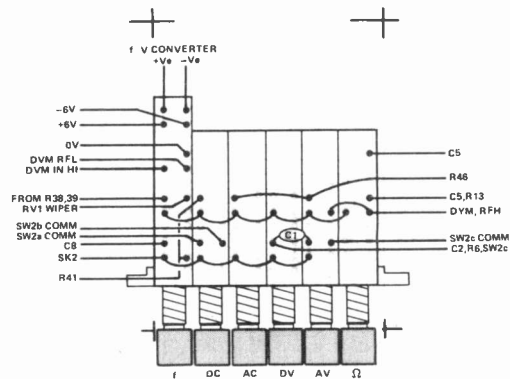


Fig.3. The mode switch assembly fits on its own PCB (above).

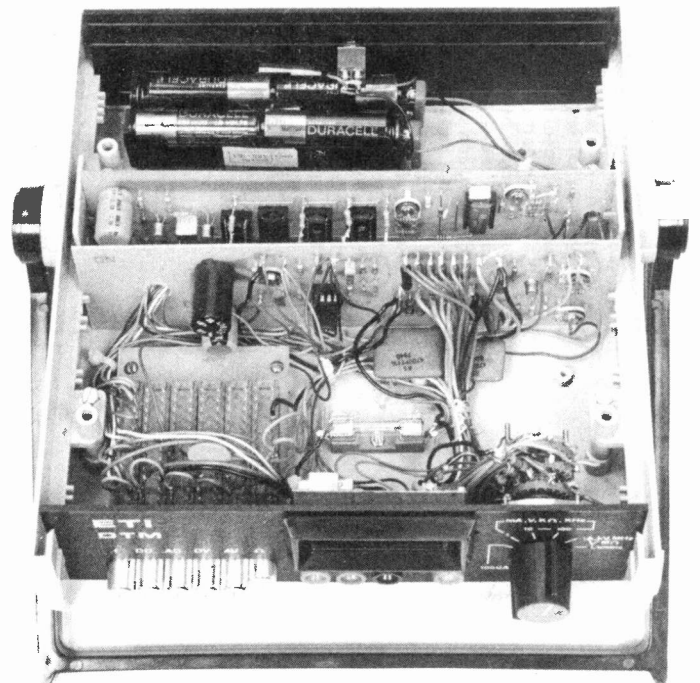
and SW1a) and make all appropriate connections. Give the unit a functional check on all ranges by connecting appropriate test resistors to the DTM test terminals.

Note that, due to the low-voltage ratiometric resistance measuring technique used in this instrument, the readout tends to jitter somewhat when used to test resistors with values in excess of 200k or so. This tendency can be minimised by keeping test leads as short as possible, to avoid hum pickup.

Make the connection from R25 (on PCB A) to Diode Test Socket SK1. Short SK1 to SK2 and adjust RV2 for a reading of 100.0 on the 100 uA DC range. Remove the short and check that a reading of 00.0 is obtained. Connect a silicon diode between the two sockets and check that a reading of about 60.0 is obtained in the forward direction and 00.0 in the reverse.

## Frequency Ranges

Construct the frequency-to-voltage converter circuit on PCB B and make its supply connections via SW1g (+6 V) and SW1h (-6 V) and the supply common line. Make the input connection to the PCB from SW1a and the output connection to SW1c. Wire up SW2e as shown, noting that a 4k7 resistor is connected directly to each of the 1kHz, 10



# PROJECT: Digital Test Meter

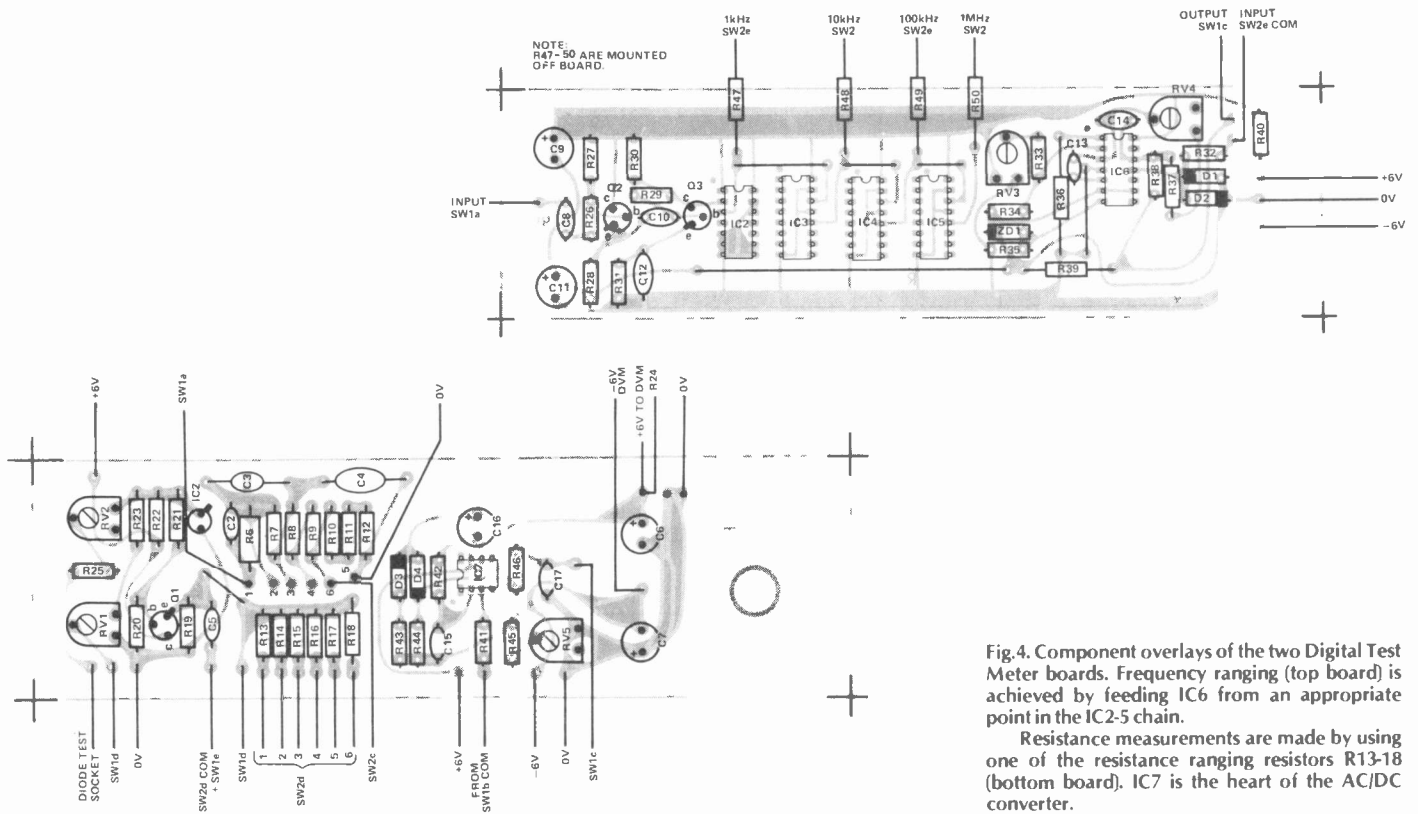


Fig.4. Component overlays of the two Digital Test Meter boards. Frequency ranging (top board) is achieved by feeding IC6 from an appropriate point in the IC2-5 chain.  
Resistance measurements are made by using one of the resistance ranging resistors R13-18 (bottom board). IC7 is the heart of the AC/DC converter.

## PARTS LIST

### Resistors 1/4 W 5% unless specified

R1	0R1 1/2 W 1%
R2	1R0 1/2 W 1%
R3,12	10R 1/2 W 1%
R4,11,13	100R 1/2 W 1%
R5,10,14	1k 1/2 W 1%
R6,18	10M 1/2 W 1%
R7,17	1M0 1/2 W 1%
R8,16	100k 1/2 W 1%
R9,15	10k 1/2 W 1%
R19,30,39	1k0
R20,24,25,43,44	10k
R21,26	5k6
R22	3k3
R23	22k
R27	680k
R28,45	3k9
R29,46	470k
R31	47R
R32,47,48,49,50	4k7
R33	390k
R34,35	2k2
R36,41	100k
R37	820k
R38	15k
R40	22R
R42	2M2

### Potentiometers

Rv1,2	4k7 miniature horizontal preset
Rv3	47k miniature horizontal preset
Rv4	470k miniature horizontal preset
Rv5	2k2 miniature horizontal preset

### Capacitors

C1	10n 2kV ceramic disc.
C2	33p silver mica
C3	470p silver mica
C4	4n7 silver mica
C5	150n polycarbonate
C6,7,9,11	470u 16v electrolytic, PCB type.
C8	100n polycarbonate
C10	470n polycarbonate
C12	2n7 ceramic
C13	470p ceramic
C14	10n polycarbonate
C15,17	220n polycarbonate
C16	4u7 electrolytic, PCB type

### Semiconductors

DVM	176M Rev. C.
IC1	Zn423
IC2	4093B
IC3,4,5	4017B
IC6	9400CJ
IC7	CA3140
Q1,2,3	BC109
D1-4	IN4148

### Miscellaneous

- SW1a, 8 pole change over interlocking push button
- SW1,b,c,d,e, 6 pole change over interlocking push button
- SW2a-f, 2 pole 6 way wafers (3 off) rotary switch
- SW3, DPDT miniature toggle
- SK1-4, 4 mm banana sockets
- 2 off, 4 section battery holders for HP7
- 1 off, 1 1/4" fuse & holder chassis fixing or similar
- 1 off, winged knob
- Case (see buylines)

kHz, 100 kHz and 1 MHz output pins of PCB B, with the connections to SW2e made via these resistors.

When construction is complete, switch to the 1 kHz range in the 'f' mode, short the unit's input terminals and adjust RV3 for zero reading on the meter. Remove the input short, connect a 1 kHz input signal and adjust RV4 for a reading of 1.000 on the meter. Finally, check that the DTM is functional on all other frequency ranges.

## BUYLINES

Watford Electronics have agreed to supply a full kit of parts for the ETI DTM.

Our Case for this project was obtained from OK Machine and Tool. (Order as CH23 Tan) Phone 0703-610944.

Ambit International Supply the DVM176 Rev. C.

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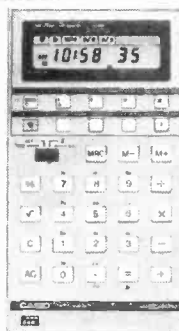
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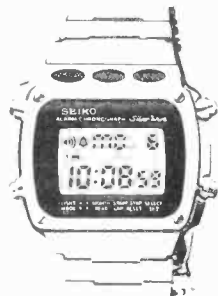
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# SURVIVAL GAME

A highly addictive but infuriating game. Escape from the tyrannical machine if you can. Naturally, the game has sound effects, LED readouts and a skill level control.

**S**urvival is a small hand-held game in which the contestant pits his wits against those of the machine. The machine is a tyrannical device, dedicated to enslaving you by repeatedly making threatening gestures towards you (indicated by a brief flash of a LED as the threat is unleashed). When a threat is made you can either submit, by doing nothing, or you can defy the tyrant by pressing a JUMP button and trying to escape up a flight of steps (indicated by a vertical column of ten LEDs).

To escape, you must press the JUMP button only when the threat LED is on. Each time you make a successful jump, you move a discrete amount towards the top of the steps and eventual escape (indicated by a pulsed WIN sound as the top LED of the column illuminates). If you make a single wrong move while on the steps, however, the tyrant will instantly strike you (indicated by a 'bleep' sound) and send you tumbling back down to the bottom of the steps. Alternatively, if you submit to the threats (by doing nothing) the tyrant will slowly lure you down from your perilous perch.

## An Evening's Work

The machine makes a threatening move once every second or so, but the actual threat lasts for only a fraction of this time. The game is provided with a SKILL level control, which enables the threat duration (and thus the escape time) to be varied from over 200 mS to less than 50 mS. At the lowest skill level, it is possible to escape from the tyrant in only four to five successful moves. At the top skill level, between thirty and forty successful moves are needed to ensure escape. The escape 'steps' are exponentially weighed, so that climbing becomes progressively more difficult with each move.

The SURVIVAL game is designed around three ICs and three transistors, is reasonably inexpensive to build and is powered from a single 9V battery. The project can be built in one or two evenings.



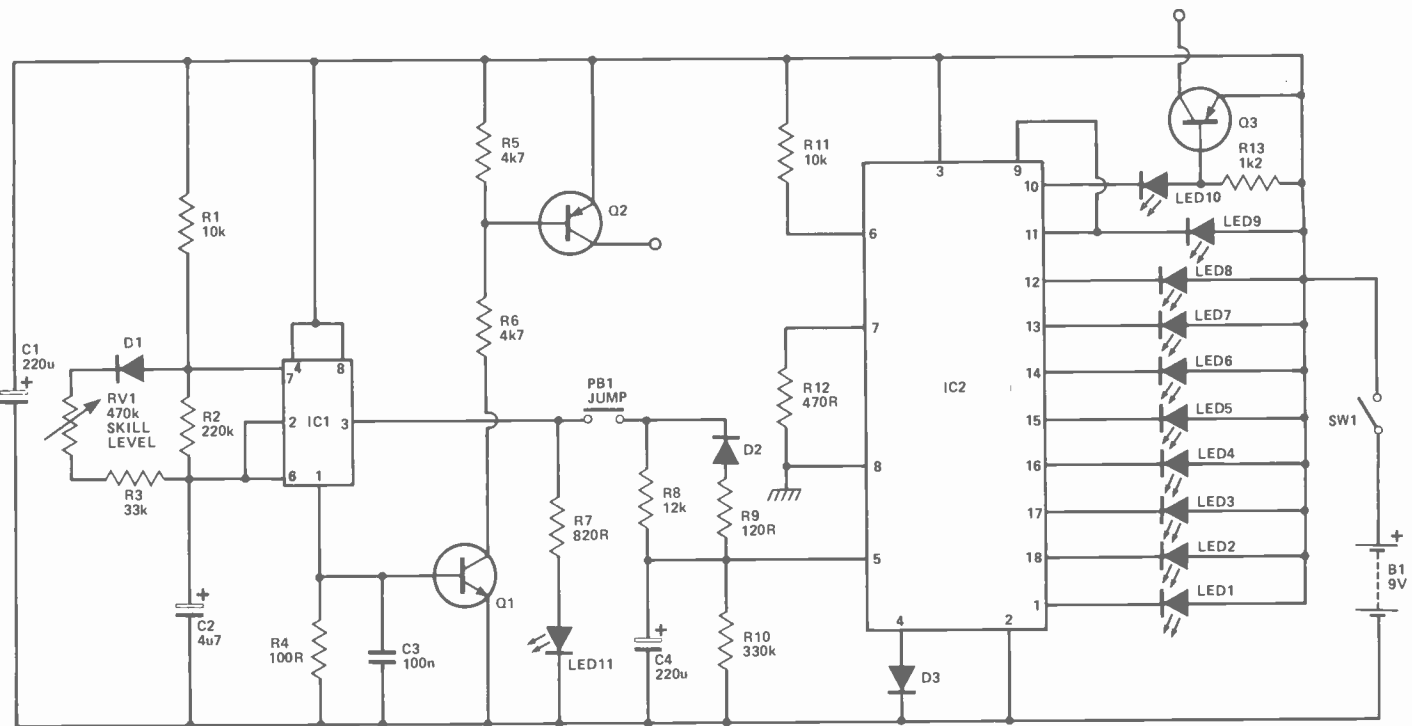
## Construction

Construction of this project should present few problems if the overlay is followed with care. Note that IC3 is a CMOS device and should be mounted in a suitable socket.

When construction of the PCB is complete you can either make temporary connections to the eleven LEDs and the transducer, etc and give the unit a functional check, or you can dive in and fit the whole shebang in a suitable box and give the unit a functional check afterwards. If you decide on the latter approach, note that the unit typically consumes some 30-40 mA and should ideally be powered from a PP7 or larger battery, but that our own prototype is in fact powered (or under-powered!) from a PP3.

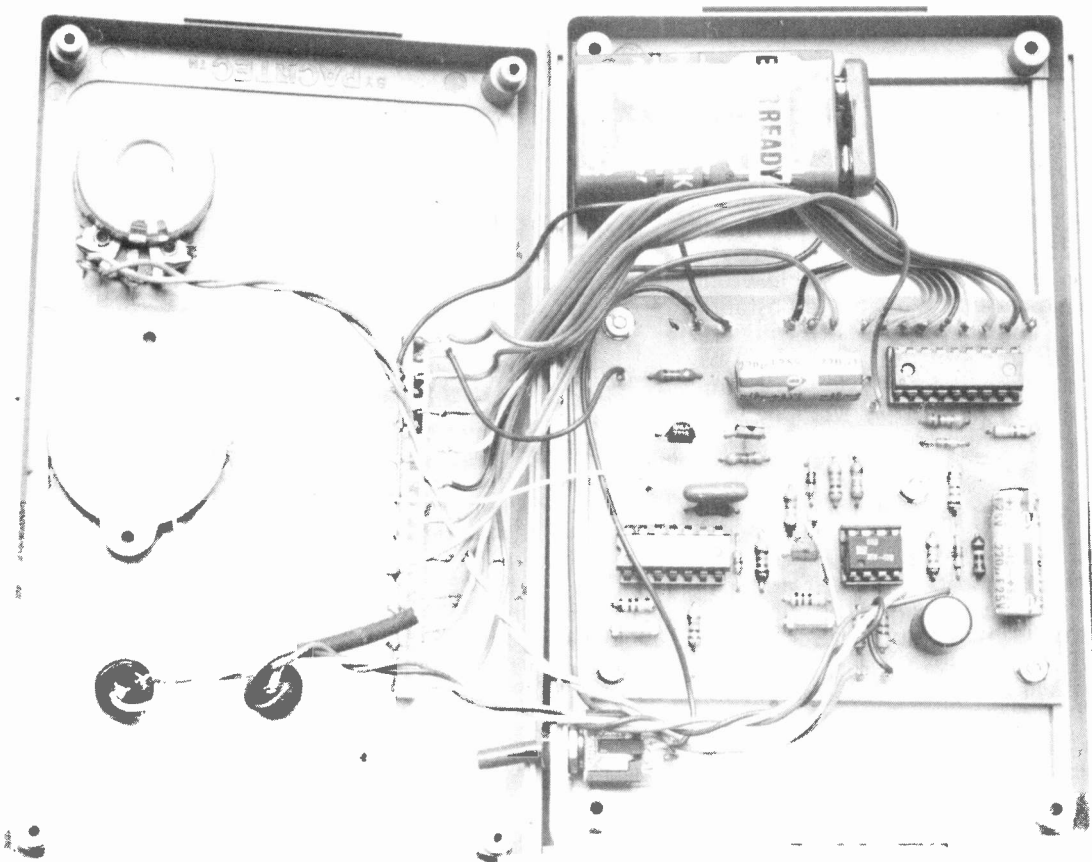
It is advisable, before completing the interwiring, to functionally check the performance of each of the eleven LEDs used in the unit.

When construction is complete, switch the game on and check that LED 11 flashes briefly once every second or so and that the flash duration can be varied by RV1. You can check the action of C4 and the ten-LED read-out circuit by temporarily shorting the top of R8 to the positive supply line, in which case the LEDs in the column should sequentially illuminate and the WIN alarm (a pulsed tone) should sound when the upper LED (LED 10) turns on. Finally, remove the temporary short and press PB1 when LED 11 is off, checking that the column of LEDs turn off and a brief tone is generated. Your game is then complete and ready for use.



NOTE:  
 D1-4 ARE 1N4148  
 Q1 IS BC108  
 Q2 & 3 ARE BC212L  
 IC1 IS 555  
 IC2 IS LM3914N  
 IC3 IS CD4011B  
 Tx IS AMBIT PB2720  
 PIEZO SOUNDER

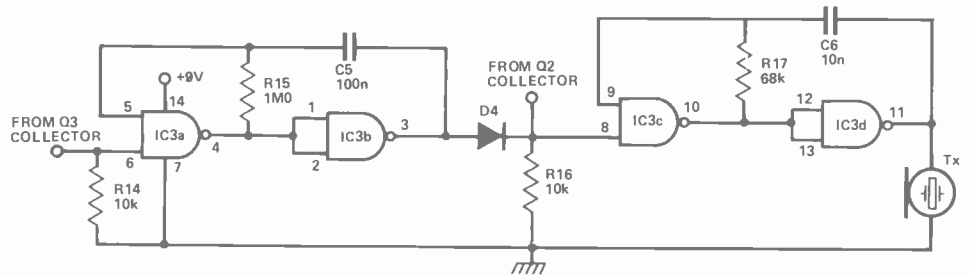
Fig.1a. Circuit diagram of the game. Q2,3 collectors connect to the sound effects part of the circuit (Fig.1b). Press PB1 every time LED 11 flashes on to ascend the ladder of LEDs 1 - 10.



Construction of the Survival game is relatively straightforward — PCB in one half of the case, LEDs and controls in the other.



Fig.1b. The sound effects generator consists of two gated astable multivibrators. The game just isn't complete without it.



## HOW IT WORKS

The basic operating principle of the game is quite simple. IC1 is a low frequency (less than 1 Hz) astable; its output switches alternately between the low (zero) and high (+9 V) states, driving LED 11 on whenever the output is high. The idea of the game is to close PB1 whenever LED 11 is on, thereby causing C4 to slowly charge up via R8, but to ensure that PB1 is open whenever LED 11 is off, thereby preventing C4 from rapidly discharging via R9 and D2. The voltage of C4 is monitored by a LED voltmeter (IC2 and ten LEDs) and the game is won when C4 charges to roughly half supply voltage (LED 10 on). IC3 is used as a sound effects generator and produces a brief tone whenever C4 goes into the discharge mode or a pulsed tone when the game is won.

The operation of the IC1 astable is slightly unusual. Here, C2 alternately charges (LED 11 on) via R1-D1-RV1-R3 in parallel with R2 and discharges (LED 11 off) via R2 only, thereby producing a non-symmetrical output waveform in which LED 11 is on for a shorter period than it is off. The on/off ratio is variable via RV1, which thus acts as a Skill Level control.

The pin 1 ('ground') terminal of IC1 is taken to the 0V line via the base-emitter junction of Q1, shunted by R4 and C3. Whenever C4 is inadvertently discharged by closing PB1 at the wrong time, the capacitor discharges through this junction and turns Q1 on,

thereby causing Q2 to turn on and activate the IC3c-IC3d half of the sound-effects generator circuit.

Capacitor C4 charges slowly in the exponential mode via R8 when PB1 is correctly closed and discharges rapidly via R9 and D2 when PB1 is incorrectly closed. The capacitor discharges very slowly via R10 when PB1 is open. The C4 voltage is monitored by LED voltmeter IC2, which drives a line of ten LEDs in the 'dot' mode. The voltmeter is programmed (via R11) to read full scale (LED 10 on) when C4 is charged to approximately half supply volts and is offset by approximately 600 mV via D3. The base-emitter junction of Q3 is wired in series with LED 10, causing Q3 to turn on and activate the IC3a-IC3b half of the sound effects generator when LED 10 turns on (game won).

The sound effects generator is made up of two gated astable multivibrators. IC3c-IC3d act as a fast (1 kHz or so) astable which directly drives a piezo transducer or sounder and is gated on via Q2 collector whenever PB1 is incorrectly closed. IC3a-IC3b act as a slow (a few Hertz) astable which is activated via Q3 collector when LED 10 turns on and pulses the fast astable on and off to produce a distinctive pulsed-tone GAME WON sound.

The entire circuit is powered from a 9 V battery. The circuit typically consumes some 30-40 mA, so this battery needs to be a PP7 or larger size.

## PARTS LIST

Resistors all 1/4 W 5%

R1,11,14,16	10k
R2	220k
R3	33k
R4	100R
R5,6	4k7
R7	820R
R8	12k
R9	120R
R10	330k
R12	470R
R13	1k2
R15	1M0
R17	68k

Potentiometer

RV1	470k
-----	------

Capacitors:

C1,4	220u electrolytic axial
C2	4u7 electrolytic
C3,5	100n polycarbonate
C6	10n polycarbonate

Semiconductors:

IC1	NE555
IC2	LM3914
IC3	4011B
Q1	BC108
Q2,3	BC212L
D1-D4	1N4148
LED 1-10	TIL 220 or square LEDs
LED 11	TIL 220 standard red 0.2"

Miscellaneous

PB1	momentary push button
SW1	SPST miniature toggle
B1	PP3
Tx1	transducer (See buylines)
	Ceramic resonator
	Case (See buylines)

## BUYLINES

All components used in the ETI Survival game are common types and should present no problems.

The case for this project can be obtained from OK Machine & Tool Ltd. Phone: 0703-610944. Order as Series HP colour tan. Ambit International are stockists for the transducer.

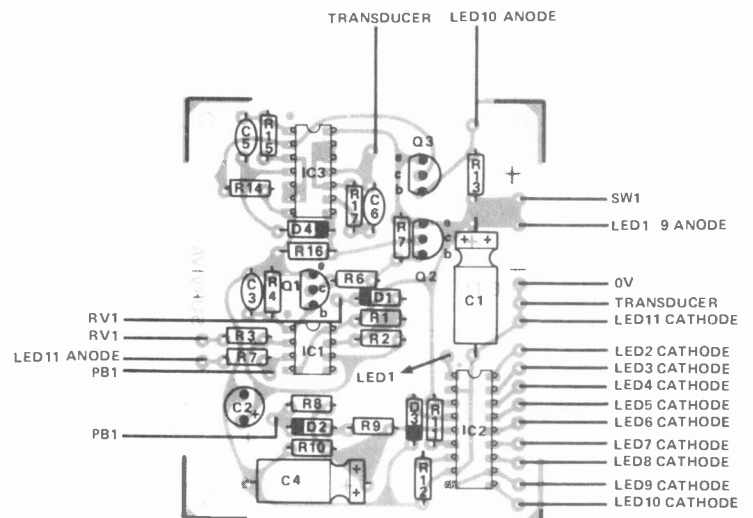


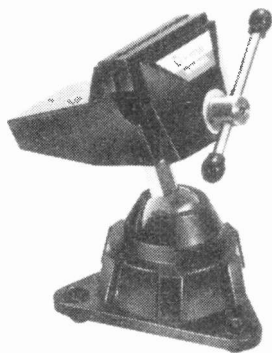
Fig.2. Component overlay. Lots o' LED leads to lace up — there's nothing to it.



If you need a little vice — consult the

# VICE SQUAD

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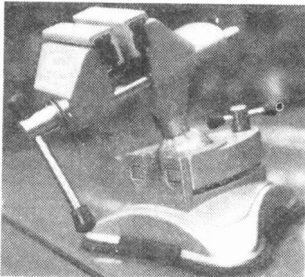
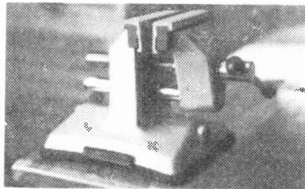
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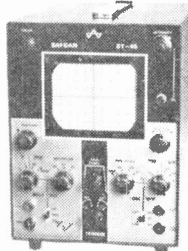
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### ACCESSORIES

Passive Probe switched (X1, REF × 10)  
100MHz bandwidth £11.50 + VAT  
BNC to 4mm Socket Adaptor £2.95 + VAT

### TRIGGER

Internal 0.5 div (20Hz-2MHz), 1 div (2MHz-5MHz)  
External 100mv (20Hz-2MHz), 200mv (2MHz-5MHz)  
Bright Line Auto  
Trace free runs in absence of signal  
Trigger Level selects triggering point  
Trigger (+)ve and (-)ve slope selection

### FRONT PANEL

Black-Silver-White-ST-45-S The Silver Scope  
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### GENERAL

Blue display graticule ruled 8 x 10 div (6.4cm x 8cm)  
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# ENVELOPE SHAPER

Is it Mantovani or a Project 80 synthesiser? You can't tell the difference with this VCES designed by R.C. Blakey



Conventional ADSR envelope generators are adequate for most practical purposes since they are capable of providing a reasonable simulation of the amplitude envelopes of many musical instruments. The Project 80 Voltage Controlled Envelope Shaper (VCES) is provided for those who wish to obtain more realistic simulation or to obtain dynamic control over envelope shape. It is also a useful tool for innovative synthesis. The design incorporates the following features; bending of the standard exponential attack, decay and release curves to other shapes; alteration of attack, decay and release times by an external voltage thus allowing the envelope to be altered in proportion to the note played; the use of non linear sustain; built-in timer for re-triggering to create dual peak envelopes and also the generation of a delayed AD envelope.

## Design and Application

The VCES is based on the CEM 3310 Voltage Controlled Envelope Generator produced by Curtis Electromusic Specialties. While it is well suited for use as a conventional ADSR envelope generator for both monophonic and polyphonic synthesisers the facilities provided on chip also make it ideal for configuring a complex envelope generator. The attack (A), decay (D), and release (R) parameters have a scale sensitivity of 60 mV/decade (18 mV/octave) while sustain level (S) is linearly proportional to the voltage applied to pin 9. To facilitate generation of complex shapes each of the four inputs has been buffered by an op amp configured as a summer and our standard 0 to +10 V control voltages allow the A, D and R times to be varied from 2 mS to greater than 20 S. Likewise for the sustain input a voltage of 0 to +10 V varies the sustain level from 0 to 100% of the peak attack voltage which has also been normalised to +10 V.

The A, D and R responses follow an exponential curve. These characteristic curves may easily be altered in this design by taking a proportion of the output from the module and feeding it back to the appropriate input for the attack curve. The greater the amount of feedback the more convex the response and, although the overall time constant will increase, this may be adjusted over a wide range with the manual control provided. If the output is inverted prior to feedback then the attack curve will become concave in shape. Some of these curves are closer approximations to

conventional instruments while others offer some novel responses. The shape of the decay curve, or the release curve, may be similarly altered and thus the VCES offers virtually unlimited scope for generation of envelope shapes. The use of low frequency waveforms to modify the time constants is also practical but setting up to obtain useful results is quite time consuming. Two attenuators, with or without inversion, are provided and the 80-5 Processor module may be used for distribution and attenuation when more complex patching is required.



Fig.1. The effect of feedback on the attack response.

## Tremolo

The sustain level also has provision for external control and one application is to apply a low frequency waveform to this input in combination with an attenuator and perhaps the manual control to produce a varying sustain. If this envelope is now used to control a VCA the effect is a tremolo only during the sustain part of the note. In the design both the upper and lower levels of the sustain control have been clamped for protection.

Another application for voltage control of envelope shape is the automatic alteration of the time constants or sustain level while the instrument is being played.

## Time and Time Again

A simple timer has been incorporated in the design which allows re-triggering, or initial trigger delay, for periods up to about 2.5 S. The effect of re-triggering is to produce an envelope with two peaks, which is a transient effect exhibited by a number of conventional instruments. Often, however, as such instruments reach their peak output the

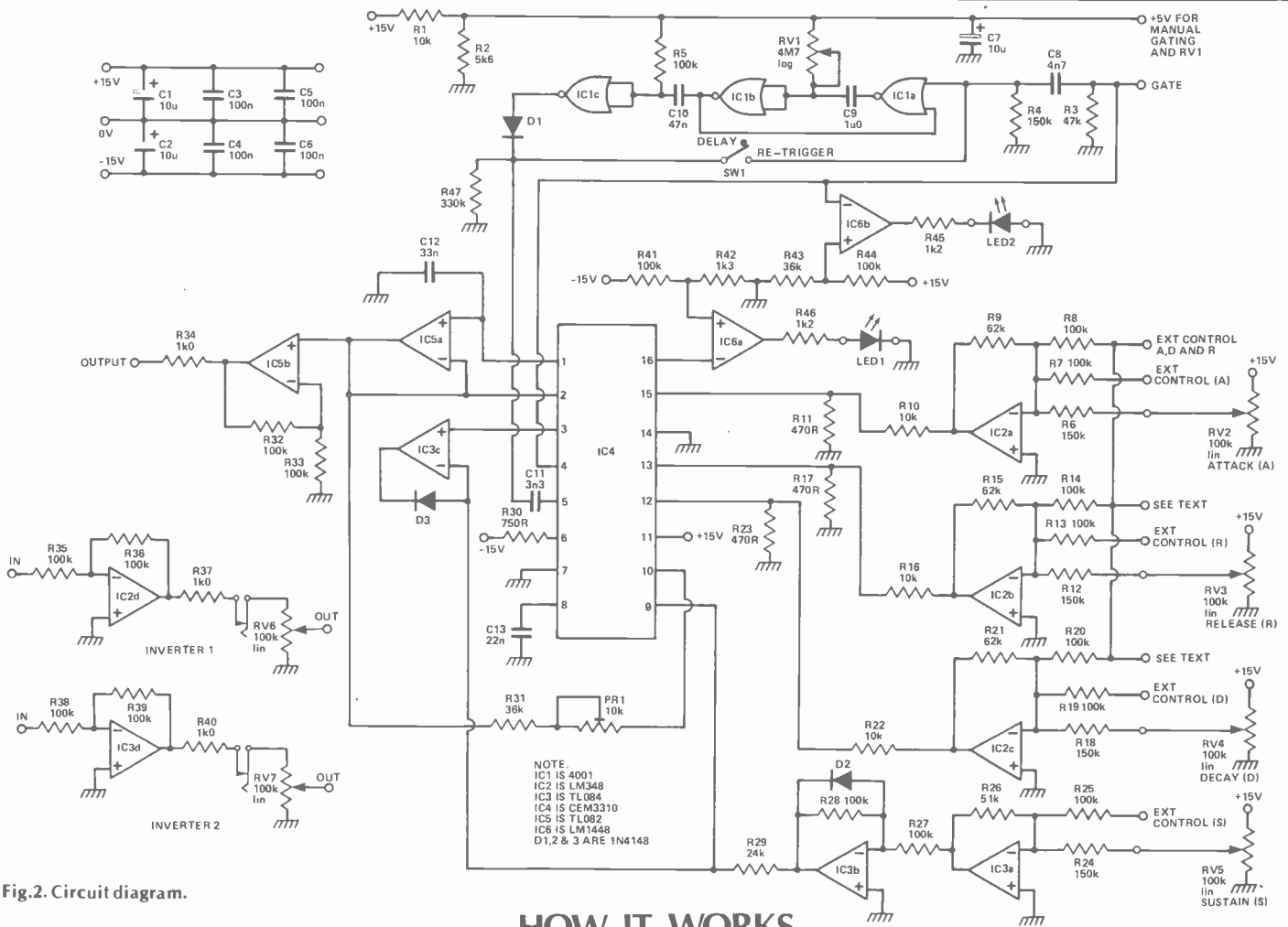


Fig.2. Circuit diagram.

## HOW IT WORKS

The attack, decay and release control inputs (pins 15, 12 and 13 respectively) have a control sensitivity of 18 mV/octave and a 10k/470R attenuating network is placed ahead of these inputs. The time constants of the attack, decay and release curves are determined by  $R_x C_x$  times the exponential multiplier,  $\exp(-V_c/V_T)$ ; where  $R_x$  is  $R_{31}$  plus part of  $P R_1$ ;  $C_x = C_{12}$ ;  $V_c$  = the control voltage at the appropriate pin; and  $V_T = kT/q$ . The values of  $R_x$  and  $C_x$  have been chosen to minimise errors and to retain the very low voltage feedthrough which is a feature of the CEM 3310. With the values used an increasing negative voltage at the 10k/470R attenuator will increase the time constant and a voltage from 0 to about -5V6 will give a range of 2 mS to 20 S for each time control input. To obtain both external and manual control of the time constants an inverting summer with a nominal gain of 0.62 has been placed ahead of the attenuating resistors; in the case of the attack control, using IC2a and associated resistors R6 to R9 ahead of attenuator R10/R11. Thus increasing positive voltages up to +10 V will now give the same control range. R7,8 are for external control voltages while RV2 via R6 provides manual control over the same range. R8 is connected with R14 (release control) and R20 (decay control) such that an external voltage applied to R8 will simultaneously change all three time constants.

Sustain level on the CEM 3310 is determined by the voltage at pin 9 and a voltage from 0 to +5 V will change the sustain level from 0 to 100% of the peak attack voltage. To obtain both manual and external control of sustain and retain the control polarity this input is preceded by IC3a and IC3b configured as two inverting summers with an overall gain of 0.5. Thus 0 to +10 V at R25 will produce the 0 to 100% sustain level control. Manual control is obtained with RV5 and R24. If the sustain voltage were to exceed the peak attack to 100% sustain level control. Manual control is obtained with RV5 and R24. If the sustain voltage were to exceed the peak attack voltage then the envelope will ramp up to this higher voltage level with undesirable results. Pin 3 of the CEM 3310 outputs the peak attack voltage and so the sustain level and pin 3 are connected to IC3c arranged as a precision peak follower to prevent the aforementioned situation.

The output buffer within the CEM 3310 (pin 2) has adequate drive capability for most applications but in this design it may be used to drive several inputs and overloading of the buffer will result in a loss of performance. The internal buffer has been bypassed by IC5a and the output increased to the Project 80 standard of +10 V by a non inverting amplifier, IC5b, which has a gain of two.

The attack output pin (pin 2) provides a voltage of between -0V4 and -1V2 only during the attack phase to provide a visual indication of the attack phase using LED 1. Pin 16 is connected to IC6a arranged as a comparator. IC6b is also a comparator and will turn on LED 2 when a gate voltage is present.

The CEM 3310 requires both gate and trigger pulses to generate an ADSR envelope. The 80-10 module is designed to operate with a gate voltage of +5 V and the trigger is generated by differentiating the gate pulse using C8 and R4 which is then applied to pin 5 via C11 (SW1 closed). To obtain the re-triggering and delay facilities IC1a and IC1b are used to form a monostable. The time delay is determined by the charging time of C9 via RV1 and when the voltage on C9 exceeds the threshold voltage of IC1b its output will go low and reset the monostable. IC1c is used to generate a second trigger pulse whose short duration is determined by the time required to charge up C10, to the threshold voltage level, via R5. With SW1 closed two trigger pulses are therefore generated when RV1 provides sufficient resistance to produce a noticeable delay. With SW1 open only the delayed trigger pulse is presented to pin 5 of IC4, which will allow it to operate in an AD mode.

To operate the CEM 3310 from  $\pm 15$  V supplies it is necessary to place a series current limiting resistor on the negative supply line to pin 6. The value of R20 has been chosen to comply with the general equation  $R_{EE} = (V_{EE} - 7.2)/0.010$ . For the timer a nominal +5 V is derived from the voltage divider formed by R1,2 since power supply to IC1 is not critical. These latter components may be changed to suit other gate voltages.

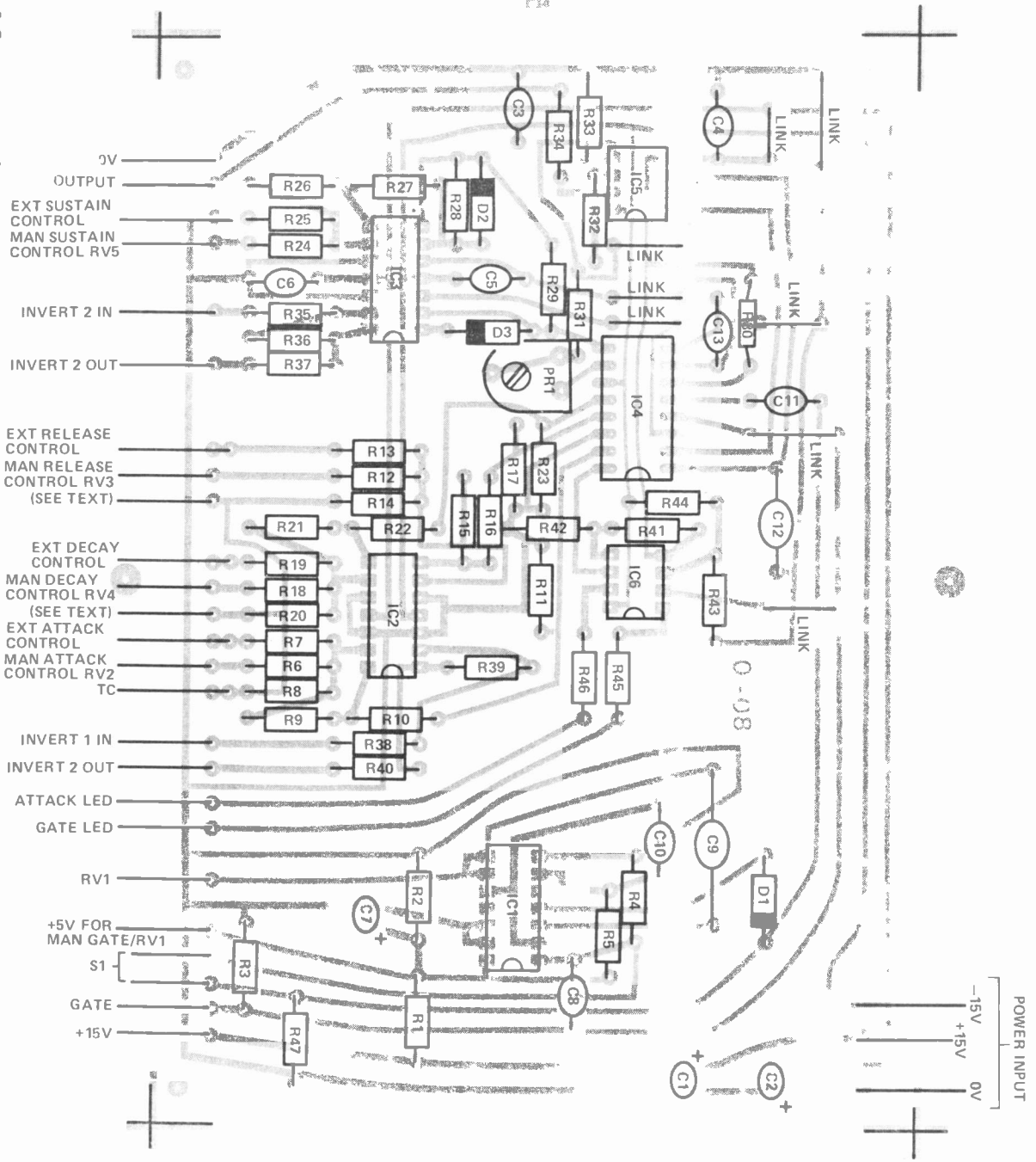


Fig.3. Component overlay

## PARTS LIST

Resistors, 1/4w, 5% carbon film unless specified.	
R1	10k
R2	5k6
R3	47k
R4,6,12,18,24	150k
R5,7,8,13,14,19,20,25,27,	
28,32,33,35,36,38,39,	
41,44	100k
R9,15,21	62k
R10,16,22	10k 1% metal film
R11,17,23	470R 1% metal film
R26	51k
R29	24k
R30	750R
R31,43	36k
R34,37,40	1k0
R42	1k3
R45,46	1k2
R47	330k
Potentiometers	
PR1	10k carbon
RV1	4M7logarithmic
RV2,3,4,5,6,7	100k linear
Capacitors	
C1,2,7	10u 25 V PCB electrolytic
C3,4,5,6	100n polyester
C8	4n7 polycarbonate
C9	1u0 polyester
C10	47n polyester
C11	3n3 polycarbonate
C12	33n polycarbonate
C13	22n polyester
Semiconductors	
IC1	4001B
IC2	LM248N
IC3	TL084CP
IC4	CEM3310
IC5	TL082CP
IC6	LM1458N
D1,2,3	1N4148
LED 1	Red LED
LED 2	Green LED
Miscellaneous	
SW1	SPST sub-miniature toggle switch
PCB, case, etc.	

sound alters due to the presence of noise and complex waveforms in the transient. A better simulation of this effect is obtained by using two envelope generators, two sound sources, a dual VCA and mixing the outputs from the latter together. In this example the VCES timer is in the delay mode and will initiate an AD envelope when the trigger occurs. It should be noted that only AD envelopes are practical in the delay mode since if the sustain level is above zero the voltage will ramp up to the set level when the gate pulse is received.

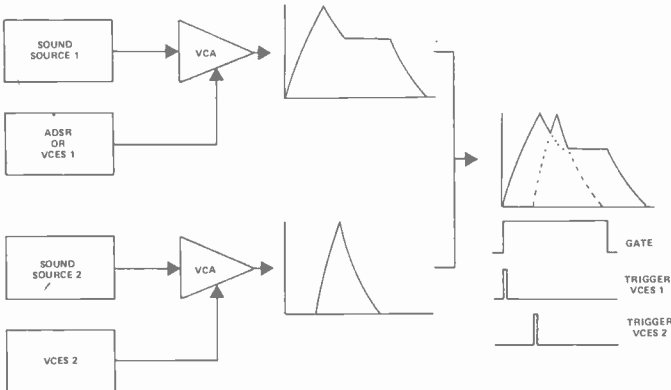


Fig.4. Patch for obtaining realistic transient effects.

## Construction

In common with other Project 80 modules the Voltage Controlled Envelope Shaper may be panel mounted or installed in a Teka Alba A23G case. The latter, however, does not have sufficient panel area to neatly accommodate all of the facilities provided. In the cased module illustrated we have omitted the two inverters and controls RV6 and RV7.

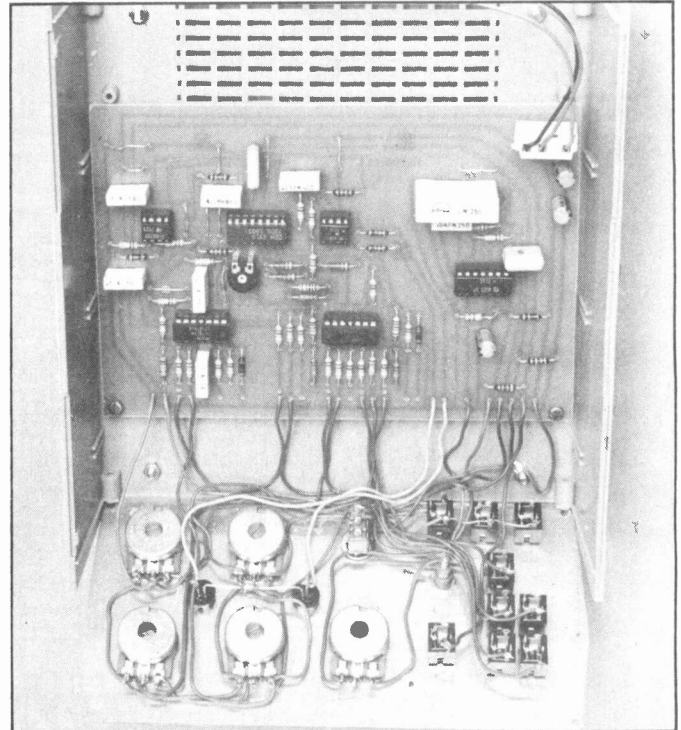
The panel markings for the inverters are  $-$ ,  $+$  and A1 (or A2) with the latter being associated with the attenuating potentiometer RV6 (or RV7). Taking Inverter 1 as the example: R35 is wired to the jack socket marked  $-$  at the connection which makes contact with the jack plug; the output of the inverter (R37) is wired to the jack socket marked  $+$  but to the connection disabled when a jack plug is inserted, whereas the other connection on this socket is wired to RV6; finally the wiper of RV6 is wired to the make connection on the A1 jack socket. This allows a jack plug into the  $-$  socket to access the inverter and the output is obtained at A1, with attenuation when required. For non-inverted voltages which require attenuation these are obtained via the  $+$  socket with the output at A1.

One external control of attack, decay and release times is commoned and accessed on the PCB at R8. This allows all three time constants to be altered simultaneously and is connected to jack socket marked TC, denoting time constants. If required, however, the constructor may obtain two independent controls for each time constant by cutting the PCB tracks that join up the inputs of R8, R14 and R20. PCB connections are provided at R14 and R20 to cater for this modification.

The module may be manually gated by connecting a push-to-make switch from the  $+5V$  line to the gate input.

## Calibration and Testing

The attack, decay and release manual controls are numbered 0-10 for reference purposes since once external voltages are applied a time calibration becomes meaningless.



Tackle the control wiring methodically, otherwise you're in for a case of the wiring jungles.

PR1 allows more than one module to have the same time constants for a given input voltage. For precise calibration a triggered timing device is required but in most instances the following technique is adequate. Set PR1 to mid-position and connect a voltmeter between ground and the junction of R6 and R9. Turn RV2 until a voltage of  $-5V6$  is obtained. Set all other control pots to zero. Gate the module manually and time the attack time as shown by the attack LED being on. The manual push button is held down until the LED goes off. Gate the unit several times to allow all components to stabilise for this long attack time and then commence adjusting PR1 to give an attack time of 20 S.

Note that the gate LED is only on while the manual button is depressed. Next set the attack time for a short duration, switch to re-trigger mode, turn RV1 fully clockwise and manually gate the module and keep push button held down until the test is complete. The attack LED should come on when the button is first depressed and again about 2.5 S later when the unit re-triggers. Keep settings the same but put the switch into delay mode. In this test the attack LED should come on about 2.5 S after manually gating the unit. Finally connect the output to a VCO which is in turn connected to an audio amplifier and set the attack, decay, sustain and release controls to about mid-position. Gate the module and release the push-button when a steady note is obtained. The test is a simple means of checking that the A,D,S and R functions are all operational. The functioning of the inverters may also be checked in the same way by putting the output from the VCES through the inverters without attenuation prior to the VCO. In this test the envelope will be inverted, that is, the frequency starting high, decreasing, holding steady and then finally going high again.

## BUYLINES

An 80-10 Voltage Controlled Envelope Shaper module kit (PCB plus components) is available for the inclusive price of £19.20 from Digisound Limited, 13 The Brooklands, Wrea Green, Preston, Lancs. PR4 2NQ.





# RIAA PREAMP

Fit a magnetic cartridge to your stereo system with our economical pre-amp design

Ceramic or crystal cartridges have found wide application in lo to mid-fi stereo systems. Manufacturers like them because they are cheap. As they have a high output level (100mV-2V) no preamp is required enabling a simple and economical system to be readily assembled. Of course, the disadvantage is that the quality of reproduction reflects the cost.

The next step up the hi-fi ladder is the use of a magnetic cartridge. However, you cannot simply plug one in. Magnetic cartridges have a comparatively low output level and their playback response coupled with all the jiggery-pokery that goes into the manufacture of a record results in a very squeaky sound.

## Stylish Motion

Ceramic and magnetic cartridges are distinguished by their different responses to the movement of the stylus as it follows the fluctuations of the groove. A ceramic transducer produces an output proportional to the deflection amplitude of the stylus, whereas the output of a magnetic cartridge reflects the rate of change (velocity) of the stylus. Recordings could be made in either a constant velocity or constant amplitude (against frequency) mode. Each has its advantages. In fact a combination of the two is used in an attempt to get the best of both worlds and a standard was set out by the Record Industry Association of America (RIAA — get it?).

## Ideal Response

Our graph show the RIAA playback equalisation curves with the ideal response shown dotted and what you actually get indicated with a solid line. With a 0 dB reference at 1 kHz, it can be seen that the response ranges over nearly +20 dB between 20 Hz and 20 kHz, a scale of 100 to 1. The high gain at low frequencies means that care must be taken to avoid mains hum pick up and screened connecting cables are essential.

## Two into One

The preamp and equalisation are neatly combined in one circuit. Our design utilises a single chip from National which features dual amplifiers with an internal resistor matrix. Use of the internal resistors enables an RIAA response to be achieved with just a few components. The unit exhibits a gain of 46 dB (200) at the 0 dB reference frequency of 1 kHz and may be powered from any 10-14V supply. Current consumption is around 16 mA maximum.

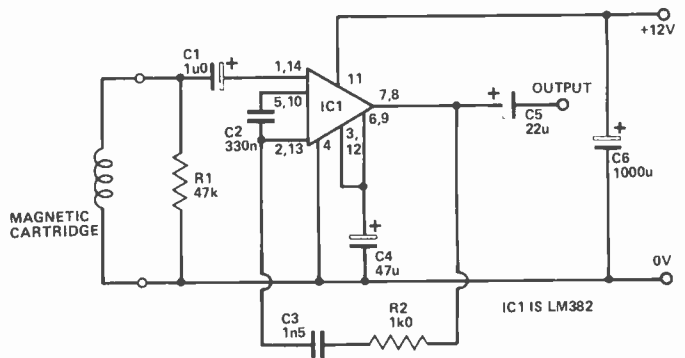
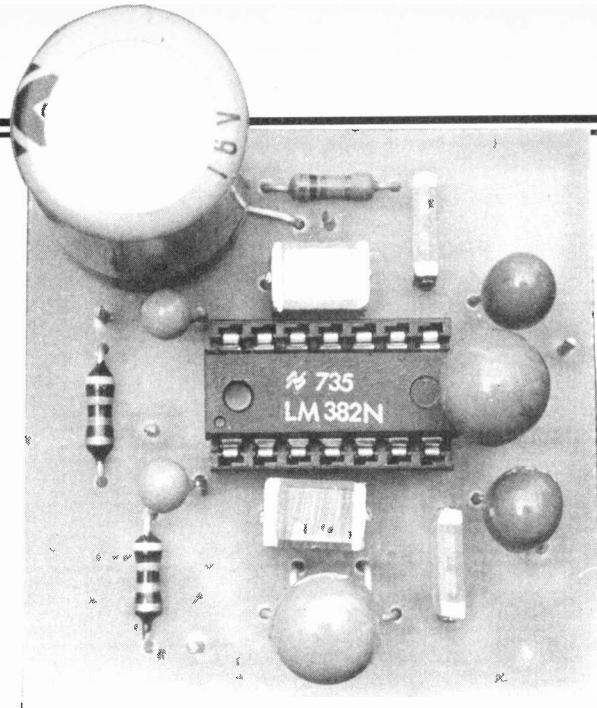


Fig.1. Circuit diagram.

## HOW IT WORKS

The desired RIAA frequency response is achieved through the use of a resistor-capacitor network in the feedback loop of an op-amp. Use of an internal resistor matrix in the LM382 chip enables a very simple practical circuit to be used. The circuit is absolutely conventional. A 12 V supply was chosen as the LM382 is characterised for operation in automobiles and its output is biased to 6 V.

The circuit offers a gain of 46 dB (200x) at the RIAA 0 dB reference frequency of 1 kHz. As the output of a typical magnetic cartridge is in the range 2-7 mV, this should result in a preamp output of around 1 V, an ideal level for the 'line' input of most amps. A 47k resistor at the input provides the standard cartridge load and a single 1,000 uF capacitor is used for overall supply decoupling.

Note that the integrated circuit pins are identified for the left and right channels with pairs of numbers on the circuit diagram. Also that all components except IC1 and C6 are duplicated on the component overlay.

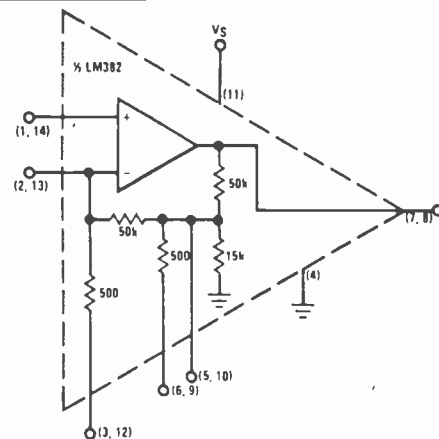
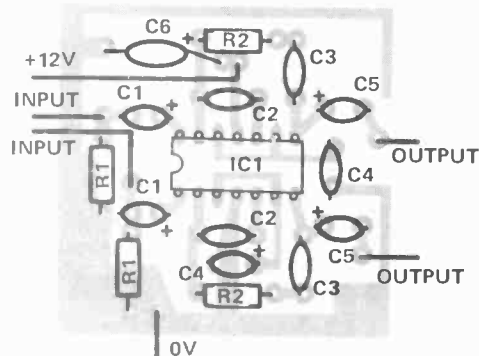


Fig.2. Internal structure of the LM382.



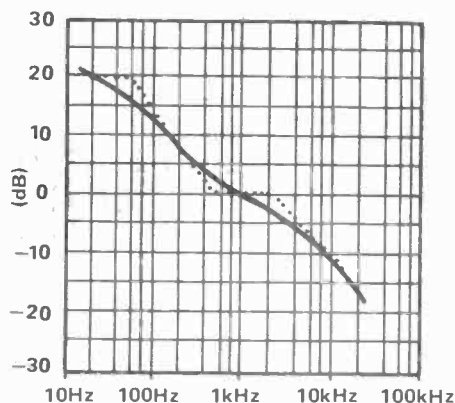
**PARTS LIST**

<b>Resistors</b>	
R1	47k
R2	1k0
<b>Capacitors</b>	
C1	1u0 tantalum
C2	330n polyester
C3	1n5 polyester
C4	47u tantalum
C5	22u tantalum
C6	1000u electrolytic
<b>Semiconductor</b>	
IC1	LM382

**BUYLINES**

No problems here. All the components should be readily available from your usual suppliers.  
 The LM382 can be obtained from Watford Electronics & Delta Tech and Co.

Fig.3.(left) Component overlay.  
 Fig.4.(below) RIAA playback equalisation curve.

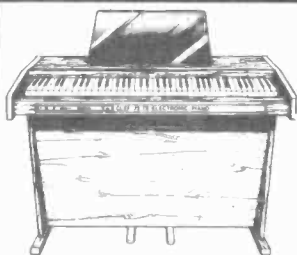


**Construction**

Use of a printed circuit board is recommended for this project. If you use another method of construction, ensure that connecting leads are kept short and locate the decoupling capacitor close to the supply pins of the integrated circuit. The unit may be assembled into a metal case for good screening. Once assembled, just connect your cartridge to the inputs and connect the outputs to your amp, either directly to the 'line' input or via the passive tone controls if you have them. Then put on your favourite disc and relax and enjoy it.

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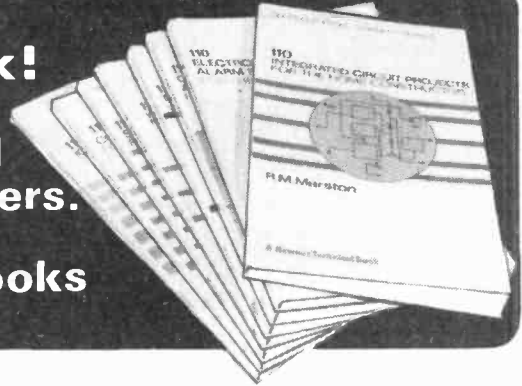
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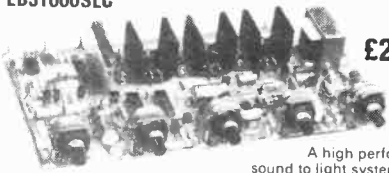
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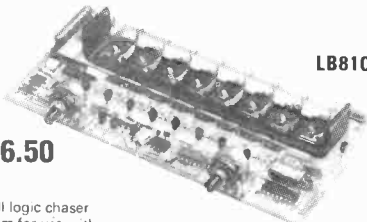


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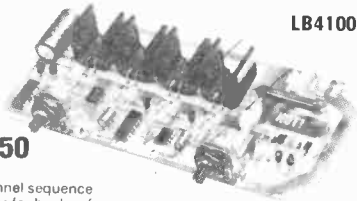


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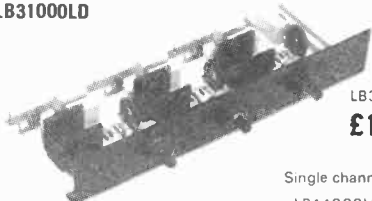


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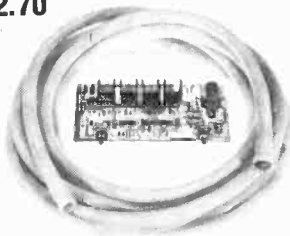
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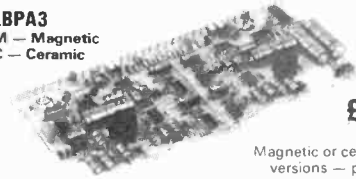
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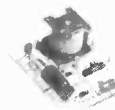
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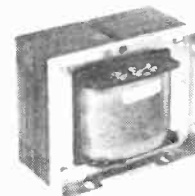


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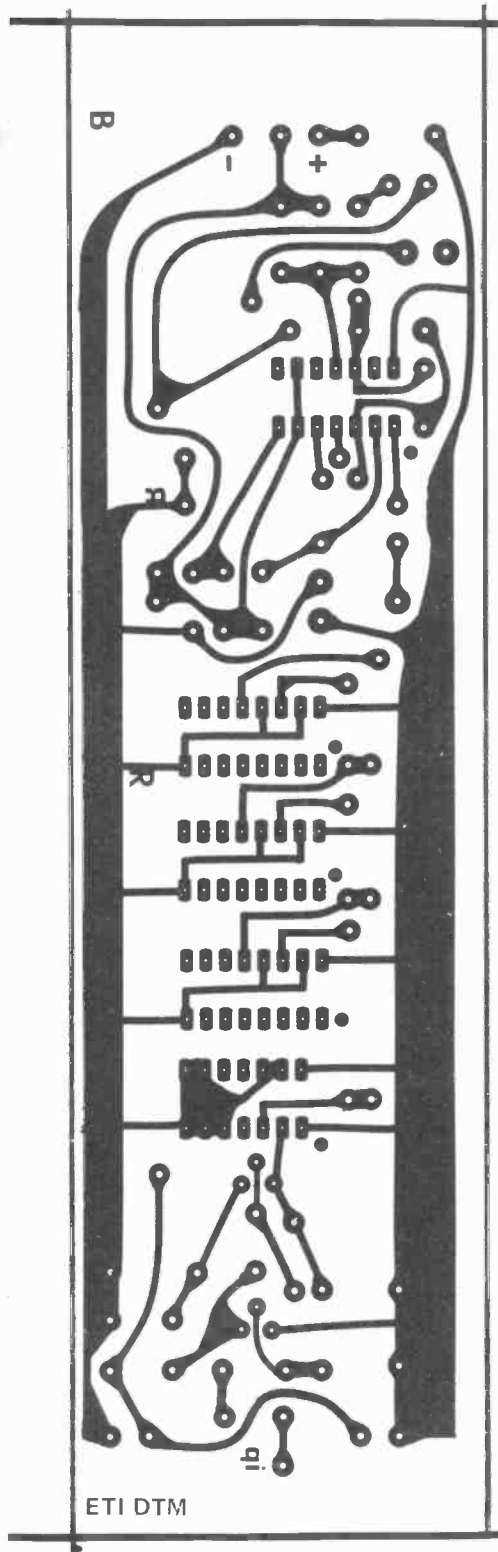
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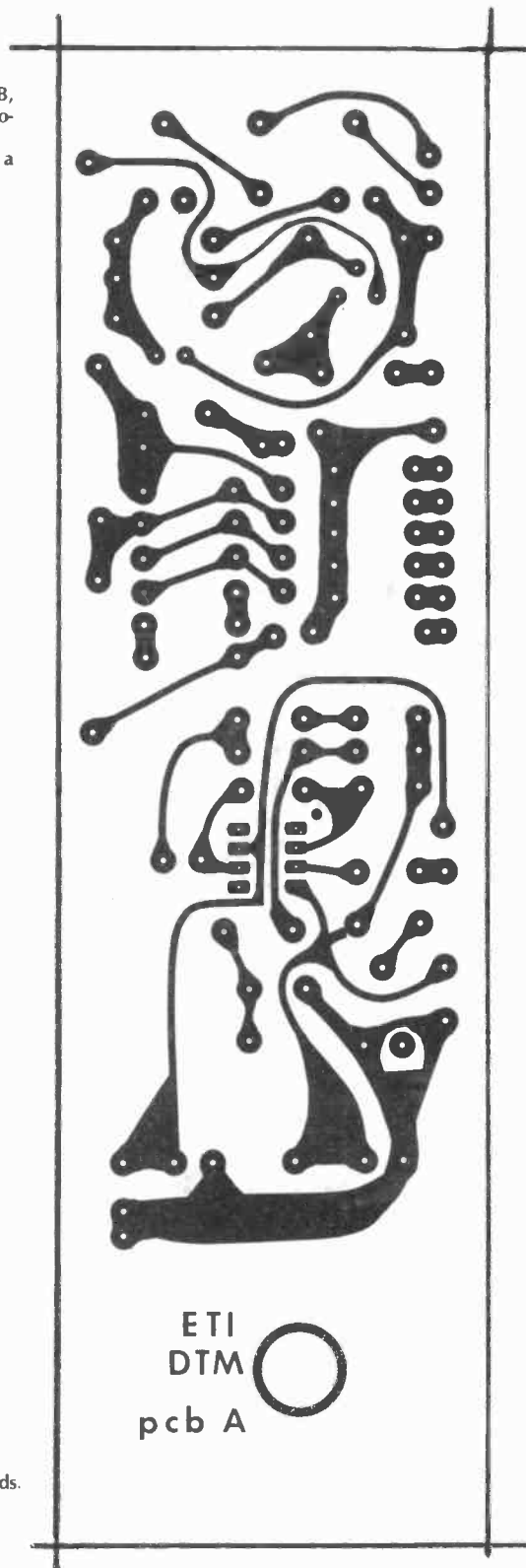
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# PCB FOIL PATTERNS

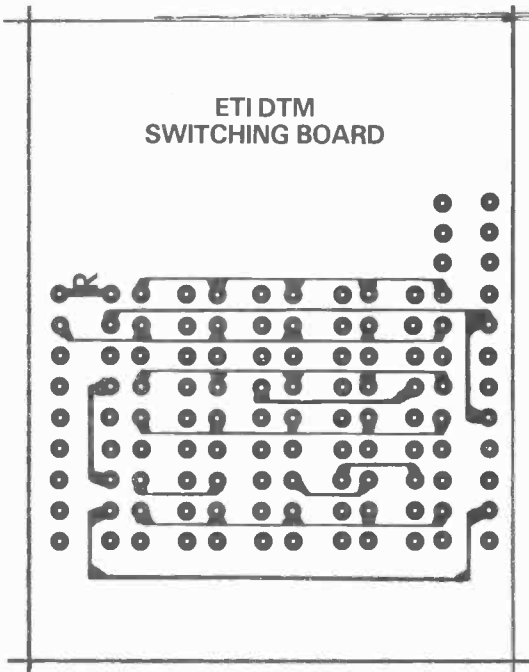


Left: Foil pattern for PCB board B, from the ETI Digital Test Meter project.

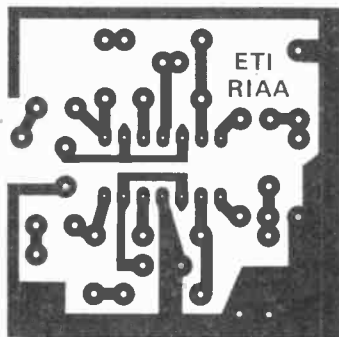
Note that this project comprises a total of three boards.



Right: The second of the DTM boards.

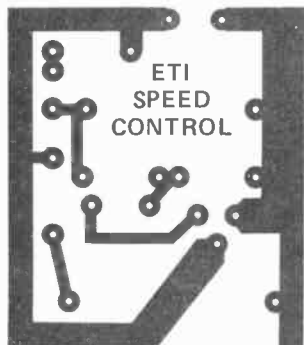


Above: The switching board for the DTM project.

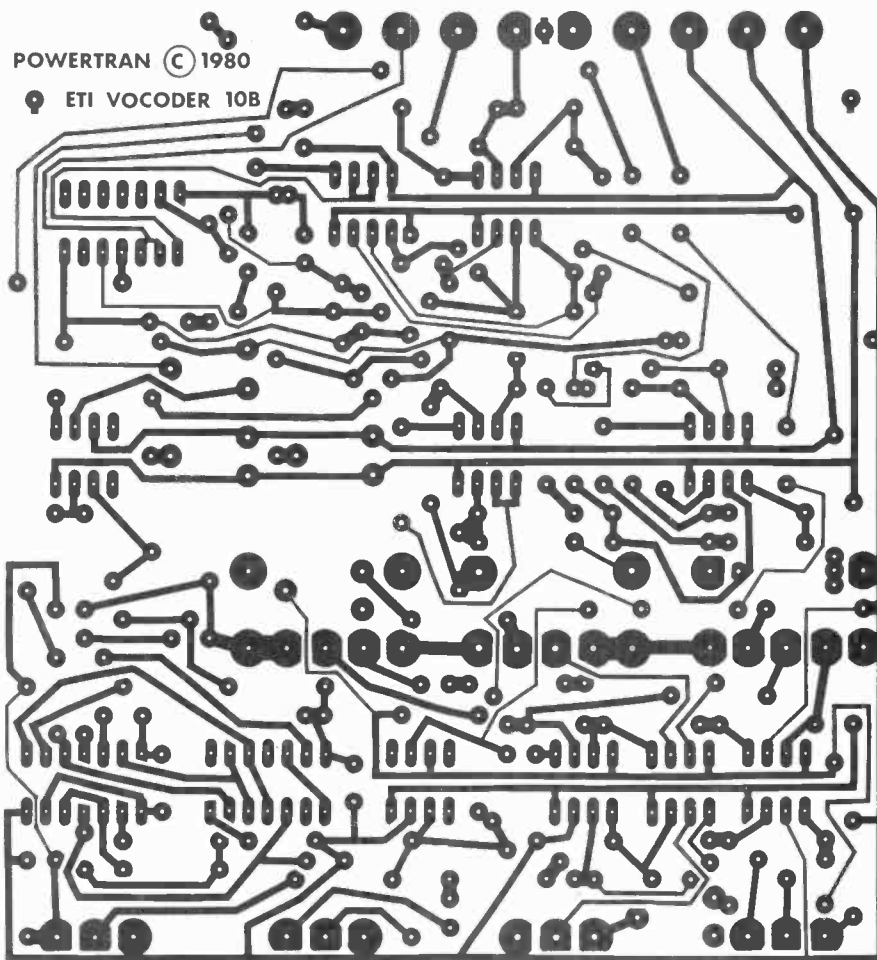


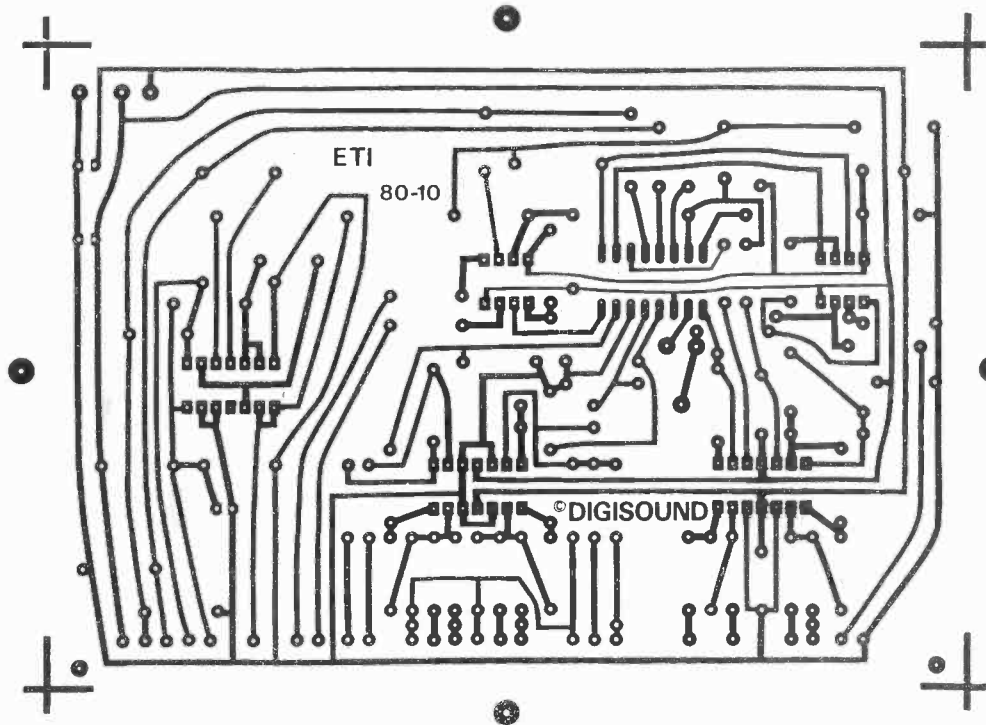
Above: The RIAA preamp foil pattern. The board is intended to be mounted inside existing equipment and space maybe left for fixing.

Below: Vocoder board B. The large PCB is not shown here as it is too large to go on the page. An SAE to Modmags will secure a copy.

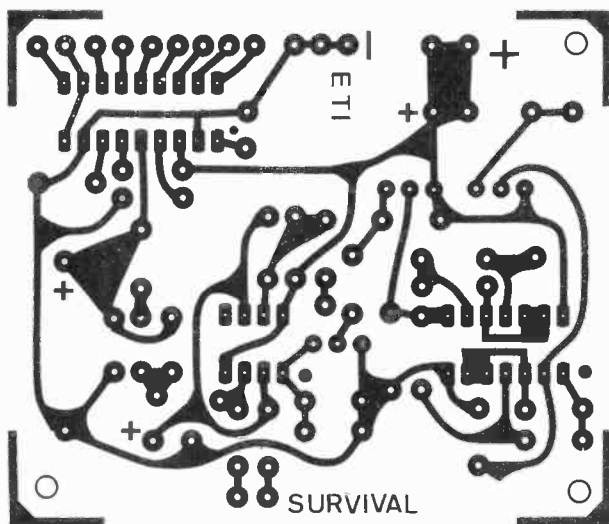


Above: The Drill Speed Controller PCB. Construction is not critical here and other methods may be employed. Take care with the PCB as mains voltage will be present.



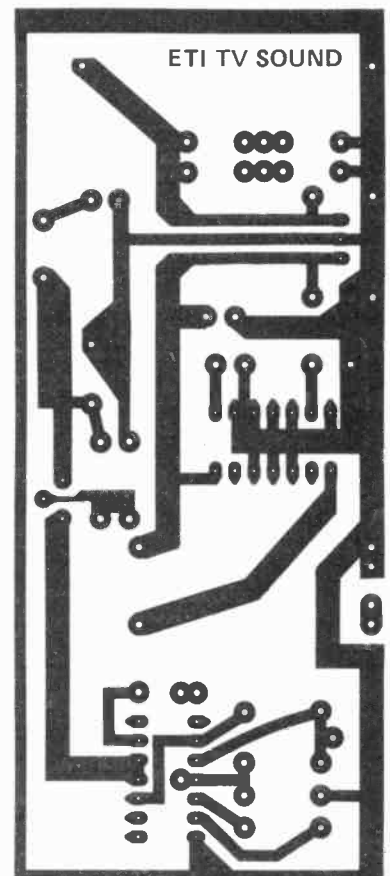


Above: Project 80 board for this month's module. Note that copyright exists on the board and firms may not reproduce the PCBs for sale.



Above: Foil pattern for the SURVIVAL game. This has been designed to fit the specified case.

Right: The monitor amplifier board for the TV Sound Tuner. This circuit is an optical extra to aid tuning and setting up.





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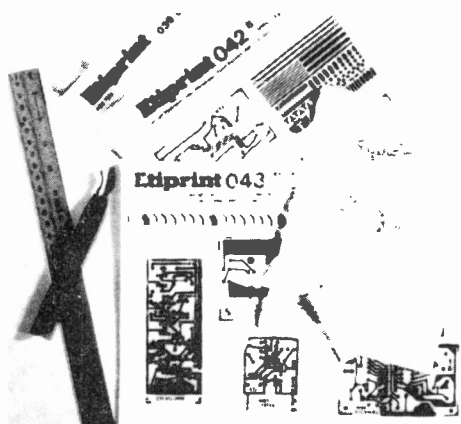
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<b>039A</b>	Hum Filter Logic Probe	Dec 79	<b>041A</b>	ETI Audiophile ETI VCA Signal Trace ETI HC Electromyogram	Mar 80	<b>043</b>	IR60 preamp, Receiver, PSU, Servo Tester, VU-PPM	May 80
<b>039B</b>	Long Period Timer Rain Alarm Touch Switch Flash Trigger Pseudo Random Noise Gen	Dec 79	<b>041B</b>	VCM Heater Controller	Mar 80	<b>044A</b>	IR60 Function Board (Top & underside) Control Circuit, Line Transmitter, Tape Response Meter Ohmmeter	June 80
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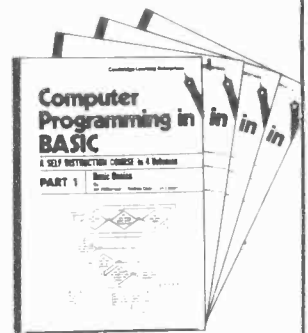
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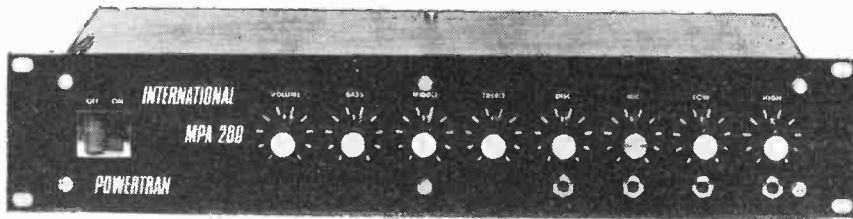
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## MPA 200 100 WATT (rms into 8Ω) MIXER / AMPLIFIER

Featured as a constructional article in ETI, the MPA 200 is an exceptionally low priced — but professionally finished — general purpose high power amplifier. It features an adaptable input mixer which accepts a wide range of sources such as a microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward. The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc. — complete down to the last nut and bolt.



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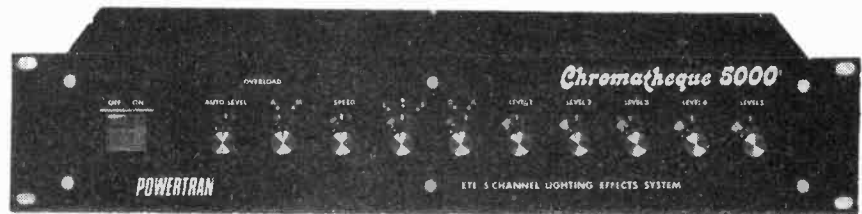
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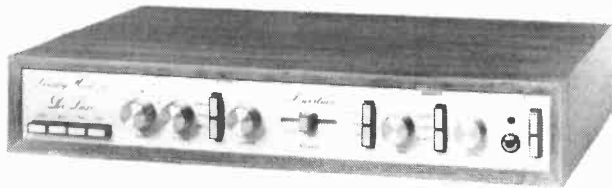


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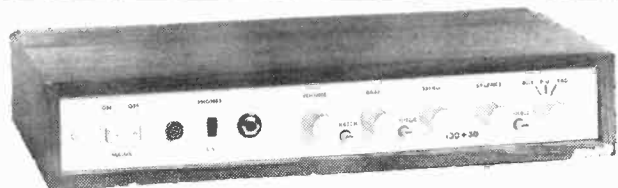
SYNTHESIZER KITS ON PAGE 8. MORE KITS AND ORDERING INFORMATION ON INSIDE FRONT COVER.

All kits also available as separate packs (e.g. PCB, component sets, hardware sets, etc.). Prices in our FREE CATALOGUE.



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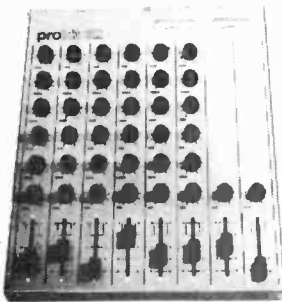
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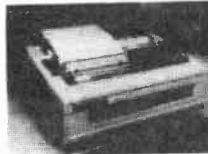
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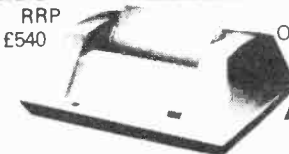


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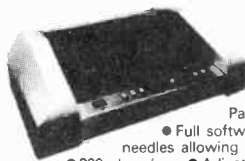
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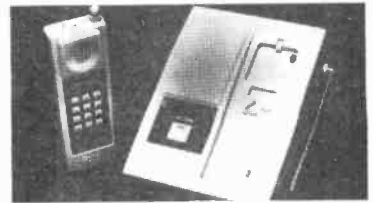


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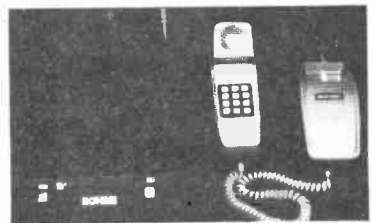
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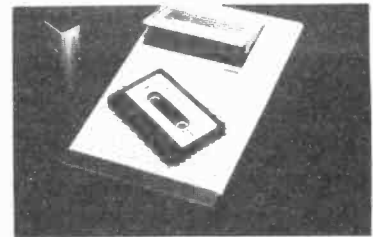
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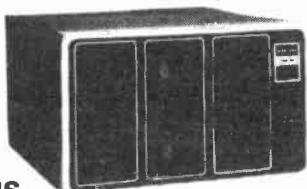
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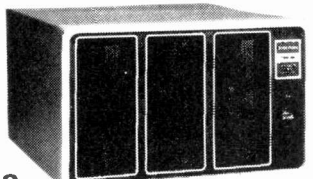
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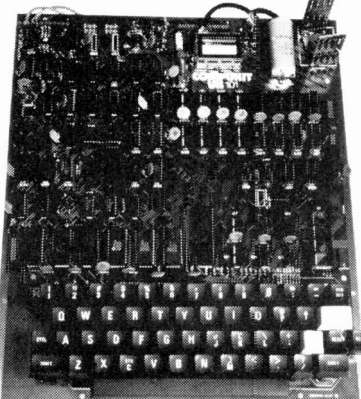
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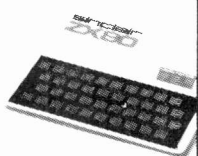
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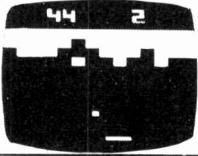
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