

# electronics today international

JULY 1975

30p

## PROJECT

### BUILDING GUIDE

### AMBISONICS - the technical details

### NEW VAT ROLINGS USING THE LM377 VOLTAGE MULTIPLIERS LINE AMP PROJECT STAGE MIXER



# TELETEXT TAKE OFF!

**BUMPER  
TECH-TIPS  
&  
PAGES**

# Sinclair Scientific kit

## Britain's most original calculator – now in kit form

The Sinclair Scientific is an amazing calculator.

It offers logs, trig, and true scientific notation over a 200-decade range – features normally found on calculators costing around £50 or more.

Yet even ready-built, it costs a mere £21.55 (including VAT).

And as a kit it costs under £15!

## Forget slide rules and four-figure tables

On the Scientific, you can handle *directly*

all three trig functions,

their inverses,

$\log_{10}$ ,  $\text{antilog}_{10}$ , giving quick access

to  $x^y$  (including square and

other roots),

plus, of course, the four arithmetic functions and any calculation based on them.

In fact, virtually all complex scientific or mathematical calculations can be handled with ease.



## So is the Scientific difficult to assemble?

No. Powerful though it is, the Sinclair Scientific is a model of tidy engineering.

All parts are supplied – all you need provide is a soldering iron and pair of cutters. Complete step-by-step

instructions are provided, and our Service Department will back you throughout if you've any queries or problems.

Of course, we'll happily supply the Scientific or the Cambridge already built, if you prefer – they're still exceptional value. Use the order form.

## Features of the Scientific

- 12 functions on a simple keyboard
- Scientific notation
- 200-decade range
- Reverse Polish logic
- 25-hour battery life
- Genuinely pocketable

## Features of the Cambridge

- Only  $4\frac{1}{4}'' \times 2'' \times \frac{1}{16}''$ . Weight  $3\frac{1}{2}$  oz.
- Fully-floating decimal point.
- Algebraic logic.
- Constant on all four functions (+ - × ÷).
- Constant and algebraic logic combine to act as limited memory.
  - Clear, bright 8-digit display.
  - Operates for weeks on 4 AAA batteries.



# Sinclair Cambridge kit

At its new low price, the Sinclair Cambridge kit remains unbeatable value.

The Cambridge is now Britain's most popular pocket calculator. And it's not surprising. Check the features – then ask yourself what other calculator offers such a powerful package at such a reasonable price.

## Take advantage of this money-back no-risk offer today

The Sinclair Cambridge and Scientific kits are fully guaranteed. Return either kit within 10 days, and we'll refund your money without question. All parts are tested and checked before despatch – and we guarantee any correctly-assembled calculator for a year. This guarantee also applies to calculators supplied in built form.

Simply fill in the preferential order form below and post it – today!

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me

Scientific kit – £14.95 inc. VAT

Scientific built – £21.55 inc. VAT

Cambridge kit – £9.55 inc. VAT

Cambridge built – £13.99 inc. VAT

\*I enclose a cheque for ..... made out to Sinclair Radionics Ltd, crossed.

\*Please debit my \*Access/Barclaycard account number: \_\_\_\_\_

\*Delete as required

Signed \_\_\_\_\_ Name \_\_\_\_\_

Address \_\_\_\_\_

Please print. FREEPOST – no stamp required.

ET1/7/75

Sinclair Radionics Ltd,  
London Road, St Ives, Huntingdon, Cambs., PE17 4JH. Tel: St Ives (0480) 64646  
Reg. no: 699483 England. VAT Reg. no: 213 8170 88



# electronics today international

JULY 1975

Vol. 4. No. 7.

## Special Feature

BUMPER TECH-TIPS . . . . .	38
----------------------------	----

*Eight pages of this very popular feature*

## Main Features

VAT AND COMPONENTS . . . . .	7
<i>How the new rates affect the hobby</i>	
THE HOME WORKSHOP . . . . .	10
<i>Space, light, tools and components — getting it all together</i>	
THE ART OF SOLDERING . . . . .	13
<i>How to make sound solder joints — essential to successful building</i>	
TELETEXT TAKE OFF! . . . . .	18
<i>Things are beginning to move on this major British TV development</i>	
HIGH VOLTAGE FOR LOW COST . . . . .	31
<i>Theory and practice of voltage multipliers</i>	
HOW AMBISONICS WORKS . . . . .	35
<i>ETI dissect the inventor's patents</i>	
USING THE LM377N . . . . .	49
<i>A chip containing two 2W audio amplifiers</i>	
UNDERSTANDING COLOUR TV . . . . .	58
<i>Line and field synchronisation</i>	
ELECTRONIC'S IT'S EASY . . . . .	60
<i>How regulated power supplies work</i>	

## Projects

LINE AMPLIFIER . . . . .	24
<i>Boost microphone outputs with this low noise amplifier</i>	
STAGE MIXER . . . . .	26
<i>16-line amplifier sub-mixes to eight channels — plus monitor</i>	
ETI 3600 SYNTHESISER . . . . .	54
<i>Building the voltage controlled filter</i>	

## News & Information

NEWS DIGEST . . . . .	6
INPUT GATE . . . . .	47
PREVIEW OF AUGUST'S ETI . . . . .	47
PROJECT BOOK NO. 2 . . . . .	48
ELECTRONICS TOMORROW . . . . .	64

ETI PULSAR DIGITAL ALARM CLOCK OFFER . . . . .	46
--	----

*A magnificent product for only £13.95!*

Cover: Have you ever seen a tidy electronics workshop? A bit of ETI's lab is shown here: see Project Building Guide on page 10. Teletext receivers will soon be available to the public — page 18 (photo courtesy of Texas Instruments).

EDITORIAL & ADVERTISEMENT OFFICE  
36, Ebury Street, London SW1W 0LW.  
Tel. 01-730 8282.

---

HALVOR W. MOORSHEAD  
*Editor*

ROBERT C. EVANS  
*Advertisement Manager*

STEVE BRAIDWOOD, G3WKE  
*Assistant Editor*

JEAN BELL  
*Production*

HELEN COHEN  
*Administration*

VALERIE FULLER  
*Subscriptions & Back Numbers*

International Editions

COLLYN RIVERS  
*Editorial Director*

Australia

BRIAN CHAPMAN  
*Technical Editor*

BARRY WILKINSON  
*Engineering Manager*

France

DENIS JACOB  
*Editor-in-chief*

CHRISTIAN DARTEVELLE  
*Editor*

---

Published by: Modern Magazines (Holdings) Ltd  
36, Ebury Street, London SW1W  
0LW.

Electronics Today International is published on  
the second Friday in the month prior to the  
cover date.

Distributed by: Argus Distribution Ltd.

Printed by: Q.B. Newspapers Limited,  
Colchester.

---

### International Associates:

Australia: Modern Magazines (Holdings) Ltd,  
Ryrie House, 15 Boundary Street, Rushcutters  
Bay 2011, Sydney, Australia.

France: Electroniques Pour Vous International,  
17 Rue de Buci, Paris, France.

USA: ACP, Room 401, 1501 Broadway, New  
York, USA.

European News Bureau: H. Dvoretzky, Manager,  
107 Fleet Street, London EC4.

---

**READER QUERIES:** These can only be answered  
if they relate to recent articles published in the  
magazine. Rarely can we supply information in  
addition to that published. Written queries must  
be accompanied by a stamped, self-addressed  
envelope, and telephone queries must be brief, not  
before 4.00 pm and can only be answered subject  
to the availability of technical staff.

**BACK NUMBERS:** Back numbers of many issues  
are available for 30p each plus 10p postage.

**SUBSCRIPTIONS:** Great Britain, £4.25 per year,  
Overseas, £4.75 per year. (Air Mail £7.50).

**COPYRIGHT:** All material is subject to World-  
wide Copyright protection. All reasonable care  
is taken in the preparation of the magazine to  
ensure accuracy but ETI cannot be held responsible  
for it legally. Where errors do occur, a correction  
will be printed as soon as possible afterwards in the  
magazine.

ETI PROJECTS BOOK  
NUMBER TWO  
SEE PAGE  
48



# -the lowest prices!

## 74 Series T.T.L. I.C.'S

BI-PAK STILL LOWEST IN PRICE, FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

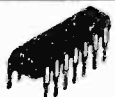


Table listing various IC types (7400, 7401, etc.) with quantities and prices.

DEVICES MAY BE MIXED TO QUALIFY FOR QUANTITY PRICE. (TTL 74 SERIES ONLY) DATA IS AVAILABLE FOR THE ABOVE SERIES OF I.C.'S IN BOOKLET FORM. PRICE 35p.

## NOW WE GIVE YOU 50W PEAK (25W R.M.S.) PLUS THERMAL PROTECTION!

### The NEW AL60 Hi-Fi Audio Amplifier

FOR ONLY £4.25

- Max Heat Sink temp 90°
• Thermal Feedback
• Frequency Response 20Hz to 100KHz
• Latest Design Improvements
• Load - 3, 4, 8 or 16 ohms
• Distortion better than 0.1% at 1KHz
• Signal to noise ratio 80dB
• Overall size 63mm x 105mm x 13mm
• Supply voltage 15-50 volts



Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F., enthusiast.

FULLY BUILT - TESTED and GUARANTEED

## STABILISED POWER

### MODULE SPM80

£3.25



SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection.

TRANSFORMER BMT80 £2.75p. & p.40p

## INTEGRATED CIRCUIT PAKS

Manufacturers' "Fall Outs" which include Functional and Part Functional Units. These are classed as "out of spec" from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

Table listing Integrated Circuit Paks (UIC00, UIC01, etc.) with contents and prices.

Paks cannot be split, but 25 assorted pieces (four mix) is available as PAK UIC X1.

## STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market. The PA100 stereo pre amplifier has been conceived from the latest circuit techniques.

Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.



only £14.25

## LINEAR I.C.'S - FULL SPEC.

Table listing Linear I.C.'s (72702, 72709, etc.) with quantities and prices.

## DTL 930 SERIES LOGIC I.C.'S

Table listing DTL 930 Series Logic I.C.'s (72702, 72709, etc.) with quantities and prices.

## DUAL-IN-LINE SOCKETS.

Table listing Dual-In-Line Sockets (14 & 16 Lead Sockets) with prices.

## AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.

Table comparing parameters (Harmonic Distortion, Load Impedance, etc.) for AL10, AL20, and AL30 modules.

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

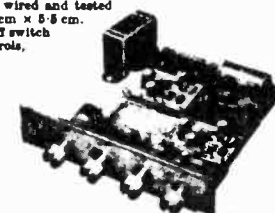
Table comparing working conditions (Maximum Supply Voltage, Power output, etc.) for AL10, AL20, and AL30 modules.

## TEAK VENEERED CABINETS for: STEREO 20

TC 20. £3.95 p&p 45p
TC 100. £6.50 p&p 40p.
E.M.I. LEK 350 Loudspeaker System Enclosure kit in Teak Veneer, including speakers.

## The STEREO 20 £14.45 p & p 45p

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm x 14 cm x 5.8 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amp.



## TRANSFORMERS

Table listing transformers (T461, T538, BMT80) with prices.

## POWER SUPPLIES

Table listing power supplies (PS 12, SPM 80) with prices.

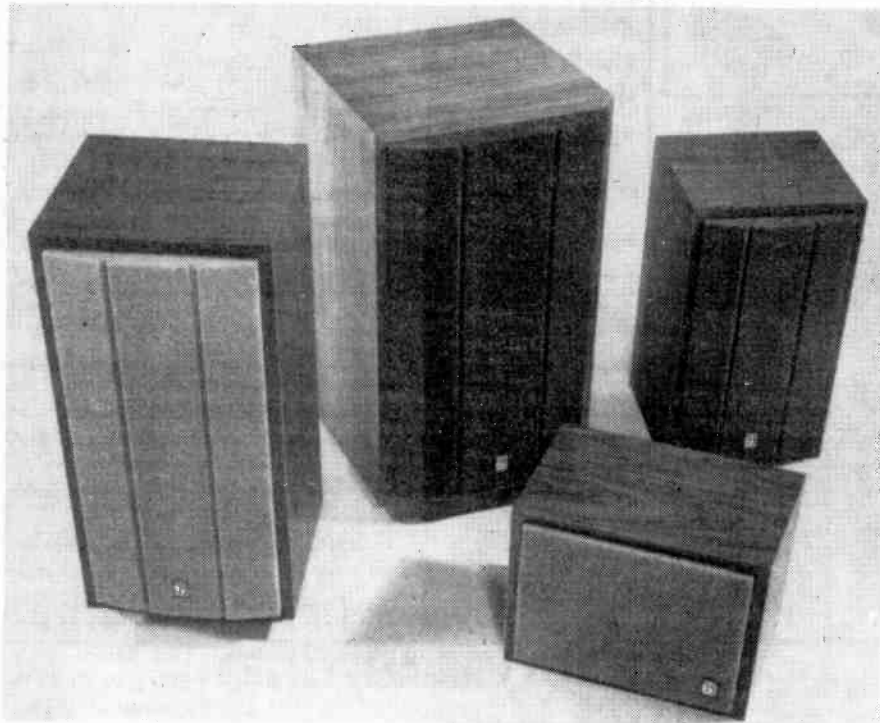
## PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies.

## BI-PAK

P.O. BOX 6, WARE, HERTS
Guaranteed Satisfaction or Money Back

# news digest



## BIC VENTURI LOUDSPEAKERS

These BIC Venturi speakers utilise a new method of reproducing bass frequencies based on the Venturi principle. The acoustic energy output is much higher and a much purer signal results.

Low-velocity air motion in the cabinet is transformed to high velocity air motion in a venturi-coupled path. At very low bass frequencies the amplitude of the signal from the opening of the venturi-coupled path is substantially greater than from the front of the woofer itself. The venturi-coupled path functions also as an acoustic low pass filter, removing unwanted harmonic content. All the BIC Venturi speakers feature a continuously variable "Brightness" control on the front panel.

There are four speakers in the

range. The Venturi Formula 1 will handle up to 50 rms, and will cost approximately £45.00 each (excluding VAT). The Venturi Formula 2 will handle 75 rms watts, and will cost approximately £65.00 each (excluding VAT). The Venturi Formula 4 will handle 100 rms watts and will cost approximately £80.00 each (excluding VAT). The last speaker in the range is the Venturi Formula 6 which gives a response of 20Hz to 23kHz, and can handle 125 rms watts. The price will be approximately £130.00 (excluding VAT).

These speakers carry a three year (parts and labour) guarantee and are available through Belmont A/V Limited Fircroft Way, Edenbridge, Kent.

## DIGITAL WATCH PRICES TUMBLE

Digital watches may soon be selling for less than £30 — and could be as low as £12 in two years time.

This forecast was made by Victor Kiam of Benrus Corporation during a digital watch seminar held in New York earlier this month. As if to illustrate Kiam's point, Litronix (Cupertino, California) announced a range of five LED readout watches costing from \$50 — \$60 (£20 — £24).

Not all manufacturers are aiming for ultra-low prices however. Intersil for example are about to introduce an LED readout wristwatch range (called Cronus) selling for around £80 — £150

## NEW COMET DISCOVERED

Astronomers in the Crimea have discovered a new comet — provisionally named 1975-E. It is relatively close — not more than 400 million miles away but the size and orbit have not yet been calculated.

## SASER?

Professor S. Altshuler of Kazan University, USSR, is developing acoustic generators and amplifiers working on the same principles as the laser. They are the outcome of the university's research into acoustic paramagnetic resonance in solid body physics.

## FRANCIS GRAHAM

It is with deep regret that we announce the death of Frank Graham on May 17th at the tragically early age of 27 after a long illness which he bore cheerfully.

Frank was ETI's regular photographer and although rarely credited in the magazine, few issues in the last two years did not carry his work. Although not a staff member, Frank was a regular visitor to ETI's offices and we downed many a pint with him. He was invariably cheerful, helpful and, was a perfectionist in his photography. We shall miss him.

## LASER MISSILE INTERCEPTOR

The US armed forces may soon have a laser missile interceptor. Air Force reports state that prototype deuterium fluoride lasers have been successfully tested at 'very very high' power outputs.

Power output is apparently so high that the laser beam burns straight through heavy gauge stainless nickel steel plate.

## SOVIET RADAR BLAMED FOR HIGH HEART DISEASE

A Russian radar tracking station near the Finnish town of Ilomaritsi may be responsible for a sharp increase in heart disease and cancer according to Dr. Milton Zaret, an American microwave expert.

The Finnish border towns have the highest rate of heart disease in the world and cancer has increased inexplicably.

## ELECTRONIC CHEQUEBOOK CALCULATOR

A pocket calculator that will hold and display bank cheque account balances for a year or more is shortly to be announced by the US Mostek Corporation.

During the times that the calculator is 'off' data is stored in a static shift register (drawing a mere 100 microamps). This data is then clocked solely when access is required.

The unit is expected to retail for less than £16 and will be built into a plastic chequebook holder.

## VAT AND COMPONENTS

When the Chancellor, Mr. Healey, introduced the higher rate of VAT (25%), this was clearly done to tax 'luxuries'. Amongst other categories of goods qualifying for the higher rate are Radio, TV and Audio equipment; When component suppliers received the new instructions they found in the small print a number of other categories, most of which were obvious candidates - TV aerials etc. - but also listed specifically were transistors, valves, resistors, coils and capacitors suitable for use in these higher rated goods. The position of kits was not covered.

H.M. Customs and Excise, who administer and collect VAT, were asked by ETI what the new rate covered. They have been placed in the unenviable position of having to interpret the new rulings. It became clear that the Customs and Excise were as confused as everyone else! As a result, Halvor Moorshead, Publisher and Editor of ETI, organised a deputation of representatives of the components retailers to meet Customs and Excise to arrive at a workable interpretation. The companies represented were: Marshall's, Ambit, Heathkit, Electrovalue, Henry's Radio, Home Radio, Bi-Pak, Bi-Pre-Pak, Maplin, Doram, L.S.T., Bywood, Chromasonics, Tandy, Crescent Radio and Garland Brothers.

Representation was made to obtain a workable definition, not to protest

the rate, as Customs and Excise cannot make such decisions. The outcome was that the following list was proposed by the delegation and accepted as an interim definition by H.M. Customs and Excise.

### SUBJECT TO 25% VAT

1. Transistors FET's and valves,
2. Resistors - fixed value types.
3. Capacitors including variable capacitors.
4. Potentiometers and presets.
5. Diodes and Rectifiers.
6. RF Coils, IF transformers ceramic filters.
7. Moving coil loudspeakers.
8. Microphones and accessories, headphones and earphones.
9. Linear IC's inc. Amps, Op. Amps and PLL.
10. Radio, TV and audio modules.
11. Radio, TV and audio equipment parts and accessories such as aerials preselectors, cabinets, dials, printed circuit board, (for Group 2 items) and ferrite aerials.
12. Musical keyboards and accessories, guitar pick-ups, spring-line units.

All other goods are subject to 8% including digital IC's, transformers, test gear etc. Copies of letter received by ETI from H.M. Customs and Excise confirming this are available to

*bona fide* manufacturers and component suppliers from ETI on request.

Kits were also covered. Where the built-up kit would qualify for the higher rate, the VAT will normally be charged at 25%. Where a kit, when built-up, would qualify for 8%, the whole kit will be 8% *except* when those components which normally fall in the 25% category comprise more than 33 1/3% of the final value. In practice, this means that virtually all kits which would qualify for the 8% rate when built, continue to be at 8%.

This dual rate is causing enormous problems amongst the component suppliers, so bear with them.

It certainly appears that components have been put in the higher rate to avoid loop-holes, *not* because the Chancellor wanted to tax the electronics enthusiast. This seems very unfair to us and if you agree there *is* something you can do about it - you don't have to sit back and take it: write to your M.P. If the number of M.P.'s, especially Labour ones, are convinced by your argument, the Government may change their mind - it's not as far-fetched as it appears - there are many precedents for corrective Legislation where it is found that the original draft has loop-holes and people are being taxed for something which was included only to prevent loop-holes. Don't complain to your component suppliers, or to us - write to your M.P.

### ANALOGUE MEMORY

A device to store an analogue waveform, to play it back at a slow speed for oscilloscope or x-y plotter display, has been introduced by Kemo (9 Goodwood Parade, Elmers End, Beckenham, Kent BR3 3QZ). The AM1024 digitises a time segment of

the signal and stores up to 1024x9-bit words.

Sampling interval is controlled either by internal crystal, for the range 3µs to 300ms, or by an external source, for longer intervals. The store is fed continuously until the memory is instructed to hold the waveform, then this is read out to the display.

### SINCLAIR WIN QUEEN'S AWARD

The Queen's Award to Industry, 1975 has been won by Sinclair both for outstanding export achievement and for technological innovation in scientific calculators: only two company's have won Awards in both categories this year.

In the three years up to March 1974, exports increased 10-fold to £2,232,000 or 56% of turnover.

The Award for technical innovation is for the Sinclair Scientific which will be well-known to ETI readers. Sales topped £1 Million, over half of them exported. Of the UK sales a significant proportion resulted from the ETI/Sinclair reader offer in October 1974.

Other electronics companies to win the Queen's Award are two divisions of BICC, EMI and Micro Consultants, a company employing only 80. In the latter case the Award was for Technical Innovation for its range of video analogue and digital converters.

### ETI/DANAMETER COMPETITION -APRIL 1975 ISSUE-

This competition closed on April 30th and, as usual, it was a great success. The correct answers are shown.

We were slightly apprehensive about setting the level too high but reactions from readers show that generally people prefer something challenging.

No. 8 down "Earliest 'air' crossing of the Atlantic refers to Marconi's radio experiments - we did put 'air' in inverted commas to draw attention to this but quite a lot of people got it wrong.

The first three correct entries drawn after the closing date were from:

- S.D. Boyd of Stubbington, Hants.
- M.P. Conroy, Wimbledon Chase, London SW20.
- D.M. Weiss, London NW6.

1	2	9	2	3	6		4	7		
		6		5	1	6	4	1	7	5
8	1	0	9	7		9		7		
9			10	7		3		2		
0			7		11	5	12	7	3	
13	1	14	2	7	15	0		0		
		5		16	7	4	9	0		

## MYSTERY WALKIE TALKIE

London's Fire Brigade are currently evaluating a 'mystery' walkie-talkie system that enables firemen to communicate with each other even inside steel-framed buildings.

The 'mystery' is that no-one — including Plessey, who developed it — totally understands just how it works!

Communication within steel-framed buildings has always been a major problem, UHF and VHF radios are useless in these conditions and cable linked systems are cumbersome and prone to damage.

Plessey, under contract to the Home Office investigated the problem and found that rf energy at 3MHz will penetrate steel-framed buildings. The frequency seems to be fairly critical and, say Plessey there must be some metal structure around for the system to work. 'It works' says a Plessey spokesman, 'but honestly we don't know why'.

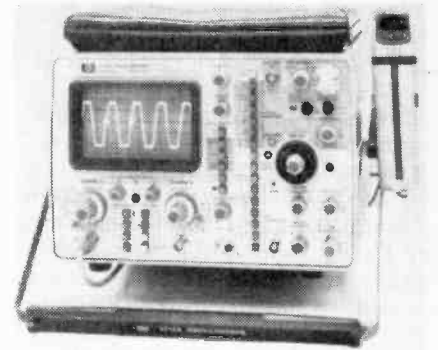
Twenty four sets of the new system — known as Figaro — have been supplied to Britain's fire brigades for evaluation. The first real-life test came during the recent Moorgate underground train disaster where it was used to communicate from the disaster site underground up to street level. The system apparently worked extraordinarily well.

## TIMER IC

The Ferranti ZN1034E is an IC that will accurately time processes lasting from milliseconds to weeks. The 14-lead DIL package requires only one external resistor and capacitor. It has a drive capability of up to 25mA. It can be powered by battery, from a 5V TTL rail, or from the mains.

Features of the ZN1034E include repetitive and cascade operation, an internal/external calibration facility, mains contact or TTL triggered timing sequence initiation, a temperature stability of  $<0.01\%/^{\circ}\text{C}$  and accurate repetitive timing of typically 0.01%. It provides time intervals up to 7500CR through its 12-stage counter, and gives complementary TTL compatible outputs.

The ZN1034E utilises digital and precision linear functions on the same chip. The frequency of the on-chip oscillator is determined by an externally connected capacitor and resistor. In addition, fine adjustment can be achieved by connections of a calibration timing. Pulses from the oscillator feed through a 12-stage binary divider which times out after 4095 counts. A voltage regulator is incorporated and two modes of operation can be used. The one off price is £2.99 from Edmondson Electronic Components Ltd., 30-50 Ossory Road, London SE1 5AN.



## OSCILLOSCOPE RESOLVES TIME INTERVALS TO 100 PICOSECONDS

A new 200MHz dual-channel oscilloscope, Model 1712A from Hewlett-Packard, can resolve time-interval measurements to 100 picoseconds. It is easy, with dual delayed sweep, using two markers, to define the interval of interest on the screen with that resolution. A special output delivers a voltage precisely proportional to the selected time interval. With a 4½-digit DVM, digital readout with 100-ps resolution is possible, to make such timing measurements as risetimes, propagation delay, and clock-phasing with ease and precision approaching those attained with the micro-processor-equipped HP 1722A. The price is £1,643.

Hewlett-Packard Ltd., King Street Lane, Winkersham, Wokingham, Berks. RG11 5AR.

## SINGLE CHIP MICROCOMPUTER

The TMS 1000 is a complete self-contained micro-computer system on one P-Channel MOS Chip. It contains an 8192 bit ROM for programming, a 256 bit RAM for data storage, and a 4-bit binary ALU. In addition the chip has 13 control outputs set under program control, 1 4-bit parallel input port and a separate 8-bit parallel output port. An incoming binary word of up to 64 bits is read in in 4-bit hexadecimal digits and operated on by the ALU in digit sequence.

There are two mask programmable areas on the chip in addition to the program ROM. The instruction decoding PLA can be mask programmed to provide variations of, and mergings of, the base set of 43 instructions, and the 8-bit output formatting logic is mask programmable to allow the user to specify any 8-bit output code including BCD, 7-segment and ASC II.

The TMS 1000 has an on-chip oscillator, activated by an external resistor and capacitor, or an external clock can be connected. At the nominal clock frequency of 500kHz the instruction cycle time (for assembly instructions) is 12 microseconds.

Applications of the TMS 1000 are envisaged in terminal controllers, fuel-metering, credit card verifiers, printer controllers, vending machines, weighing machines, in fact all types of industrial control systems requiring in excess of 5000 parts per year, where the use of a microprocessor chip set would be unnecessarily complex and expensive.

Texas Instruments Limited, Manton Lane, Bedford.



WELL FRANK, ... WE SEEM TO BE GETTING A BETTER CLASS OF ANTI-GRAVITY MACHINE THESE DAYS; EH?!



# NEW CHIP PRICES as from 1st May 75

## DIGITAL DISPLAYS

DL707	Common-Anode 0.3" LED display	£ 1.70
DL704	Common Cathode DL707	£ 1.70
DL701	Common-Anode 0.3" ±1	£ 1.70
DL747	Common-Anode 0.6" LED display	£ 2.45
DL750	Common-Cathode DL747	£ 2.45
DL746	Common-Anode 0.6" ±1	£ 2.45
3015F	Minitron filament 12.5mm	£ 1.25
3017F	Minitron filament 17.5mm	£ 2.00
RDS1	Itoka filament 2.5"	£ 8.00
RDM2	Itoka filament 5.0"	£24.80
DG12	Phos-diode 12.5mm	£ 1.20
5LT01	Phos-diode 4 digit clock display	£ 5.80

## DIGITAL CLOCKS

DIGITRONIC I16	Six digit clock	£31.00
DIGITRONIC I17	With 1/10th seconds	£34.00
DIGITRONIC I10	6 digit Quartz clock	£43.50
DIGITRONIC I1S	Mains Stopwatch Clock	£54.00
DIGITRONIC I11	Time/Date/Alarm Clock	£37.50
CHANTICLEER	4 digit alarm clock	£16.60

## MHI KIT SYSTEMS

(For Common-anode LEDs)

MHI-5314	5314 chip, driver & PCB	£ 6.60
MHI-7001	7001 chip, driver & PCB	£10.00
MHI-5025	5025 chip, driver & PCB	£ 9.35
MHI-D707/6	6 DL707 LEDs plus PCB	£11.00
MHI-D707/4	4 DL707 displays plus PCB	£ 7.60
MHI-D747/6	6 DL747 displays plus PCB	£15.15
MHI-D747/4	4 D1747 displays plus PCB	£10.25
MHI-D727/6	6 Digit 0.5" units plus PCB	£14.50

## DIGITAL CLOCK CHIPS

### CLOCK CHIPS:

MM5314	Basic 12/24Hr, 6 digit, 50/60Hz chip. 7 seg outputs. Very popular, simple chip.	£ 4.44*
MM5311	As MM5314 but with additional BCD outputs.	£ 5.18
MK50250	6 digit alarm chip with alarm tone output, Standard basic alarm facilities.	£ 5.60*
CT7001	Time, Date & Alarm on one 6 digit chip. The Alarm can be used in 3 modes including a time switch. Clock-Radio & Snooze features. 7 seg outputs, 50/60Hz or 100.8kHz input frequency.	£ 7.30*
CT7002	As CT7001 but with BCD outputs not 7 seg.	£ 7.30
TMS3952	Stopwatch chip, most reqd. stopwatch functions 6 digits (hhmmss or mmmsss), 300kHz input. 7 seg output. Special price.	£10.50
HEEC2	8 digit (HhMmSsss), stop/start/reset, 50Hz/60Hz/100kHz input, BCD output hard-wired alarm with repeat (snooze). Can also be used as 8 digit decade counter.	£ 8.50
CT6002	CMOS chip for Liquid-crystal displays, 12Hr, 1Hz colon, input 32768Hz or 65536Hz. Runs on 1.5V hearing aid battery for a year.	£15.00
MM5316	4 digit non-mplxd alarm chip, will direct drive l-c or phosphor-diode displays.	£9.25

\* Available in a MHI kit.

We advise the use of sockets for all ICs, 24/28/40 pin £1.00.

BYWOOD ELECTRONICS,  
181 Ebbw Road,  
Hemel Hempstead,  
Herts. HP3 9RD.  
Tel: 0442-62757

All prices on this advert exclude VAT.

# BYWOOD

# SPARKRITE MK2

## CAPACITIVE DISCHARGE ELECTRONIC IGNITION KIT

"Sparkrite MK 2" is a high performance, high quality, capacitive discharge, electronic ignition system. Sparkrite completely eliminates problems of the contact breaker. Misfires due to contact breaker bounce is electronically eliminated, contact breaker burn is eliminated, the condition of the contacts is not relevant to the performance of the ignition, and the system is no longer dependent on the dwell period for recharging.

### SPARKRITE WILL GIVE YOU:

Up to 20% better fuel consumption, instant all weather starting, cleaner plugs they last up to 5 times longer without attention, faster acceleration, higher top speed, longer coil and battery life, efficient fuel burning and less air pollution, smoother running, continual peak performance.

### THE KIT COMPRISES EVERYTHING NEEDED

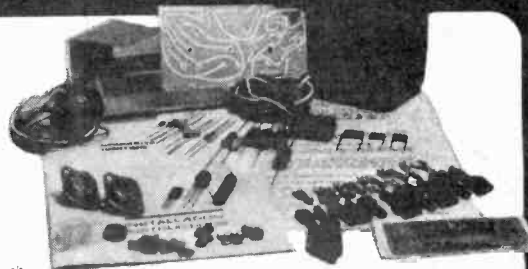
Ready drilled pressed steel case coated in matt black epoxy resin, ready drilled base and heatsink, top quality 5 year guaranteed transformer and components, cables, coil connectors, printed circuit board, nuts, bolts, silicon grease, full instructions to make the kit negative or positive earth, and 10 page installation instructions.

WE SAY IT IS THE BEST SYSTEM AT ANY PRICE

Voted best of 8  
ignition systems tested  
by Popular Motoring

### PRICES

DIY assembly kit £10.93 incl. V.A.T. post and packing Ready built unit £13.86 incl. V.A.T. post and packing (Both to fit all vehicles with distributor ignition up to 8 cylinders)  
Switch for instant changeover from "Sparkrite" ignition to conventional ignition £2.79 incl. V.A.T. post and packing R.P.M. limiting control £2.42 incl. V.A.T. post and packing (Fitted in case on ready built unit, dashboard mounting on kit.)  
We can supply units for any petrol-engined vehicle (boat, motorcycle, etc.) with coil/contact breaker ignition. Details on request.  
CALL IN AND SEE US FOR A DEMONSTRATION.



## ELECTRONICS DESIGN ASSOCIATES of WALSALL

### ALUMINIUM BOXES

Prices include lids, screws and V.A.T. (8%). 18p should be added to the total order value for postage and packing.

No. 7	5 1/2" by 2 1/2" by 1 1/2" high	47p
No. 8	4" by 4" by 1 1/2" high	46p
No. 9	4" by 2 1/2" by 1 1/2" high	46p
No. 10	5 1/2" by 4" by 1 1/2" high	49p
No. 11	4" by 2 1/2" by 1 1/2" high	46p
No. 12	3" by 4" by 1 1/2" high	38p
No. 13	6" by 4" by 2" high	58p
No. 14	7" by 5" by 2 1/2" high	75p
No. 15	8" by 6" by 3" high	93p
No. 16	10" by 7" by 3" high	£1-14

### FLUORESCENT LIGHT KIT

You can build this reverse polarity protected 12 volt, 8 watt, fluorescent light. Everything needed is supplied: white enamelled ready drilled metalwork, ready drilled heatsink, printed circuit board, high quality components and transformer, end caps, cable, the fluorescent tube, nuts bolts washers, and simple assembly and operating instructions.

### PRICES

Assembly Kit £3.46 inc. V.A.T. post and packing.  
Ready built £4.10 inc. V.A.T. post and packing.  
DIY user 59p inc. V.A.T. post and packing.  
When complete the light has many uses: workshop and workbench illumination, garage lighting, emergency lighting, lighting for camping, caravanning, and boating, as an inspection lamp and many more.

## ORDER NOW TO

TO ELECTRONICS DESIGN ASSOCIATES DEPT ET/7  
82 Bath Street, Walsall, WS1 3DE. Phone 33652.

FROM Name: \_\_\_\_\_

Address: \_\_\_\_\_

Qty. \_\_\_\_\_

SPARKRITE MK 2 DIY Assembly kits @ £10.93
SPARKRITE MK 2 Ready Built Negative earth @ £13.86
SPARKRITE MK 2 Ready Built Positive earth @ £13.86
Ignition changeover switches @ £2.79
R.P.M. Limit systems in the above units @ £2.42
Fluorescent light assembly kits @ £3.19
Fluorescent light built units @ £3.78
Diffusers for the above @ 59p
of number aluminium boxes @ _____
of number aluminium boxes @ _____
of number aluminium boxes @ _____

I enclose cheque/P.O. for £ \_\_\_\_\_

Cheque No. \_\_\_\_\_

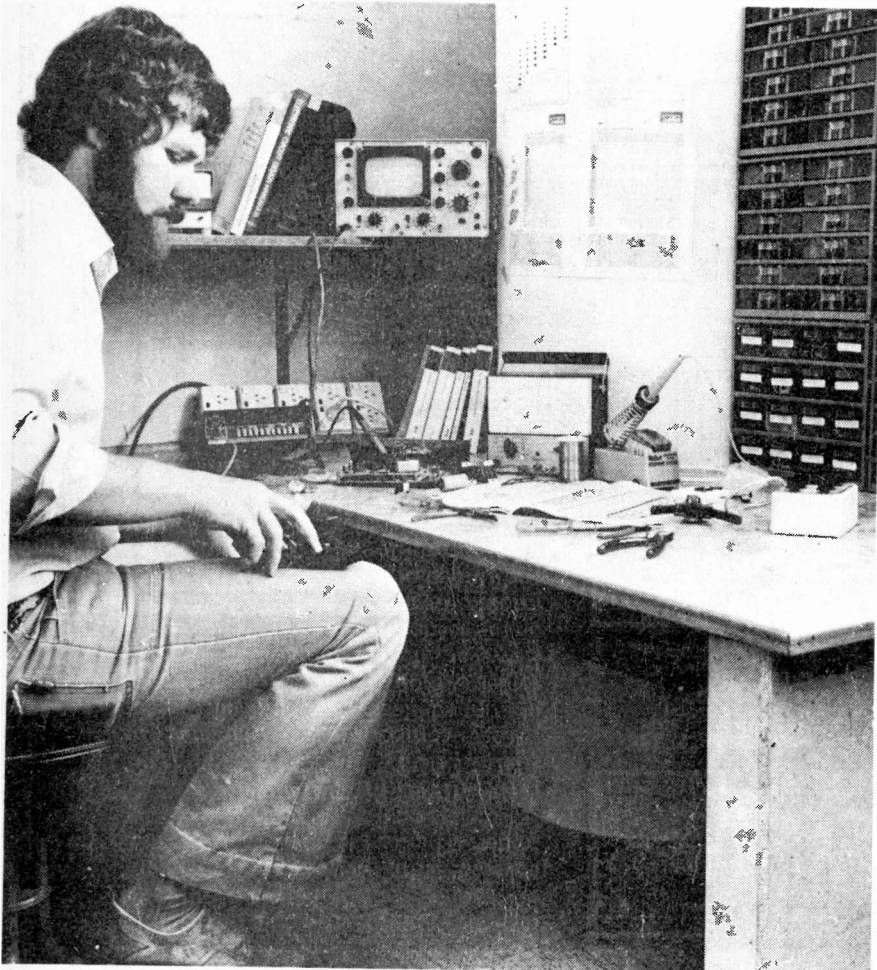
(Send SAE if brochure only required)



## Project Building Guide

# THE HOME WORKSHOP

Space, light, power, components, tools — save time and money with ETI's home workshop guide.



*Even an awkward corner like this can be utilized effectively. Note particularly the equipment shelf, storage bins, array of power points and linoleum on top of bench.*

### WORKSHOP KIT

The following list of tools and basic components has been carefully compiled to assist the novice constructor setting up a home workshop from scratch.

Virtually nothing on the list is redundant.

Test gear has not been included as this will form the basis of a further feature article to be published shortly.

Very roughly, all the items listed above should cost somewhere between £50 and £75 — naturally though prices will vary from supplier to supplier, and to some minor extent with the quality of the tools offered.

### TOOLS

Soldering Iron — approx 20 watt 240 volt  
Iron rest & wipe pad  
Side cutters  
Long nose pliers  
Neon indicator screwdriver  
Wire strippers  
3 x screwdrivers including one medium  
‘Philips’ head

### HARDWARE

500 grams tinned copper wire 22 Swg (0.711mm)  
‘Savbit’ solder  
Solder wick  
500 grams tinned copper wire 22 Swg  
2 x 100 metre reels hook-up wire  
(one 7/0076 and one 10/010 different colours)  
Assorted spaghetti (not plastic)  
50 x ½" x 1/8" bolts  
50 x 1" x 1/8" bolts

NOT all of us are blessed with space in which to build a workshop and many experimenters must be satisfied with the kitchen table or invade a small corner of the "sewing" room.

For those who can find a suitable space the requirements of a good workshop may be summarized under the headings of location, benches, light, power, storage and tools.

## THE LOCATION

As much space as possible is required if one is to undertake electronics as a serious hobby, anything from 2 x 2 metres upwards is needed. Electronic equipment (and the experimenter) is adversely affected by extremes of temperature. The area must also be dry as damp floors or walls will rapidly corrode contacts and cause rapid general deterioration of valuable equipment. A location should therefore be chosen that is clean and

dry and not subject to temperature extremes.

## BENCHES

The work bench should be strong and rigid as heavy equipment may be used on the bench.

Pine board or similar material makes an excellent bench top but, whether pine board, floor boards or ordinary other materials are used, it is advisable to surface the top with linoleum, tiles or sheet to provide a good stainproof and continuous surface.

A well-braced frame work should be constructed from 75 x 50 mm timber or, alternatively a steel frame may be constructed using Dexion angle or box section tube.

An equipment shelf should be provided along the rear of the bench at least 300 mm wide and 300 mm above the bench. Such a shelf allows the working space to be kept free of test equipment.

## LIGHT

The rule is as much light as possible. A good general illumination should be provided and, in addition, a desk lamp capable of swivelling to illuminate the interiors of equipment should be provided. If fluorescent general illumination is used purchase a twin lamp fitting that has lead/lag ballasts. Flicker is much reduced with this system and, although a little more expensive, you will save much eyestrain.

## POWER

Whilst in general very little mains power is required in an electronics workshop many pieces of equipment must be powered simultaneously and hence a multitude of power points is required.

Here we must emphasise that such power points *must be properly wired* — you seldom get a second chance with mains power. Make sure your

100 hex nuts (1/8")  
50 x 1/4" 'self tappers'  
50 x 1/2" 'self tappers'  
50 x 1" 'self tappers'  
2 x 6" square 0.2" pitch matrix board  
2 x 6" x 9 holes/0.15 pitch matrix board  
1 x 3.75" x 3.12" and 1 x 3.75" x 8.12"/0.1  
pitch Veroboard  
1 x resistor mounting strip (48 lugs per side)  
3 x 3 lug tag strips  
2 x 5 lug tag strips  
1 x 10 lug tag strips  
1 x 12 way screw terminal strip  
12 x assorted grommets

## COMPONENTS

### Resistors 1/2 watt 5% tolerance

5 x all standard values from 10 to 820 ohms  
15 x all standard values from 1k to 82k ohms  
5 x all standard values from 100k to 8.2 M ohms  
plus 20 x 1k $\Omega$ , 4.7k $\Omega$ , and 10k $\Omega$   
(660 resistors)

### Capacitors

3 x all standard values from 10pF to 820pF  
(Miniature Philips or similar)  
3 x all standard values from 0.001 $\mu$ F to 0.47 $\mu$ F  
plus 5 x 0.1 $\mu$ F and 0.01 $\mu$ F  
3 x 1 $\mu$ F capacitors  
2 x all following electrolytics (25 Vdc)  
microfarads (1, 2, 2.2, 3.3, 4.7, 10, 16, 25,  
47, 100, 200, 330, 470, 640, 1000)

### Trim pots

1 x 500 $\Omega$ , 1k $\Omega$ , 2.5k $\Omega$ , 5k $\Omega$ , 10k $\Omega$ , 25k $\Omega$ ,  
50k $\Omega$ , 100k $\Omega$ , 250k $\Omega$ , 500k $\Omega$ , 1M $\Omega$  (LIN)

### Potentiometers

1 x 2.5k $\Omega$ , 10k $\Omega$ , 25k $\Omega$ , 50k $\Omega$ , 100k $\Omega$ ,  
500k $\Omega$  (LIN)  
1 x 50k $\Omega$  (LOG)

### Relays and Switches

1 x 6-17 Volt (200 ohm) relay double pole C/O  
2 x DPDT 3A toggle switches  
1 x SP miniature push button (push-on)

### Semiconductors

6 x BC108 or equivalent transistors  
2 x BC178 or equivalent transistors  
1 x BFR80 transistor  
1 x BFR40 transistor  
1 x BC328 transistor  
1 x BC338 transistor  
1 x 2N3055 transistor  
1 x 2N2646 UJT  
1 x 2N6027 (D13T1) PUT  
1 x 2N5459 PUT  
6 x 1N914 silicon signal diodes or similar  
6 x 1N4004 silicon power diodes or similar  
1 x LED  
1 x OA90 germanium diode (or similar)  
1 x 400mW 4.7V zener diode  
1 x 1.5W 5.6V zener diode  
1 x 1.5W 6.8V zener diode  
1 x 1.5W 10V zener diode  
1 x 1.5W 12V zener diode  
1 x 1.5W 15V zener diode  
1 x ORP 12 light sensitive resistor

### Integrated circuits

1 x NE555 timer IC  
1 x  $\mu$ A 741 operational amplifier  
2 x LM301 operational amplifier

# THE HOME WORKSHOP

power installation is correctly wired and safe — after all it's your life. It is illegal to modify household power distribution yourself but it is legal to wire a bench so that it may be plugged into an existing power point. Although the bench power lead may be plugged into a single 13 amp power outlet such outlets only have a single pole switch. Hence for safety a two-pole switch, which breaks both active and neutral to the bench circuit, together with a neon indicator and fuse should be fitted such that the bench circuits can be completely isolated even though still plugged into the outlet.

To wire the bench use 23/0076 three-core flex if the current drain does not exceed seven amps and 40/0076 if the current does not exceed 10 amps. Choose the ratings of fuse and double-pole switch to suit. Make particularly sure that the earth is *solidly* connected to each power point and wire the power points according to Fig. 1.

Plugs should be wired to correspond. This is VERY important as a reversal of live and neutral can be dangerous, for, if a single pole switch is used to switch off equipment and you fail to pull out the plug — there could still be a live voltage present if the plugs etc. are incorrectly wired.

It is essential to check that the outlet socket (into which the bench sockets are plugged) also be wired correspondingly.

The only way to be sure is to actually measure the AC voltage between the pin that *should* be neutral, and the earth pin (with power switched on of course).

It is quite normal to have the odd volt or two between neutral and earth — but if there's 240 volts or so there (and little between live and earth) then the outlet socket has been 'incorrectly' wired by the installation electricians. Have it corrected by a suitably qualified person.

If you don't have a meter available check by connecting a 240 volt bulb between neutral and earth — and live and earth. It should be energized when it is between live and earth.

## STORAGE

An electronics workshop needs tons of storage capable of efficiently storing everything from small components through tools to electronic equipment so that they can be located with a minimum of fuss.

For small components the small moulded-plastic drawer cabinets are ideal. For tools and other medium sized gear a set of conventional

drawers is required, whilst for storing equipment, tins of lacquer etc, a cupboard with several shelves is ideal. Storage is expensive, but, if properly implemented, it can save many frustrating hours of searching.

## TOOLS

Very few tools are required for basic electronic work — soldering iron, set of screw drivers and side cutting and long nose pliers will do to get started.

As one progresses other things will become essential. Typical second line purchases will be a set of files, a vice, an electric drill, and set of drill bits, nibbling tool, tin snips, steel rule and scriber.

All tools purchased should always be of the best quality that you can afford, cheap tools are *never* cheap in the long run, they do not perform satisfactorily and they wear out quickly. Purchase *only* those tools that you actually require to do a specific task and only add to your collection when it becomes obvious that you cannot do without a specific tool. It is all too easy to spend a lot of money on a collection of fancy tools which seldom, if ever, get used.

Choose your tools carefully, take care of them, and they will last for years. ●

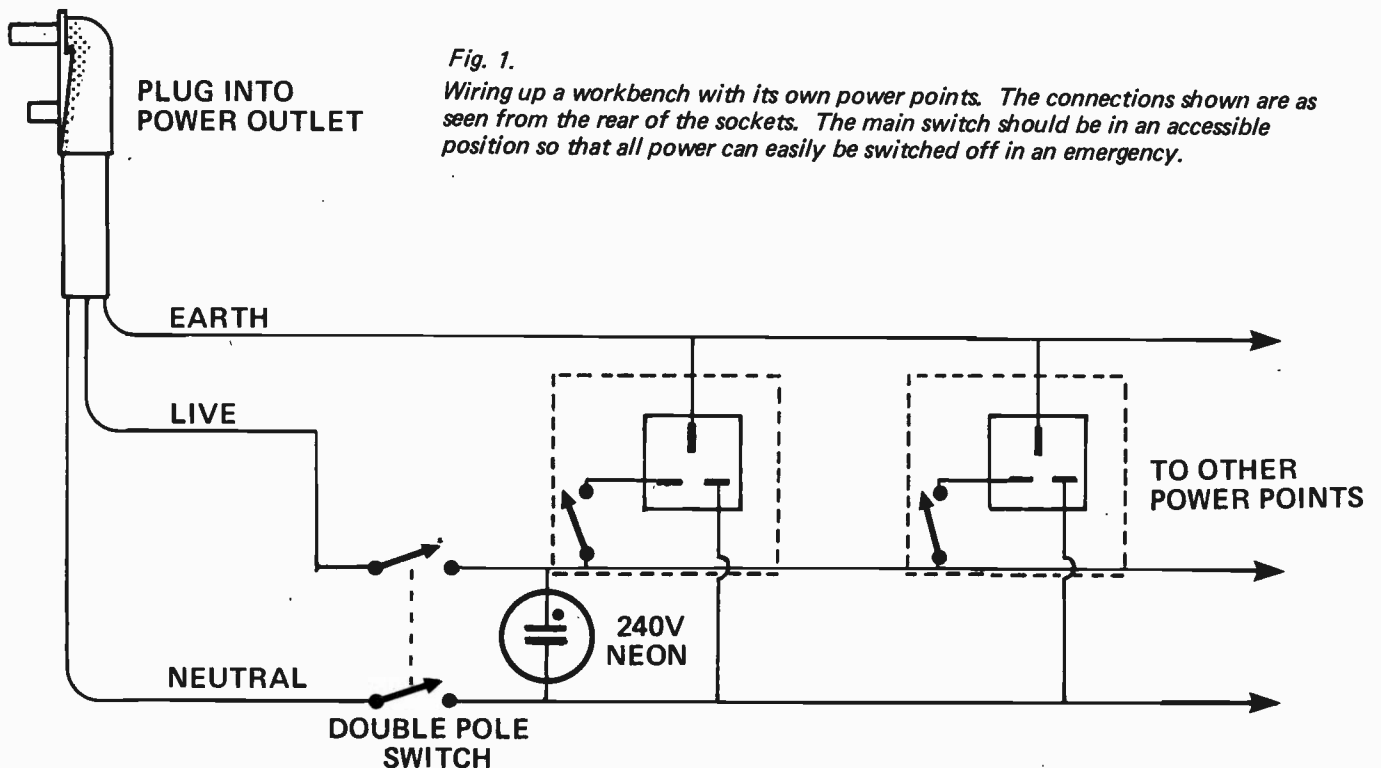


Fig. 1.

Wiring up a workbench with its own power points. The connections shown are as seen from the rear of the sockets. The main switch should be in an accessible position so that all power can easily be switched off in an emergency.



## How to make sound solder joints

# THE ART OF SOLDERING

**SOLDERING** is an art — an art that is essential to the successful building of fault-free electronic circuits. Suppliers of kits tell us that about 90% of all problems with kits are due to faulty solder joints. Hence the beginner (if he wishes to avoid much frustration and, possibly expensive service charges) *must* learn to solder correctly.

In essence, soldering is a method of making joints having low electrical resistance. It is not primarily used to give mechanical strength. If mechanical strength is required the component must be separately supported.

### SOLDER

A good solder should have a low melting point, low electrical resistance, should go very quickly from liquid to solid state (and vice-versa) and should be capable of rapidly fusing to the metal surfaces being soldered.

Solder, for electrical connections, is an alloy of tin and lead. Pure tin melts at 327°C and is plastic over the range 183° to 327°C, whilst pure lead melts at 232°C and is plastic over the range 183° to 232°. Either metal, used alone, is unsuitable as any movement whatsoever whilst the soldering metal is in its plastic state will result in a faulty joint. However when lead and tin are mixed it is found that the melting temperature of the mixture is lower than for either metal alone, and the plastic temperature range is decreased. When the composition is 63% tin and 37% lead the mixture has no plastic region and goes from solid to liquid at precisely 183°C. However, in practice it is found that a very small region of plasticity is desirable in a solder for electronics, and the usual proportions are 60 percent tin and 40 percent lead. Other alloys are made for special purposes, but only 60/40

composition should be used for electronic purposes as this provides optimum-strength with lowest-resistance of electrical joints combined with the most desirable plastic range of about 5°C.

### THE NEED FOR FLUX

All metals (even when freshly cleaned), are covered with a non-metallic film of oxide which prevents solder fusing to the metal. The oxide has a surface tension which effectively *isolates* the solder from the metal. For a reliable, low-resistance joint this oxide *must* be removed during the soldering process, and this is performed by the use of a flux.

The flux used for electrical soldering is a high grade of wood or gum resin together with a small quantity of activator. The molten resin effectively wets both solder and metal, whilst the activator dissolves the oxides on the surface, allowing the solder to flow freely and form a molecular bond with the metal.

In order to dispense automatically the correct amount of flux, modern solders have the flux contained within cores in the solder itself. Five cores are generally used, throughout the entire length of the solder — so no additional flux is needed. Any excess flux hardens on the surface of the joint but it is completely non-corrosive.

Fluxes are also made for non-electronic uses. These are generally acidic and must *never* be used on electronic equipment as component leads and printed circuit board tracks will be corroded. Additionally the use of such a flux will completely void any warranty on a kit or electronic equipment on which it is used.

### SAVBIT SOLDER

If the soldering iron has a copper bit the copper will gradually be dissolved in the molten solder. Thus the tip wears away quickly and requires constant filing and retinning. To overcome this problem some soldering iron tips have a copper core with an outer skin of iron. Another solution to the problem is to add a small amount of copper to the solder alloy. This prevents the absorption of further copper and greatly extends tip life. Such solder is known by the trade name of 'Savbit'. The use of the Savbit solder can extend the life of ordinary copper tips up to ten times.

### SOLDERING IRONS

There are many types of soldering iron on the market and those most commonly used in electronics may be grouped into three main categories.

- (1) Quick heat irons.
- (2) Continuous heat irons.
- (3) Temperature controlled irons.

### QUICK HEAT IRONS

Irons of this type generally work from a transformer which supplies a low voltage at very high current. The two main types are solder guns and low-voltage irons.

The solder gun passes a current of about 50 amps at 0.5 volts through a short length of copper wire, thus heating it quickly to very high temperatures. These irons usually include a reel of solder which is automatically fed to the tip each time a trigger is pressed.

The low-voltage irons have a copper tip against the rear of which a carbon contact is made. A current of around 30 amps at 3 volts is passed via this contact whenever the sleeve switch is actuated.

Both these types of iron are ideal for

# THE ART OF SOLDERING

intermittent handyman use. However some irons of this type do not have an electrostatic screen on the transformer (which means delicate ICs and transistors could be damaged by leakage currents) and, if used improperly, are prone to overheat components and possibly damage them, and/or, the printed circuit board upon which the components are mounted. Such irons, (i.e. those without electrostatic shields) should therefore only be used for general electrical work for soldering to chassis and other tasks where large reserves of heating power are required. They are not recommended for printed circuit board assembly or general electronic service work. So before buying an iron of this type do make sure it has an electrostatic screen between the primary and secondary windings of the associated transformer.

## CONTINUOUS HEAT IRONS

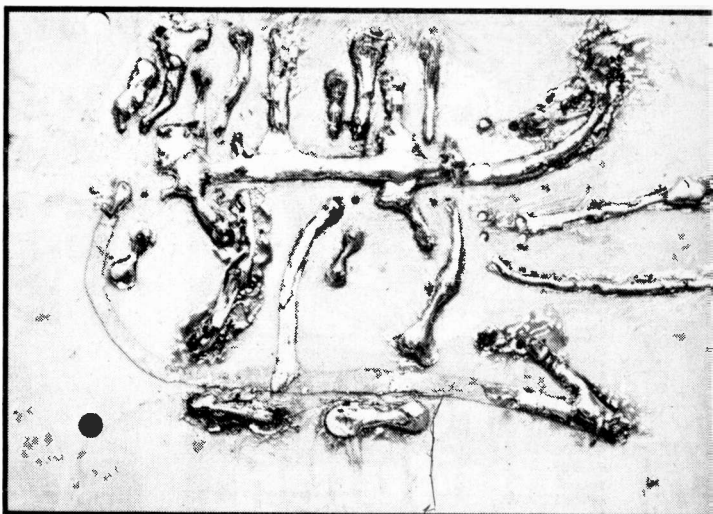
The most universally used irons are those of the continuous heat type. These irons are heated by an element of resistance wire wound around (but insulated from) the rear end of the copper tip. They are manufactured in wattages from about 6 to 250 watts but, for average electronic work, those most commonly used are rated between 15 and 30 watts.

These irons are slow to heat and hence are usually left running continuously. Such operation, although adequate, causes problems with oxidation of the tip. The tips therefore require constant attention and fairly frequent replacement.

Many workers find that these inexpensive irons are entirely adequate

### How not to do it!

*So much heat has been applied to this board, that in places the tracks have been damaged. In other places insufficient heat, or improper fluxing, has caused the surfaces to be not wetted properly. So much solder has been applied that one does not know where the tracks really are, or whether the joints are good or not! A kit supplier would be quite justified in refusing to accept responsibility for a project, built this way and not working.*



despite the drawbacks of continuous operation. They are light, cheap and well insulated.

## HEAT CONTROLLED IRONS

For continuous use on a production line or in an electronics laboratory a temperature controlled iron is often used. Those irons are relatively expensive but are unsurpassed, for accurate soldering and for minimizing damage to components and printed circuit boards due to overheating.

A typical temperature controlled iron, (manufactured by Weller), uses a switch operated by a magnet and spring assembly (within the barrel of the iron) to control temperature.

When a ferromagnetic material is heated it is found that at a certain temperature, which depends on the material, all magnetic properties are lost. This temperature is known as the Curie point and is typically 1000°K for iron, 633°K for nickel and 1393°K for cobalt. Thus by alloying these or other ferromagnetic materials

the Curie point of a material may be set to any required temperature.

On the Weller iron the tip has a small piece of material at the rear, called the sensor. This is designed to have a specific Curie point. When the tip is cold the sensor attracts the magnet and hence the switch closes heating the iron. When the tip reaches the Curie temperature the sensor pad is unable to hold the magnet which is then forced back by the spring. The switch therefore opens, removing power to the iron. It can be seen therefore that the iron will switch on and off automatically to maintain the desired temperature.

These irons operate from a 24 V transformer within the stand and are supplied with a variety of tips of different shape and operating temperature. The temperature is stamped on the base of each tip. Thus, one can pick the operating temperature most suited to the class of work.

Where 60/40 solder is being used for new soldering, a bit temperature of 250°C (500°F) will be adequate. This allows adequate margin over the melting point of 215°C to allow for heat conducted away by the component or terminal etc. Savbit No 1 solder melts at a slightly higher temperature, and for this a temperature of at least 275°C (550°F) is required.

For unsoldering, a higher temperature is needed again. This is because the surface of the solder becomes oxidized and heat flow is impeded. Hence for general service work we recommend a tip temperature of at least 315°C (600°F) and perhaps even 370°C (700°F) for large connections etc.

The tips for temperature controlled irons are all iron plated and should never be filed. The tips are cleaned during use by wiping on the small sponge supplied. This should be kept

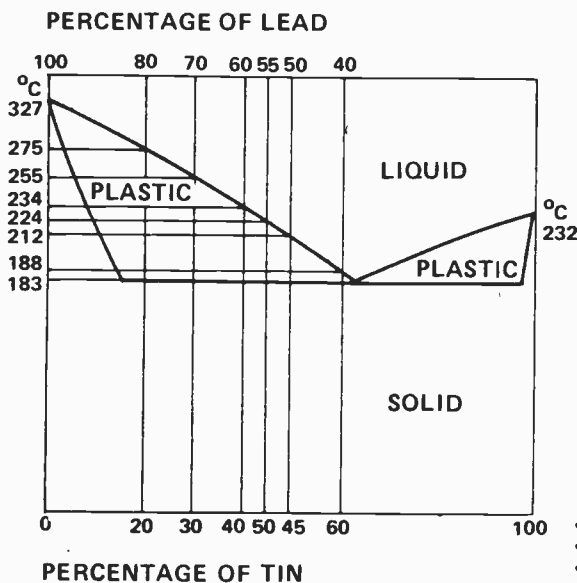


Fig. 1. How melting temperature and plastic range are affected by the relative percentages of lead and tin in a solder alloy.

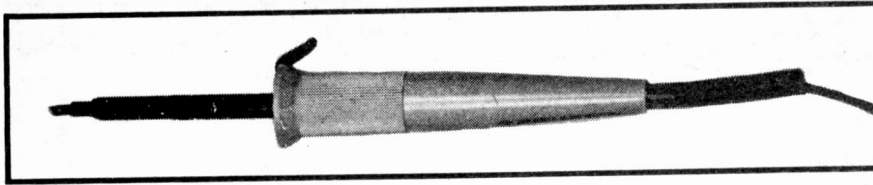


Fig.2. An ideal type of continuous heat iron — this one is from Adcola and is rated at 19 watts.

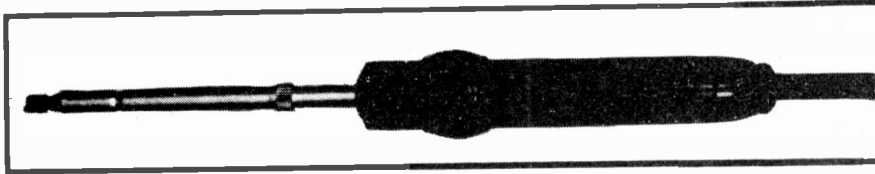


Fig.3. The Scope iron is of the quick heat type, it has enormous heating power. It heats within six seconds and is therefore switched on each time a joint is to be soldered by the sleeve switch on the handle.

damp. If really dirty, steel wool or fine emery paper may be used.

If you can afford it this type of iron is by far the best available. The plated tips will last ten times as long as plain copper types, the irons heat in 30 to 40 seconds and have heating power equivalent to a 100 watt continuous type.

#### TINNING THE IRON

To make sound solder joints it is necessary to keep the tip of the iron clean and well tinned.

Iron-clad tips only need to be

cleaned occasionally with fine emery cloth whereas copper tips will need to be dressed with a file and retinned at regular intervals.

Whenever a plain copper tip becomes pitted, and oxidation scale builds up between the heating element and the tip, the efficiency of the iron will drop considerably. To recondition the tip, clean off the oxide scale and, while the tip is cold, dress it with a file to remove the pitted surface on the end of the tip.

Heat the iron and apply solder at the lowest iron temperature which will

melt it. Wipe the iron on a damp cloth or sponge until the whole tip is covered with a bright coating of solder. The iron is now ready for use.

#### PREPARING COMPONENTS AND LEADS

Most components have plated or pre-tinned leads which will accept solder without any special preparation. However, if the components are old, or the leads tarnished or oxidized, the leads to be soldered should be cleaned and tinned before attempting to solder them in position. To do this apply the iron and the solder to the lead until a uniform coating of solder is obtained. If the lead is unusually dirty, and will not take solder, pull it through a piece of doubled over emery paper.

Stranded hook-up wire should be prepared by stripping away about 7 mm of insulation from each end. The strands should then be twisted together and tinned, and as detailed above, before the wire is attached.

#### MECHANICAL ASSEMBLY

When assembling components to printed circuit boards the component leads should be fitted through the correct holes and spread slightly, as shown in Fig. 8 so that the component is held firmly in position. Always mount the component such that its value, if printed on it, is visible. This facilitates later servicing.

Components are inserted from the non-copper side of the board, as shown in various pictures throughout this article, (this may seem totally obvious to experienced enthusiasts but it's surprising how often we and kit suppliers come across boards on which the components have been mounted on the copper side!).

When fitting components to terminals or tag strips turn the lead half way around the lug or tag so that the component is mechanically secure. This prevents component movement (and resulting faulty joints) whilst the solder is cooling. Do *not* make a full turn, or more, around the lug as this will make it very difficult to remove the component in later servicing.

#### SOLDERING

The iron must be fully up to working temperature and the tip clean and coated with 'wet' solder. It should actually look 'wet' and shiny. If it doesn't, touch it briefly with the solder and wipe off surplus onto a damp sponge.

Now press the tip against the terminal (or printed circuit board track) and the end of the component lead. Preheat like this for two to three seconds.

Still keeping the iron in position, apply solder to the joint — never to

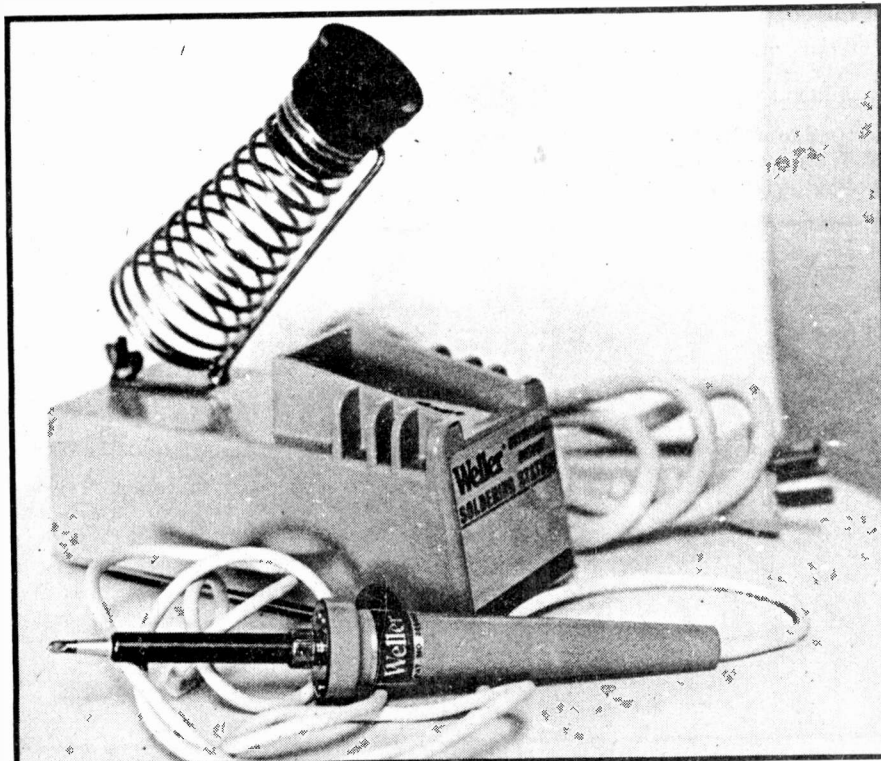
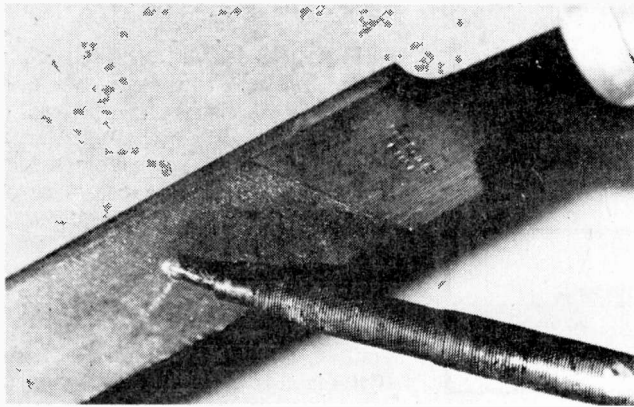


Fig.4. The Weller temperature controlled iron. The stand incorporates a transformer in the base. The operating temperature is selected simply by changing the tip.

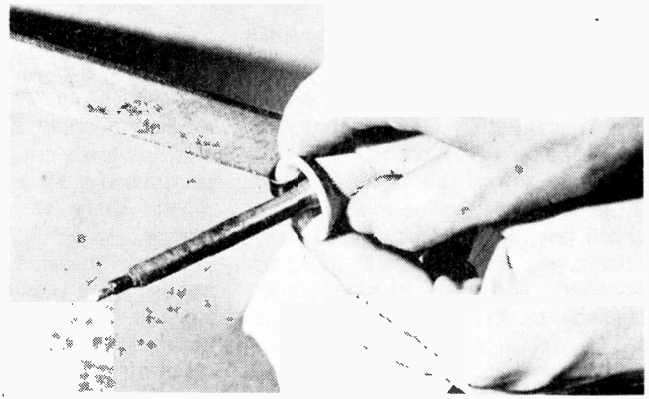
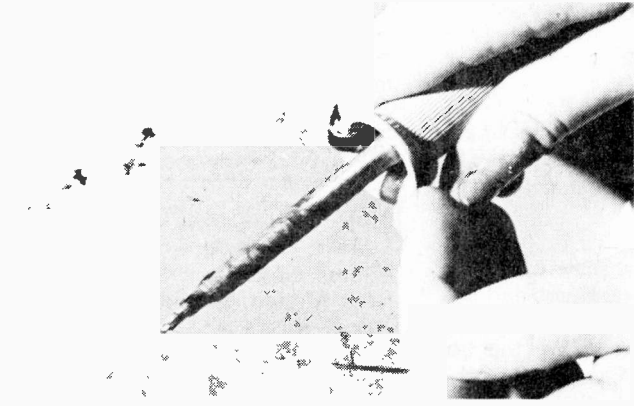
# Project Building Guide THE ART OF SOLDERING



*Fig.5. To tin the iron first file the tip so that a clean copper surface is obtained. Any pitting of the tip should be completely removed.*

*Fig.6. Next apply solder with the iron — just hot enough to melt the solder.*

*Fig.7. Finally wipe the tip with a damp cloth to obtain a uniform clean and shiny coating of solder over the entire tip.*



the iron. Continue to apply solder only long enough for the solder to flow evenly over the joint. After removing the iron you must let the joint harden before moving either the component or the PC board. Then snip off any excess lead.

A correctly soldered joint should be bright and smooth. Poor joints look crystalline and grainy or, the solder tends to be in blobs (that is solder has not wetted the surface properly).

Take care not to apply too much solder as it is difficult, then, to see if the joint is a good one. Solder bridges may also be formed.

## REMOVING COMPONENTS

If it is necessary to remove a component from a printed circuit board the solder should be removed from the joint by 'wicking'. To do this remove about half an inch of insulation from a piece of stranded hook up wire, dip the prepared end into liquid resin and lay it on top of the solder joint. Then apply the flat tip of the iron above the wire and joint until the solder melts and is sucked up by the wire. Repeat the procedure if necessary to remove all excess solder from the joint. Alternatively a proprietary product such as 'Solderwick' (braid that is pre-fluxed) may be used.

After all excess solder is removed, it

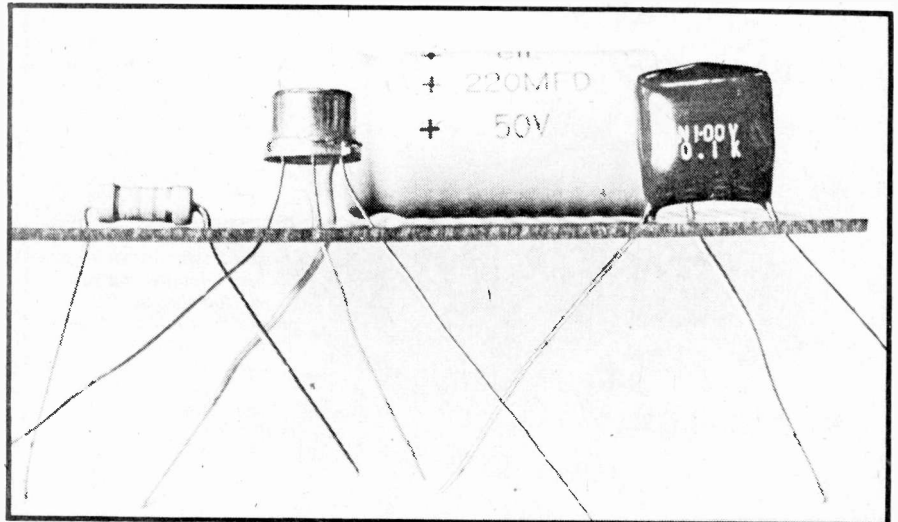
is a simple matter to pry the component loose. Removing components by means of vacuum solder suckers (although effective) must be done very carefully indeed as there is a tendency for the devices to lift the copper tracks from PC boards. Although, as we have said, the method is very effective we don't really recommend it for amateur use.

Solder bridges, if they occur, should be removed by wicking and resoldering, or by heating the bridged

area with the iron and wiping quickly with a soft cloth or with a brush to remove excess solder. Resolder the cleaned joints using less solder.

## SOLDERING SEMICONDUCTORS

Most semiconductors will be damaged if subjected to too much heat. Hence transistors and ICs, etc, should be soldered quickly and cleanly. If you doubt your ability to do this — use a heat shunt (eg pair of long nose pliers), between the end of the lead being soldered and the



*Fig.8. When components are fitted to a board the leads should be splayed, as shown, to keep them in position prior to soldering. Position components so that values and voltage ratings may be seen. This facilitates later servicing.*

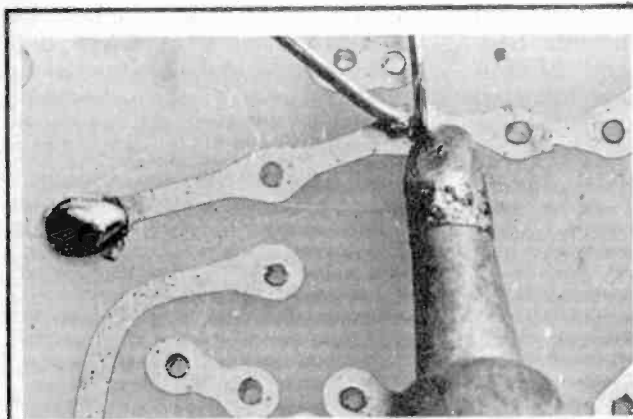


transistor body, to divert heat from the device.

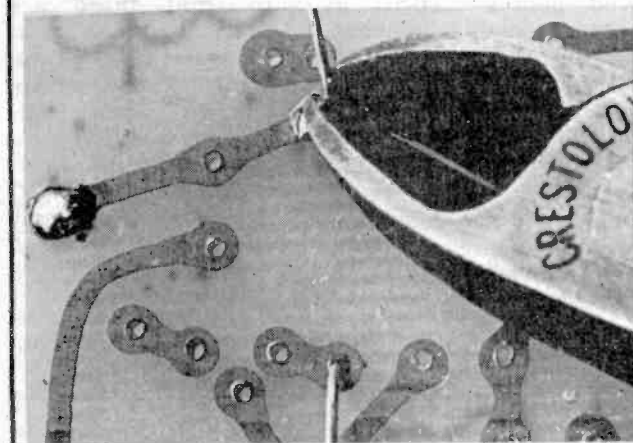
Integrated circuits based on MOS or CMOS technologies are particularly prone to damage during soldering not only due to heat, but also by electrostatic charges or leakage currents. These devices should be left with their pins inserted in the black conductive foam (in which they are usually supplied) until they are to be used. Avoid touching the pins of the IC as even static discharges from the

body can possibly cause damage.

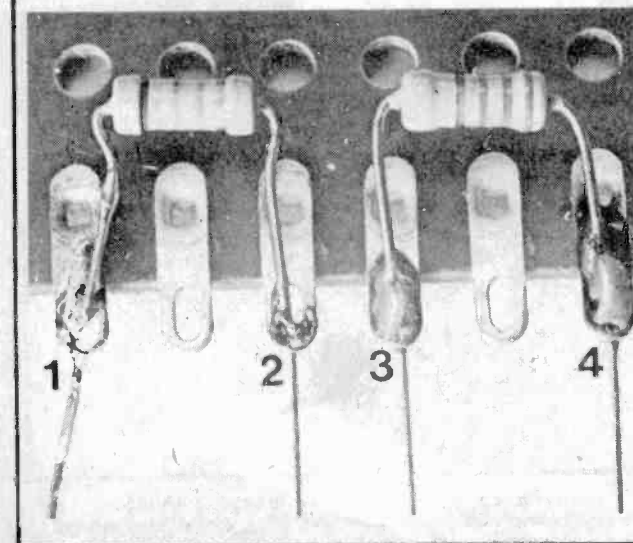
MOS and CMOS ICs should be the last components to be fitted to the board. They should be inserted quickly and cleanly, and the power supply pins should be soldered first. This activates the built-in protective circuitry and the remaining pins may then be soldered without fear of damage. Beginners may well find that it is safer to use an IC socket for MOS and CMOS ICs as soldering directly to the IC is not then required.



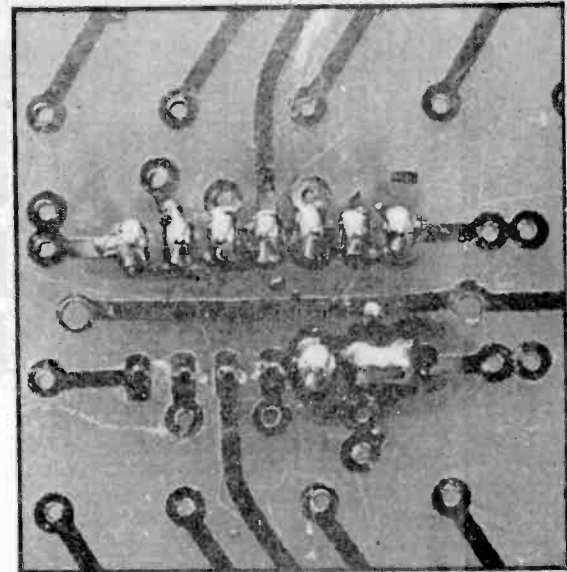
*Fig. 9. Apply the soldering iron to the joint so that the track and component wire are heated together for about two seconds, then apply the solder to the joint – NOT to the soldering iron tip.*



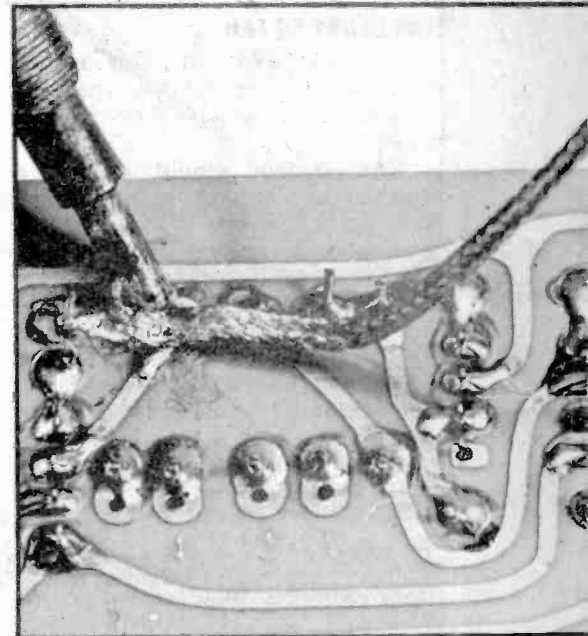
*Fig. 10. Allow the joint to cool completely undisturbed and then snip off the excess component lead. A joint that has been disturbed during cooling will appear crystalline and will probably be 'dry' (that is it will have a high resistance which will affect circuit operation).*



*Fig. 11. How the joint will appear – from left to right (1) too much heat results in solder leaving the joint. Movement of joint before it cooled results in the crystalline appearance. (2) Insufficient solder and not enough heat – solder has not wetted the tag. (3) A good joint should be smooth and shiny. (4) Solder has not thoroughly wetted the tag – the joint could be dry.*



*Fig. 12. Too much solder may cause solder bridges. The top row of joints to this IC are fine but on the bottom row too much solder has resulted in a solder bridge (bottom right).*



*Fig. 13. To de-solder using Solderwick apply the braid over the joint and place the iron on top of the braid until the solder is sucked up.*



*Fig. 14. In a 'dry' joint the solder has not properly bonded to either or both metal surfaces, or the joint has been moved during the plastic region of the molten solder. Such joints have a high electrical resistance and low mechanical strength. Here this resistor lead 'dry-jointed' to a potentiometer may be pulled away quite easily.*

ON MAY 6TH A TECHNICALLY BRILLIANT CURIOSITY BECOME A PRACTICAL PROPOSITION:

# TELETEXT TAKES OFF!

BBC's CEEFAX is already operating a regular, live service; trouble is that practically no one has been able to decode it — until now.

CEEFAX, ORACLE, TELEDATA, TELETEXT — names being tossed around right now that have caused enormous confusion to many people, tending to disguise what is perhaps the third most important landmark in television history to date (the other two being high-definition pictures in the mid-30's and NTSC colour in the late 40's and early 50's).

## THE STORY SO FAR . . .

In October 1972, BBC Engineering announced a completely new TV development which they named CEEFAX.

The system would enable a number of "pages" of text to be selected by anyone with a suitably equipped TV receiver for display on the screen. At the time, this received considerable publicity — not unnaturally most of it from the BBC itself — but we are today bombarded with so many ingenious gimmicks and curiosities that it has only dawned slowly what enormous potential it has and how soon it is likely to be part of our everyday lives.

*The BBC CEEFAX service as it was until very recently. Even now the entire equipment including two input consoles, the computer, monitors etc is contained in about 400 square feet. CEEFAX is put out from the 7th floor of the BBC Television Centre. In the picture Sub-Editor Ian Irving is preparing a News bulletin while Research Assistant Adrian Robson is operating the controls, and has summoned-up a Weather map of Britain.*

Competition is always healthy and the IBA were not far behind with their own system: ORACLE. This was essentially the same but included some improvements. Sensibly the BBC, IBA and BREMA (representing the TV set industry) got together in a working committee to establish a single standard. This committee announced in March 1974 that a unified system had been agreed. This not only incorporated the best of CEEFAX and ORACLE but built on them — the resulting standard being a significant advance on the original specification.

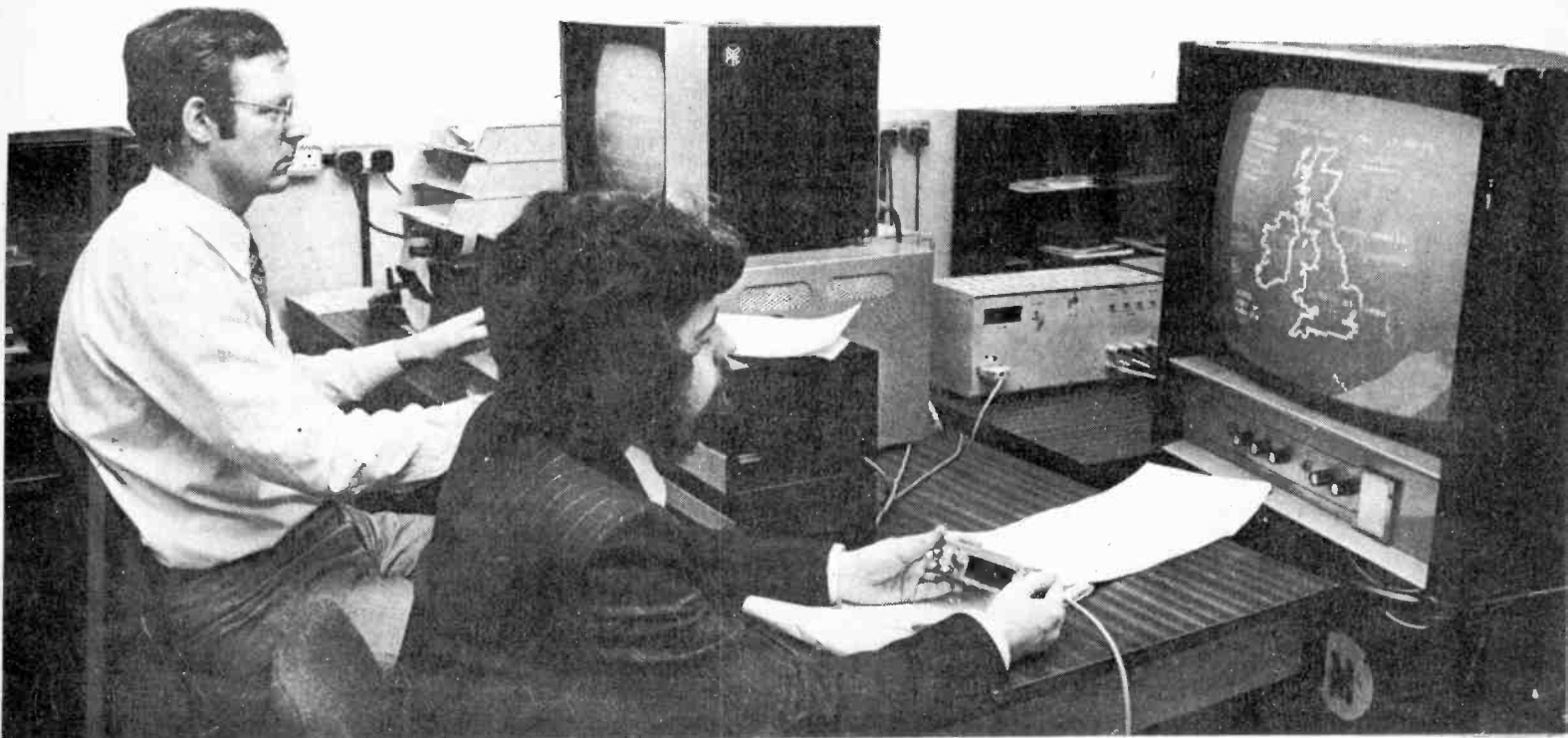
The BBC, who have shown enormous faith in this development, applied for, and received, permission for a two-year experimental transmission period; this started in September 1974. Since that date, for eight hours a day, a regular, live service (albeit experimental) has been carried on BBC-1 UHF transmitters throughout the country.

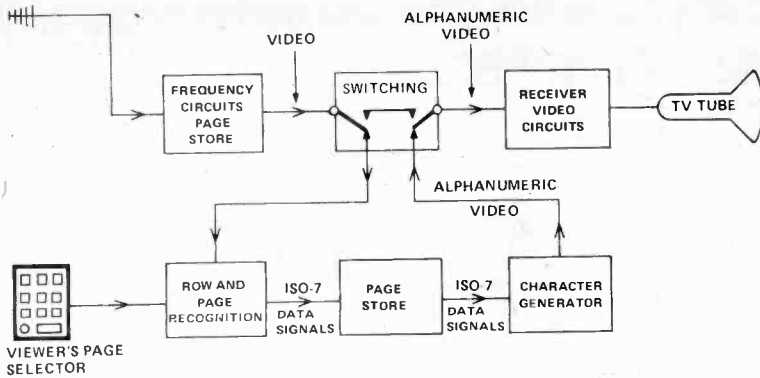
The confusion over terminology is enormous. The BBC, who after all can claim to have been the inventors and driving force, continue to

call the system (as well as the service) CEEFAX; the IBA are sticking to ORACLE for their service. Outside well-wishers dubbed the combined systems TELEDATA, until it was pointed out that this was a registered name for something completely different! As previously reported in ETI, the name TELETEXT has been adopted, though it has not yet caught on. We've opted for it in our title for we believe it will eventually become the standard for the system, though CEEFAX and ORACLE will remain in use for the respective services.

All very well — a new service, available now to anyone with a receiver — but where are they? The BBC estimate that there are between 80 and 100 receivers in the country — mostly built by the set makers for testing; the rest are owned by the BBC itself with perhaps half-a-dozen built by enthusiasts.

(With typical modesty the BBC tell us that until very recently, if anything went wrong with transmissions they would 'phone up their viewers to tell them!)





An ultra-simple block diagram of a Teletext receiver.

Why the apparent lack of interest outside the BBC and IBA?

The problem arises over the enormous complexity of the equipment necessary to decode and display Teletext. The system is operating at the forefront of current technology: bank upon bank of TTL and memory chips have, until now, been necessary and the cost of parts alone is in the order of £400. Complete circuits are *not* available — at least none that we know of. We have not even been able to get permission to publish a meaningful block diagram! However, things are beginning to move...

### THE BREAKTHROUGH

Despite the apparent lack of interest, at least one semiconductor company, Texas, have been investigating Teletext seriously. At a major launch on May 6th, Texas disclosed that they have completed development work on a Teletext module, to be known as TIFAX, that preproduction samples will be available in about four months with production quantities available in early 1976. If all goes as planned, the first receivers available to the public will be on sale in about a year.

The extra cost of a Teletext receiver can only be estimated. The first sets are expected to be about £125 dearer, but by 1978, Texas estimate the market at 1,000,000 sets a year with £25-£50 being the extra cost. There is no technical

reason preventing Teletext being incorporated with monochrome sets but it will probably only be available as an option on colour sets.

### HOW DOES IT WORK?

When the specification for the 625-line TV standard was drawn up, the state-of-the-art was far behind that of today. To tell the electron beam that it had reached the end of its frame, and to give it time to reach the top again, a sync pulse followed by 25 blank lines are transmitted. Current techniques need nothing like this number of lines.

Teletext is transmitted on two lines: 17 and 18 (330 and 331 on the interlace). Anyone in Britain who hasn't yet seen Teletext encoded lines has only to reduce the height control and view the top of the picture — it's impossible to miss them.

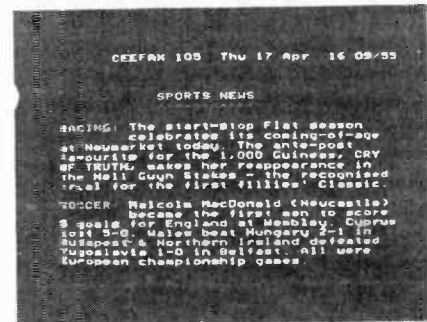
On these lines, data in binary form is pushed out at 6.9375 Mbits/s. This information however, is meaningless by itself — it bears no relation to the normal analogue picture: this has led to a misunderstanding amongst even well informed engineers. The binary coded signal only gives instructions to equipment at the receiver end about what to display — it does not provide the display.

Let us take a close analogy to explain the point (though not actually part of Teletext). Most stations use at some time or other a simple clock display. This is a standard pattern which remains unaltered except for the seconds hand.

To display this on a screen for one second requires on a conventional display some  $6 \times 10^6$  bits of information to be broadcast (625-line frequency bandwidth is 6MHz). If the shape of the clock was generated in the set itself it would require only *one* bit per second to display the same shape — that item of information being a signal for the seconds hand to move on: this



A major attraction of Teletext is likely to be the Newsflash. Receivers will probably be designed to enable the viewer to choose for Newsflashes to be superimposed on a regular programme either in a box as shown or in white.



Racing results etc are ideal candidates for Teletext and it is this area that the BBC intend to expand in the near future.

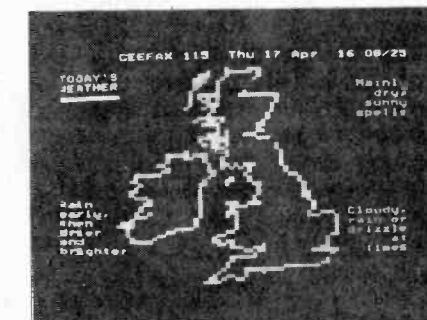
On this display only 17 lines are used but each page can be up to 24 lines (including the header) and 40 characters across.

As many 'pages', including this one, are not full, it takes less than 0.24 seconds to build-up. Blank lines are not represented by a period with no display but by coding. This reduces the access time considerably.

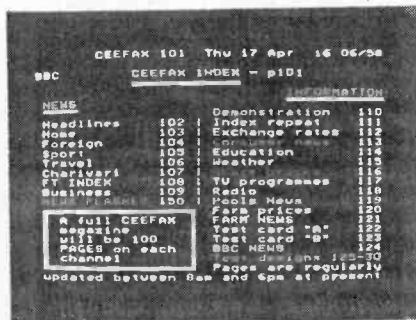


The caption on the screen hardly needs repeating. In practice, experiments using sub-titles are by no means complete as the update time on a page is too long.

Teletext could of course make a major difference to the deaf by providing sub-titles for many programmes at a very low cost at the transmitting end.



Simple graphics such as maps are an integral part of Teletext.



The index page of CEEFAX used until recently. This is transmitted more frequently than the other pages to give faster access (one in every 10 pages).

# TELETEXT TAKES OFF!

would represent an enormous saving in data transmission. It is by making good use of this technique that an enormous amount of information can be transmitted using Teletext in only two lines.

The specification of Teletext allows for 100 "pages" of information to be transmitted, each comprising 24 lines of 40 characters each. These characters can be in six colours and white and can be used to display simple graphics.

As the coded information is transmitted for only a tiny fraction of the time that it is displayed, the coded signals have to be stored in a memory.

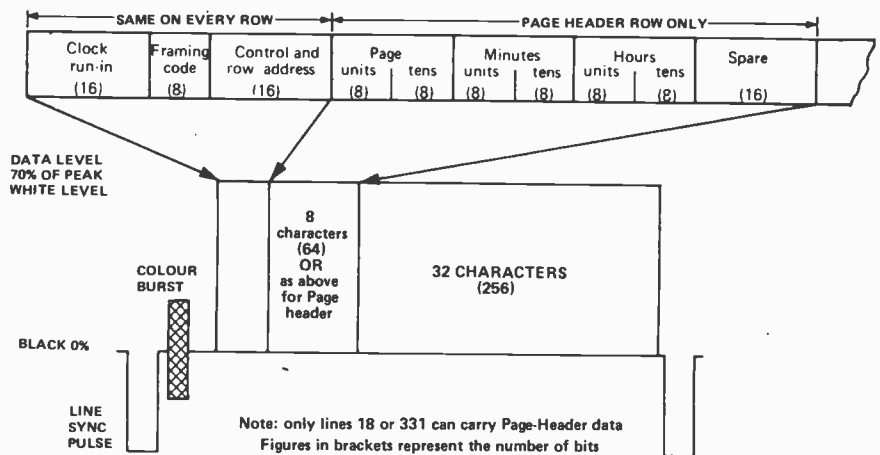
Every page starts off with a special row called the "page header". This shows the page number, the date and the time (updated every second). Special codings are incorporated at the beginning of the page header so that the receiver knows that a page is beginning and which page it is. When these signals match those selected by the viewer, the receiver starts to display the header row followed by the rest of that page.

Each TV line (17, 18 and their interlace) carries one line of Teletext data and as each page is made up from 24 lines, it will take 0.24 seconds to build up a complete page. This delay only occurs when the page is first displayed for the information is held in the memory and can be accessed immediately. When a Teletext page is updated, it takes nearly a 1/4-second to complete the corrected page.

Apart from updating, pages can of course be cycled. On a particular page number, a series of different displays can be transmitted in sequence, but the viewer will not have the choice of starting on, say, the first page (like dialling the weather on the 'phone).

## VIEWER CONTROLS

Receivers will have an additional control panel — most companies seem to favour something not unlike a calculator keyboard. The function keys will be labelled *Pictuie* (for normal TV reception), *Teletext* and *Picture and Teletext* (the latter superimposed on the former). Other keys can be "Update" — bring up newflashes automatically when something new happens. "Time" for selecting a particular page for display at a preselected time, etc.



The organisation of Teletext data on lines 17, 18, 330 and 331.

For Teletext the calculator keyboard must be used. If you know the page number you want, this is punched up and the information stored. When the lines are broadcast with the same coding that you have selected, the Teletext data is fed into the memory and on the next frame the memory takes over the screen and plays out its coded messages to the character generator. The first line will always comprise the page number, title and the time.

The remaining 23 lines, each capable of 40 characters, is then displayed.

## THE NEXT STEPS

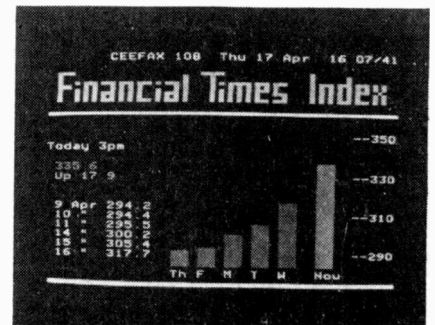
At least one TV manufacturer has not touched Teletext yet: building a receiver using TTL, etc, would only be for curiosity they claim and the development cost would be enormous. However, with complete modules soon to be available things can start to move. Texas say that their TIFAX module is designed for absolute minimum connections inside the receiver. This could mean that connections are limited to the keyboard — output from the TV's video, power supply, leads to three interface transistors at the drive stage of the tube and a feed from the line timebase.

## COLOUR

The Teletext characters can be displayed in white, the three primary colours and their complementaries. The first reaction is that this is a gimmick of unnecessary luxury: in fact, as Teletext is connected to the receiver at the c.r.t. drive stage, colour is very simple — it is estimated that it adds perhaps only 10% to the total cost, a small price to pay for the additional readability.

## ACCESS TIME

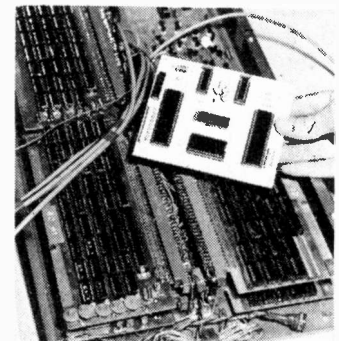
With the 50 pages currently being



A good example of what can be done with Teletext — and is actually being transmitted by BBC's CEEFAX. The words *Financial Times Index* are made up from the graphics part of the alpha-numeric generator rather than the straight-forward alphabet.

At the top is shown the service (CEEFAX), the page number, the day and date with the time — correct to the second — on the right.

This page could well be cycled with other related data such as major share price movements, gold and commodity prices and the current value of the pound. These would be on sub-pages which would repeat every 15 seconds or so.



The enormous technical complexity of Teletext can be judged by the necessary circuitry in the background. This is now replaced by Texas Instruments' TIFAX module which will be similar in appearance and outward simplicity to the module being held.

broadcast by the BBC it can take up to 15 seconds to get your required page — when the full capacity of 100 pages is broadcast this will double. This access time is considered unacceptable by many who are familiar with the system. It is quite possible to incorporate a memory for each page, but this would add enormously to the cost.

Continued on page 22.



# TELETEXT TAKES OFF!

Continued from page 20.

What may well happen is that decoders will have four or five memories which will hold those pages likely to be used most frequently. The Texas TIFAX module has only the basic memory.

## ADD-ON MODULES

Can existing sets be modified? In theory, yes, but a large market is not envisaged. An add-on module will be considerably more complex if it is simply to plug into the aerial socket — and a colour facility is very

unlikely.

If modules become available to the hobby market, a competent engineer should be able to connect it into the set quite easily — there are few enough connections to make. We shall have to wait and see what happens in this field.

## THE FUTURE

The success of Teletext depends entirely on the public's willingness to pay the extra cost for the receiver. One of the surprising features is the tiny cost to the broadcasting authorities in providing the service. The BBC's experimental CEEFAX service is believed to be costing under £30,000 a year — less than the cost of one major TV programme. Even when operating with a full staff, a nationwide service will

cost only about as much as a local radio station!

The capacity of Teletext is enormous. Only two lines are being used at present, but 16 are available: this would give an 800 page capacity per channel or 2400 on the three networks! The potential is enormous.

It is natural that electronic engineers drool over such an ingenious and interesting development — like children with a new toy — but it is the non-technical public who will determine the success of Teletext, and the public's interest will depend on the extra cost of the equipment. A start has been made by Texas in developing a moderately-priced module and it is now up to the TV set manufacturers to make the sets available.

# SELECTED BOOKS FROM ETI

## 1 TRANSISTOR POCKET BOOK

by R. G. Hibberd

A comprehensive guide to the characteristics and uses of various types . . . £3.05

## 2 BASIC ELECTRONIC PROBLEMS SOLVED

by D. A. Smith

A reference source of the pertinent basics illustrated with clear diagrams . . . £1.90

## 3 ELECTRONICS SELF-TAUGHT WITH EXPERIMENTS AND PROJECTS

by James Ashe

Covers basic principles of electronics. Projects include a large number of simple circuits . . . £2.15

## 4 BEGINNERS GUIDE TO ELECTRONICS

by T. L. Squires and C. M. Deason

A 'short cut' for those wishing to obtain a quick acquaintance with modern electronics . . . £2.20

## 5 INTRODUCING AMATEUR ELECTRONICS

by I. R. Sinclair

The book for the complete novice of any age as no previous knowledge is assumed . . . £1.55

## 6 RADIO-ELECTRONICS HOBBY PROJECTS

Thirty-two novel and useful projects (originated from U.S.A.) . . . £1.75

## 7 I.C. PROJECTS FOR AMATEUR AND EXPERIMENTER

Edited by Wayne Green

Over 30 circuits using I. C.'s both linear and digital (originated from U.S.A.) . . . £1.75

## 8 DIGITAL ELECTRONIC CIRCUITS AND SYSTEMS

by N. M. Morris

The ideal book for the enthusiast confused by logic and digital techniques . . . £2.55

## 9 GETTING THE MOST OUT OF YOUR ELECTRONIC CALCULATOR

by W. L. Hunter

Helps you get infinitely better value out of the average modern calculator . . . £2.15

## 10 BEGINNERS GUIDE TO TRANSISTORS

by J. A. Reddihough and I. R. Sinclair

Covers the basic theory and practice of modern transistors . . . £2.10

## 11 110 OPERATIONAL AMPLIFIER PROJECTS FOR THE HOME CONSTRUCTOR

by R. M. Marston

Outlines the essential characteristics of the op-amp and presents 110 useful projects (limp cover) . . . £2.10

## 12 AUDIO HANDBOOK

by Gordon King

Deals fully with all aspects of audio reproduction . . . £5.25

## 13 64 HOBBY PROJECTS FOR HOME AND CAR

by Bob Brown and Mark Olsen

A variety of novel circuits, many of them unique, which should please almost everybody . . . £2.10

## 14 THE OSCILLOSCOPE

by George Zwick

Starts from first principles and takes the reader to an advanced level . . . £2.05

## 15 HOW TO USE VECTORSCOPES, OSCILLOSCOPES AND SWEEP-SIGNAL GENERATORS

by Stan Prentiss

Goes into the whole subject deeply in 250 heavily illustrated pages . . . £1.90

## 16 99 WAYS TO USE YOUR OSCILLOSCOPE

by A. Saunders

Describes how to solve particular problems using a 'scope . . . £1.75

## 17 WORKING WITH THE OSCILLOSCOPE

by A. Saunders

A book devoted to circuits and illustrations of waveforms that should be present . . . £1.80

## 18 TOWERS' INTERNATIONAL TRANSISTOR SELECTOR

A super best-seller — details given elsewhere in this issue . . . £3.40

All prices include Postage and Packing

Please list titles (with price) separately. Cheques, etc., to be payable to Electronics Today International and sent to:

ETI BOOK SERVICE, 25 Court Close, Bray, Maidenhead, Berks.



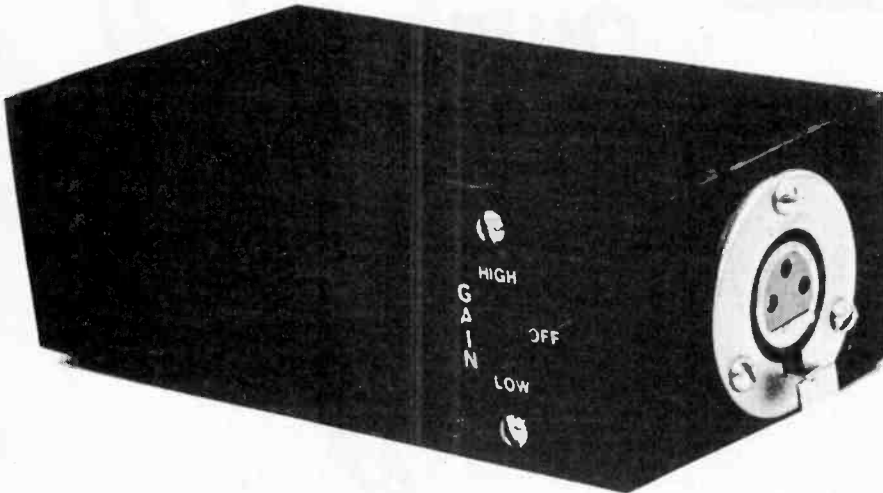


# LINE AMPLIFIER

Boost microphone output with this low noise amplifier.



## PROJECT 430



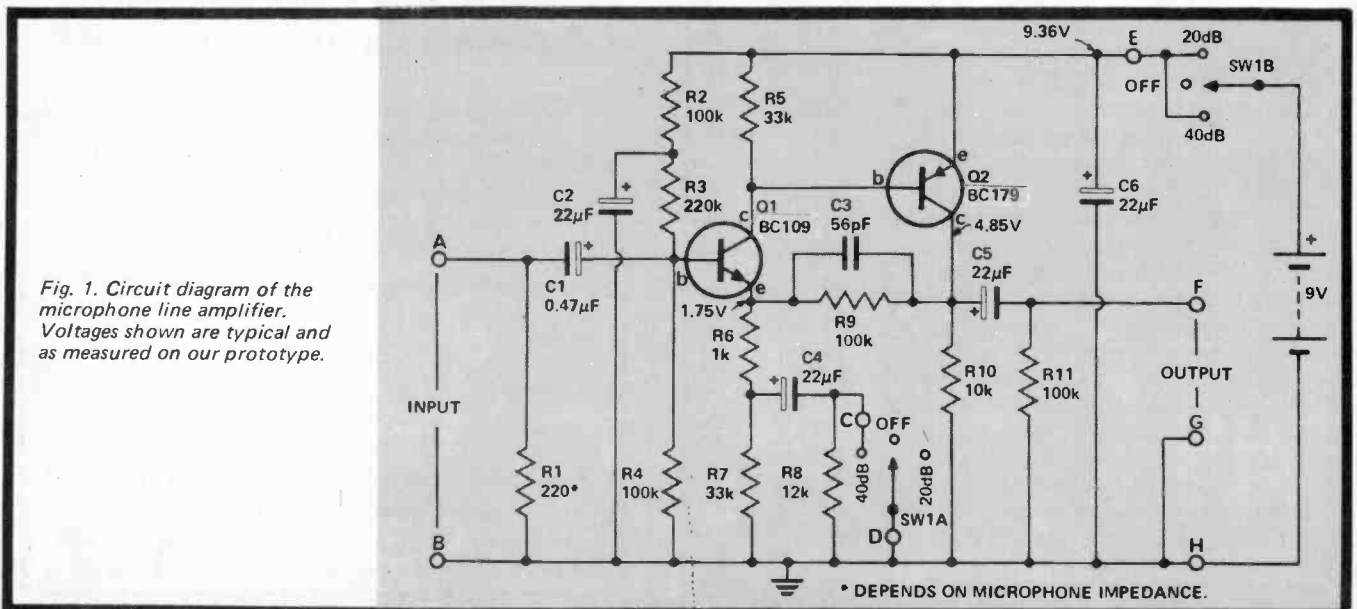
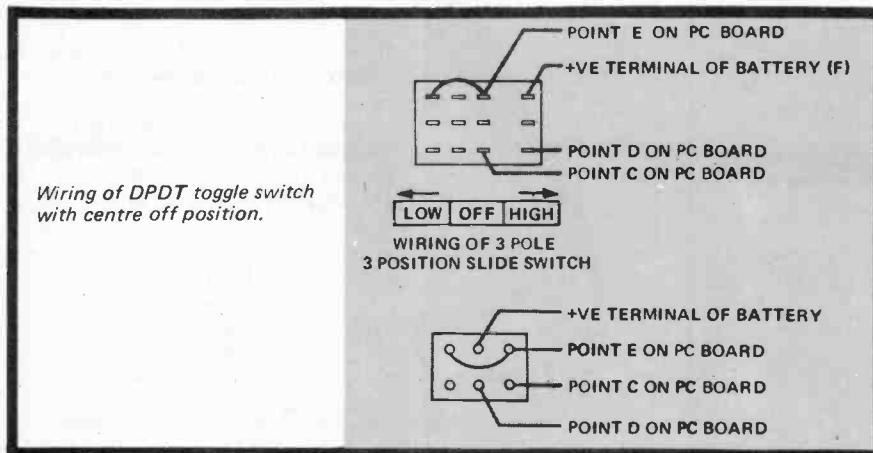
The completed line amplifier. Note the use of Cannon plugs and the gain switch on the side.

MODERN high quality microphones are low impedance units having a very low output voltage. To minimize noise, picked up on long leads, it is usually necessary to use special balanced and screened leads together with balancing transformers. An alternative approach is to use a low noise amplifier to boost the signal before passing it down the cable. The ETI 430 line amplifier, described here, is intended for this purpose.

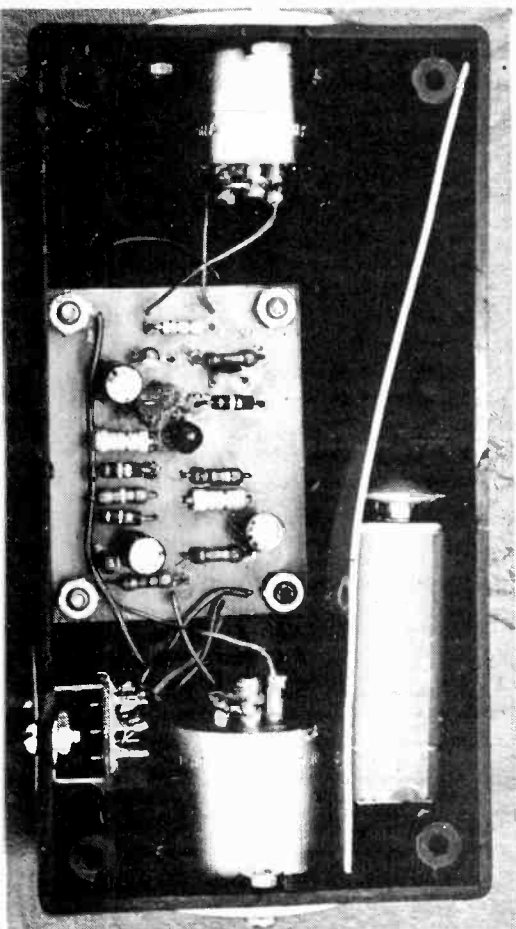
Such a unit, when used with the ETI Master Mixer (described in April, May, June and July 1973) provides either 20 or 40 dB of gain prior to the mixer. This allows the mixer to be used on the low-sensitivity range. Thus the larger signal now available, effectively over-rides the inherent noise of the first amplifier in the mixer.

The overall effect of using such an amplifier is to vastly improve the signal-to-noise ratio of the particular microphone channel and to eliminate the need for an expensive balanced and screened cable and balancing transformer.

To reduce the possibility of mains — hum pickup we have used a small nine volt battery to power the unit. Since the current drawn is a mere 0.5 mA, the battery should last about three to







Internal layout of the line amplifier.

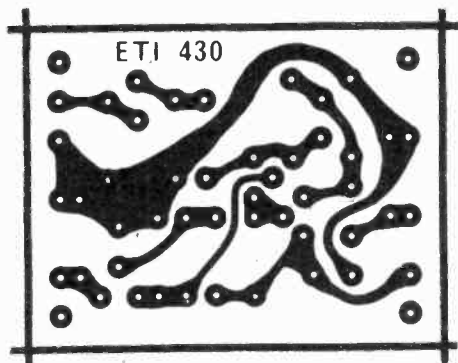


Fig.2. Printed circuit board layout for the amplifier. Full size 55 x 42 mm.

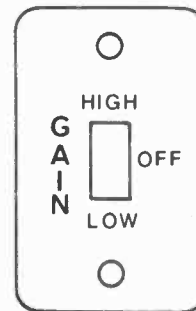


Fig.3. Artwork for the gain switch label. (Shown full size).

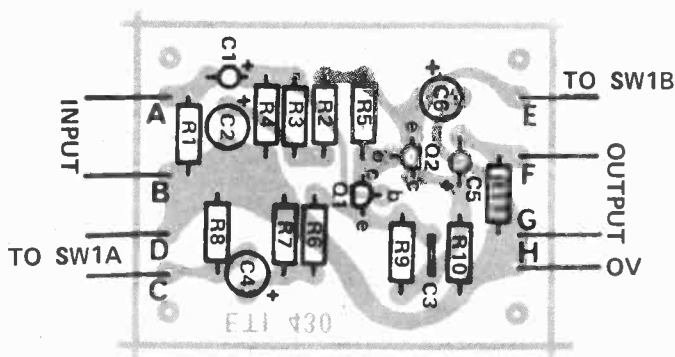


Fig.3. Component overlay. Note particularly the orientation of the transistors and electrolytic capacitors.

four hundred hours before replacement is required.

The ETI line amplifier can of course be used to great advantage with any recording equipment where low noise operation is necessary. When used with the Master Mixer the low impedance input should be used but the terminating resistor (fitted across the mixer input socket) should be removed so that a 4.7 k input impedance is obtained.

### CONSTRUCTION

The circuit is not critical in any way hence, practically any construction method may be used. However, the use of the printed circuit board specified will considerably simplify construction.

We used an unbreakable plastic box (polycarbonate) to house our unit but if the unit is to be used in the proximity of power cables etc it would be advisable to mount the unit in a metal box (diecast or similar). This is especially so if an input impedance above 1 k is to be used as the higher the impedance the more likely is hum pickup.

If Cannon plugs are used, as in our prototype, pins 1 and 2 should be linked and used as the earth line. Pin 3 is then used as the active line.

### MEASURED PERFORMANCE

<b>IMPEDANCE</b>			
Input	selectable up to 68k max		
Output	≈ 1.5k		
<b>GAIN</b>			
High	40 dB		
Low	20 dB		
<b>OUTPUT VOLTAGE</b>			
Maximum	3 volts		
<b>INPUT VOLTAGE</b>			
Maximum (high range)	30 mV		
Maximum (low range)	300 mV		
<b>FREQUENCY RESPONSE</b>			
10 Hz – 30 kHz	+0 – 3 dB		
<b>EQUIVALENT INPUT NOISE</b> (referred to 1 mW into 600Ω)			
High Range	–110 dBm		
Low Range	–102 dBm		
<b>DISTORTION</b>			
Output Voltage	100 Hz	1 kHz	6.3 kHz
300 mV	<0.1%	<0.1%	<0.1%
1 V	0.17%	0.2%	0.17%
2 V	0.5%	0.5%	0.5%
3 V	1.75%	1.8%	1.7%

# LINE AMPLIFIER

## HOW IT WORKS — ETI 430

The line amplifier is basically a two transistor amplifier having a selectable gain of either 20 dB (x10) or 40 dB (x 100).

The input impedance of the amplifier (referring to Fig. 1) is determined by the combined values of R1, R3 and R4 — all in parallel. The parallel impedance of R3 and R4 is 68 k and this is therefore the upper limit of input impedance ( $R = \infty$ ).

For impedances less than 5 k the values of R3 and R4 may be ignored and R1 is set to the same value as the desired input impedance. Hence the circuit as shown matches microphones having 200 ohm output impedance.

Resistor R2, in conjunction with R3 and R4 determines the dc bias for transistor Q3 whilst capacitor C2 decouples the input bias network

from any supply rail noise. The output of Q2 is fed back to the emitter of Q1 thus providing negative feedback which as well as supplying a dc bias, sets the ac gain of the stage.

The gain of the amplifier may be calculated using the following formula (assuming ideal transistors).

$$\text{Gain} = \frac{R9 + R6 + (R7//R8)}{R6 + (R7//R8)}$$

Thus for  $R8 = 12 \text{ k}$  the gain is 11.2 or 21 dB. For  $R8 = 0$  the gain is 101 or 40 dB. The actual gain obtained is slightly lower than this due to the finite betas of the transistors used.

The value of capacitor C3 determines the upper 3 dB point of 30 kHz whilst capacitors C1, C4 and C5 all give individual break points at the low end of 5 Hz, 7 Hz and 1.5 Hz respectively.

## PARTS LIST — ETI 430

R1	resistor	selected to suit input impedance
R2,4,	"	
9,11	"	100 k 1/4W 5%
R3	"	220 k " "
R5,R7	"	33 k " "
R6	"	1 k " "
R8	"	12 k " "
R10	"	10 k " "
C1	Capacitor	0.47 $\mu\text{F}$ 25V TAG
C2,4,5,6	"	22 $\mu\text{F}$ 16V electrolytic
C3	"	56pF ceramic
Q1	Transistor	BC109 etc.
Q2	"	BC179 etc.
SW1	Switch	2 pole 3 position slide or 2 pole centre off toggle
PC board ETI-430		
Cannon sockets (male and female)		
Cord plugs (male and female)		
Box to suit (preferable metal), 9 V battery and clip input and output sockets etc.		



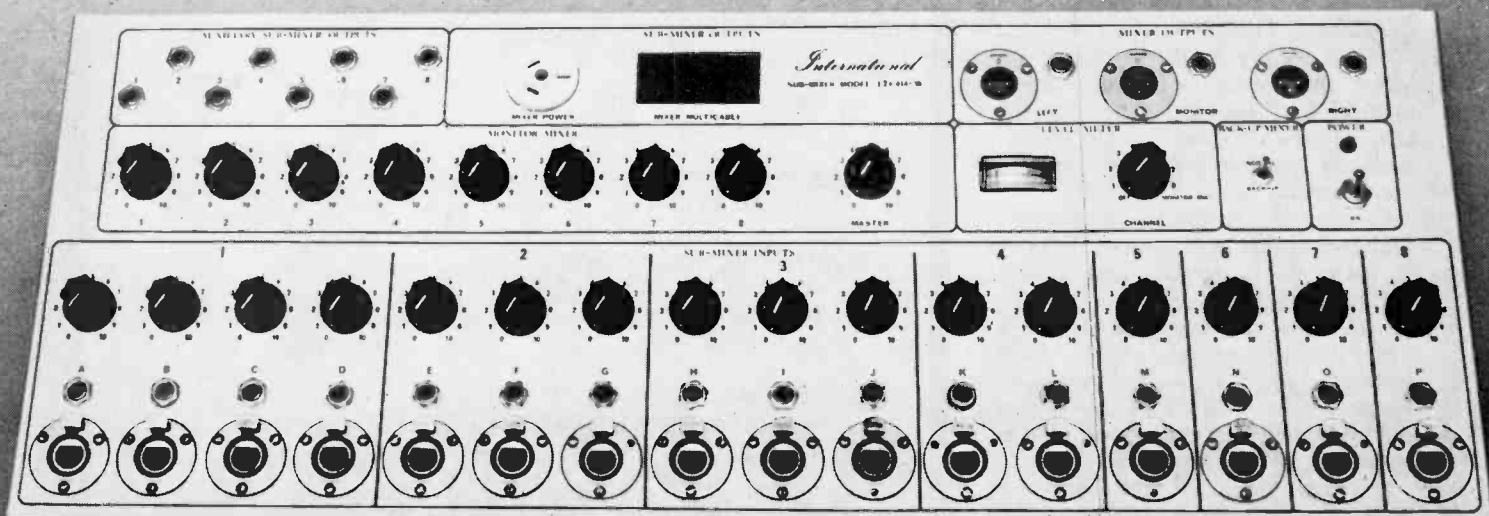
PROJECT 414

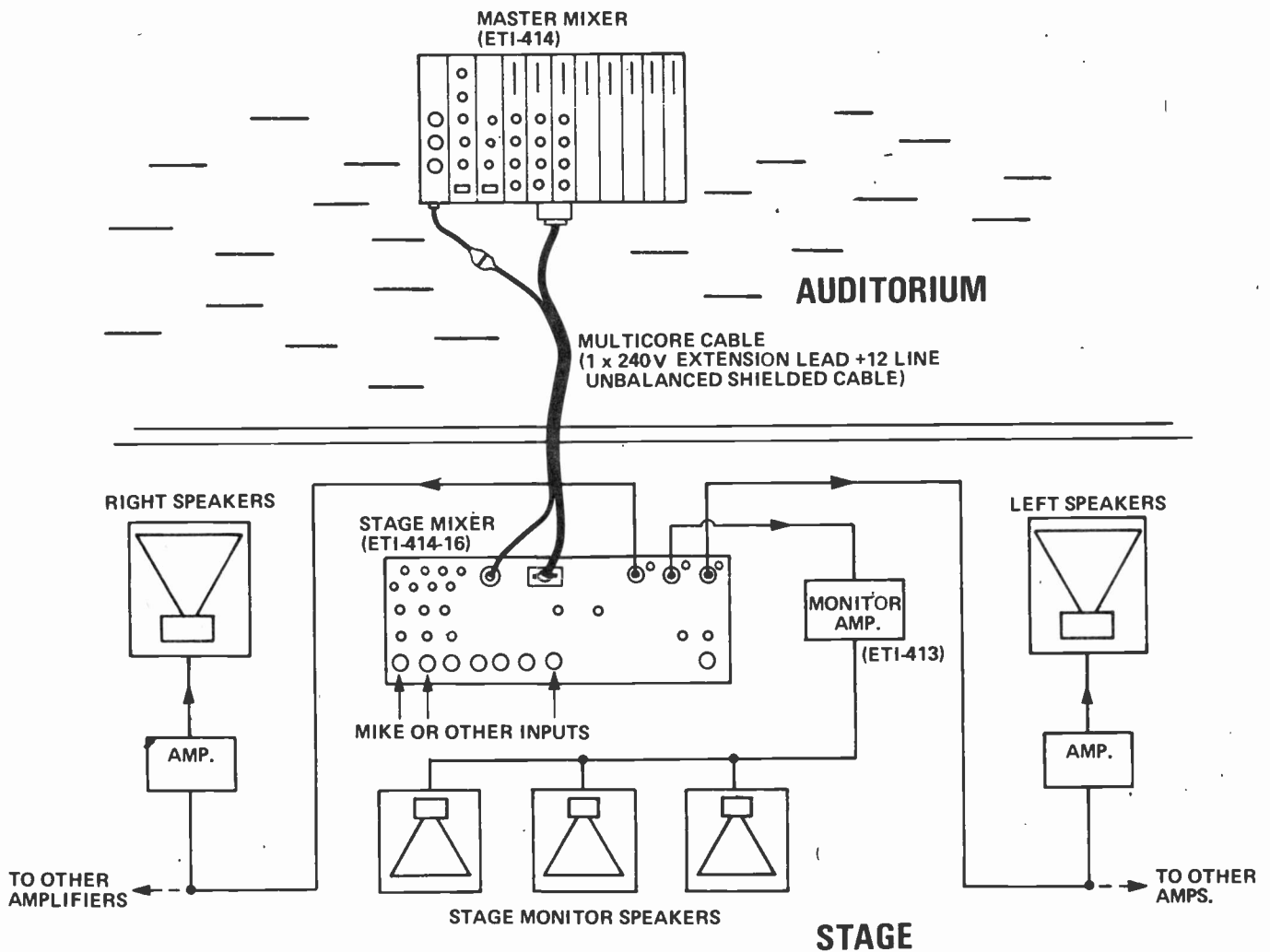
# STAGE MIXER

Sixteen amplifiers sub-mixed to eight channels — plus monitor

SEVERAL hundred of our Master Mixers (described April, May, June and July of 1973) have been built and are in use by groups and recording studios throughout Britain. Whilst this mixer has been

enormously successful, there are several areas in which improvements can be made which will still further improve the flexibility and usefulness of this instrument especially for on-stage performances.





*This is the way that the ETI Stage Mixer would be used for a live performance.*

### LONG-LINE WORKING

For most live performances the master mixer is best located in the listening area so that the mix can be continuously monitored, and controlled, for best effect. Whilst such

operation is possible with the ETI Master Mixer, the inputs are not designed for long line work, especially with low-output, or unbalanced high impedance microphones. This deficiency may be overcome by using

a line amplifier for each input.

### THE NEED FOR SUB MIXERS

The next obvious deficiency in stage applications is that several microphones are often needed to mike

SPECIFICATION		MAXIMUM INPUT on maximum gain on minimum gain	
NO OF INPUTS	16		30 mV 1 V
NO OF OUTPUTS	8 normal + 1 monitor	GAIN	50 dB 36 dB
NOMINAL INPUT maximum gain	10 mV	Any number of inputs can be connected to any submixer. However no input may be connected to more than one sub-mixer. The VU metering is switchable to any one output channel.	
NOMINAL OUTPUT maximum nominal	8 volts 3 volts	TABLE 1 Selection value of R11 (or 21, 31 etc)	
INPUT IMPEDANCE selectable	< 68 k	Input Impedance	R11 220Ω 680Ω 150 k
SIGNAL TO NOISE re 10 mV single channel input	74 dB		

# STAGE MIXER

the drums, of the several speakers of an organ etc. This requires the use of separate mixers, in front of the main mixer, to avoid wasting the 8-channel master mixer's capability. To overcome both these disadvantages we have incorporated 16 line amplifiers and eight sub-mixers into a common unit such that the 16 channels may be grouped in any desired combination to

the eight master mixer channels. The grouping shown for our prototype stage mixer (in the block diagram Fig. 1) is 4,3,3,2 plus 4 individual channels. This may of course be varied to suit individual requirements.

## THE STAGE MIXER

Thus the unit described here is a 16 channel to eight channel sub-mixer

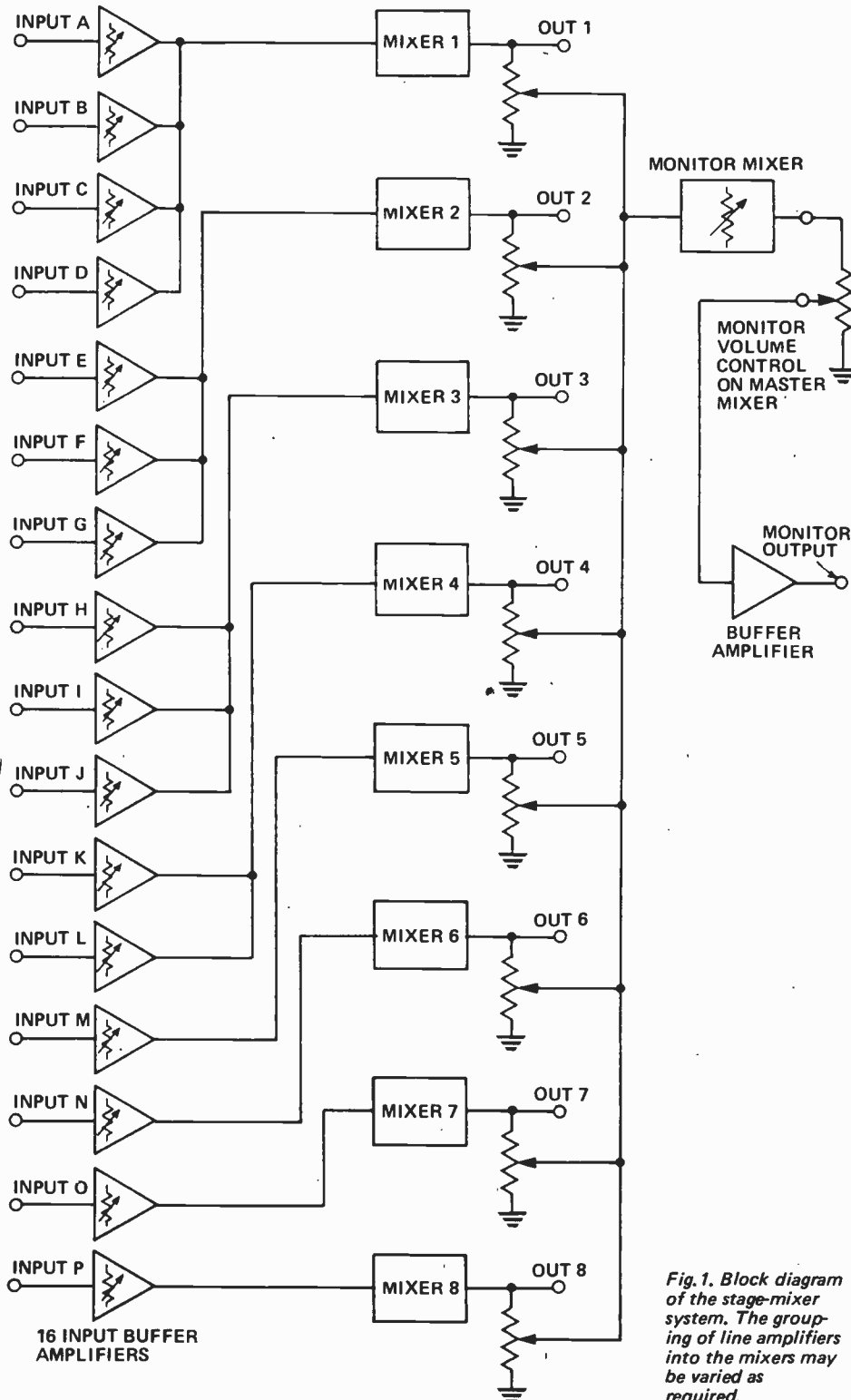


Fig. 1. Block diagram of the stage-mixer system. The grouping of line amplifiers into the mixers may be varied as required.

which is specifically designed for use on stage. It accepts high or low impedance microphone inputs, which may be balanced or unbalanced. The unit provides eight high-level outputs for transmission to the master mixer.

The inputs may be made by either Cannon connectors or by standard tip-and-sleeve jacks. We strongly recommend that Cannon connectors be used for on-stage work because of their ruggedness. The input impedance of each channel may be tailored to suit the individual microphone (or other source) by selecting one resistor.

The gain of each line amplifier is adjustable from unity to 63 (36 dB) and the sub-mixer adds a further (14 dB), that is, a total of 50 dB gain is available.

The output level of each channel (even from a low output microphone) will be of the order of 1 volt and may be as high as 22 volts peak-to-peak without overload distortion occurring. Thus an extremely wide dynamic range may be accommodated by this mixer and the same dynamic range will also be accommodated by the Master Mixer. The Master Mixer, when used with the stage mixer may be used switched to the low sensitivity input position and such operation greatly improves the signal-to-noise ratio.

## MONITOR FACILITIES

The original Master Mixer does not incorporate any monitor facilities. It is possible to use the echo-mix channel for monitoring but the level controls for each channel will also affect the monitor output. This is undesirable as if a louder level is required in the auditorium the monitor will also become louder — introducing a danger of acoustic feedback occurring.

Within the stage mixer we have incorporated a special monitor mixer which has its own level control followed by a buffer amplifier. A second 'Master' monitor volume control is physically located on the main mixer so that it can be adjusted should acoustic feedback occur.

## BACK UP MONITOR

Facilities are provided such that should the Master Mixer fail, or the cables between the two mixers be damaged etc, the stage mixer may be switched to provide an output direct to the PA system.

In this mode a 'Back up' switch takes the output from the monitor mixer and transmits it direct to both channels of the PA system. The monitor signal is still transmitted to the monitor amplifier when the mixer is in this mode. In normal use the 'back up' switch must be at 'normal'.

When the stage mixer is in 'back up' mode the master monitor level

control, located on the Master Mixer, is by-passed (full volume) regardless of whether the Master Mixer is connected or not.

### FINAL OUTPUTS

The Master Mixer outputs (i.e. left and right stereo plus monitor mix) are returned to the stage as part of the multicore cable and terminated on the 'stage mixer' with both 'Cannon' and standard 'Jack' type connectors.

### METERING

A VU meter is provided on the stage mixer which can be used to monitor the output of any of the eight (sub) mixers or the stage monitor output. This meter will be useful for initial level settings on each sub-mixer.

### POWER OUTLET

A switched, 240 volt power outlet is provided on the stage mixer. This is intended to provide power for the Master Mixer via an extension cable. Thus the power cable and the multicore cable are the only ones required between the two mixers.

### HOW IT WORKS – ETI 414

#### LINE AMPLIFIER

The line amplifier used is similar to the ETI 430 line amplifier except that the gain is variable from unity to 40 dB (actually 36 dB in a practical circuit).

The input impedance of the amplifier (referring to Fig. 2) is determined by the combined value of R11, R12 and R13 – all in parallel. The parallel impedance of R12 and R13 is 68 k and this is therefore the upper limit of input impedance ( $R = \infty$ ).

For impedances less than 5 k the values of R12 and R13 may be ignored and R11 is set to the same value as the desired input impedance. Hence the circuit as shown matches microphones having 200 ohm output impedance.

The output of Q12 is fed back to the emitter of Q11. This path via R17 in parallel with RV11 and C14 provides negative feedback as well as supplying a dc bias which sets the overall gain of the stage.

The gain of the amplifier may be calculated using the following formula (assuming ideal transistors).

$$\text{Gain} = \frac{(R17//RV11) + R15}{R15}$$

When the gain control is at maximum the gain is 102 or 40 dB (in practice 36 dB), and when the gain control is at minimum R17//RV11 is zero and the gain is therefore unity.

The signals from any number of line amplifiers may be summed by one of the sub mixers (eight per board IC1-IC8) the output from each mixer is taken directly to output socket to the Master Mixer, and via a 22k level control to the monitor mixer, IC9.

The output of the monitor mixer is taken to the master-monitor, level control on the Master Mixer and then returned to a buffer amplifier in the stage mixer, IC10.

In an emergency (main mixer faulty) SW2 disconnects the outputs from the Master Mixer and connects the output of the monitor amplifier to the PA channels.

Power for the Stage mixer is provided by a conventional supply which provides plus and minus 15 volts for the mixer amplifiers and plus 19.6 volts for the line amplifiers.

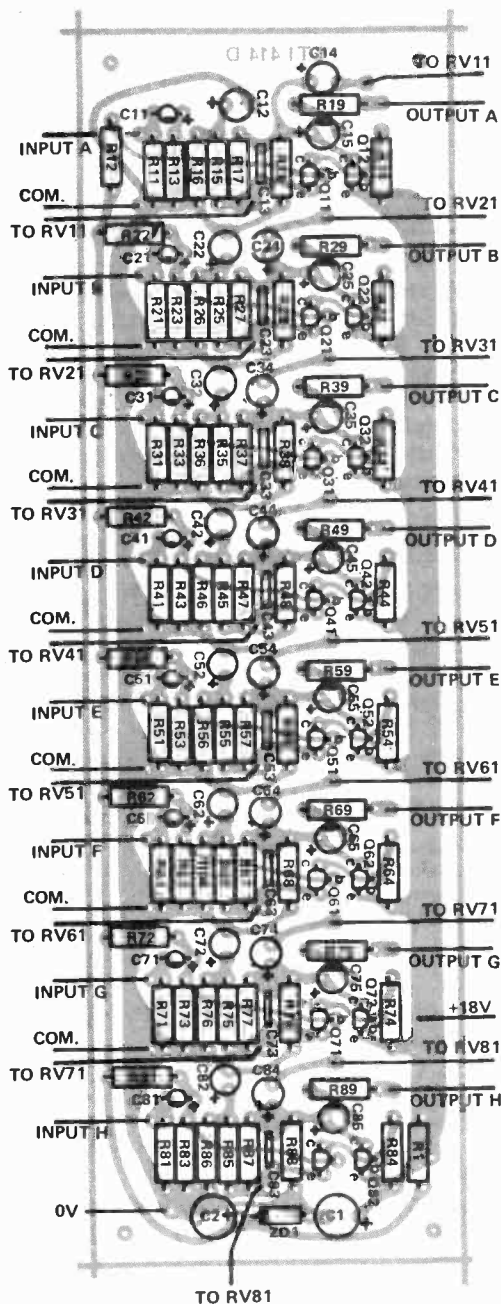


Fig. 2. Component overlay for the preamplifier board.

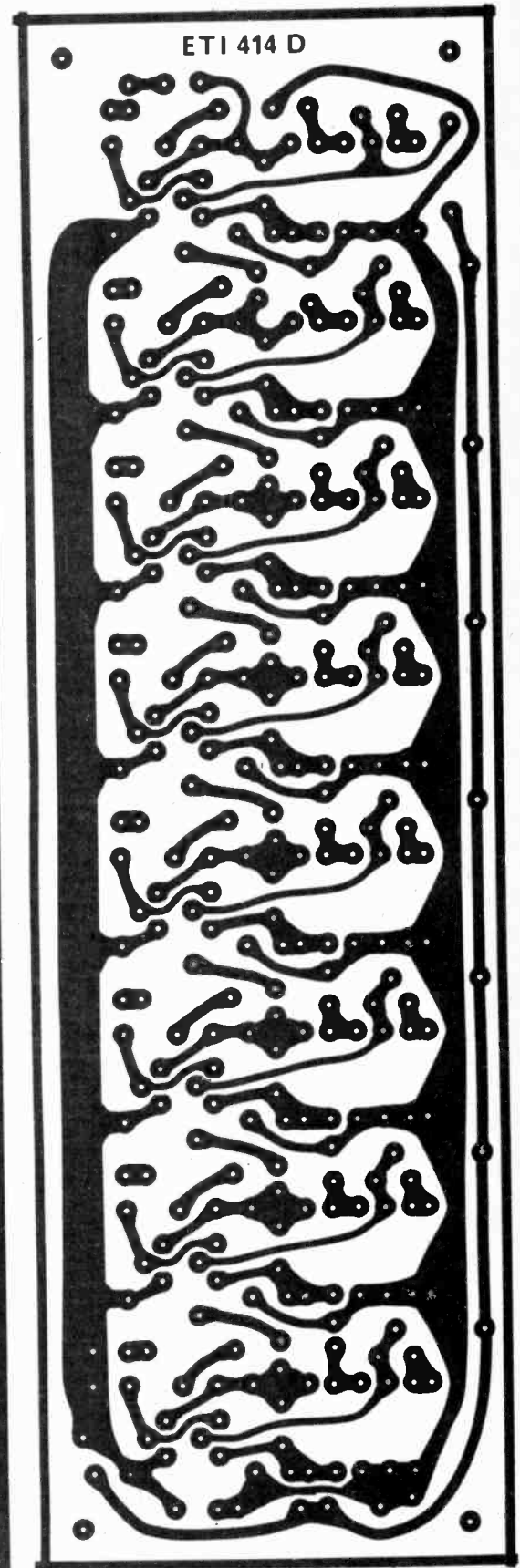
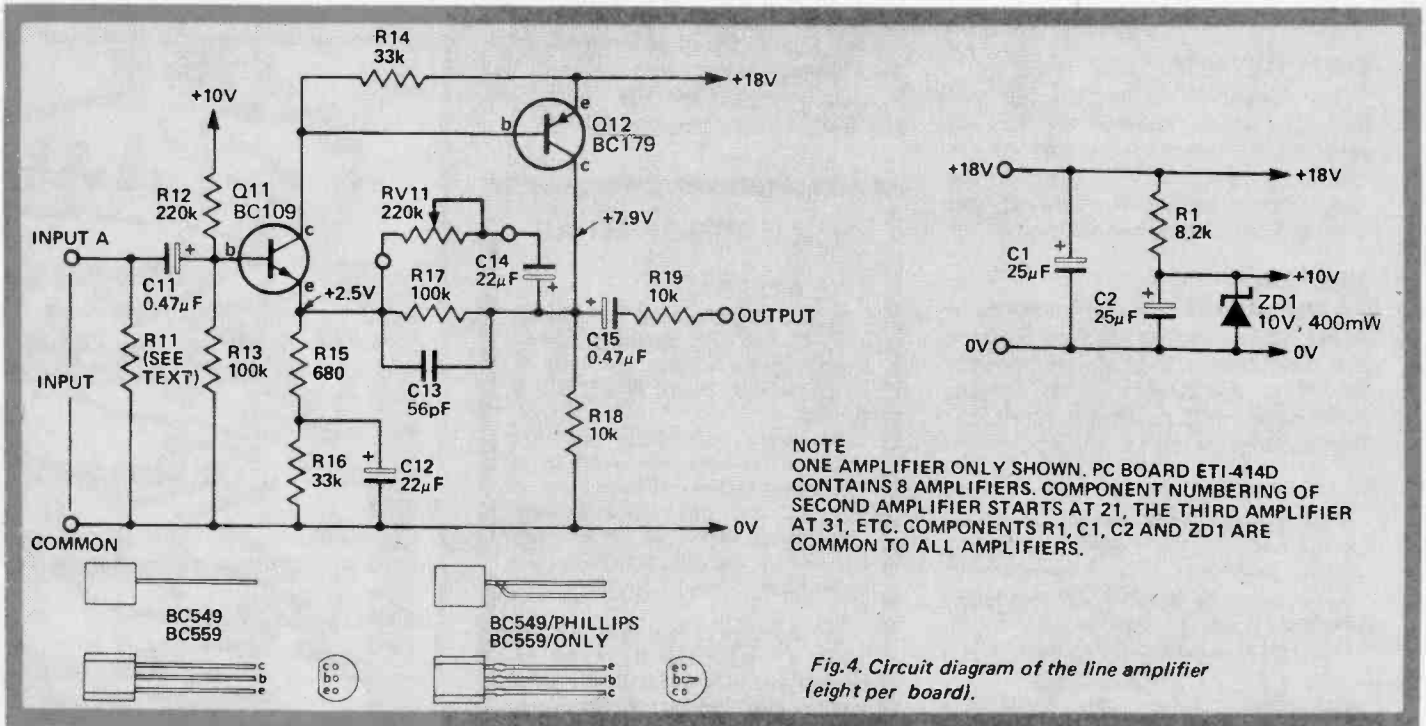


Fig. 3. Printed circuit board layout for the preamplifiers (two required for 16 channels). Full size 223 x 63 mm.

# STAGE MIXER



## ETI MASTER MIXER

This article is closely associated with the ETI Master Mixer project carried in the April, May, June and July 1973 issues. Back numbers are not available of the complete set but the Master Mixer project has been reprinted in the ETI Project Book 1. This is available to readers for 75p + 10p postage.

Orders should be sent to:  
ETI Top Projects (No.1),  
Electronics Today International  
36 Ebury Street,  
London SW1W 0LW.

### CONSTRUCTION

Full constructional details will be provided next month. In the meantime the mixer as described may be partially built by assembling two line amplifier boards (eight channels each), as described in this article. Of course the unit could be extended by adding an additional line amplifier board without other modification (i.e. 24 channels

mixed down to eight) however further amplifier boards may not be added without modification, but a second mixer board may be used if further extension is required.

When assembling boards take particular care with orientation of ICs, transistors, diodes and electrolytic capacitors.

*To be continued next month . . .*

## STAGE MIXER PARTS LIST

### PARTS LIST GENERAL

Chassis  
Box  
Escutcheon  
16 Cannon sockets  
3 Cannon plugs  
27 Phone jacks — mono — 6.4mm  
1 LED and panel holder  
1 11 position 1 pole rotary switch  
1 VU meter  
1 240V power outlet similar  
1 21 pin socket  
26 Knobs  
12 1" spacers  
nuts, bolts, 3 core flex & plug etc.

### SUB-MIXERS, POWER SUPPLY

R2,5,8,11 resistor 100Ω ¼w 5%  
R14,17,20 " 100Ω ¼w 5%  
R23,25,28 " 100Ω " "  
R29,30,31 " 390Ω ½w "  
R1,4,7,10 " 47k ¼w "  
R13,16,19,22 " 47k " "  
R3,6,9,12 " 100k " "  
R15,18,21 " 100k " "  
R24,26,27 " 100k " "  
RV1,2,3,4 potentiometer 22k rotary log  
RV5,6,7,8 potentiometer 22k rotary log  
RV9 potentiometer 470k rotary log  
C4,5,6 capacitor 0.1µF polyester  
C1,2,3 capacitor 470µF 25V electrolytic  
IC1-IC10 integrated circuit µA741C Mini dip or TO5

D1-D4 diode 1N4001 or similar  
ZD1,2 Zener diode 15V,400mW

T1 transformer 240V/15-0-15V  
PC Board ETI-414E  
SW1 switch DPDT toggle 240V rated  
SW2 switch 4PDT toggle

### INPUT AMPLIFIERS

16 off are required for all components below

R11 resistor see text  
R15 resistor 680Ω ¼w 5%  
R18, 19 resistor 10k ¼w 5%  
R14,16 resistor 33k ¼w 5%  
R13 resistor 100k ¼w 5%  
R12 resistor 220k ¼w 5%  
RV11 potentiometer 220k rotary log.  
C13 capacitor 56pF ceramic  
C11, 15 capacitor 0.47µF TAG Tantalum  
C12 capacitor 22µF 16V electrolytic

Q11 transistor BC549 or similar  
Q12 transistor BC559 or similar

2 off are required for all components below —

R1 resistor 8k2 ¼w 5%  
C1, 2 capacitor 25µF 25V electrolytic  
ZD1 Zener diode 10V,400mW  
PC Board ETI-414D

# HIGH VOLTAGE FOR LOW COST

Simple diode-capacitor networks can be cascaded to deliver any desired voltage.

IF YOU NEED a power supply for a high-voltage low-current application, your best bet is probably the voltage multiplier circuit. It's inexpensive. It's simple. And you can get any voltage you want by cascading multiplier stages. The voltage is limited only by the ratings of the components you use.

A voltage-multiplier circuit contains diodes and capacitors, with the devices connected to develop a dc output that is a multiple of the peak or peak-to-peak input voltage. There are two major variations of the circuit: multipliers that use an even number of diodes and those that use an odd number of diodes.

The basic rectifier circuits in Fig. 1. (equations assume perfect diodes and capacitors, loads are considered light) can be combined to form a complete family of half-wave multipliers. A

full-wave multiplier can be made by combining two half-wave multiplier sections, one positive and one negative (Fig. 2). The major disadvantage of a full-wave multiplier is that the secondary side of the transformer nearest the core requires heavy insulation to withstand one-half the output voltage. Therefore inductive coupling is worse and efficiency lower than for a transformer used with the equivalent half-wave type. Thus half-wave multipliers are better for most high-voltage power supplies.

Figure 3 shows the two variations of half-wave multipliers. Each of these circuits consists of identical sections cascaded, except for the first stage in Fig. 3a. The first section of a multiplier with an odd number of diodes is a simple half-wave rectifier. This first section of a multiplier with

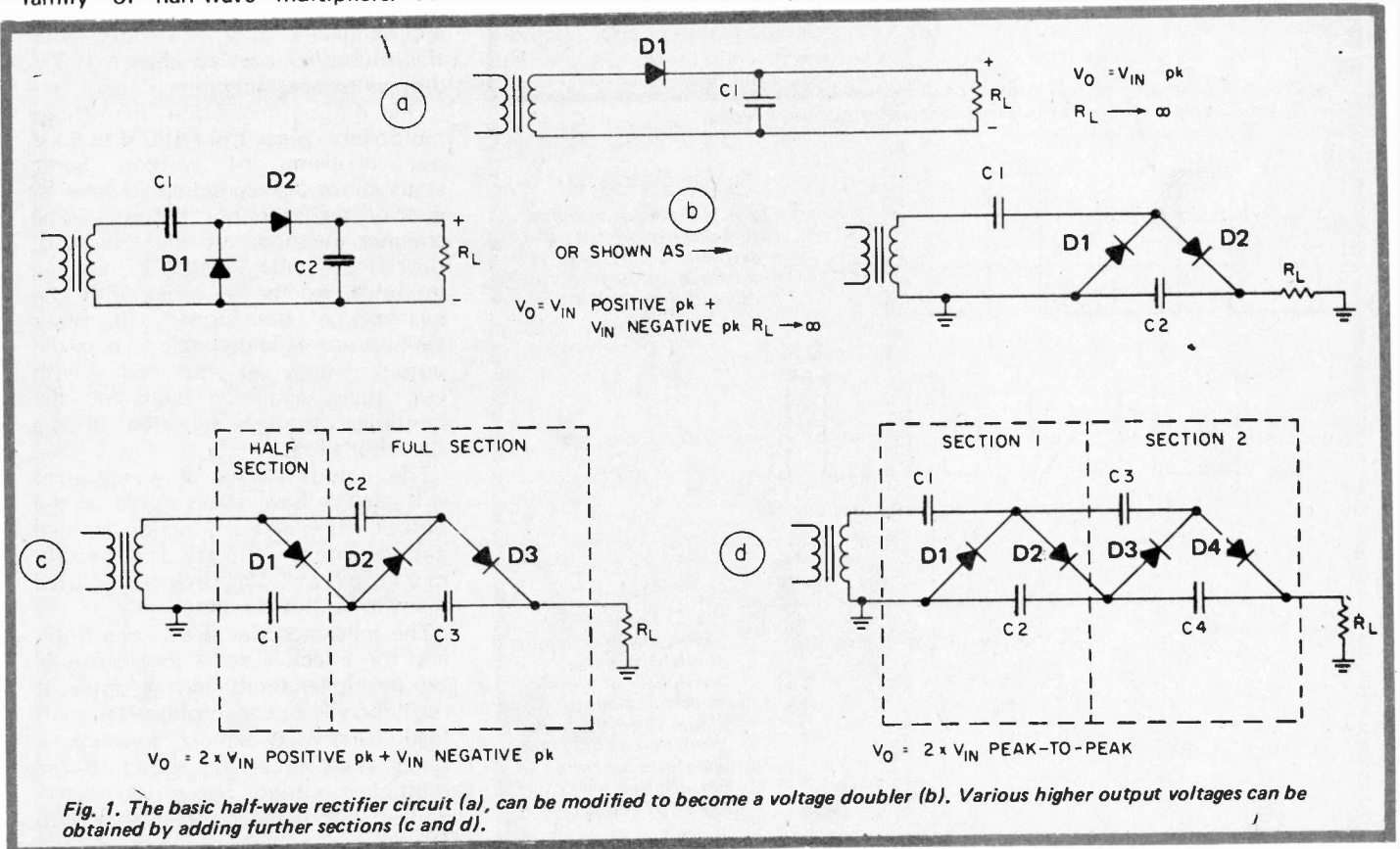
an even number of diodes is a half-wave doubler. A basic rule of thumb for multiplier designs is: For waveforms that are symmetrical about zero, use an even number of diodes; for asymmetrical waveforms, use an odd number.

## CALCULATING THE OUTPUT VOLTAGE

The regulation of a multiplier with a load is a function of the input's source impedance, the values of the capacitors in the multiplier, the forward drop of the diodes and the turn-on and turn-off times of the diodes. The output voltage of a multiplier is approximately

$$V_{out} = N \frac{(V_1 + V_2)}{2} - \frac{N^3}{12Cf} \cdot I_{out}$$

Here N is the number of diodes or capacitors used for circuits like those shown in Fig. 3;  $V_1$  is the positive peak input voltage;  $V_2$  is the negative



# HIGH VOLTAGE FOR LOW COST

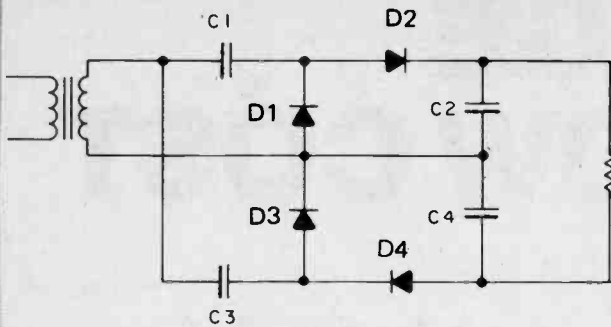
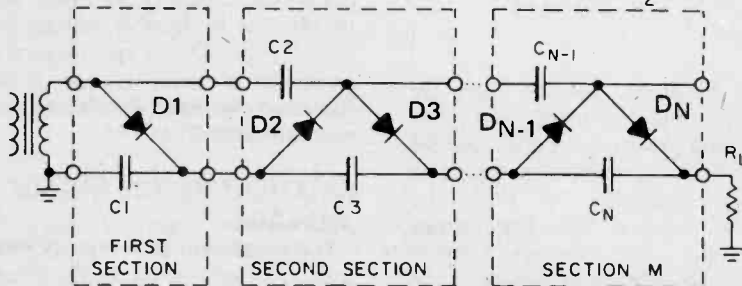


Fig. 2. The full-wave voltage quadrupler circuit requires a transformer with heavy secondary insulation.

$$M = \text{SECTIONS}$$

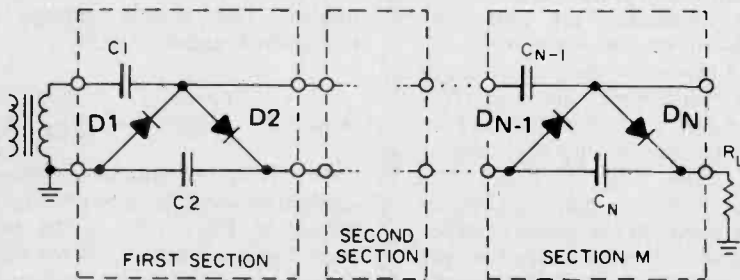
$$M = \frac{N+1}{2}$$



(a)

$$M = \text{SECTIONS}$$

$$M = \frac{N}{2}$$



(b)

Fig. 3. A multiplier with an odd number of diodes works best for asymmetrical waveforms (a). An even number of diodes (b) is best for symmetrical waveforms.

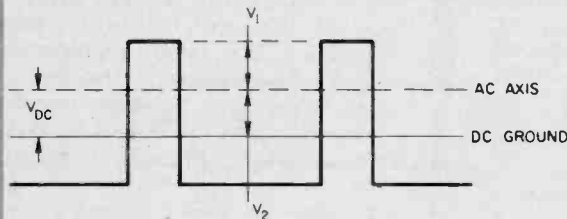


Fig. 4. A recurring waveform with a positive peak  $V_1$  and negative peak  $V_2$  is used as an input for the voltage multiplier circuit described in Fig. 5.

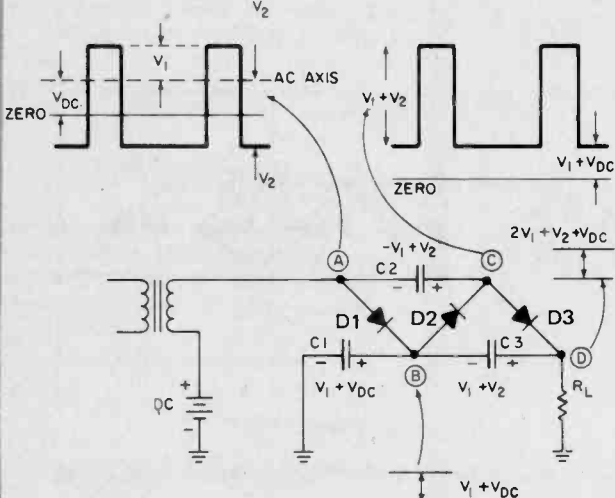


Fig. 5. The voltage waveforms at different points within the multiplier circuit with an odd number of diodes show the transformation of the pulse waveform described in Fig. 4 into a much higher dc voltage.

peak input voltage;  $C$  is the capacitance in farads;  $f$  is the frequency of the input, and  $I_{out}$  is the current in amperes. This equation assumes a sufficiently large load capacitance, equal value capacitors, and ideal diodes. It will produce sufficiently accurate results for all practical purposes.

## WATCH DIODE SWITCHING CHARACTERISTICS

The turn-on and turn-off times of the diodes are important if high frequencies are involved. Both turn-on and turn-off must be kept fast, if regulation and efficiency are to be maintained.

The forward drop of the diodes is usually not a significant factor. For example, a typical multiplier, rated for 25 kV at 2 mA, has six diodes — each with a forward voltage drop of approximately 15 V at 10 mA. Thus this multiplier has less than a 100-V drop when operating.

The output regulation of voltage multipliers ranges from 100 V to 5 kV per milliamp of current. Some applications use regulation schemes to control power-supply output. Some common methods are shunt dc load, rectified pulse feedback and a saturable reactor in series with the high-voltage transformer. In other applications, it is desirable to have the output voltage sag with load — with very poor regulation built into the multiplier through selection of the capacitor's value.

The output voltage of a multiplier will always have some ripple in the output. Ripple is a function of load capacitance, input frequency, multiplier impedance and input-to-output coupling.

The load capacitance acts as a filter, and the effective series impedance of the multiplier limits voltage ripple. If regulation is not a consideration or if load current is almost constant, a series resistor can be added to the multiplier output. The series resistor will act with the load capacitance as an RC filter.



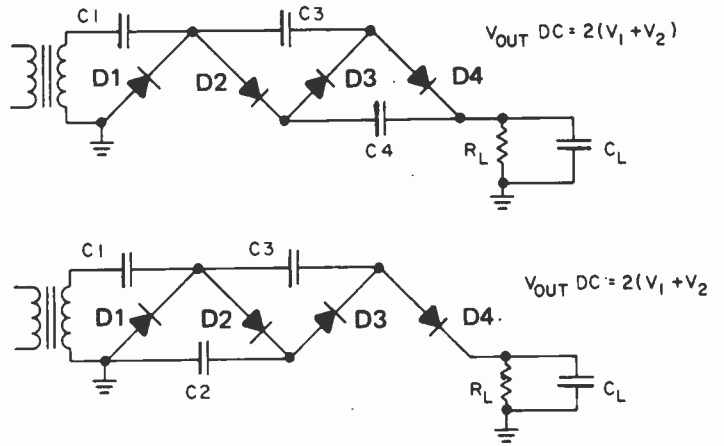
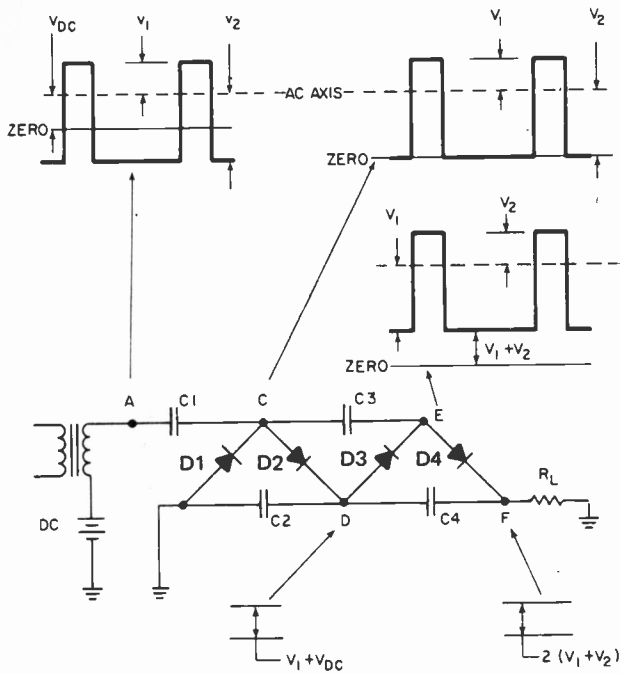


Fig. 7. To reduce component cost and count if the load is capacitive remove one of the doubling capacitors.

Fig. 6. The multiplier circuit with an even number of diodes and the same input as described in Fig. 4 produces an even larger dc output voltage than the circuit of Fig. 5.

## HOW MULTIPLIERS WORK

The multiplier circuit can handle any waveform, but the three most common for multiplication are sine, pulse (or square) and trapezoidal wave. The only waveform restrictions are that the rise and fall times of the input signal be slower than the diode switching time.

In the signal in Fig. 4,  $V_{in}$  is a recurring waveform composed of the positive peak  $V_1$ , the negative peak  $V_2$  and an ac axis that can be displaced from dc zero by voltage  $V_{dc}$ .

Figure 5 shows the voltages at each point of a 1.5-section multiplier. The half-wave, 1.5-section multiplier (three diode) operates as follows: During the positive peak of  $V_{in}$ , diode  $D_1$  conducts to charge  $C_1$  to a voltage equal to  $V_1 + V_{dc}$ . Capacitor  $C_2$  acts as a coupling capacitor to couple  $V_{in}$  to point C. Diode  $D_2$  conducts on the negative voltage peak at point C when the voltage tries to become more negative than the anode of  $D_2$  (the anode voltage of  $D_2$  is  $V_1 + V_{dc}$ ). Diode  $D_3$  conducts on the positive peak at point C and charges  $D_3$  to  $V_1 + V_2$ . The output,  $V_{out}$ , is the sum of the voltages on  $C_1$  and  $C_3$ :

$$V_{out} = V_1 + V_{dc} + V_1 + V_2 = 2V_1 + V_2 + V_{dc}$$

Only dc voltages are applied to  $C_1$  and  $C_3$ ; these capacitors are therefore dubbed "dc capacitors." An ac voltage is applied to  $C_2$ , which is called an "ac capacitor." If the input voltage is symmetrical about the zero axis, the multiplier output will be three times (either) peak voltage,  $V_{out} = 3V_1$ . This circuit is called a tripler. If, however, the waveform is such that  $V_2$  is much greater than  $V_1$ , the output voltage is approximately twice  $V_1$ . The circuit could be called a doubler. For clarity, we can use the diode count to define multiplier capability.

The operation of the four-diode multiplier — a two-section, half-wave unit — is similar to that of the three-diode multiplier (Fig. 6). Capacitor  $C_1$  blocks the dc bias from the remainder of the multiplier and acts as a coupling capacitor to couple  $V_{in}$  to point C. Diode  $D_1$  conducts when the negative voltage at point C becomes more negative than the anode of  $D_1$  (the anode of  $D_1$  is at 0 V). This causes  $C_1$  to charge to a voltage equal to  $V_2 - V_{dc}$  and simultaneously causes the positive peak at point C to reach  $V_1 + V_2$ .

The positive voltage at point C turns on  $D_2$  and charges  $C_2$  to  $V_1 + V_2$ . Capacitor  $C_3$  acts as a coupling capacitor to couple the input waveform at point C to point E. Diode  $D_3$  conducts when the cathode voltage becomes more negative than the anode voltage (the voltage at point D). The positive peak will be at a voltage equal to the charge on  $C_3$  plus the peak voltage at point C. This positive voltage will cause  $D_1$  to conduct and charge capacitor  $C_4$  to  $V_1 + V_2$ . The output,  $V_{out}$ , is the sum of the voltage on  $C_2$  and  $C_4$ :

$$V_{out} = (V_1 + V_2) + (V_1 + V_2) = 2V_1 + 2V_2$$

Both  $C_2$  and  $C_4$  are dc capacitors. Points D and F are "dc points", and  $C_1$  and  $C_3$  are ac capacitors. In both the odd-diode and even-diode circuits, the diode peak-inverse voltage (PIV) ratings should be at least  $V_1 + V_2$ . In the even-diode multiplier,  $C_1$  should have a voltage rating of at least  $V_2$ . In the odd-diode multiplier,  $C_1$  should have a voltage rating of at least  $V_1 + V_{dc}$ . All the other capacitors should have a voltage rating of at least  $V_1 + V_2$ . Negative output voltages can be obtained if the diode polarities are reversed.

The high-frequency components of the input voltage are the most easily coupled into the output. But the higher frequencies are also easier to filter at the multiplier output when necessary. The most unpredictable ripple component, though, is generated by stray capacitive coupling of the input to the output terminal. This coupling is difficult to control. The mechanical layout of the multiplier can reduce it, and if more ripple reduction is required, an electrostatic shield can be used to isolate the output area further from the input.

## VARIATIONS FOR SPECIAL APPLICATIONS

For applications with a very high load capacitance, any one of the dc capacitors can be omitted in the multiplier and it will still function (Fig. 7).

While this appears to be a good way to reduce component costs and package size, consider what happens when the output terminal is arced to ground: the distribution of voltages on the diodes becomes unequal, which causes more stress on some diodes

# HIGH VOLTAGE FOR LOW COST

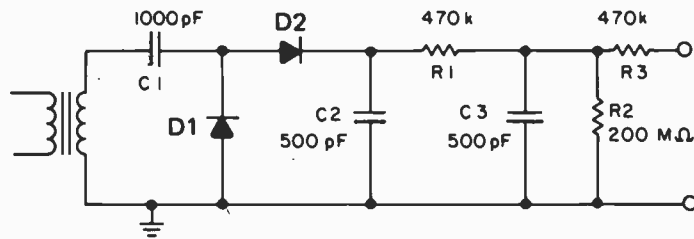


Fig. 8. A voltage doubler can be combined with a filter to provide very low ripple outputs. (The example shown gives a 30 kHz, 10 kV, 50μA output)

than others. The uneven distribution can cause a diode's peak inverse rating to be exceeded and a malfunction to occur. For better transient protection, leave all the capacitors in the circuit.

Many applications require a second voltage that is proportional to the output voltage. A tap at any dc point of the multiplier can be used. The ratio of the voltages can be determined if you examine the circuit up to the tap as a complete unit and the total multiplier as another.

Consider carefully the maximum average current. The multiplier current ratings are intended to keep the components cool enough to perform reliably. It will help, of course, if the high-voltage drive source has some

maximum-load protection that reduces the input voltage if too much current is demanded.

The multiplier must withstand all arcing, including that between the output lead and ground, and also direct shorts of the output lead to ground. The multiplier must sustain the peak current drawn by the arc or short as the internal capacitors discharge.

A resistor in series with the output lead serves two functions: (1) It reduces the Q of the oscillator circuit that is established during arcing, thus reducing considerably the stress on the diodes, and (2), it limits the peak current to a value that the diodes can handle safely. The value of this

resistance must be high enough to do the limiting job but not so high as to promote arcing around or through the resistor body or overheating at maximum current drain when the output arcs to ground.

## CONSIDER THE MECHANICAL LAYOUT

The mechanical design, mounting method and location of the multiplier can all affect current capability.

Remember that very high voltages may be involved so pay particular attention to component layout and insulation — also ensure that there are no sharp edges that might otherwise initiate corona discharge.

Now Available From ETI ...

# Towers' International Transistor Selector



When we saw 'Towers International Transistor Selector' we were so impressed that we have made arrangements with Technical Book Services to supply readers directly.

This 142-page book gives comprehensive details of over 10,000 British, US, European and Japanese transistors including electronic and mechanical specifications, manufacturers and available substitutes.

ALL FOR

**£3.40** INCLUDING POSTAGE

HOW THE INFORMATION IS GIVEN (SHOWN HERE REDUCED SCALE)

TRANSISTOR NUMBER	PM OA LT	PACK-AGE	LEAD INFO	V <sub>CB</sub> MAX	V <sub>CE</sub> MAX	V <sub>EB</sub> MAX	I <sub>C</sub> MAX	T <sub>J</sub> MAX	P TOT	F T MIN	C OB MAX	H FE	H FE BIAS	USE	MFR	EURO EDVT.	USA EDVT.	ISS
2N438	NG	T05	L04	30V	25V	25V	300mA	85C	150mW	1500K	25P	20PN	50MA	RMS	0BS	ASY29	2N1304	0
2N438A	NG	T05	L04	25V	25V	25V	300mA	85C	150mW	1500K	25P	20PN	50MA	RMS	0BS	ASY29	2N1304	0
2N439	NG	T05	L04	25V	25V	25V	300mA	85C	100mW	3H	18P	30PN	50MA	RMS	0BS	ASY29	2N1304	0
2N439A	NG	T05	L04	25V	25V	25V	300mA	85C	150mW	3H	18P	30PN	50MA	RMS	0BS	ASY29	2N1304	0
2N440	NG	T05	L04	30V	15V	25V	300mA	85C	150mW	5H	15P	40MN	50MA	RMS	0BS	ASY29	2N1304	0
2N440A	NG	T05	L04	25V	25V	25V	300mA	85C	150mW	4P	18P	40PN	50MA	RMS	0BS	ASY29	2N1304	0
2N441	PG	T036	L13	40V	25V	20V	4A	95C	50mW			20/40	5A	AMG	MOB	AD212	2N1100	0
2N442	PG	T036	L13	50V	30V	30V	4A	95C	50mW			20/40	5A	AMG	MOB	AD212	2N1100	0
2N443	PG	T036	L13	60V	45V	40V	4A	95C	50mW			20/40	5A	AMG	MOB	AD212	2N1100	0
2N444	NG	T05	L04	15V	10V	10V	25MA	85C	150mW	400K	30P	15TP	1MA	ALG	0BS	AC176	2N2430	0
2N444A	NG	T05	L04	40V	10V	10V	25MA	100C	150mW	400K	28P	20/40	20MA	ALG	0BS	AC176	2N2430	1
2N445	NG	T05	L04	15V	10V	10V	25MA	85C	150mW	1M	32P	35TP	1MA	RMS	0BS	ASY29	2N1304	0
2N445A	NG	T05	L04	30V	10V	10V	50MA	100C	150mW	2M	28P	40/160	20MA	RMS	0BS	ASY29	2N1304	0
2N446	NG	T05	L04	15V	10V	10V	50MA	100C	150mW	4P	30P	60TP	1MA	RMS	0BS	ASY29	2N1304	0
2N446A	NG	T05	L04	15V	10V	10V	50MA	100C	150mW	8P	28P	40/160	20MA	RMS	0BS	ASY29	2N1304	0

Cut TO: TOWERS INTERNATIONAL TRANSISTOR SELECTOR ETI Book Service 25 Court Close, Bray, Maidenhead, Berks.

Please find enclosed cheque/P.O. for £3.40 (payable to ETI)

NAME ADDRESS

# HOW AMBISONICS WORKS

DURING the past year or so *Electronics Today*, together with several overseas publications have described, as far as we have been able, the so-called Ambisonic surround-sound system.

These articles attracted very considerable interest, but had to be limited to the *philosophy* of the proposed new system as no *specific* details could be obtained.

However a search through the British Patent files resulted in our finding Patent No 1369 813 dated October 1974 'Improvements in or Relating to Reproduction of Sound'. The Patent is in the name of Britain's National Research Development Corporation — and the inventor is named as Peter Berners Fellget.

Working from the information contained within this Patent — and from previously released information — Brian Chapman has prepared this article setting out for the first time just how Ambisonics actually works.

IN THE continuing quest to obtain more realistic audio reproduction we have seen stereo replace mono, and various attempts made to extend conventional stereo's two channels to four — the so-called quadraphonic systems.

The sound images created by current systems seem artificial in that they appear to be distributed along the walls of the room. Furthermore the actual source of many sounds appears to shift position at times. This can sometimes be very disconcerting. We know of one record in which a contralto instantaneously moves from the front to the back of the room everytime she sings above C<sup>3</sup>.

What is required for realism is that the ambience information, normally experienced in a live performance, also be reproduced more realistically than it is at present, and that a listener should be able to determine the direction from which the original sound was produced — and that that direction be stable.

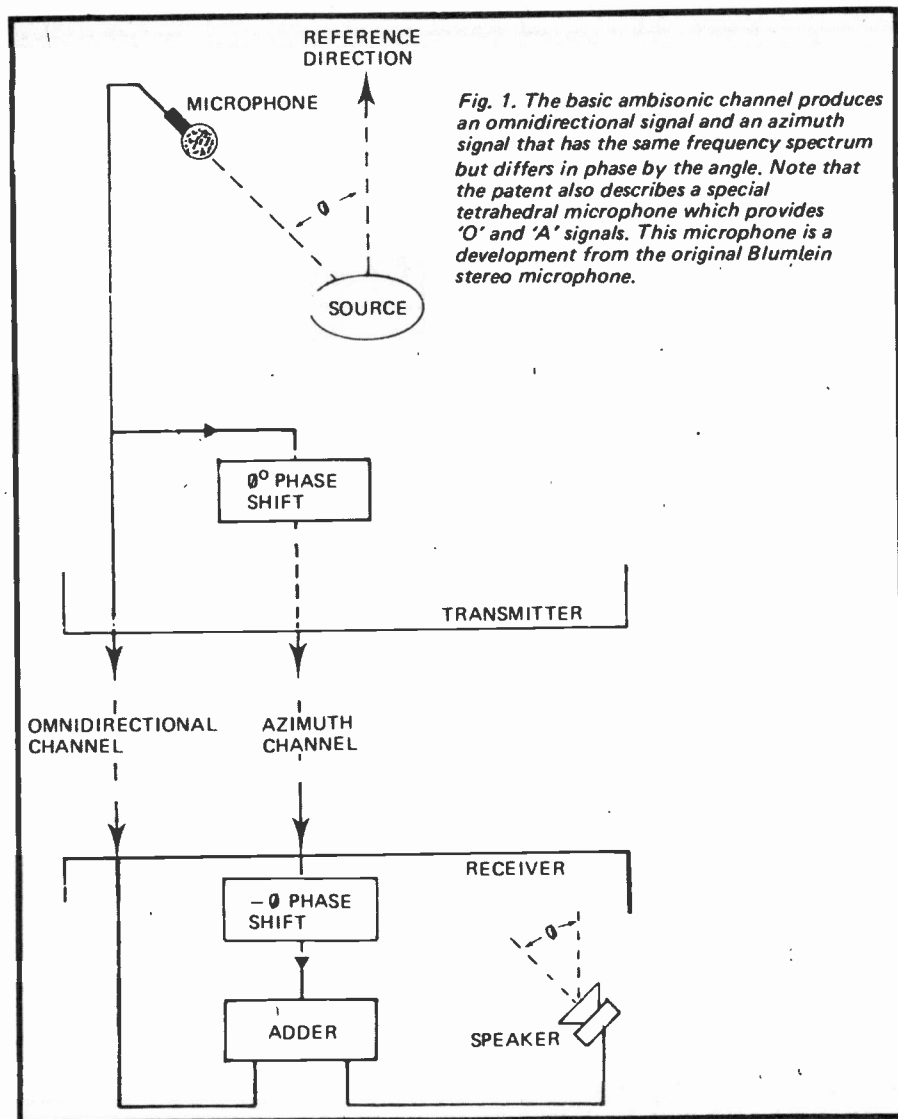
The Ambisonic system attempts to surround the listener with the direct *and* the reverberant sound, from *all* directions, such that the original sound field is reproduced as accurately as possible.

Whilst it is certainly *possible* to encode height as well as full azimuth information with this system, such periphonic systems will probably not be commercially used for some time. This discussion is therefore limited to systems which reproduce the sound field in the horizontal plane only, that is, pantaphonic systems.

To do this a totally different concept of recording is required which nevertheless can be encoded on to two transmission channels in a similar manner to conventional stereo discs and tapes.

The Ambisonic system adopts a completely different approach that does not exhibit the directional ambiguities common to existing systems. When recording, a number of microphones are used each of which provides an omnidirectional, 'O', signal and an 'azimuth' 'A' signal which is phase shifted by the angle between the individual microphone and a reference direction. This process is shown in Fig. 1.

In an actual system, at least three microphone setups must be used in order to obtain full directional coverage. All the omnidirectional signals are simply added into one channel and all the azimuth signals into another. Such a system of four microphones is shown in Fig. 2. Here the left front microphone is taken as the reference direction and hence its signals are passed direct to both transmission channels. The other three microphones are summed directly into the 'O' channel and via appropriate



phase-shift networks to the 'A' channel.

It should be noted at this point that the phase-shift networks in an actual system are of the 'all-pass' filter type. Hence the phase of both 'O' and 'A' channels may be shifted together; the apparent phase-shift to the 'A' channel being the difference in phase between the two.

Thus the content of each channel is a continuum of signals rather than a set of discrete signals. That is the two channels of information are representative of the sound-field surrounding the source. This means that although a system such as the transmitter of Fig. 2a, and the receiver of Fig. 3a may be used, a speaker at any azimuth orientation may be added simply by feeding it with appropriately phase shifted signals.

A system in which four microphones at 90° spacing are used, will transmit the signals as shown vectorially in Fig. 2b. To correctly decode this, at the receiver, a decoder, as shown in Fig. 3a, is required. Vector diagrams, adjacent to each speaker, show the signal fed to that particular speaker.

To better understand the decoding process let us trace the decoding to the right-front speaker as detailed in the vector diagrams on Fig. 3b. This shows the azimuth channel being firstly shifted by 90° and then inverted (phase-shift of 180°). When the azimuth and omnidirectional channels are subsequently added we find that the left back signal is completely cancelled, a twice amplitude right

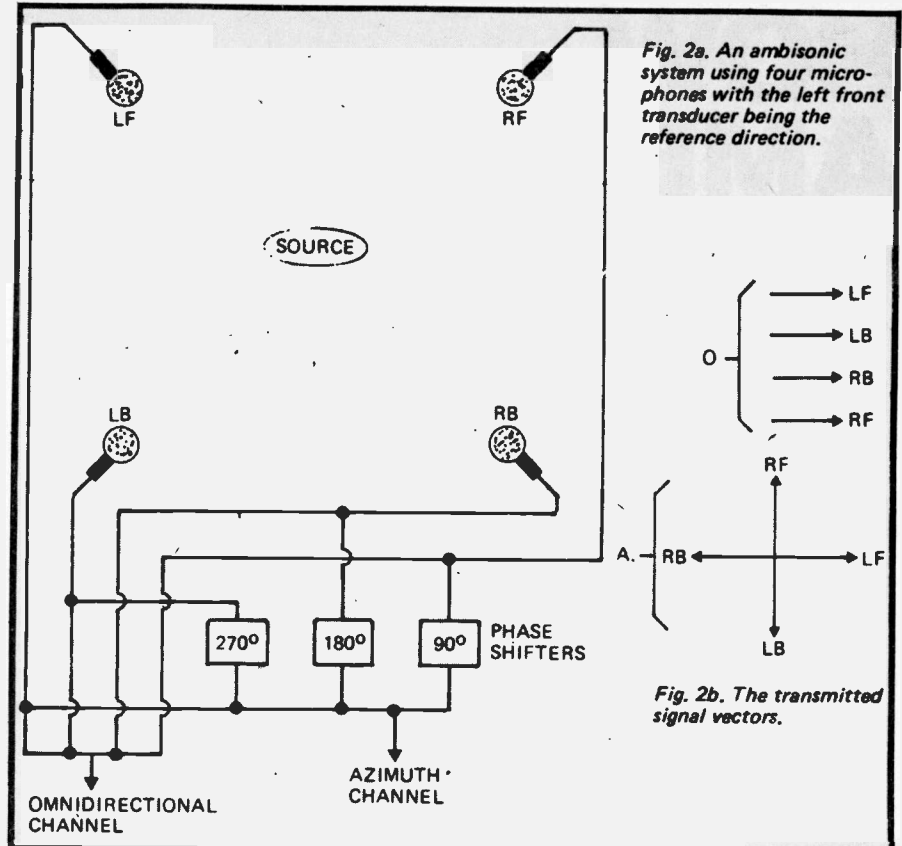


Fig. 2a. An ambisonic system using four microphones with the left front transducer being the reference direction.

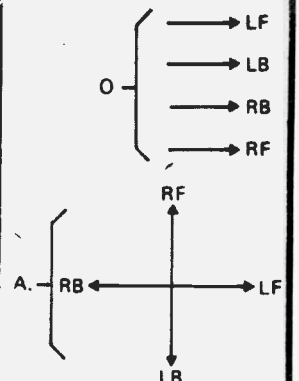


Fig. 2b. The transmitted signal vectors.

front signal is obtained and right back and left front signals of 1.4 times amplitude are also obtained at phase angles of plus and minus 45°.

Thus the diagonal separation is infinite but that between pairs on one side is only 3 dB. (This figure of 3 dB is in conflict with the Patent — there Professor Felgett shows the side

channels — vectorially — as having 0.707 amplitude, equivalent to 9 dB down on the main signal. We have asked three suitably qualified people to check our figures — and all agree that the correct result is 3 dB. Thus unless there is some factor not described in the Patent we cannot see how 9 dB separation can be obtained).

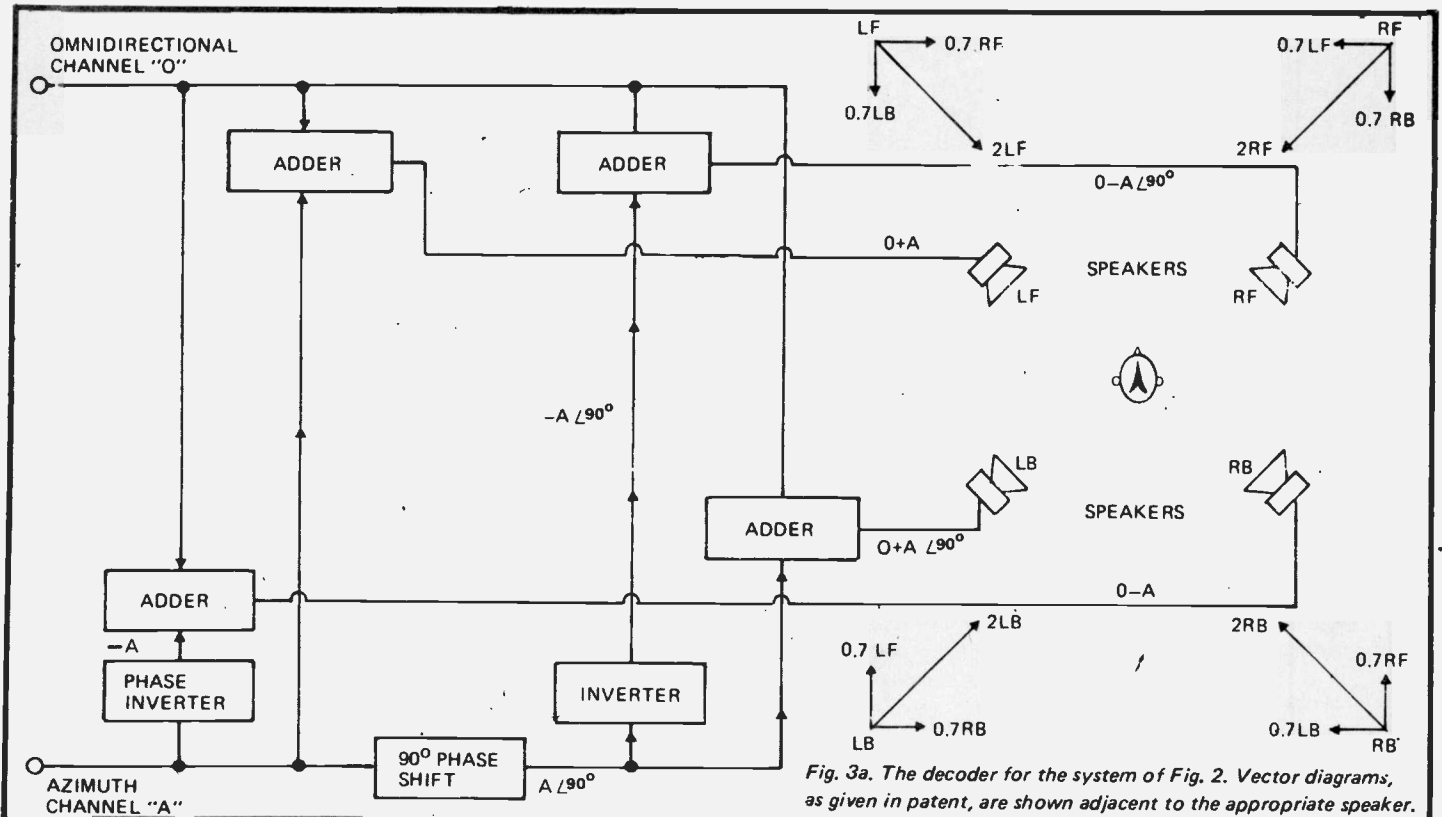
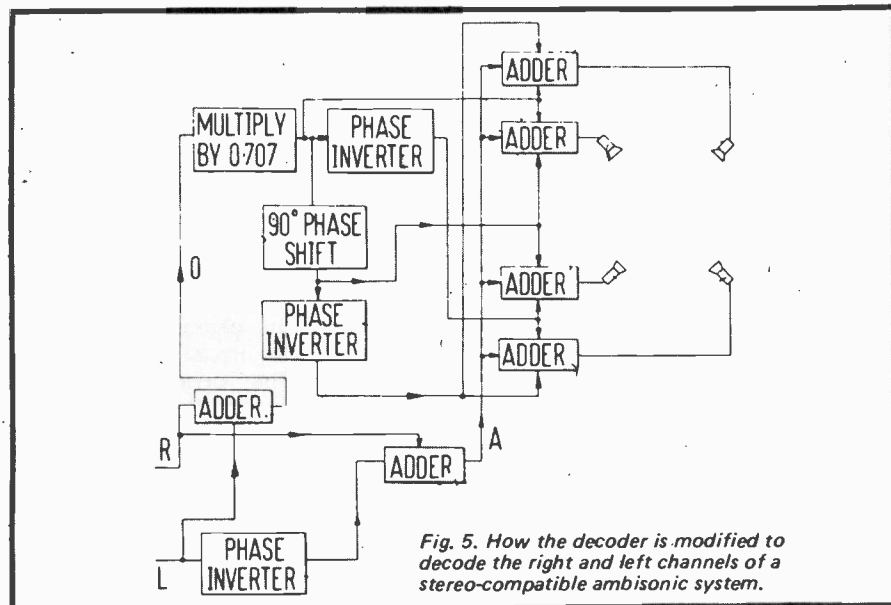
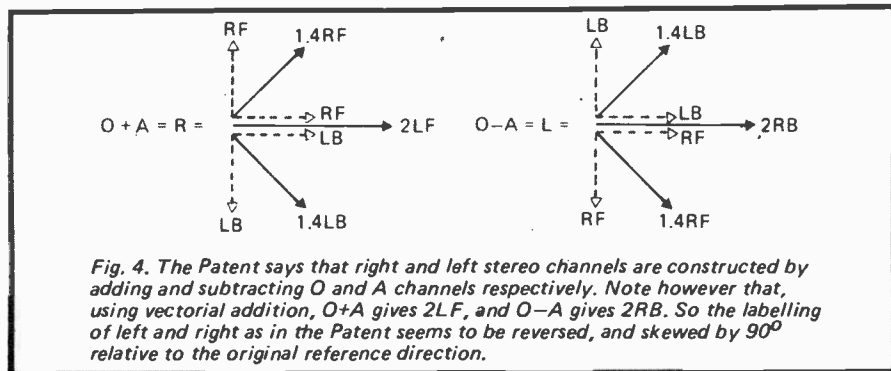
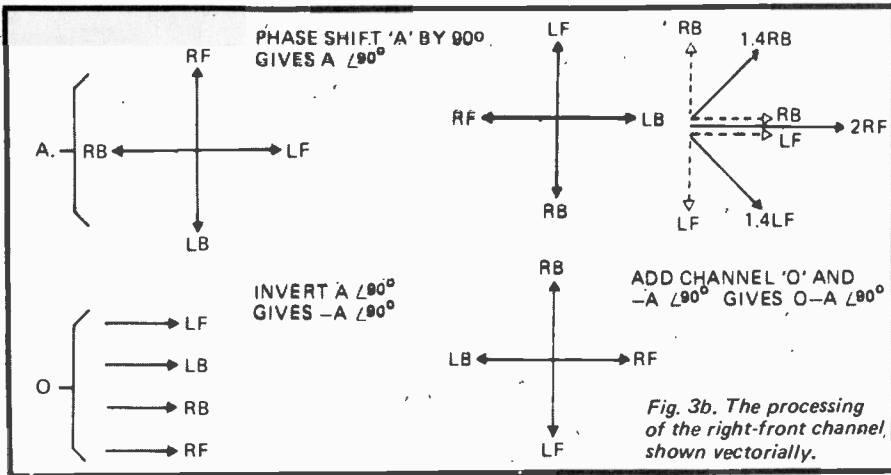


Fig. 3a. The decoder for the system of Fig. 2. Vector diagrams, as given in patent, are shown adjacent to the appropriate speaker.



However separation does not have the same meaning for ambisonics as it does for conventional four channel. Ambisonics reproduces a field surrounding the listener rather than four separate sound sources.

### COMPATABILITY WITH STEREO

The system described in Fig. 2 and 3 is not compatible with existing stereo systems but may readily be processed to be so. To generate right and left signals the 'O' and 'A' channels are added and subtracted respectively at the transmitter. At the receiver the decoder must be modified as shown in

Fig. 5 to recover the 'O' and 'A' signals. The 0.707 multiplier must be incorporated to halve the power in the 'O' channel, which was doubled in the first adder, and thus restore balance between 'O' and 'A' channels.

The Ambisonic system is thus very flexible in the number of speakers which may be used. It gives unambiguous directional information and has infinite separation diagonally and 3 dB (or 9dB!) separation between adjacent speakers. Finally it may readily be made compatible with conventional stereo systems and offers the ultimate capability of height, as well as horizontal transmission.

# A SECOND CHANCE

To buy these issues of ETI:

Testing Speakers with Random Noise  
Bass Booster  
Inverter for Fluorescent Lighting  
Electronic Decision Maker  
*in March 1973*

Digital Logic  
Improving Bridge Measurements  
Protecting Reed Relays  
New Sound for your Guitar  
*in June 1973*

Solid Electrolyte Devices  
Tracking Weight & Record Wear  
Cryogenics and Superconductivity  
Simple UHF Preamplifier  
Car-Buyer's Metal Detector  
*in August 1973*

Electronic Calculators, how to repair them  
NASA the First 15 Years  
Anti-Theft Auto Alarm  
Digital Stopwatch  
*in January 1974*

Directory of Hand-Held Calculators  
Digital Clock Kits Review  
50W Stereo Amp  
Temperature Meter  
*in August 1974*

Handling CMOS  
Temperature Alarm  
Light Sensitive Switch  
Linear IC Tester  
Printimer  
Add-On Amp (for Quad)  
*in November 1974*

How TV Cameras Work  
Tacho-Timing Light  
LM380 Record Player  
LM380 Intercom  
Spring Line Reverb Unit  
*in December 1974*

### Articles in BOLD are PROJECTS

These articles are just a selection from the many printed in these issues. Many other back issues can be supplied. For a complete listing of articles before May 1974, see the Index in that month's issue. To order send 30p for each issue plus P&P (10p for one; 15p for more than one) to Back Numbers Dept., ETI Magazine, 36 Ebury Street, London SW1W 0LW, clearly stating the issues you require.  
We cannot supply the following:  
April, May and November 1972,  
February and November 1973,  
March and September 1974.

# tech-tips

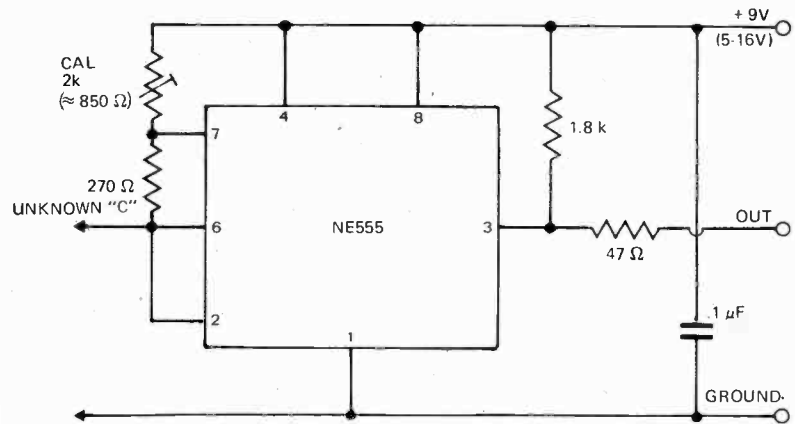
## SIMPLE DIGITAL CAPACITANCE PROBE FOR COUNTER

This simple adaptor enables a digital counter to be used to measure capacitance.

Various ICs may be used but the 555 series is the most practical and readily available.

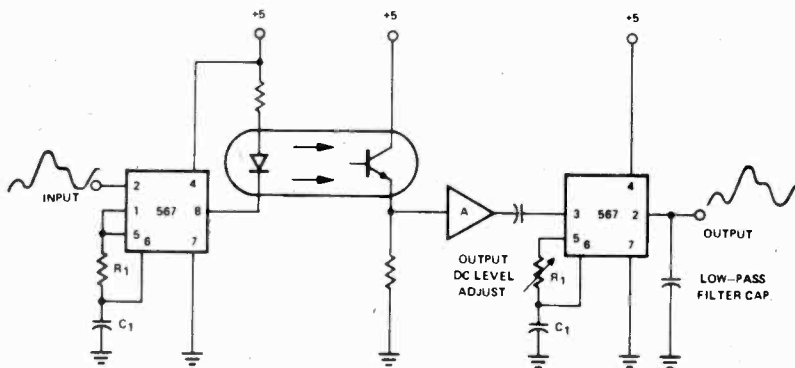
Probe output is coupled to the digital counter via coax. The counter is switched to the 'period' ranges with seconds read as  $\mu\text{F}$ , milliseconds as nF and microseconds as pF.

Accuracy depends on the accuracy of the calibration capacitors and of the power supply regulation. A calibration chart could of course be used if great accuracy or small capacitance value is required.



The prototype unit accurately measured a 50 000  $\mu\text{F}$  capacitor and a 2  $\mu\text{F}$  could still be measured accurately with a 47 k resistor paralleled across it. Lowest measurable value was about 500 pF.

## INFORMATION TRANSFER



SOMETIMES it is necessary to transfer an analogue signal from one system to another without making any electrical connections.

This can be done with two phase-locked-loops in an fm system using light as the transmission medium. Because of the high degree of electrical isolation obtained, low level signals can be transmitted without interference, even if there is a large potential difference between the sending and receiving circuits.

The circuit is shown above right.

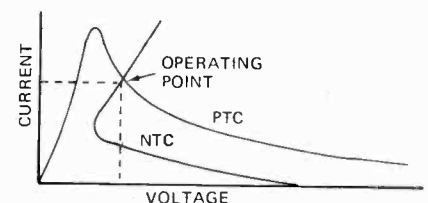
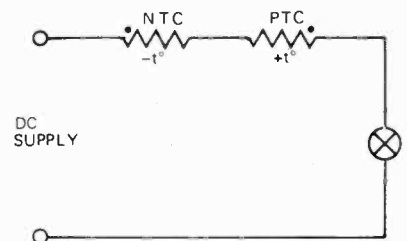
Transmitter is an NE 567 phase-locked-loop IC operating as a voltage controlled oscillator which drives the LED section of an

opto-coupler. The LED will flash at the operating frequency of the oscillator which is in turn dependent on the input signal level and the values of R, and C.

The output signal from the opto-coupler drives an amplifier which provides an output of sufficient amplitude (50 to 200 mV) to drive the receiving NE 567 phase-locked-loop. The receiver operates as an fm detector which demodulates the output of the opto-coupler to provide the original input signal. The inherent non-linearity of the transfer function in the two phase-locked-loops cancel one another out to give an extremely linear information transfer.

## THERMISTOR OSCILLATOR

A simple very low frequency oscillator can be made by interconnecting one positive temperature co-efficient and one negative temperature co-efficient thermistor in series. For conditions of oscillation the characteristics of the two devices have to be chosen carefully. The operating point is determined by the intersection of the two curves.

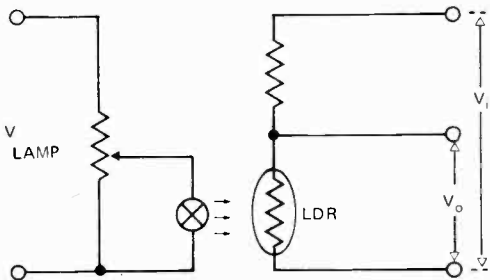


# SPECIAL

## CRACKLE-FREE POTENTIOMETER OPTO-ISOLATOR

The resistance of a light dependent resistor (LDR) varies as the light falling upon it varies – hence its name! When wired into a divider network it forms an excellent crackle-free potentiometer.

It also provides excellent electrical isolation of the manual control – often a valuable feature where high voltage circuits must be isolated from low voltage circuits.

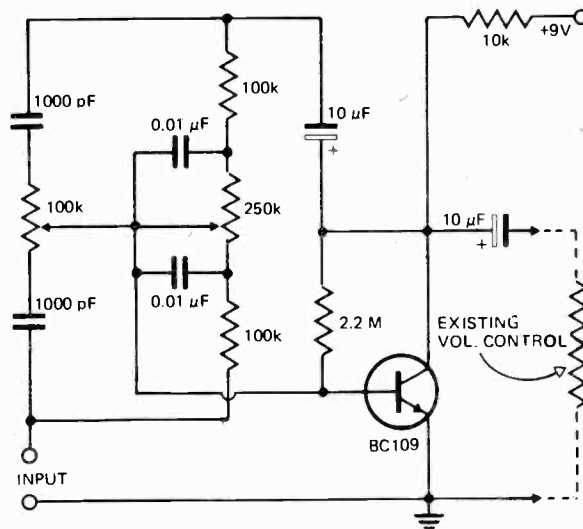


## TONE CONTROL CIRCUIT

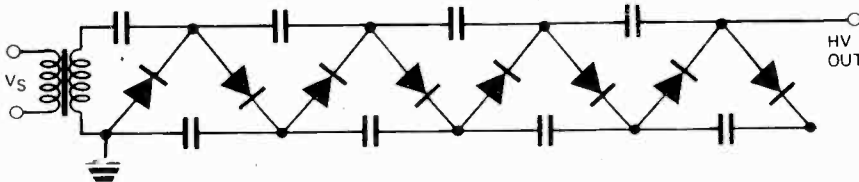
This simple single-transistor circuit will give approximately 15 dB boost or cut at 100 Hz and 15 kHz respectively. A low noise audio type transistor is used, and the output can be fed

directly into any existing amplifier volume control to which the tone control is to be fitted.

The gain of the circuit is near unity when controls are set in the "flat" position.



## VOLTAGE MULTIPLIER



Sometimes a very high voltage is required for applications such as for ionisers or a CRT supply.

secondary of an ordinary power transformer can have its output voltage multiplied any number of

With this circuit the high voltage times determined by the number of stages "cascaded".

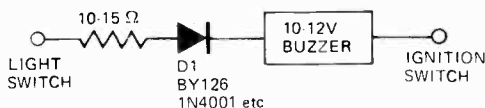
It is important to note that the rating of individual diodes and capacitors should be twice the transformer output voltage  $V_s$ .

The capacitor value and diode rating are determined by the required output current.

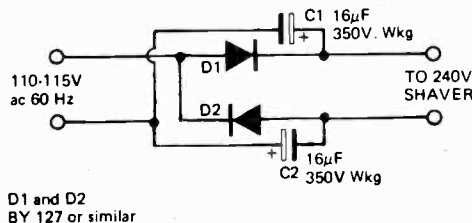
## AUTOMOBILE LIGHT REMINDER

This circuit ensures that car lights are switched off when the ignition is turned off.

Any low power silicon rectifier diode will be satisfactory together with a suitable 12 V buzzer or bell. Only two connections are required. The alarm will sound if you leave the lights on after cutting the ignition.



## TRAVELLER'S SHAVER ADAPTOR



D1 and D2  
BY 127 or similar

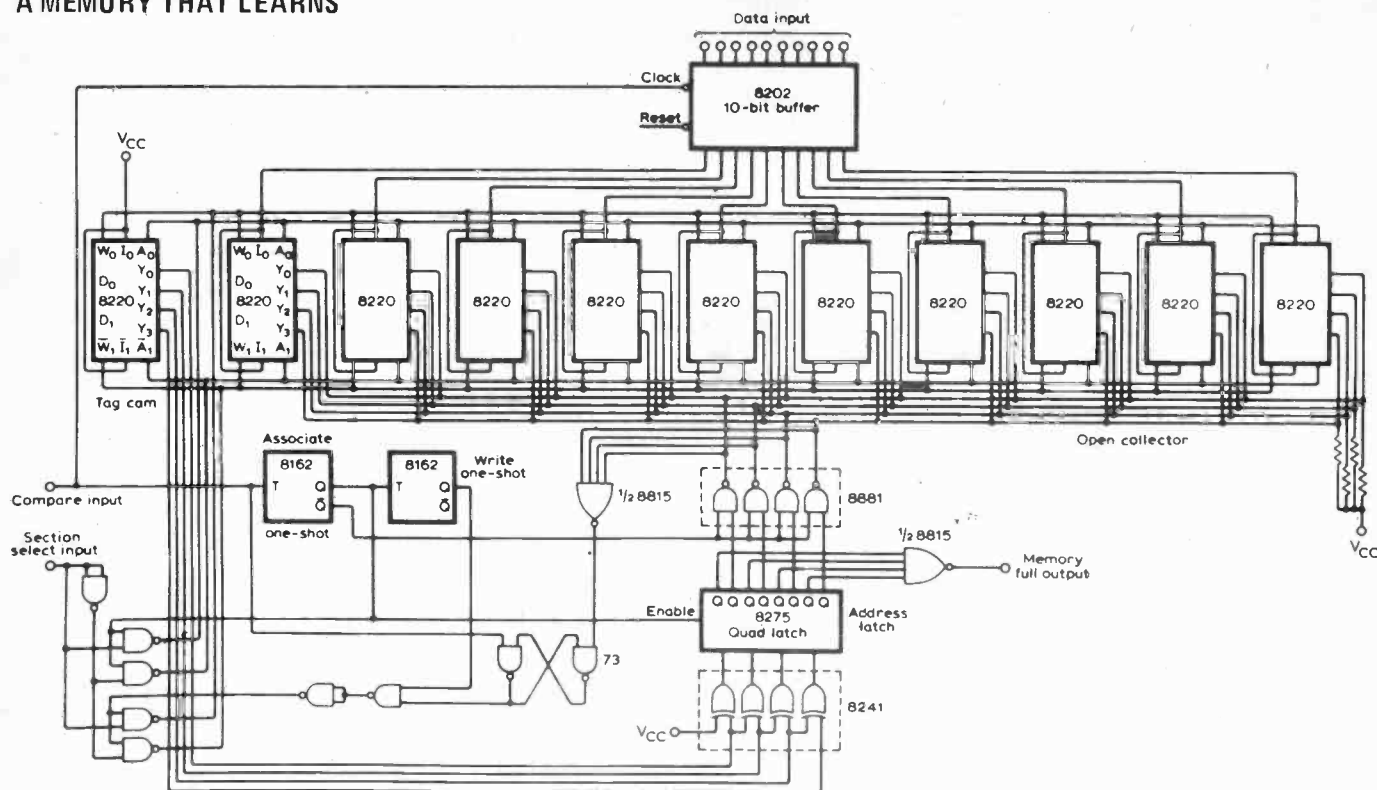
Many overseas countries have 115 volts mains supplies. This can be a problem if your electric shaver is designed for 220/240 volts only.

This simple rectifier voltage doubler enables motor driven 240 volt shavers to be operated at full speed from a

115 volt supply.

As the output voltage is dc the circuit can only be used to drive small ac/dc motors. It cannot be used, for example, to operate vibrator-type shavers, or radio sets unless the latter are ac/dc operated.

## A MEMORY THAT LEARNS



There is currently a great deal of interest in Content Addressable Memories (CAMs) and they are finding use in more and more applications. However, it is probably true to say that the novel characteristics of the CAM have not yet been fully realised.

The CAM is simply a memory with the ability to make a comparison between data already stored and data which is presented to the input. When several CAMs are connected in an array it is possible to apply feedback in such a way as to make a word which has just been read from the memory the next address. Circuits such as these can be made to generate or recognise sequences of digital words.

In the recognition mode, for instance, a CAM array with associated external logic could recognise a dangerous sequence of events in a process control system and could be made to take the appropriate action or alert staff to the impending danger.

Here is a memory constructed from Signetics 8220 CAMs, which has the ability to reject or accept new data depending on what is already in the memory. Once the memory has learned a data word, it will not accept another identical word. In addition, the memory automatically decides at what address new acceptable data is to be stored and ensures that new

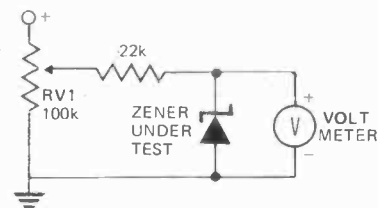
information is not written into locations which are already occupied.

Each 8220 is a CAM capable of storing four words of two-bits and the memory as a whole can store eight 10-bit words. Although the storage capacity of the memory is 80-bits (8 x 10), eleven CAMs are employed which together have a capacity of 88-bits (11 x 2 x 4). The eleventh CAM has been called the tag CAM because it keeps track of the locations within the memory which are occupied, and allocates a new address for acceptable information.

The memory is sub-divided into the two sections of equal capacity and either of the two sections can be selected using the "section select input". Input data is presented to the 10-bit buffer and the "compare input" is activated. This clocks the data into the buffer and initiates a comparison process in which each word already stored within the memory is compared with the data in the buffer. If a location within the memory is found to carry data identical to that within the buffer, one of the 8220's Y outputs will go 'high' and the write command will be inhibited. If no accurate match is found, the data in the buffer is written into the address specified by the 'tag' CAM.

Exclusive-OR gates connected to the Y outputs of the tag CAM specify the next available address and ensure that memory locations are filled successively. The address at the outputs of the exclusive-OR gates is latched into the quadlatch before the 'write' command is available to the CAM array. Thus the Y lines of unavailable memory locations are forced to logic '0'.

## ZENER DIODE CHECK



Unmarked Zener diodes may be tested using this simple circuit.

An external power supply giving a voltage higher than the highest expected rating of the Zener diodes to be tested is required.

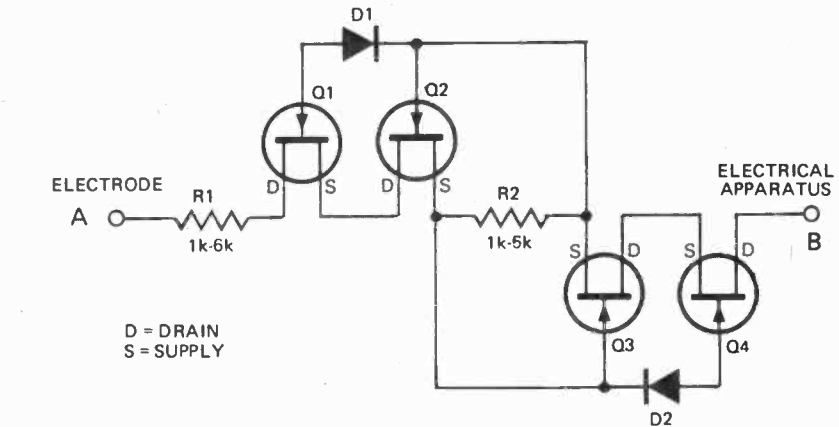
Potentiometer RV1 is adjusted until the meter reading stabilizes. This reading is the Zener diode's breakdown voltage.



## CURRENT LIMITING CIRCUIT

Danger of accidental shock exists during the use of electrocardiographs and other electrical apparatus that are connected directly to the patient. As part of the Skylab program, a circuit was developed to prevent accidental shock through electrodes to the test subjects.

The circuit allows undistorted signal voltage transfer, as long as the current remains low. If a high current begins to flow from the electrode terminal A toward apparatus terminal B, it will produce a potential difference across resistor R2 (left side of R2 will be at a higher potential than the right side). This potential biases the gate electrodes of the field-effect transistors, Q3 and Q4, to produce an extremely high impedance. Similarly, a current flow in the opposite direction is cut off by a bias on the gates of Q1



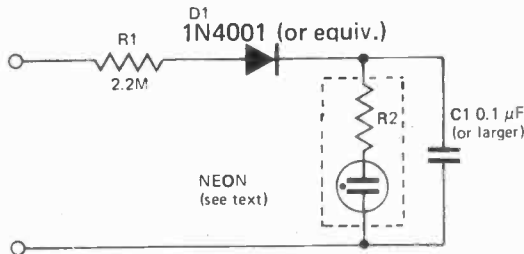
and Q2.

This circuit effectively protects the patient from dangerous shock that could be caused by a failure in the electrical apparatus. When a 1000 Hz signal at 141 Vac (rms) is applied to

the terminals of the network, the current is limited to approximately  $87\mu\text{A}$ .

This circuit can also be used to protect sensitive electrical measuring instruments.

## NEON FLASHER WARNING



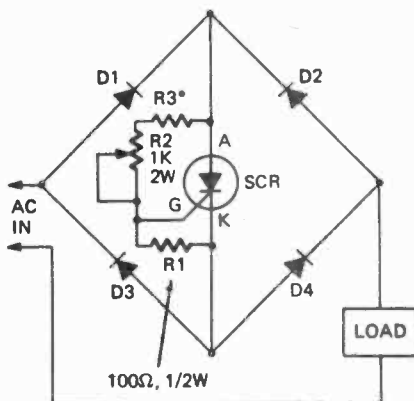
This neon flasher could be used for triggering a triac etc. having the

advantage of showing when the device is being triggered and being an economic, reliable triggering device. Average current drawn by the neon is around 25 micro-amps and the triac etc. would need an appropriate trigger current. This circuit is ultra-reliable but not very stable as regards to its flashing rate.

A flashing pilot light is likely to be more attention-getting than a pilot light which is continually on. This circuit will cause a neon to flash at a rate determined by the value of

the capacitor placed in series between the diode and mains, neutral line. The neon may be used on its own or with a 270 k resistor in series with it as used in ready assembled 240 V pilot lamps. However, the value of R2, if used at all, is dependent on the flashing rate and effect desired by the individual constructor. All voltage ratings on components have been deliberately increased to protect the components from overload. R1 should be left as 2.2 Meg., the flashing rate being determined by the values of C1 and R2.

## FULL-WAVE SCR CONTROL



This circuit enables a single SCR to provide fullwave control of resistive loads.

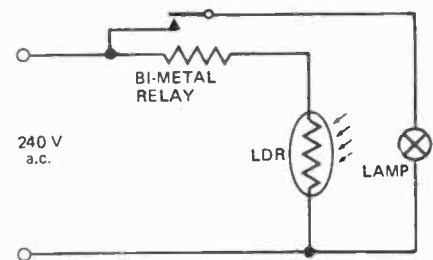
Resistor R3 should be chosen so that when potentiometer R2 is at its minimum setting, the current in the load is at the required minimum level. Diodes should have same current and voltage rating as the SCR.

## AUTOMATIC TWILIGHT SWITCH

Here is a circuit which will automatically light your porch light or activate any other device when the ambient light drops below a certain level.

A light dependent resistor is used in series with a relay.

The resistor has a value in excess of 1 megohm when illuminated, this drops to below 110 ohms when dark.



It is important that the LDR be positioned in such a place as not to receive any spurious illumination as this will cause the relay to drop out intermittently.

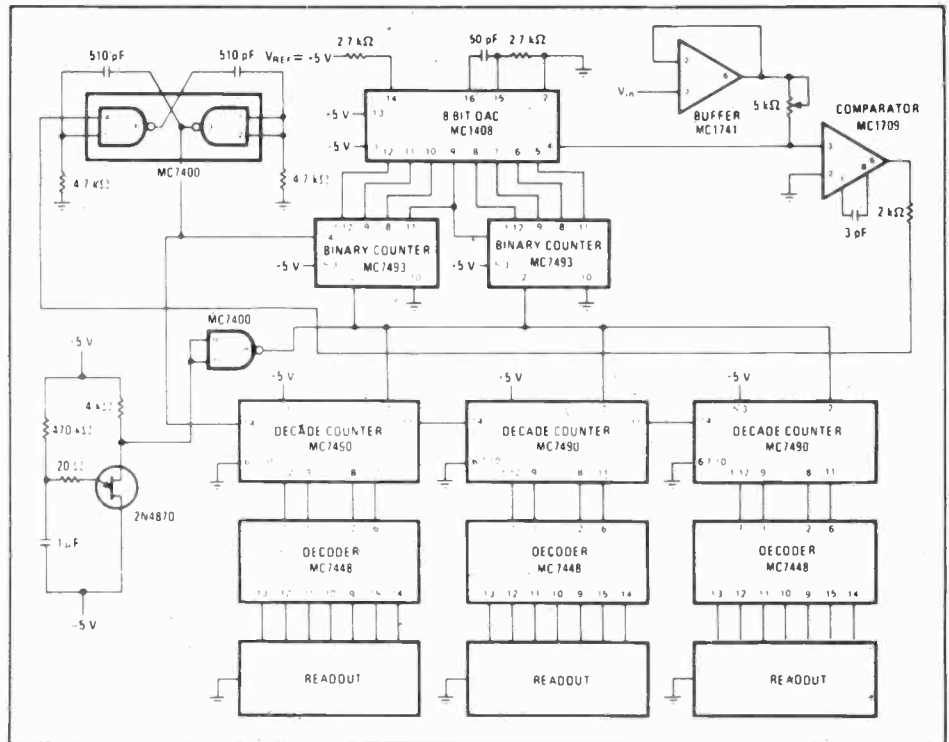
A bimetallic strip type relay will give sufficient delay to ensure that incident light flashes have no influence.

## SIMPLE DIGITAL VOLTMETER

This meter, is a closed-loop system that uses a clocked binary counter feeding a digital-to-analogue converter to produce a staircase ramp. The output of the converter is compared to the unknown input signal, and the clock pulses are terminated when the input signal level and the staircase function level are equal. The number of clock pulses occurring during the comparison process are therefore proportional to the voltage of the unknown input signal.

Clock pulses are generated by two cross-coupled TTL NAND gates at a frequency of 330 kHz so that 256 pulses can be counted in less than a millisecond. Such a high-speed clock has two main advantages: counting can be done without causing display flicker and the need to have latches to store the previous total count while the system is sampling is obviated. The clock pulses are applied to two sets of counters — a binary counter chain in the feedback loop that controls the converter, and a binary-coded-decimal counter chain that provides an easy interface with the seven-segment digital readouts.

The D/A (MC1408) converter generates an output sink current that is proportional to the value of the applied digital word. The maximum full-scale value of this current, which is typically 2 mA, is set by a reference voltage and a reference resistor. The converter's output current is compared with the current from an



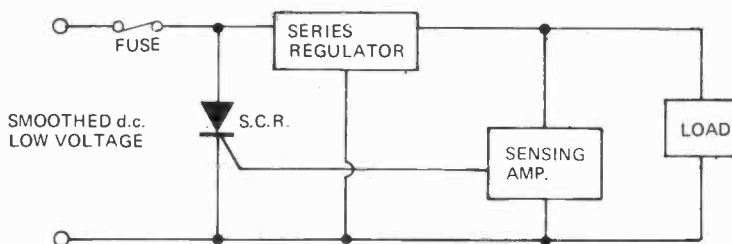
input buffer amplifier which, in addition to giving the meter a high input impedance, supplies an output current of up to 2 mA for comparison with the output of the converter.

A second amplifier acts as a high-gain comparator to stop the clock when the current ramp from the converter exceeds the current from the input buffer amplifier. A unijunction-transistor oscillator is used to reset both sets of counters so that the unknown voltage is resampled about every 0.5

seconds, and BCD-to-seven-segment decoders convert the outputs of the BCD counters to the proper format for the seven-segment light-emitting-diode displays.

For the components used here, the meter can measure up to 2.55 V (to within  $\pm$  millivolts) in 10 mV steps. Different full-scale values can be obtained by using suitable input voltage dividers or by providing the appropriate fixed-gain, rather than the unity-gain, input buffer shown.

## IMPROVED SCR CROWBAR PROTECTION



Conventional SCR crowbar power supply overvoltage protection circuits have some drawbacks.

In the conventional circuit the SCR is connected directly across the output of the power supply. For normal operation the negative gate bias on the

SCR is such that it remains in the non-conducting condition.

In the event of an overvoltage at the load terminal the sense amplifier applies a positive voltage to the gate, causing the SCR to conduct and effectively short circuit the output so

protecting components in the load circuit.

Provided that the series regulator has a current-limiting circuit and that it has not failed, the SCR should maintain its protection until the mains input has been disconnected. In fact unless the overvoltage is caused by a fault in the power supply unit itself, interruption of the mains input is all that is necessary to reset the system.

However, the protection should be fully effective even in the event of a failure in the power supply, as it is potentially the most hazardous in terms of damage to the load.

Internal power supply faults must be considered because they are usually of a sustained nature. In addition to component failure, faults can arise

from external causes such as the ingress of swarf or moisture when the equipment is unattended, so that the SCR in a conventional arrangement may have to carry a significant overload for a fairly long period.

It must also be remembered that a fault in a power supply may prevent the current-limit circuit functioning, but the current drawn may not be sufficient to blow the fuse.

By transferring the SCR from the output to the input of the series regulator, full protection against power supply faults is obtained. In the event of an overvoltage the SCR will pass the full short-circuit unregulated current, so that the fuse will blow every time.

In addition the heavy current is only

passed momentarily so that complex heat sinking is not required.

This arrangement also gives complete protection against damage due to mains voltage surges, not only to the load circuit but to the power supply as well. However, this arrangement provides only minimal protection against incorrect connection of a separate high voltage source.

Some protection is afforded when a momentary high voltage is applied via a fairly high source impedance because the series regulator emitter-follower would be subjected to a reverse voltage when the SCR went into conduction and would act as a moderately low impedance diode.

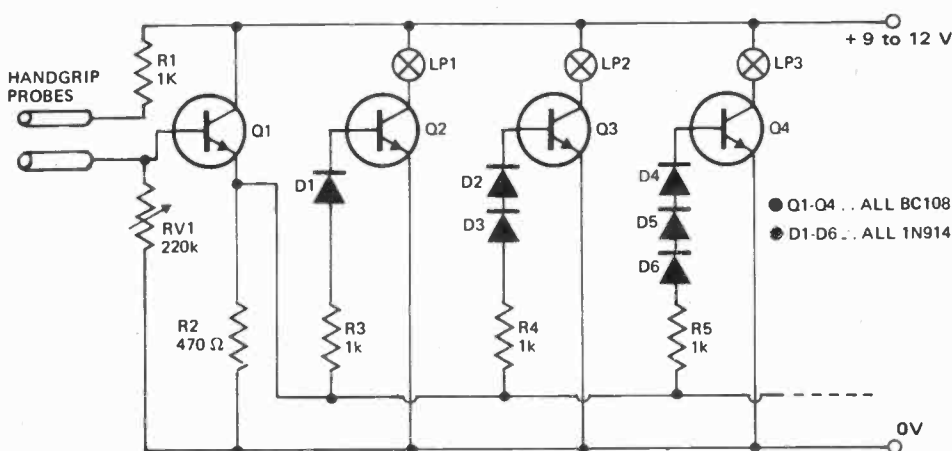
Virtually no protection is provided against the application of sustained

spurious voltage but even with the conventional arrangement little protection would be provided against a fault of this kind.

For instance, the load and the sensing amplifier are likely to be damaged before the SCR operates, or if it does operate and the incorrect voltage is not removed quickly it would probably be destroyed.

In the light of experience the engineers at Weir Electronics claim that the modified configuration provides better protection than the conventional method. Some degree of compromise is inevitable, but the fact that a positive fuse replacement action is required to restore the supply every time with the second method is in itself a safety factor.

## STRENGTH TESTER



Here is a circuit that will quickly tell you and your friends whether it is safe to go onto the beach with no chance of someone kicking sand into your face or conversely that a session with the Charles Atlas academy is advisable!

The idea is to grip the two handgrips which are made out of 25 mm wood dowling (broom handle) covered with aluminium foil.

The stronger the grip, the better the electrical contact made and depending on the strength of grip one two or more lamps will light up.

The circuit operates on the principle that skin contact resistance can be determined to some extent by the amount of pressure applied between the palms and the probes.

The greater the pressure, the lower the resistance and hence the higher the

voltage output of the emitter of Q1.

Bases Q2, Q3... are connected to the emitter follower via progressively more series diodes (D1, D2... D6...). Each lamp in the collector circuit will require a progressively higher voltage output from Q1 emitter to ignite. (i.e. a stronger grip).

The number of lamps can be increased as much as one likes, with each stage input having a larger number of series diodes. In the further stages it is not necessary to stack all those diodes since a single Zener will do just as well. For more than four stages reduce the value of R2 to 220 ohms.

RV1 adjusts the sensitivity: Reducing its value lowers the sensitivity.

## SOLDERING IC's

As it is no longer an economic proposition to use IC sockets for the cheaper IC's on the market, a method of soldering them without damage can be extremely useful. Cheap commercial soldering heatsinks do not appear to be available, but sprung letter clips could have been made for the job. These are available from most stationers.

These are almost an exact fit for a 14-pin DIL IC. They clamp tightly over the tops of the IC pins, ensuring that heat is rapidly dissipated and that the pins are all at the same potential (preventing damage to CMOS IC's).

These clips could save a small fortune in IC's, they also enable IC's to be unsoldered without damage providing care is taken.

## IDENTIFYING 74 SERIES SUPPLY PINS

When unmarked IC's are suspected of belonging to the 74 series a simple method of finding the supply pins is possible. If the resistance is checked between any two pins using a multimeter set on the 1 ohm range, all pins with the exception of the supply pins will give readings as open circuit or as a diode. When the supply pins are checked a reading is obtained both ways, the lower reading will be obtained when the positive lead from the multimeter is connected to Vcc.

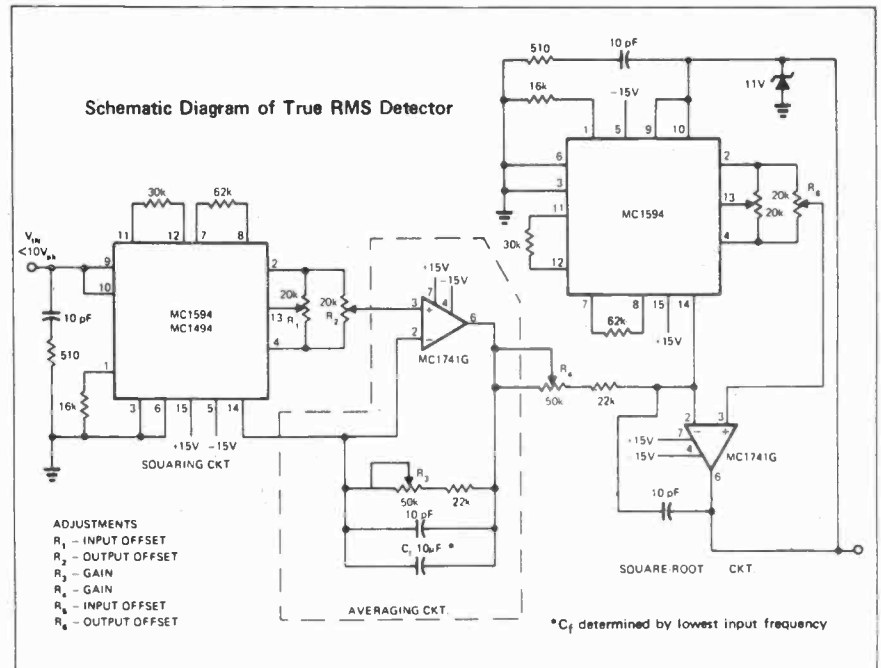
## MULTIPLIER/OP AMP CIRCUIT DETECTS TRUE RMS

To get an RMS value when you can't afford the time it takes to heat an element, try this technique. It may not be feasible for a multimeter but how about a sampling voltmeter good up to 600 kHz?

Mathematically, the RMS value of a function is obtained by squaring the function, averaging it over a time period  $T$  and then taking the square root:

$$V_{RMS} = \sqrt{\frac{1}{T} \int_0^T v^2 dt}$$

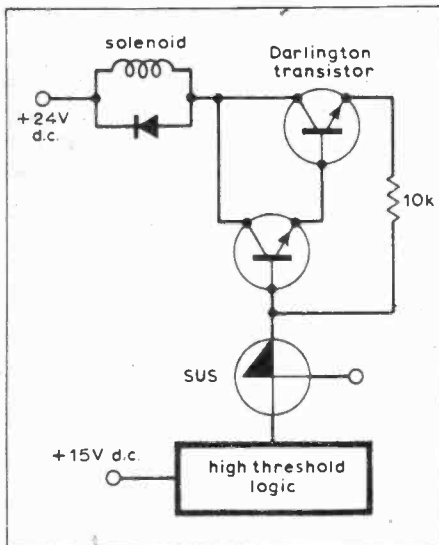
In a practical sense this same technique can also be used to find the RMS value of a waveform. Using two multipliers and a pair of op amps, an RMS detector can be constructed. The first multiplier is used to square the input waveform. Since the output of the multiplier is a current, an op amp is customarily used to convert this output to a voltage. The same op amp may also be used to perform the averaging function by placing a capacitor in the feedback path. The



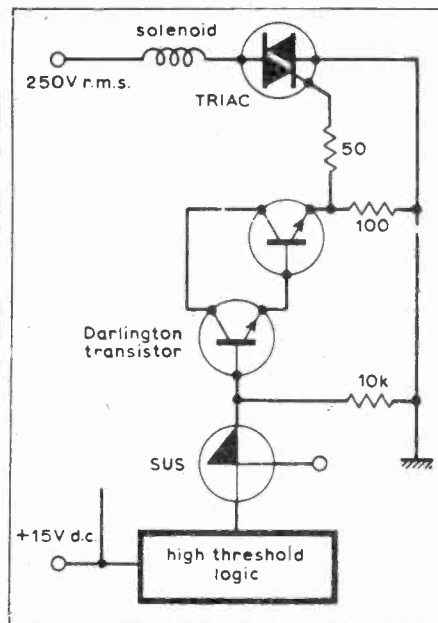
second op amp is used with a multiplier as the feedback element to produce the square root configuration. This method eliminates the thermal-response time that is prevalent in most RMS measuring circuits.

The input-voltage range for this circuit is from 2 to 10 Vpk. For other ranges, input scaling can be used. Since the input is dc coupled, the output voltage includes the dc components of the input waveform.

## INCREASING THE NOISE IMMUNITY OF LOGIC CONTROL SYSTEMS



In many industrial control systems, the output from logic circuitry is used for simple on/off control of a solenoid. However, the situation is often complicated by the presence of high levels of electrical noise. Although a high input noise immunity of the logic circuitry can be obtained with the use of high threshold logic ICs, such as Motorola



Semi-conductors' MHTL range, the power amplifier feeding the output logic signal to the solenoid must be specially designed for maximum noise immunity in both the on and off conditions.

An extremely simple and low-cost

solution involving the use of a silicon unilateral switch (SUS) has been proposed by Motorola Semiconductors.

The SUS is connected between the logic circuitry and the output amplifier as shown in Fig. 1 for a dc solenoid, and for an ac solenoid the connection is shown in Fig. 2. With an SUS with a  $V_s$  of 8 V and a  $V_f$  of 1.3 V, positive-going noise pulses with the solenoid switched off would have to exceed 8 V for a spurious energisation of the solenoid; negative-going noise pulses occurring while the solenoid is on would have to reduce the input to the output amplifier to below 2 V, from between 12.5 and 15 V, for a spurious de-energisation.

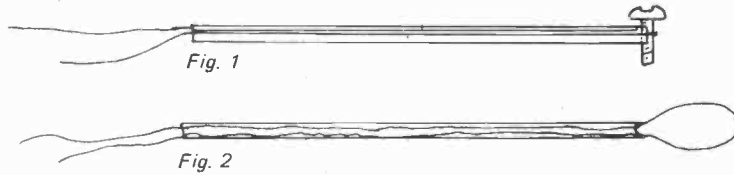
An additional advantage is that the regenerative portion of the SUS switching waveform effectively boosts the drive to the inductive load of the solenoid, speeding up the response to control signals.

High-threshold logic, operating from a 15-V supply, produces a logic '0' output of 0 to 1.5 V and logic '1' output of 12.5 to 15 V. Noise amplitudes which increase the '0' level to 6.5 V and reduce the '1' level to 8.5 V can be tolerated.

Touch-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to the Editor, Electronics Today International, 36 Ebury Street, London SW1W 0LW.

## SCREW STARTER



Useful holders for 'starting' small screws can be made from the inside plastic ink tube of empty ball point pens.

Remove the plastic ink tube, clean it if necessary, and cut a V notch in one end. Pass a loop of linen thread

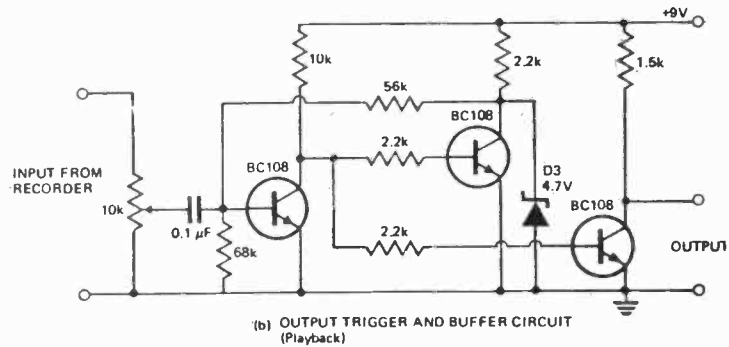
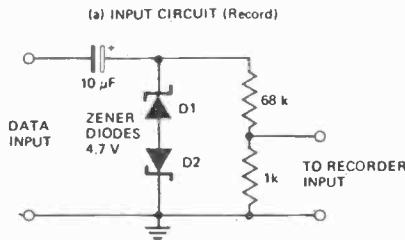
through the tube, (a length of fuse wire as a 'pull through' helps in this) — and you have your holder. See Fig. 1.

In use a screw is simply inserted in the loop and the loop pulled up tight — Fig. 2. The screw can now be manipulated into awkward places with

ease. For holding screws, from which the loop may be lifted once they're started, it's a good idea to have a few knots in the double thread inside the tube. This increases the friction inside the tube, and there's then no need to maintain tension on the thread.

For holding spacer sleeves, between a pc board and chassis for example, the thread must not be knotted, as the thread could not then be removed. In this case, once the sleeve is positioned and the securing screw started, simply pull one end of the thread and the holder comes free. You then rethread the holder.

## DIGITAL TAPE RECORDER ADAPTOR



The two circuits shown allow digital data to be recorded and replayed on an ordinary domestic recorder.

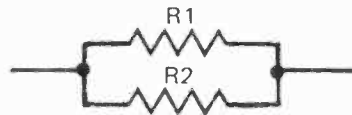
The input circuitry differentiates the

digital pulses which are then recorded. On playback the recorded pulses are fed into a Schmitt trigger whose output is then amplified restoring the

required binary data waveform.

The potentiometer RV 1 is adjusted so that on playback only the peaks will actuate the trigger.

## RESISTORS IN PARALLEL



R2 \ R1	10	12	15	18	22	27	33	39	47	56	68	82	100
10	5.00	5.45	6.00	6.43	6.88	7.30	7.67	7.96	8.25	8.48	8.72	8.91	9.09
12	5.45	6.00	6.67	7.20	7.76	8.31	8.80	9.18	9.56	9.88	10.20	10.47	10.71
15	6.00	6.67	7.50	8.18	8.92	9.64	10.31	10.83	11.37	11.83	12.29	12.68	13.04
18	6.43	7.20	8.18	9.00	9.90	10.80	11.65	12.32	13.02	13.62	14.23	14.76	15.25
22	6.88	7.76	8.92	9.90	11.00	12.12	13.20	14.07	14.99	15.79	16.62	17.35	18.03
27	7.30	8.31	9.64	10.80	12.12	13.50	14.85	15.95	17.15	18.22	19.33	20.31	21.26
33	7.67	8.80	10.31	11.65	13.20	14.85	16.50	17.88	19.39	20.76	22.22	23.53	24.81
39	7.96	9.18	10.83	12.32	14.07	15.95	17.88	19.50	21.31	22.99	24.79	26.43	28.06
47	8.25	9.56	11.37	13.02	14.99	17.15	19.39	21.31	23.50	25.55	27.79	29.88	31.97
56	8.48	9.88	11.83	13.62	15.79	18.22	20.76	22.99	25.55	28.00	30.71	33.28	35.90
68	8.72	10.20	12.29	14.23	16.62	19.33	22.22	24.79	27.79	30.71	34.00	37.17	40.48
82	8.91	10.47	12.68	14.76	17.35	20.31	23.53	26.43	29.88	33.28	37.17	41.00	45.05
100	9.09	10.71	13.04	15.25	18.03	21.26	24.81	28.06	31.97	35.90	40.48	45.05	50.00
120	9.23	10.91	13.33	15.65	18.59	22.04	25.88	29.43	33.77	38.18	43.40	48.71	54.55
150	9.38	11.11	13.64	16.07	19.19	22.88	27.05	30.95	35.79	40.78	46.79	53.02	60.00
180	9.47	11.25	13.85	16.36	19.60	23.48	27.89	32.05	37.27	42.71	49.35	56.34	64.29
220	9.57	11.38	14.04	16.64	20.00	24.05	28.70	33.13	38.73	44.64	51.94	59.74	68.75
270	9.64	11.49	14.21	16.88	20.34	24.55	29.41	34.08	40.03	46.38	54.32	62.90	72.97
330	9.71	11.58	14.35	17.07	20.63	24.96	30.00	34.88	41.14	47.88	56.38	65.68	76.74
390	9.75	11.64	14.44	17.21	20.83	25.25	30.43	35.45	41.95	48.97	57.90	67.75	79.59
470	9.79	11.70	14.54	17.34	21.02	25.53	30.83	36.01	42.73	50.04	59.41	69.82	82.46
560	9.82	11.75	14.61	17.44	21.17	25.76	31.16	36.46	43.36	50.91	60.64	71.53	84.85
680	9.86	11.79	14.68	17.54	21.31	25.97	31.47	36.88	43.96	51.74	61.82	73.18	87.18
820	9.88	11.83	14.73	17.61	21.43	26.14	31.72	37.23	44.45	52.42	62.79	74.55	89.13
1000	9.90	11.86	14.78	17.68	21.53	26.29	31.95	37.54	44.89	53.03	63.67	75.79	90.91

# EXCLUSIVE TO ETI READERS

# Pulsar: £13.95

Digital Alarm Clock



When we first came across this inexpensive, superbly designed digital clock we knew that ETI readers would share our enthusiasm. So we have arranged a special consignment carrying ETI's own brand name: Pulsar. Not only that, but the price of only £13.95 (including postage and 8% VAT) is far less than you will pay for this clock elsewhere.

Pulsar is of course fully built, tested and guaranteed — and is completely electronic. The display is Planar Gas Discharge giving very bright 0.7in high characters — so bright in fact that there is a control on the back panel for reducing it!

There is a full alarm facility: using a small switch on the back displays the alarm time for setting. There is also a 'snooze' facility. You want five minutes more sleep? Just tip Pulsar forward, the 'bleeper' alarms cuts off but will start again after five minutes.

The photograph shows ETI's Pulsar as close to full size as possible. The colon dividing the hours and minutes flashes once a second while on the left the small square indicates p.m.

Available only to U.K. and Eire readers at £13.95. Demand is expected to be enormous, there is no limit, but please allow 28 days for delivery.

TO: PULSAR OFFER,  
ELECTRONICS TODAY INTERNATIONAL, 36 Ebury Street, London SW1W 0LW.

Please find enclosed my cheque/P.O. (payable to Electronics Today International) for £13.95 for a Pulsar Alarm Clock.

NAME

ADDRESS

Readers not wishing to cut their copy may order on their own notepaper.

### AN EARLY COLOUR-ORGAN

The cover of your February issue rang a very loud bell with me, as you will readily understand from a glance at the enclosed press-cuttings. These--dated August, 1928, nearly fifty years ago--gave a fair but somewhat over-glamorised account of a colour organ which I had recently constructed.

This instrument enabled the 'player' to flood a screen with light of any desired hue, saturation and luminosity within the ranges obtainable at that time, and to vary one or more of these 'dimensions' easily and swiftly, using one hand only; so that if desired a second projector could be added (for the other hand) to produce the enhanced effects of simultaneous contrast.

I used three light sources, with gelatine media approximating as nearly as possible to the primaries red, green and blue. (For more about these primaries see 'Understanding Colour TV--Part I', also by happy chance in your February issue). Careful balance of wattage ensured that when all three lamps were fully on they mixed an acceptable 'white'.

The control device was an upright lever about 20" long, pivotted universally ('joy-stick' fashion) at its lower end; the upper end being limited in its swing by a triangular gate, the 10" sides of which were in fact not straight but arcs struck from the opposite corners. The top of the lever carried a twist-grip which the operator held.

Attached to the lever just below the level of the gate were three tracker-wires, which were taken through eyes at the corners of the gate to three dimmers, one for each primary colour. With the lever resting in any one of the corners, the lamp associated with that corner was fully lit, and remained so until the lever had been moved away from the corner to a little more than half-way across the gate (in any direction). If the lever was then moved still further across, the lamp was dimmed progressively, going out completely as the lever reached the opposite side.

So, as the lever was moved about in the gate the projected colour was varied, from pure hues along the sides to neutral in the centre. In other words, the dimensions of hue and saturation were controlled by simple

movements of the lever. The third requirement, control of luminosity, was met by rotating the twist-grip referred to above, which was geared via a shaft inside the main lever to a device somewhat similar in effect to an iris-diaphragm. This permitted change of luminosity without affecting hue or saturation, and solved a problem (one of several) over which I was thankful to have the technical help of my friend Bill Debenham, who was then with the GEC.

To conclude: it was clearly desirable to be able to keep a record of any colour-sequences which seemed especially pleasing (or the reverse!), and this was done by using musical notation for luminosity and duration (the fourth dimension!) together with little triangles each containing a dot for hue and a figure (1-5) for saturation (distance of the lever from the centre of the gate).

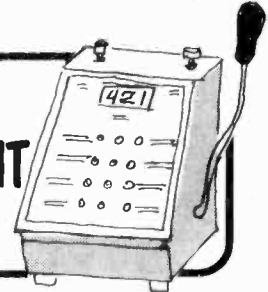
If any of your readers would like further details of this museum-piece, I should be happy to oblige!

— Conrad Volk, 11 Granville Road, Sevenoaks, Kent.

## What to look for in August's ETI



**ETI READER OFFER**  
**SPARKRITE Mk.II KIT**  
 CDI Ignition System  
 Usual price: £10.93  
**ETI READER PRICE: £7.98**



**BUILD YOUR OWN ONE-ARMED BANDIT**  
 Gamble away for hours on end — and it needn't cost you a penny — but you can also play it for real! You even select your own odds!

**HOW SEMI CONDUCTORS ARE MADE**  
 You are probably handling semiconductors every day, and have a pretty good idea about how they work, but how are they actually made? Answers in August's ETI.

**MODERN FM RECEIVER TECHNIQUES**  
 FM circuits have not been featured much in electronics magazines but there's no great mystery to FM — our feature looks into the circuits and techniques common today.

**SIMPLE LOUDNESS CONTROL**  
 Perhaps no control on an audio amplifier is more controversial than a loudness control and few circuits feature them. You can overcome this using ETI's circuit.

AUGUST ISSUE ON SALE JULY 11TH — 30p.

**electronics today international**

THE  
 ETI TOP  
 PROJECTS  
 ISSUE WAS  
 A GREAT SUCCESS  
 NOW WE BRING YOU:

# TOP PROJECTS NO.2

**75p**

ABOUT 120 PAGES PACKED WITH SOME OF THE BEST PROJECTS FROM ETI:

- AUDIO PROJECTS**
1. 50W STEREO AMP
  2. ADD-ON QUAD UNIT
  3. SPRING LINE REVERB.
  4. RUMBLE FILTER
  5. FET 4-INPUT MIXER
  6. OVER-LED TEST GEAR
  7. I.C. POWER SUPPLY
  8. AUDIO WATTMETER
  9. LOGIC PROBE

10. LINEAR IC TESTER
11. MOTORISTS
12. TRAFFICATOR CANCELLOR
13. BATTERY CHARGER
14. IGNITION TIMING LIGHT
15. METER BEATER
16. AUTOMATIC CAR THEFT ALARM
17. HI-POWER STROBE
18. PRINTIMER

(contents may be subject to minor changes before printing)

19. TEMPERATURE ALARM
  20. LM380 INTERCOM & RECORD PLAYER
  21. MISCELLANEOUS
  22. FAMILY FERRY
  23. NI-CAD BATTERY CHARGER
  24. DIGITAL STOPWATCH
  25. EARTH RESISTIVITY METER
- PLUS: SEVERAL PAGES OF  
 TECH-TIPS - MANY NOT  
 PREVIOUSLY PUBLISHED

## AVAILABLE FROM YOUR NEWSAGENT MID-JUNE

TO: ELECTRONICS TODAY INTERNATIONAL, 36 Ebury Street, London SW1W 0LW.  
 Please find enclosed my cheque/P.O. for 90p (including 15p post) for a copy of TOP  
 PROJECTS NO. 2. To be sent to me as soon as you get copies from the print-  
 ers. NAME: \_\_\_\_\_  
 ADDRESS \_\_\_\_\_



# using the LM377N

By Brian Dance.

A NEW INTEGRATED CIRCUIT containing two 2-watt audio amplifiers in a single encapsulation has recently been introduced by the National Semiconductor Company. This device is particularly attractive, since it incorporates internal stabilisation and circuits which protect it both from overheating and from excessive current due to accidental shorting of the output. In addition, the output stages are automatically 'centred' by the correct bias.

This circuit is mainly intended for use in stereo radio receivers, stereo record players, etc. where the power required is not very high. It has the advantage that a minimum number of external components are needed. However, it can also be used as a stereo driver circuit to feed power transistors when more output power is required. It is also suitable for use in intercom amplifiers, as a dual servo amplifier, etc. The high input impedance of 3 megohms greatly increases the versatility of the device.

## ENCAPSULATION

The LM377N is a 14 pin dual-in-line device with the connections shown in Fig. 1(a). An electrically equivalent device, the LM377N-10 is available with metal-tab connections, as shown in Fig. 1(b).

The bias voltage from pin 1 is used to provide the bias required by the inputs to both amplifiers (pins 6 and 9). Feedback is applied from the output of each amplifier to the 'feedback' inputs. These feedback inputs are the inverting inputs of the amplifiers concerned.

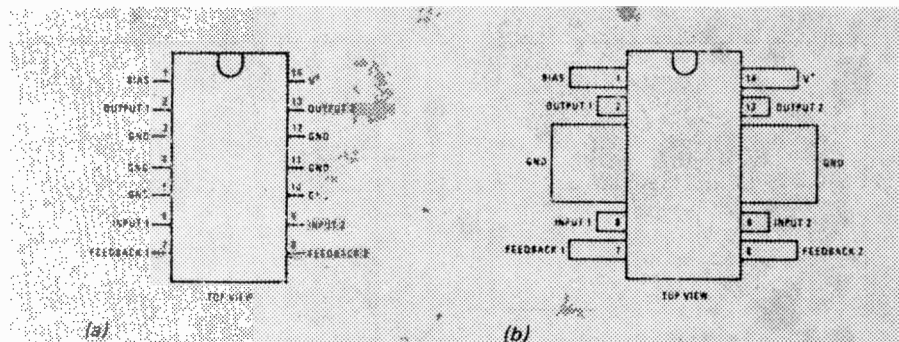


Fig. 1. The connections of the LM377N and the LM377-10.

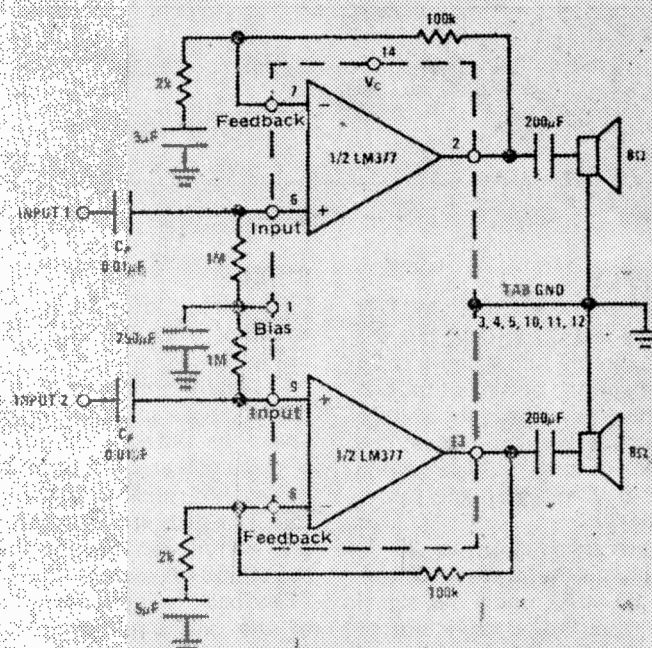


Fig. 2. A simple stereo amplifier.

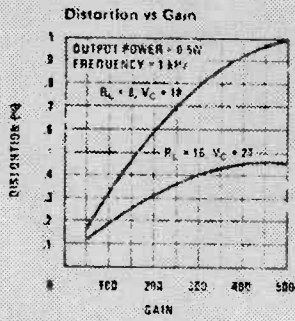


Fig. 3.

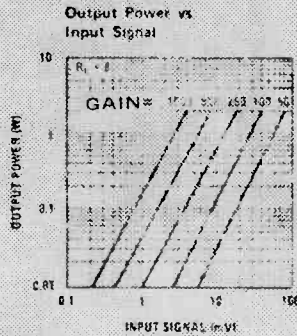


Fig. 4.

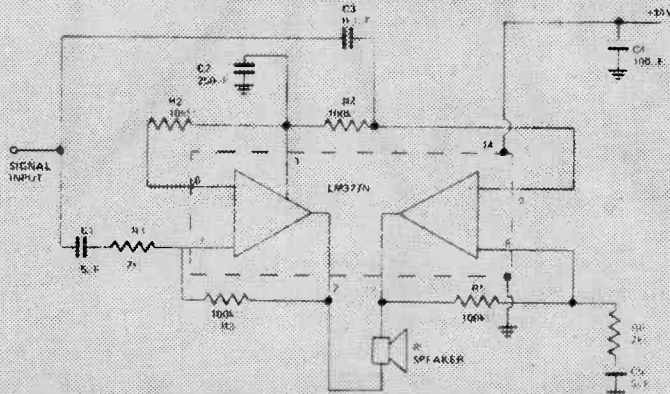


Fig. 5. A "bridge" circuit using the LM377 to provide output power up to 4W.

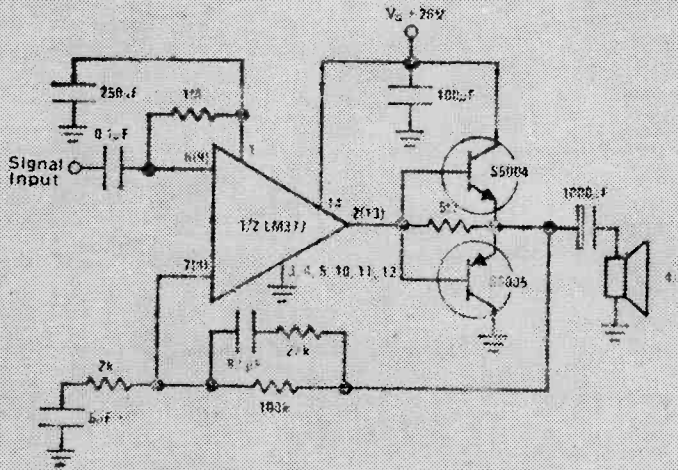


Fig. 6. A 15W amplifier using half the LM377 to drive the 55005 output transistors.

### POWER SUPPLY

The power supply to the LM377N should not be less than 10 V, but the absolute maximum upper limit is 26 V. The maximum power output is related to the power supply voltage and the loudspeaker impedance, the peak-to-peak output voltage swing being about 6 V less than the power supply voltage.

The current taken from a 20 V power supply is typically 15 mA (maximum 50 mA) under no signal conditions, rising to a maximum of 500 mA when 1.5 W is being delivered to each of two loudspeakers of impedance 8 ohms.

### CIRCUIT

The circuit of a very simple stereo amplifier using the LM377N is shown in Fig. 2.

The inputs are fed through capacitors to the device so that the bias does not reach the previous circuit. The input pins 6 and 9 are each returned through 1 megohm resistors to the bias source (pin 1) which is decoupled by C<sub>4</sub>. The bias current required by the inputs is about 500 nA each.

Feedback is applied from the output of the one amplifier (pin 2) to the 'feedback' input (pin 7) of the same amplifier. Similarly, in the other channel, feedback is taken from pin 13

through R<sub>6</sub> to pin 8.

The voltage gain of each circuit is equal to  $R_5/R_1 = R_6/R_4$  - 50 (or 34 dB). The gain may be altered by changing the ratio of these resistors, but distortion increases with gain as shown in Fig. 3 for 8 ohm speakers with an 18 V supply and 16 ohm speakers with a 24 V supply, both at 0.5 W.

The outputs at pins 2 and 13 are superimposed on a steady potential of about half the supply voltage. Electrolytic capacitors (C<sub>6</sub> and C<sub>7</sub>) must therefore be employed in series with the speakers so that only alternating currents can pass.

The input signal required to drive an 8 ohm speaker at various power levels is shown in Fig. 4 at various values of amplification. The separation between the channels can be as great as 75 dB.

### BRIDGE AMPLIFIER

An amplifier employing both sections of a LM377N is a 'bridge' or 'push-pull' circuit is shown in Fig. 5.

When the potential at pin 2 becomes more positive, that at pin 13 becomes more negative and vice-versa. Thus the power to the loudspeaker is increased. The average potential at pins 2 and 13 is the same, so no capacitor is required in series with the loudspeaker.

The bias from pin 1 is decoupled by C<sub>2</sub> and is used to supply both the non-inverting inputs at pins 6 and 9. The input signal is applied through C<sub>1</sub>R<sub>1</sub> to the feedback or inverting input of one amplifier (pin 7) and through C<sub>3</sub> to the non-inverting input of the other amplifier (pin 9). Thus the outputs from the two amplifiers are out of phase, as already discussed. The gain of each section is equal to the ratio of the feedback resistors, namely 50 in the circuit shown.

This bridge circuit can provide outputs up to 4 W. Two separate LM377N devices would be required if this circuit were used in a stereo system.

### HIGHER OUTPUT POWER

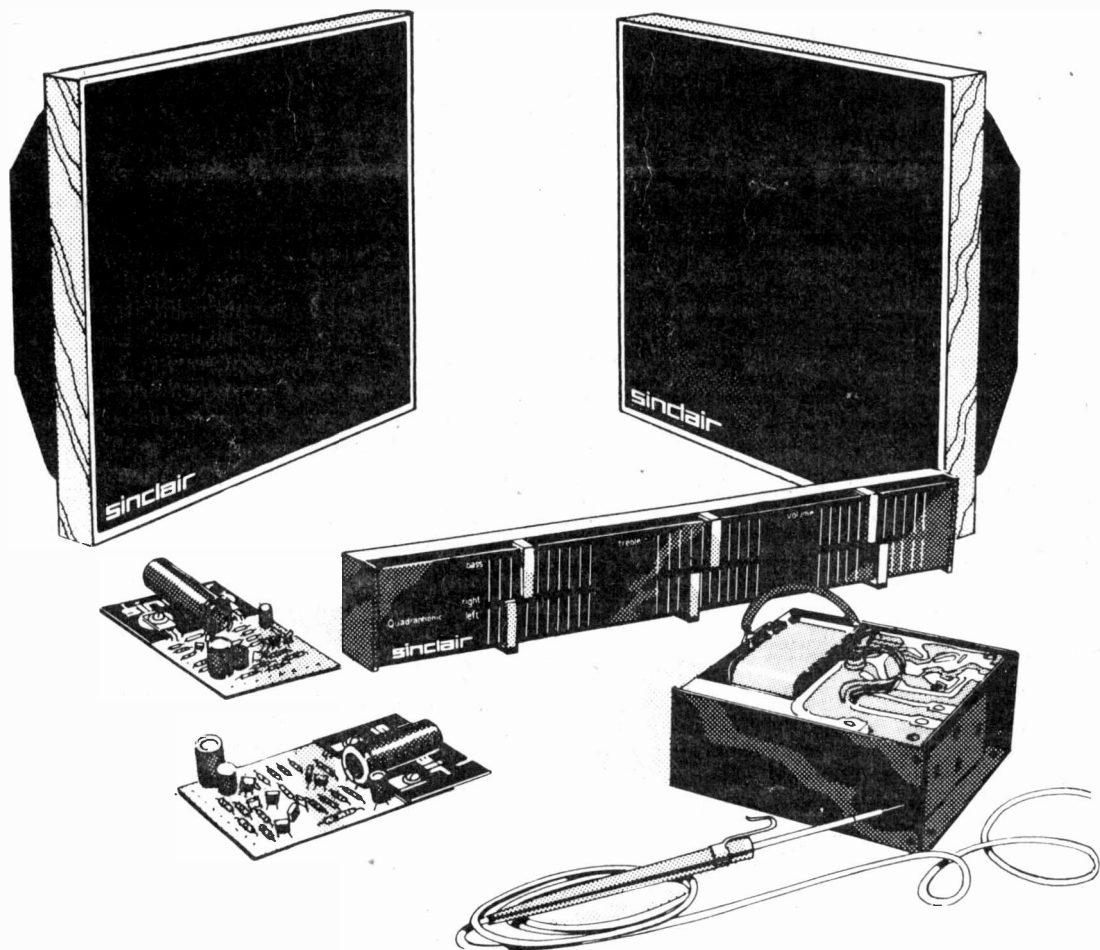
Each half of a LM377N can be used to drive a complementary pair of power output transistors using the circuit of Fig. 6. A power output level of 15 W per channel can be obtained from this type of circuit. The input, output and feedback connections shown on this circuit are for the amplifier 1; pins 9, 13 and 8 of amplifier 2 can be connected to a similar way for the other channel.

Overall feedback is used in this circuit from the output to the inverting input of the LM377. The values shown provide an overall voltage gain of 50.



# Go quad for around £50

(including the speakers!)



## Sinclair Project 80 hi-fi modules

If you've thought of switching to quad, you've probably found it an expensive process. Do you part with your existing stereo amp – which probably cost you a lot in the first place – and replace it with an even more costly quad amp? Or do you buy an expensive add-on kit – often costing as much as £90 even *without* the extra speakers?

With Sinclair Project 80 hi-fi modules, you can keep your existing amplifier ... add a quad decoder, two power amps and a power supply unit ... a couple of Sinclair Q16 speakers and you've got a high-quality, true quad system which will have cost you only £50 or so to convert!

### How does Sinclair Project 80 work?

Project 80 is a comprehensive set of hi-fi modules or sub-assemblies. Amps ... pre-amps ... FM tuner ... quad decoder ... control units ... everything you need to assemble hi-fi units. They're all designed to look alike and are all completely compatible with each other. Simply decide on the specification of the unit (stereo or quad) you want to build ... buy the necessary modules ... connect them up and house them.

You can even build a quad amp entirely from Project 80 modules. Two power amplifiers, a control unit and a power

supply give you a stereo amp for as little as £31.80 plus VAT. The necessary add-on quad modules cost only £36.80 + VAT. Together, they make up a true hi-fi quad amp for only £68.60 + VAT!

And whenever you choose, you can add extra Project 80 refinements. An FM tuner ... a scratch/rumble filter ... higher-output power amps – Project 80 is an enjoyable way to develop your own hi-fi system!

### Is it difficult to build?

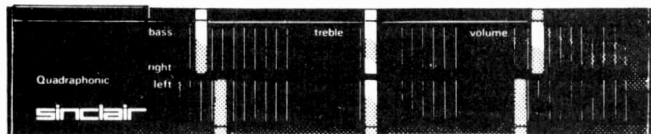
Not at all. All Project 80 module circuitry is complete in itself – all you have to do is connect the external wiring to numbered solder points.

And if you're not so hot with a soldering iron? Use Project 805 kits. Project 805 uses Project 80 modules, but provides special clip-on tagged-wire connections – positively no soldering! There are two Project 805 kits – the basic 805 stereo amplifier kit, and the 805Q quad conversion kit.

805Q can be used to convert a Project 80 or 805 stereo system, or your existing stereo system.

You'll find more details and some system suggestions opposite.

# Project 80 hi-fi modules – the easy way to true quadraphonics.



## Project 80 SQ quadraphonic decoder

Combines with and exactly matches Project 80 control unit for true quadraphonics. This unit is based on the CBS SQ system and is a complete quadraphonic decoder, rear channel pre-amp and control unit.

**Specification**  
(9 1/2 in x 2 in x 3/4 in.) Connects with tape socket on Project 80

control unit or similar facility on any stereo amplifier. Separate slider controls on each channel for treble, bass and volume.  
**Frequency response:** 15 Hz to 25 kHz ± 3 dB **Distortion:** 0.1%  
**S/N ratio:** 58 dB **Rated output:** 100 mV **Phase shift network:** 90° 10, 100 Hz to 10 kHz  
**Operating voltage:** 22 V – 35 V

**Price:** £18.95 + VAT

## Project 80 power amplifiers

Two different amplifiers, designed to be used separately or combined, with Project 80 modules or as add-ons to existing equipment. Protected against short circuits and damage from mis-use

**Z40 Specification**  
(2 1/4 in x 3 in x 1/4 in.) 8 transistors  
**Input sensitivity:** 100 mV  
**Output:** 12 W RMS continuous into 8 Ω (35 V). **Frequency response:** 30 Hz – 100 kHz ± 3 dB  
**S/N ratio:** 64 dB **Distortion:** 0.1% at 10 W into 8 Ω at 1 kHz **Voltage requirements:** 12 V – 35 V  
**Load imp:** 4 Ω – 15 Ω, safe on open circuit. Protected against short circuit

**Price:** £5.95 + VAT

**Z60 Specification**  
(2 1/4 in x 3 1/4 in x 1/4 in.) 12 transistors  
**Input sensitivity:** 100 mV – 250 mV  
**Output:** 25 W RMS continuous into 8 Ω (50 V). **Frequency response:** 10 Hz to more than 200 kHz ± 3 dB **S/N ratio:** better than 70 dB **Distortion:** less than 0.1% at 12 W into 4 Ω at 1 kHz  
**Voltage requirements:** 12 V – 50 V  
**Load imp:** 4 Ω min, max safe on open circuit. Protected against short circuit.

**Price:** £7.45 + VAT

## Project 80 power supply units

Range of power supply units to match desired specification of final system.

**PZ5 Specification**  
Unstabilised. 30 V output. Including mains transformer.

**Price:** £5.95 + VAT

**PZ6 Specification**  
Stabilised. 35 V output. Including mains transformer.

**Price:** £8.95 + VAT

**PZ8 Specification**  
Stabilised. Output adjustable from 20 V to 60 V approx. Re-entrant current limiting makes damage from overload or even shorting virtually impossible. Without mains transformer.

**Price:** £8.45 + VAT

## Project 80 SQ quadraphonic add-on kit

Converts your existing stereo hi-fi system to quad using solderless connections

Contains following Project 80 units

Project 80 SQ quad decoder/rear channel pre-amp and controls unit

2 x Z40 power amps  
PZ5 power supply unit  
Masterlink unit  
On/off switch  
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

**Price:** £44.95 + VAT

## Sinclair Q16 speaker

Original and uniquely designed speaker of outstanding quality

**Specification**  
(10 3/8 in square x 4 1/4 in deep)  
Pedestal base. All-over black front. Teak surround. Balanced

sealed sound chamber. Special driver assembly. **Frequency response:** 60 Hz to 16 kHz.  
**Power handling:** up to 14 W RMS  
**Impedance:** 8 Ω

**Price:** £8.95 + VAT

# Quad system suggestions from Sinclair

## 1. Add-on quad to existing system:

**12 W per rear channel RMS**

Quadraphonic decoder + 2 x Z40 amps + 1 x PZ6 power supply + (existing stereo amplifier) + 2 x Q16 speakers + (2 existing speakers) + (turntable). Total Project 80 cost: £57.70 + VAT.

## 2. Add-on quad to existing system:

**25 W per rear channel RMS**

Quadraphonic decoder + 2 x Z60 amps + 1 x PZ8 power supply + (mains transformer) + (existing stereo amplifier) + (2 x equivalent speakers) + (2 x existing speakers) + (turntable). Total Project 80 cost: £42.30 + VAT.

## 3. Quadraphonic system built from scratch:

**12 W per channel RMS**

Pre-amp/control unit + quadraphonic decoder + 4 x Z40 amps + 2 x PZ6 power supply + 4 x Q16 speakers + (turntable). Total Project 80 cost: £110.40 + VAT.

## What more can we tell you?

All Project 80 modules are backed by the remarkable no-quibble Sinclair guarantee. Should any defect arise from normal use within a year, we'll service the modules free of charge. And our Consumer Advisory Service is always available if you run into any problems. You'll find Project 80 at stores like Laskys and Henry's – but before you look, why not get really detailed information? Clip the FREEPOST coupon for the fully-illustrated Project 80 folder – today!

Sinclair Radionics Ltd,  
London Road, St Ives, Huntingdon, Cambs., PE17 4HJ.  
Telephone: St Ives (0480) 64646.

# sinclair

**Sinclair Project 80**  
a new concept in expandable hi-fi

No solder kits

Q16 Speaker

Sinclair Micromatic

Project 80 Stereo decoder

**To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.**

Please send me, by return post, a copy of the fully-illustrated Project 80 folder.

Name \_\_\_\_\_

Address \_\_\_\_\_

\_\_\_\_\_

ETI 7 75

Please print FREEPOST – no stamp needed

# INTERNATIONAL 3600 SYNTHESIZER

## Building the voltage controlled filter

THE VOLTAGE CONTROLLED FILTER used in the model 3600 synthesizer has been designed in the light of experience gained in using the larger 4600 unit.

It was found that the bandpass and high-pass filters were seldom used and that extra presence was required in the

lowpass filter. To this end it was decided to redesign the filter to provide a 'resonance' control which allowed the filter to be peaked, as required, just before the cut-off point.

The filter now has a more 'commercial' sound (and may readily be fitted to the larger unit if desired).

If the filter is peaked too much it will oscillate. This is an advantage as it effectively provides a useful sinewave oscillator if required.

## CONSTRUCTION

The method of assembly is similar to that used for most of the other modules. A small aluminium bracket is used to hold the printed circuit board and associated switches and potentiometers.

When assembling the components to the printed circuit board the usual care must be taken with the orientation of polarized components. Assemble the components to the board in accordance with the overlay Fig. 2 using sockets for the CMOS ICs at least. Note that IC2 MUST be a

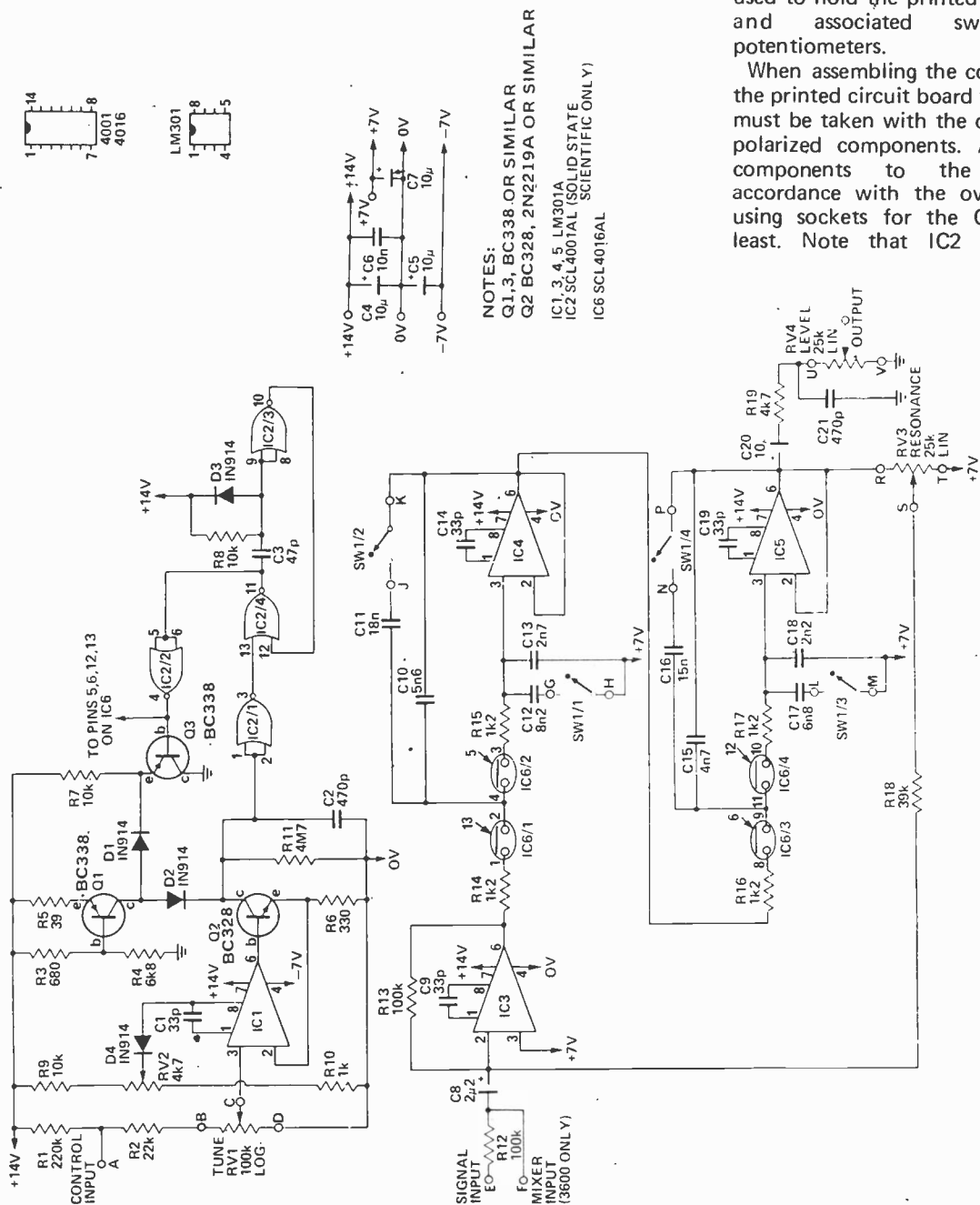


Fig. 1. Circuit diagram of filter module.

SCL4001AL as made by Solid State Scientific. Although this component is made under the same number by other companies, the Solid State Scientific version is much faster and has a much narrower linear region. If another brand is substituted the oscillator may work over a restricted range, or worse still may not work at all.

Two ways of wiring external components are shown, in Figs. 3 and 4. The second drawing (Fig. 3) applies to the larger 4600 synthesizer only.

### SETTING UP

The only adjustment necessary is to set the trim potentiometer RV2. This is done as follows. Connect the control input to +14V, turn the resonance control to maximum, such that the filter acts as an oscillator, and set the range control to low. It will be found that as the tune control is advanced the frequency will increase, drop slightly and then cease. When in this state (ceased) adjust RV2 until the oscillation starts again and is at maximum frequency.

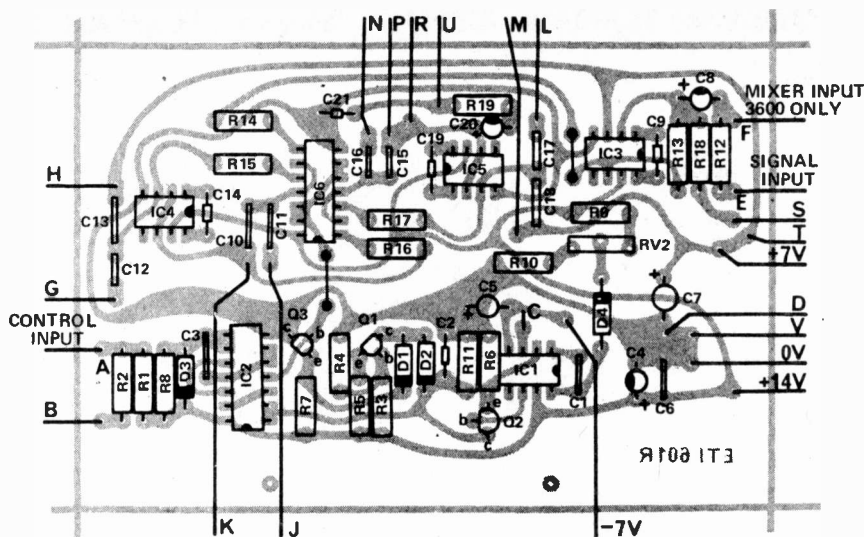


Fig. 2. Component overlay

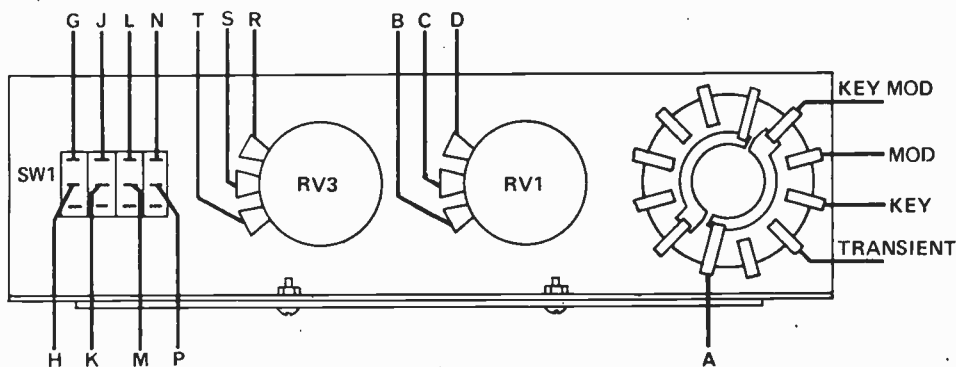


Fig. 3. Potentiometer and switch wiring for 3600 unit.

### HOW IT WORKS

The voltage controlled filter consist of three main sections:-

1. The buffer amplifier - mixer.
2. A low-pass filter.
3. A voltage controlled filter.

The buffer amplifier IC3 is used to give a level shift to the input signal and to provide a constant 100 k input impedance. A second input direct to the input of IC3 is used, in the 3600 synthesizer, for additional mixing.

The 4016 CMOS IC is a four section analogue switch which when 'on' has a resistance of about 200 ohms and when 'off' a resistance of about  $10^{12}$  ohms. Each section has its own control input but in our case all the control inputs are connected together. We may consider the switches on the filter as a normal four pole active low pass filter (two 2 pole in series). The filter has a gain of unity (output of IC3 to output of IC5) below the cut-off frequency

and an ultimate slope of 24dB octave above the cut-off frequency.

As well as an amplitude change with frequency there is also a change in phase relationship. Initially the output of the filter is  $180^\circ$  out of phase with the input (point E), and in phase when 6 dB down. It eventually moves  $180^\circ$  out of phase again as the frequency increases. The potentiometer RV3 and resistor R18 takes part of the output signal and feeds it back into the input of IC3. Below the cut-off frequency this causes the output to be attenuated, at the cut-off frequency, the signal is boosted and above the cut-off it again starts to attenuate. This causes the output to peak in the region of the cut-off frequency and then drop suddenly above that frequency. The height of the peak is adjustable. If adjusted too high the filter will oscillate.

To vary the cut-off frequency we must vary the four capacitors or the four resistors in the areas of the filter.

To obtain the two ranges we switch capacitors in or out and, to give the continuously variable range, we vary the resistors by switching them in and out at a fast rate but with a mark-space ratio which is variable.

By such switching, the effective value of a resistor becomes:-

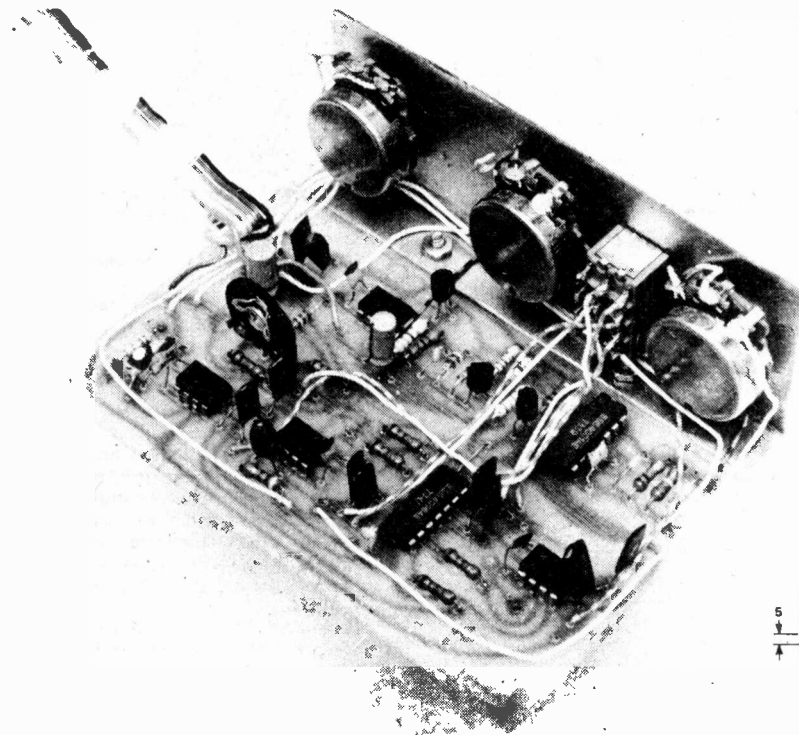
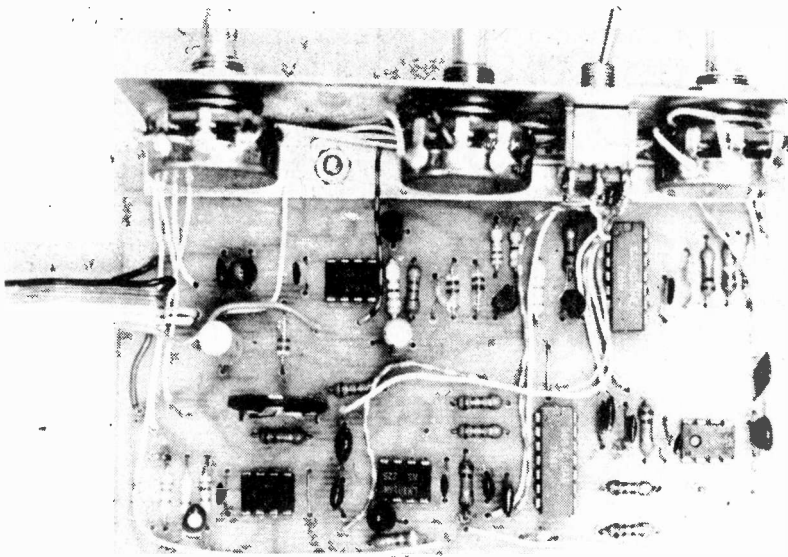
$$\frac{R \times \text{total time}}{\text{time on}}$$

and since on time is always shorter than total time the resistance can vary from 'R' upwards. We obtain a variable mark-space ratio by using a monostable of about 200 n sec triggered by a voltage controlled oscillator which is variable from 5 kHz to about 3 MHz. We therefore keep the on-time constant and vary the off-time.

The VCO is virtually identical to that shown in the February 74 issue and reference should be made to this for how it works. The only changes made is an addition to prevent the oscillator stopping either on overvoltage (RV2) or negative input voltage (R11).

# INTERNATIONAL 3600 SYNTHESIZER

Internal views of filter module.



PARTS LIST				
R5	Resistor	39ohm	5%	1/4W
R6	"	330ohm	"	"
R3	"	680	"	"
R10	"	1k	"	"
R14,15,16,17	"	1.2k	"	"
R19	"	4.7k	"	"
R4	"	6.8k	"	"
R7,8,9	"	.10k	"	"
R2	"	22k	"	"
R18	"	39k	"	"
R12,13	"	100k	"	"
R1	"	220k	"	"
R11	"	4.7M	"	"
RV1	Potentiometer	100k		Log rotary
RV3,4	"	25k		LIN
RV2	"	4.7k		Trim type
C1,9,14,19	Capacitor	33pF		ceramic
C3	"	470F		"
C2,21	"	470pF		"
C18	"	0.0022 $\mu$ F		polyester
C13	"	0.0027 $\mu$ F		"
C15	"	0.0047 $\mu$ F		"
C10	"	0.0056 $\mu$ F		"
C17	"	0.0068 $\mu$ F		"
C12	"	0.0082 $\mu$ F		"
C6	"	0.01 $\mu$ F		"
C16	"	0.015 $\mu$ F		"
C11	"	0.018 $\mu$ F		"
C8	"	2.2 $\mu$ F 16V		electrolytic
C4,5,7,20	"	10 $\mu$ F 16V		"
Q1,3	Transistor	BC338		
		or similar		
Q2	"	BC328, 2N2219A		or similar
IC1,3,4,5	Integrated Circuit			LM301A
IC2	"			SCL4001*
IC6	"			SCL4016
* MUST be Solid State Scientific				
D1-D4	Diode			1N914
SW1	Switch	4 pole 2 position		toggle
PC board ETI 601R				
3600 Synthesizer				
1 pole 5 position rotary switch metal bracket to fig. 5.				

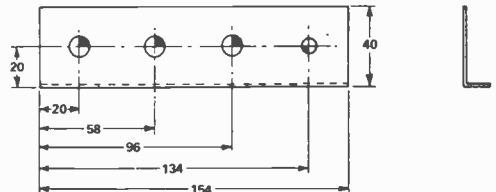
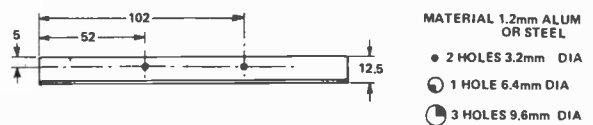
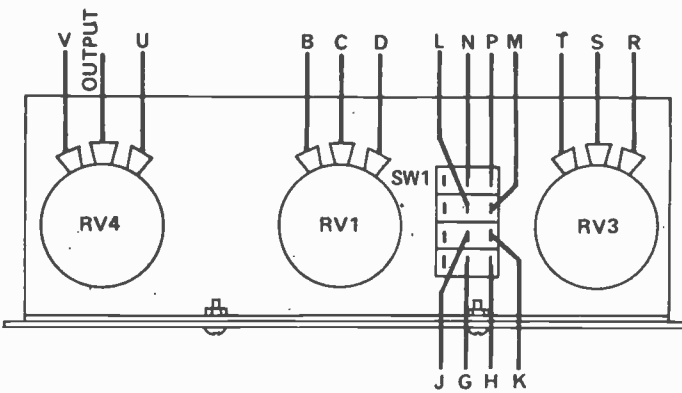


Fig. 5. This bracket is used when the filter is used with the 3600 unit. (not needed for the 4600 unit).

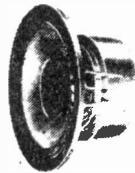
Fig. 4. If desired this filter module can advantageously replace that originally designed for the 4600 synthesizer. Here's how to wire it in to the 4600 unit.

To be continued.



# Wilmslow Audio

**THE firm  
for  
speakers!**



Baker Group 25, 3, 8, or 15 ohm	£8.64
Baker Group 35, 3' 8 or 15 ohm	£10.25
Baker Deluxe, 8 or 15 ohm	£13.75
Baker Major, 3, 8 or 15 ohm	£11.87
Baker Regent, 8 or 15 ohm	£10.00
Baker Super, 8 or 15 ohm	£18.12
Celestion PSTB (for Unilex)	£3.75
Celestion MH1000 horn, 8 or 15 ohm	£10.95
EMI 13 x 8, 150 d/c, 8 ohm	£2.94
EMI 13 x 8, 350, 8 or 15 ohm	£9.56
EMI 13 x 20 watt bass	£7.69
EMI 2 1/4" tweeter 8 ohm	£0.77
EMI 8 x 5, 10 watt, d/c, roll/s 8 ohm	£3.44
Elac 59RM 109 15 ohm, 59RM114 8 ohm	£3.44
Elac 6 1/2" d/c roll/s 8 ohm	£4.06
Elac TW4 4" tweeter	£1.75
Fane Pop 15 watt 12"	£5.25
Fane Pop 25T 12" 8 ohm	£7.50
Fane Pop 50 watt 12" 8 ohm	£12.00
Fane Pop 55 12" 60 watt, 8 ohm	£12.95
Fane Pop 60 watt 15" 8 ohm	£13.75
Fane Pop 100 watt 18" 8 ohm	£25.95
Fane Crescendo 12A of B, 8 or 15 ohm	£34.50
Fane Crescendo 15, 8 or 15 ohm	£47.50
Fane Crescendo 18, 8 or 15 ohm	£62.95
Fane 807T 8" d/c, rolls/s, 8 or 15 ohm	£4.62
Fane 801T 8" d/c roll/s 8 ohm	£8.12
Goodmans 8P 8 or 15 ohm	£5.50
Goodmans 10P 8 or 15 ohm	£5.80
Goodmans 12P 8 or 15 ohm	£13.95
Goodmans 12P-D 8 or 15 ohms	£18.95
Goodmans 12P-G 8 or 15 ohms	£15.95
Goodmans Audiom 200 8 or 15 ohm	£13.90
Goodmans Axtent 100 8 ohm	£8.44
Goodmans Axiom 402 8 or 15 ohm	£20.00
Goodmans Twinaxiom 8" 8 or 15 ohm	£10.14
Goodmans Twinaxiom 10" 8 or 15 ohm	£10.75
Kef T27	£6.06
Kef T15	£6.94
Kef 8110	£8.37
Kef B200	£9.50
Kef B139	£16.50
Kef DN8	£2.31
Kef DN12	£5.75
Kef DN13	£3.87
Richard Allan CG 8T 8" d/c roll/s	£8.06
STC 400 1 G super tweeter	£6.56
Fane 701 twin ribbon horn	£40.50
Baker Major Module, each	£13.44
Goodmans Mezzo Twinkit, pair	£47.19
Goodmans DIN 20, 4 ohm, each	£13.44
Helme XLK25, pair	£25.44
Helme XLK30, pair	£17.19
Helme XLK50, pair	£46.25
Kefkit 1, pair	£48.44
Kef kit III, each	£42.50
Peerless 3/15 (3 sp. system) each	£17.19
Richard Allan Twinkit, each	£10.37
Richard Allan Triple 8, each	£15.94
Richard Allan Triple, each	£23.12
Richard Allan Super Triple, each	£27.50
Wharfedale Linton 2 kit (pair)	£23.12
Wharfedale Glendale 3 kit, pair	£40.62
Wharfedale Dovedale 3 kit, pair	£63.12
Wharfedale Super 10 RS/DD	£16.00
Castle Super 8 RS/DD	£10.31

INCLUDING VAT AT 25% ON HI-FI, 8% ON PRO AND PA

Cabinets for PA and HiFi, wedding, Vynair, etc.  
Send stamp for free booklet "Choosing a Speaker"

FREE with all orders over £7 - "HiFi Loudspeaker Enclosures" Book

All units are guaranteed new and perfect

Prompt despatch

Carriage: Speakers 38p each, 12" and up 50p each, tweeters and crossovers 25p each, kits 75p each (£1.50 pair).

**WILMSLOW AUDIO**  
Dept. ET1

Swan Works, Bank Square, Wilmslow,  
Cheshire SK9 1HF. Tel. Wilmslow 29599  
(Discount HiFi, PA and Radio at  
10 Swan Street, Wilmslow)

## tecknowledgegy;

*Ambit has something different to offer the modern electronics enthusiast - amateur or professional.*

*Tecknowledgegy - the sort of data and information service that simply cannot be matched by any other component source. With today's new products in electronics, you need a new approach to buying to make certain that you get best advantage from the vast amount of data and information that is being published to complement the modern technology.*

Our speciality is wireless. AMBIT has all the semiconductors and inductors for all types of receiver up to 200MHz. VHF FM stereo is covered by various modules for tunerhead, IF and decoder applications.

Larsholt 7252 FM tuner: A complete varicap tuned-head+IF, with 1uV for 26dB S/N, 0.1% THD, muting, AFC, meter drive audio preamps Ready built £20.00.

Linear Phase FM IF system, with mute, AFC, AGC, meter drive. Twin IF filters and 0.1% THD. Built and aligned on a R&S Polyskop for £9.00.

EF5603 MOS and Varicap FM tunerhead from TOKO. The best in the range £8.40.

EC3302 FET and varicap FM tunerhead for lower cost systems. £5.00.

### The ALL Electric Wireless.....

A UNIQUE varicap tuned AM radio unit with IC, ceramic filter IF, and three stage tuning. Covering the medium wave in one sweep. Kit £8.00, built for £9.95.

A Unique 150mm track length slider for AM/FM varicap tuners, and any other application for a precision 50k linear WW potentiometer. £3.00 ea. 6 Button preset varicap control unit from IMI. Inc fixing bracket £3.40.

993090 MPX PLL decoder. A superb unit with pilot tone filter, audio preamps, LED beacon. Kit £6.40 - built £7.60.

91310 Low cost MPX decoder module. No corner cut though, and price includes LED beacon and TOKO pilot tone filter. Kit for £5.10, built £5.90.

### We also carry a wide range of linear ICs for audio and radio

EG The LM381N stereo preamp £1.85  
The NE560,561,562,563 PLL £3.19 ea  
CA3089E FM IF subsystem inc coil £1.94  
CA3090AQ stereo decoder inc coil £3.75

And stacks of TOKO coils and filters for radio and MPX. SAE for our free shortform lists.

Shortform price list and product summary FREE with: an SAE. Full catalogue folder cost is 40p (inc), and contains more info on TOKO and up to the minute linears than ever.

from

Ambit international  
37 High Street  
Brentwood, Essex.  
CM14 4RH  
Tel: 216029 Tlx: 995194  
VAT EXTRA: P&P 20p

BUILD THE

# TREASURE TRACER MK III

METAL  
LOCATOR



AS SEEN  
ON BBC-1  
& BBC-2  
TV

- Genuine 5-silicon transistor circuit, does not need a transistor radio to operate.
- Incorporates unique varicap tuning for extra stability.
- Search head fitted with Faraday screen to eliminate capacitive effects.
- Loudspeaker or earphone operation (both supplied).
- Britain's best selling metal locator kit.
- Kit can be built in two hours using only soldering iron, screw-driver, pliers and side-cutters.
- Excellent sensitivity and stability.
- Kit absolutely complete including drilled, tinned, fibreglass p.c. board with components siting printed on.
- Complete after sales service.
- Weighs only 22oz; handle knocks down to 17" for transport.

Send stamped, self-addressed envelope for literature.

Complete kit with pre-built search coil

**£10.90**

Plus 60p P&P  
Plus 92p VAT

Built, tested and Guaranteed

**£15.25**

Plus 60p P&P  
Plus £1.27 VAT

South Africa, Rhodesia etc:  
Send £14.00 for kit, £18.00 built, both include Air Mail.

**MINIKITS ELECTRONICS,**  
6d Cleveland Road, South Woodford,  
LONDON E18 2AN  
(Mail order only)

# UNDERSTANDING COLOUR TV

by Caleb Bradley BSc.

## Line and field synchronization

**LINE SYNC PULSES** occur at the start of every scanning line and are used to time the line scan circuit. This consists of a line frequency (15 625 Hz) oscillator which drives magnetic deflection coils mounted on the display tube. The line deflection waveform, provided by a high power output stage, is sawtooth shaped i.e. a smoothly increasing current to sweep the scanning spot from left to right followed by a rapid return to the starting value to cause an almost instantaneous right-to-left flyback to the start of the next scanning line.

How do the line sync. pulses control the line scan? Although it is possible to apply them as trigger pulses to the line oscillator (the same way the timebase oscillator in an oscilloscope is triggered), a flywheel sync. circuit is more usually used to obtain better results from weak or interference-prone signals. The basic arrangement is shown in Fig. 36.

The line oscillator is a tuned circuit type containing a voltage controlled reactive element to allow control of phase. The idea is similar to the voltage controlled oscillator in the decoder (last month) except that since the working frequency is too low for varicap diodes to be useful the voltage controlled element is usually a transistor whose conduction during

each cycle is arranged to simulate an inductor.

The 'flywheel discriminator' is really a simple driven clamp. A sample of the line scan waveform is applied to it via C1. Also applied are the line sync. pulses which are differentiated by C2. The leading edge of each pulse causes both D1 and D2 to conduct. This clamps the instantaneous value of the waveform from C1 to 0 V. The waveform is fully integrated by R1/C3 to give a dc voltage which controls the phase of the line oscillator. Clearly the value of this voltage depends on which part of the feedback waveform is clamped to 0 V.

When the line scan is synchronised correctly, the clamp operates at A in Fig.36. Should the scan begin *later* than required, point B is clamped instead. Since more of the waveform is now above 0 V the voltage on C3 moves positive. If the reactance control is arranged so that this increasing voltage *advances* the line phase the error will be rapidly corrected and the clamp point return to A. Conversely, leading scan phase (clamp at C) is corrected by decreased voltage on C3.

This simple arrangement achieves excellent performance because the steep flyback slope C-A-B gives very high phase-correction gain. The

integrator R1/C3 gives the circuit its phase inertia or 'flywheel' property. For example the line scan is unaffected if an occasional sync. pulse is lost or distorted due to interference.

Since the line oscillator is tuned close to the correct frequency by a stable L-C circuit the pull-in range of the flywheel sync. circuit can be made small. In terms of phase gain, this means a high gain at dc with the first low-pass pole at a low frequency, obtained by giving R1/C3 a long time constant. This gives relative immunity to any interference which may get through the sync. separator. In colour the accuracy of the line scan is vital because of the several timed functions derived from it.

## FIELD SYNCHRONISATION

The field scan requires a sawtooth shaped current drive to the field (vertical) deflection coil on the display tube. This causes the scanning spot to be deflected from top to bottom of the screen at a comparatively slow rate (taking 20 milliseconds during which there are 312½ line scans) followed by a fairly quick flyback to the top for the next scan.

Since the field sync. pulse is obtained by integration in the sync. separator it is less susceptible to noise than the line pulses and this allows simple

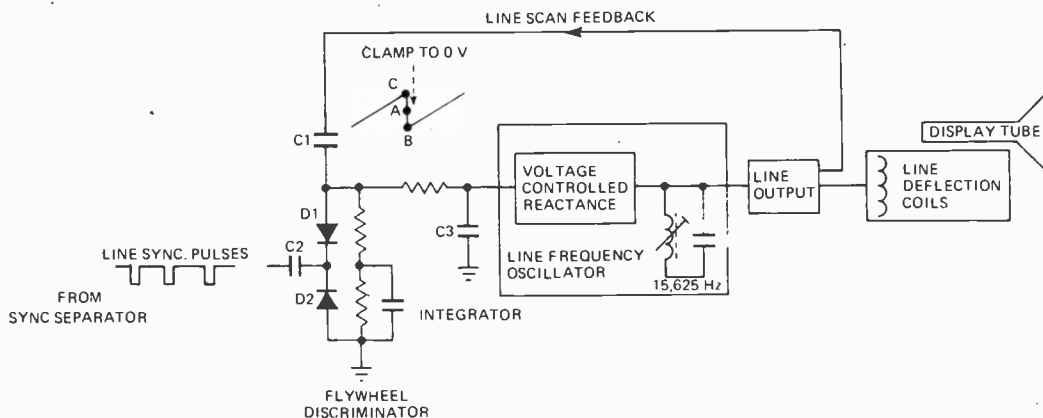


Fig. 36. Basic 'flywheel' line scan circuit.

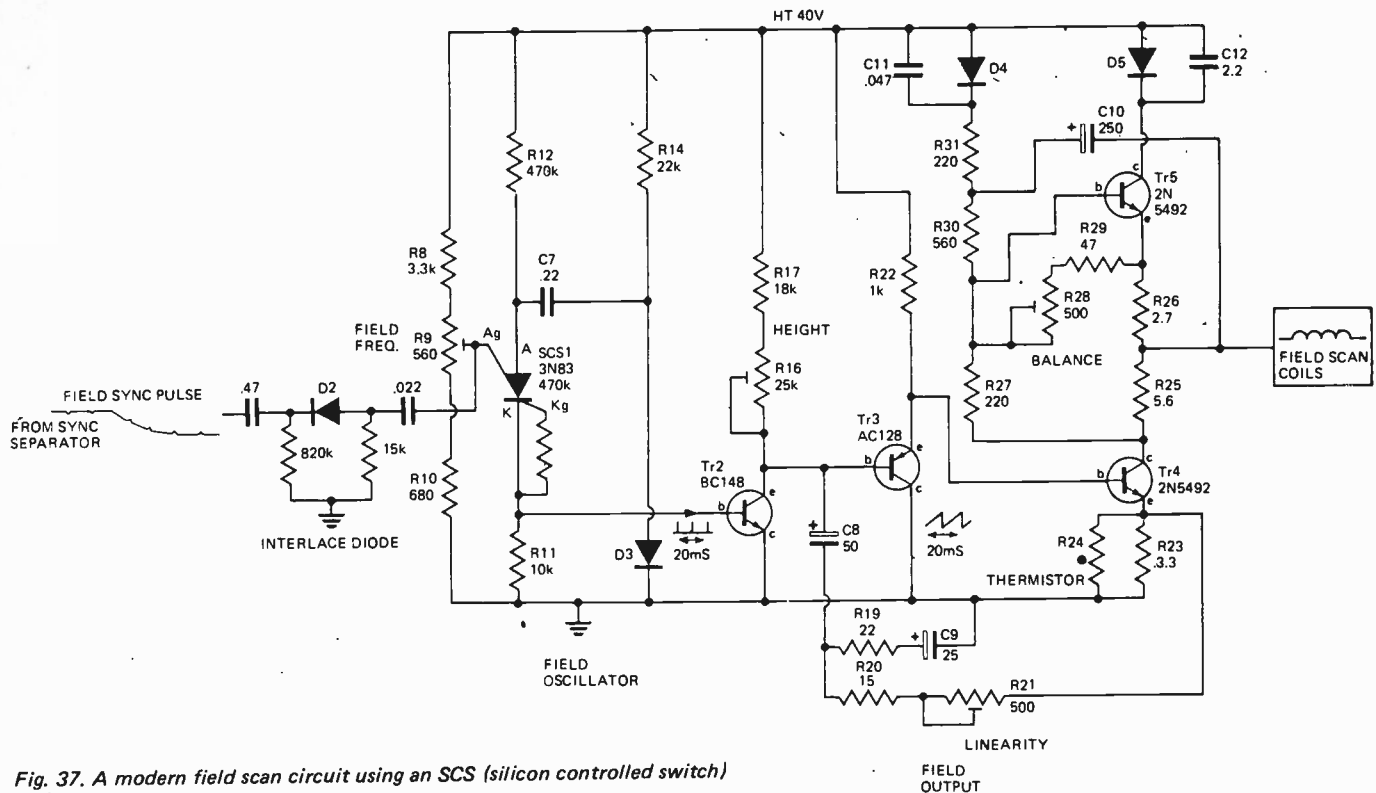


Fig. 37. A modern field scan circuit using an SCS (silicon controlled switch) oscillator.

synchronisation by direct trigger of the field oscillator. This drives the field output stage which provides the sawtooth waveform for the field scan coil. Various well known oscillator circuits are used such as multivibrators, blocking oscillators, etc. Recently a simple circuit using a silicon controlled switch (SCS) has become popular. This is a four-layer diode device with internal regeneration which resembles a thyristor (SCR) but has an extra electrode ('anode gate') which gives new means of triggering. Like the thyristor it has two states: 'off' state i.e. no conduction, followed after the trigger condition is met by the 'on' state where anode to cathode current flows. A modern field circuit is shown in Fig. 37.

### CIRCUIT OPERATION

In Fig.37 the trigger condition for SCS1 occurs when the anode voltage exceeds the anode gate voltage. Regard the anode gate voltage as fixed by the divider R8/R9/R10. At the start of the scan SCS1 is off. Current from R14 keeps D3 conducting so the right hand side of C7 is held near 0 V. The anode voltage of SCS1 rises as current from R12 charges C7. After 20mS this voltage reaches the anode gate voltage and SCS1 is triggered on. It now discharges C7, current having to flow through R11 and R14 (since D3 blocks). When the discharge current decays below the holding current for SCS1 it turns off and the next cycle begins. Thus the scan period is set by

the time constant R12/C7 and the flyback period is set by the shorter time constant R14/C7.

Synchronisation is achieved by applying negative-going field sync pulses to the anode gate. The anode voltage required to trigger SCS1 is thereby much reduced so each flyback is initiated by a sync pulse. The preset R9 is only needed to set the free-running frequency in the absence of a signal. The diode D2 stabilises the triggering point and thereby ensures accurate interlace of successive fields.

### FIELD OUTPUT

The field scan sawtooth is produced by C8 charging via R16/R17. The field-rate pulses developed across R11 in the oscillator briefly turn on Tr2 which rapidly discharges C8. The resulting sawtooth at Tr2 collector is fed via emitter follower Tr3 to the output transistors. These operate — despite first impressions — in Class A.

At the start of the scan Tr3 is bottomed with its emitter near 0 V. Hence Tr4 is off and no current flows in R23. About half h.t. voltage is present at the junction of R25 and R26. The values of R27, R28, R29 are chosen so Tr5 is conducting when Tr4 is off. During the scan Tr4 draws increasing current and the voltage developed across R25 progressively reduces the conduction of Tr5. When the flyback begins, Tr4 is cut off by Tr2/Tr3 clamping its base to 0 V. The energy stored as current in the scan coil causes the emitter and base

voltage of Tr5 to rise; when they reach h.t. the diode D5 cuts off and the scan coil 'rings' with C12 to produce a large positive half-sine wave. The voltage across the coil then gradually decreases into the next scan as Tr4 conducts again.

The bootstrap capacitor C10 provides correct base drive for Tr5 and prevents unwanted direct currents in the scan coil.

Without correction the waveform at Tr2 collector would be exponential rather than linear and this would result in compression of the lower parts of the picture. Correction is achieved by feedback from the output stage emitter resistor R23 via parabola-shaping network R19-R21/C9 placed in series with the 0 V return of C8. Many sets have a second field linearity control which affects the very top of the picture only. (This acts by differentiating the scan sawtooth by a small amount).

The thermistor R24 is a simple means of stabilising the picture height against temperature and supply voltage changes.

## NEXT MONTH:

the shadowmask tube and how to drive it.

# ELECTRONICS -it's easy!

# PART 17

SUPPLIES built permanently into equipment as fixed parameter units usually operate within reasonably well-defined operating limits. Fault conditions are, therefore, less likely to occur on the supply output, but are still a reality.

By contrast, general-purpose supplies designed to provide variable output for device testing, circuit development and multi-purpose use are prone to a number of fault conditions which could destroy components.

With the reduction in cost of power supply circuits, it is now practicable (and wise) to always employ protective devices that sense external or internal fault conditions and apply protective measures to the supply which prevent damage to both the supply and, possibly, the load being driven.

A wide variety of faults can occur. The supply itself may be damaged by excessive input overvoltage which may occur either as a steady-state overload or as a brief excitation transient. Protective measures include using a simple wire-fuse or magnetically-operated circuit breakers that can break the circuit with greater reliability and speed than fuses. The same transients may destroy the bridge-rectifier diodes, these cannot

effectively be protected by fuses or breakers. One technique to overcome this is to use diodes that are much heavier than really needed; another is to supplement these with an RC network across the output of the transformer — to provide a reduced impedance path for voltage transients.

On the output of the supply, protection is needed to prevent too low a load impedance drawing excessive current. We know that a constant current supply uses a series monitoring resistor to produce a control voltage. The same method can be used to limit output current. A simple method often used in series regulators is illustrated in Fig. 1. The diodes D1 and D2 do not conduct until the voltage drop across the small series resistor reaches the forward voltage of the diodes (0.4 for germanium, 0.7 for silicon). If the output of the supply is short circuited the diodes will conduct and limit the output current to a value

$$I = \frac{V_{D1} + V_{D2}}{R_s}$$

Thus if germanium diodes were used and  $R_s$  was one ohm the supply would limit at

$$\frac{0.4 + 0.4}{1} = 800 \text{ mA}$$

Another serious condition that can occur is for the supply to produce (if only momentarily) *overvoltage* at the output. Protection against this is essential, for excessive voltage can destroy semiconductor loads connected to the supply. The technique used is very rapidly to sense

when overvoltage occurs and immediately connect a very low resistance shunt across the output terminals. For obvious reasons this device is known as "crowbar" protection!

A well-designed "crowbar" takes into account operating times (microseconds is quite feasible), recovery time after triggering; triggering sensitivity and many other features.

The simplest crowbar arrangement is to place a suitably rated (and voltage value) Zener diode across the output, as depicted in Fig. 2. If the voltage exceeds the Zener voltage the Zener conducts, clamping the output to a point just above the normal maximum voltage available from the supply. Excessive current is controlled by the current limiting protective arrangement presumably built into the supply.

More sophisticated methods compare the output voltage to a reference source and use any sudden difference to trigger (see Fig. 3) a silicon-controlled-rectifier which shorts the output thus either blowing the supply fuse or putting the supply into current limit.

## TRACKING SUPPLIES

Many circuits, IC op-amps for instance, require dual voltages — that is, positive and negative values referred to a common zero voltage. Some circuits require that both supplies provide exactly the same value of voltage, regardless of differences in load currents or fault conditions which may affect one output only. Another

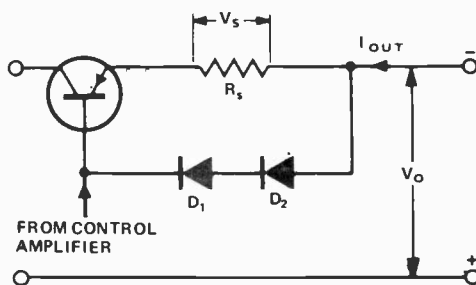


Fig. 1. Automatic current limiting is obtained with a series sensing resistor. This method of control is often used in series-pass voltage regulators.

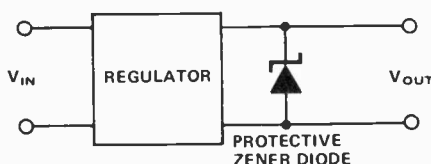


Fig. 2. A Zener diode across the output provides "crowbar" protection against overvoltage.

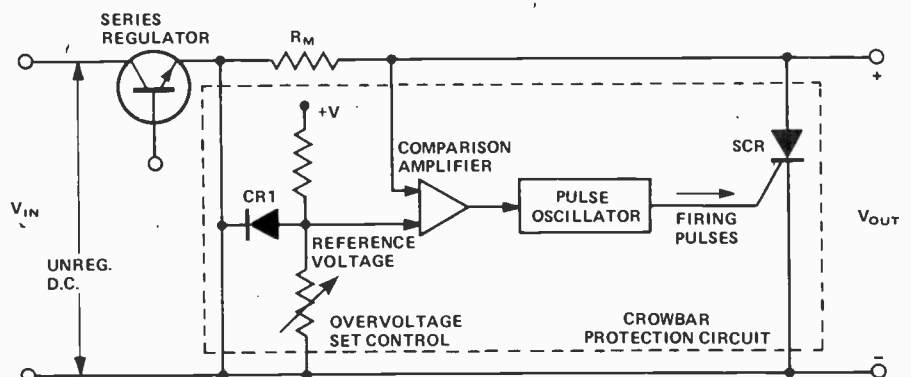


Fig. 3. Active control can provide more effective crowbar protection. This circuit uses a silicon-controlled rectifier to short the output should overvoltage occur. The supply of course must be able to withstand such a short.

need for uniform supply outputs is where a number of slave supplies are required to follow a master unit. Supplies that have this inbuilt facility to follow external voltage are said to possess auto-tracking capability.

Auto-tracking is provided by comparing the two (or more) outputs using any (negative or positive) resultant error signal to control the regulator of one supply. One arrangement is shown in Fig.4.

Auto-series operation is also available in some proprietary units. This enables a number of units to be connected in series in order to provide increased voltage. Sensing circuitry ensures that the voltage is shared evenly across each unit.

### HEAVY-DUTY SUPPLIES

The series pass regulator transistor is capable of medium-demand currents. Several transistors may be paralleled to increase the total capacity. However, the method becomes wasteful at high power levels as considerable power must be dissipated in the series pass elements.

A common way to provide greater power is to use the mechanically-driven variable transformer arrangement.

Another method uses special transformer designs that provide a reasonably wide degree of self-regulation, by varying magnetic leakage between primary and secondary windings or, by resonating the transformer windings with a tuning capacitor (transformer core saturates at a constant level).

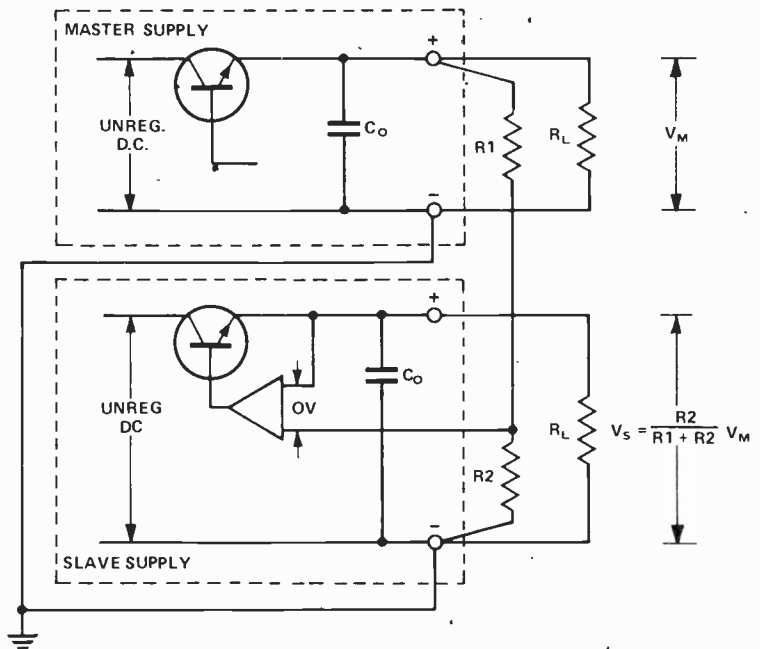
If a switch were to be incorporated, instead of the series-pass transistor, it could be operated with an on/off ratio such that the average power allowed to pass is controlled. This chopped waveform may then be filtered to provide smooth dc. Switching regulation, as this kind of operation is known, is one of the most efficient forms of regulator design because very little power is wasted. The output voltage is compared with a reference value, as before, and the resulting error signal is converted into an equivalent variable-rate, on-off digital signal. This, in turn, is used to control the on-off ratio of the series transistor switch. Where power loss must be minimized, switching regulators are essential.

### SILICON CONTROLLED RECTIFIERS

Another kind of switching regulator uses the silicon-controlled rectifier SCR diode (see Fig. 5).

Silicon controlled rectifiers, unlike ordinary silicon diodes, have four semiconductor layers and three terminals (anode, cathode and gate).

Fig.4. Auto-tracking of two supplies can be achieved by using feedback to sense the error between them apply correction to one of them.



Like a normal diode the SCR will conduct when the anode is positive with respect to the cathode. But, unless the gate is also positive, the SCR will not conduct at all! The SCR may be switched on at any point in the positive cycle by a positive voltage on its gate. Once the SCR is switched into conduction the gate loses control

until the anode-to-cathode potential falls to zero. Thus in operation a single positive pulse will switch the SCR on at any desired time within the positive half cycle and, by varying the time at which this pulse occurs we may control the average power passed by the SCR.

To pass both positive and negative

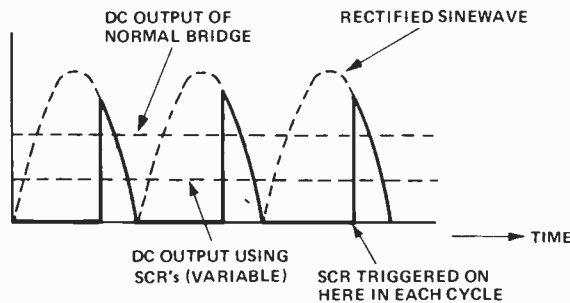
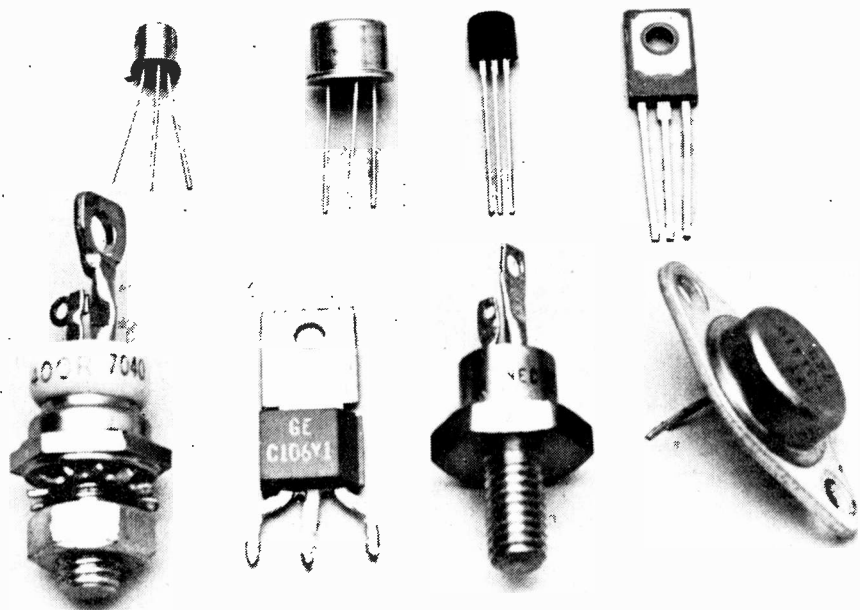


Fig.5. A range of silicon-controlled rectifier SCR's. The waveforms show how only a portion of each half cycle of the rectified sine-wave is switched through thus reducing the effective output voltage.



# ELECTRONICS -it's easy!

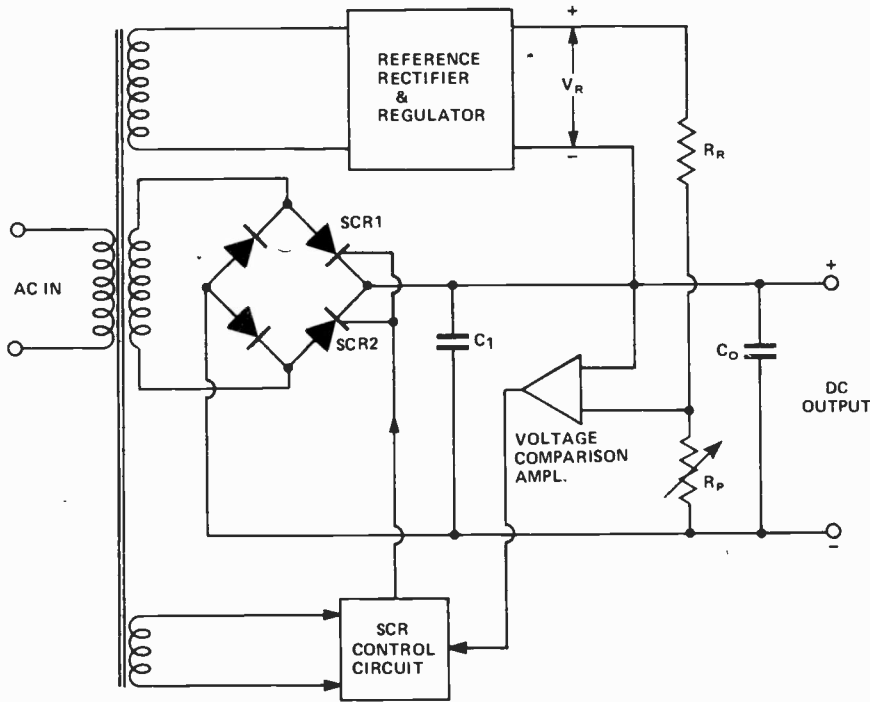


Fig.6. Use of SCR's in the power supply rectifier-bridge stage. The SCR control circuit output decides the average output of the bridge.

half cycles we must use two SCRs connected appropriately or use a special device — called a TRIAC — which can be switched on for either polarity.

The schematic of a regulated supply using SCR power control is shown in Fig. 6. The power handling limits of SCR devices range to thousands of amps. As their main feature is control of power by switching, not by dissipation of unused energy, they do not need the same degree of cooling for a given load as would the series-pass transistor method.

## INTEGRATED CIRCUIT REGULATORS

In recent years, special purpose IC components have become available that include a reference voltage supply, a comparator and a drive circuit for controlling an external series-pass regulator transistor all in one small device.

One such chip is the  $\mu A723$  shown schematically in Fig. 7. From the internal circuit diagram it is clear that these units are capable of providing excellent regulation. The output voltage is adjustable on demand by altering the proportion of the output voltage which is compared to the reference voltage by an error amplifier. Ancillary built-in circuitry provides current limiting and crowbar action if needed.

Also available are regulator IC's which have the series-pass power stage formed on single silicon chips. The LM109 and LM309 are such regulators (circuit shown in Fig. 8) and provide 5 V with output load in excess of 1 ampere. The LM309 has internal thermal overload protection, internal current limiting and is virtually blow-out proof. As is shown in Fig. 8, nothing could be simpler to use if a fixed voltage is needed. The cost is just about £1.50 — thereby, powerfully demonstrating that today's electronic discipline is a matter of system rather than component design.

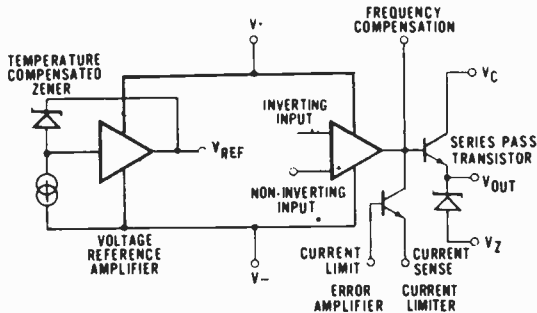
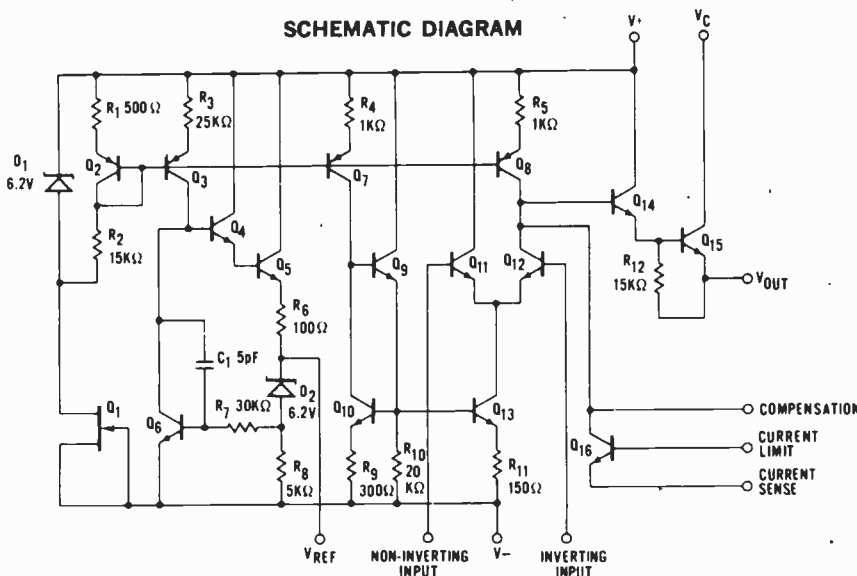


Fig.7. Circuit diagram and system schematic of  $\mu A723$  I.C. regulator chip. An external series-pass power transistor stage is needed to complete the regulator.



## Further Reading

References given in the article before last are most relevant to the design of regulators. On the more specific aspects of design and use, the following are worth considering for purchase:

"Zener diode handbook" Motorola, 1967.

"Thyristor projects using SCRs and Triacs" R.M. Marston — Butterworths, 1974.

"Silicon rectifier handbook" Motorola, 1966.

## Simple regulated supply provides 1.5 to 15 volts at up to 1 ampere.

Earlier in this course details were given of an unregulated power supply that provides a dc output varying from 18 V at no load, dropping to 10 V at maximum load.

This unit can be extended by the addition of a series-pass regulator that employs an IC regulator chip and a power transistor. It incorporates current limiting and the output can be preset to provide any voltage between 1.5 and 15 V with a load current as high as 1 amp.

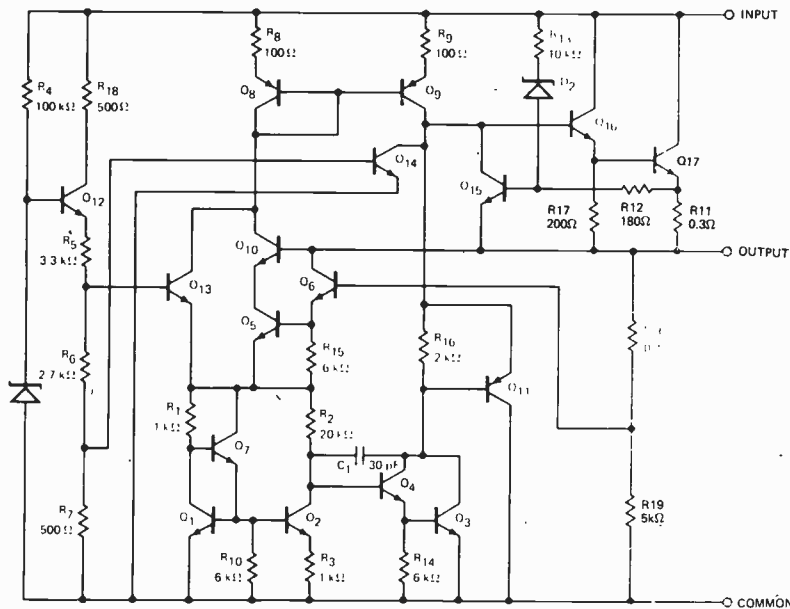
The circuit diagram for the complete regulated supply is shown in Fig. 9. By studying this, in conjunction with Fig. 8, it can be seen that adjusting RV1 provides the comparator error amplifier with a reference voltage up to the full 7.15 V produced by the built-in Zener reference circuit. Resistors R<sub>2</sub> and R<sub>3</sub> provide a divider chain that is tapped to enable the actual output voltage to be attenuated by a factor of 2.2. Thus the output is controlled so that it is 2.2 times the reference voltage provided by RV1.

The capacitor connected between pin 9 and pin 2 provides frequency compensation; improved feedback control performance is obtained by appropriate selection.

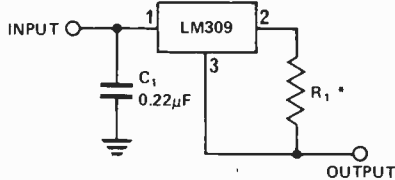
Resistor R<sub>sc</sub>, in series with the output, is a current-sensing resistance. Its value, and hence the voltage developed across it, (at pin 1) determines the current limit point. Pin 10 clamps the emitter of Q1 if V<sub>Rsc</sub> exceeds 0.6 V.

The maximum output voltage and current obtained from the unit is a function of components used. Using a 15 V centre-tapped transformer with 1 A capacity it provides 1 A at 10 V and 0.5 A at 15 V. Output voltage can be changed by altering the ratio of R<sub>2</sub> and R<sub>3</sub> with smooth manual control being obtained with RV1.

Maximum output must not exceed 25 volts.

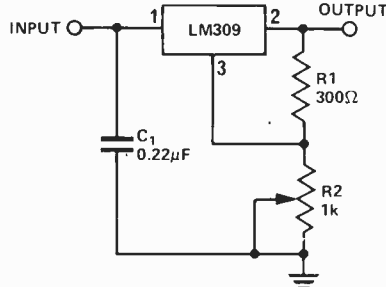


CURRENT REGULATOR

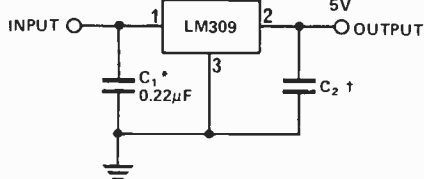


\* DETERMINES OUTPUT CURRENT

ADJUSTABLE OUTPUT REGULATOR



FIXED 5V REGULATOR



\* REQUIRED IF REGULATOR IS LOCATED AN APPRECIABLE DISTANCE FROM POWER SUPPLY FILTER.

† ALTHOUGH NO OUTPUT CAPACITOR IS NEEDED FOR STABILITY, IT DOES IMPROVE TRANSIENT RESPONSE.

Fig. 8. The LM309 I.C. regulator has the series-pass transistor (Q1) formed on the same chip. The circuitry is most sophisticated. Several different applications are shown schematically.

## ELECTRONICS – in practice

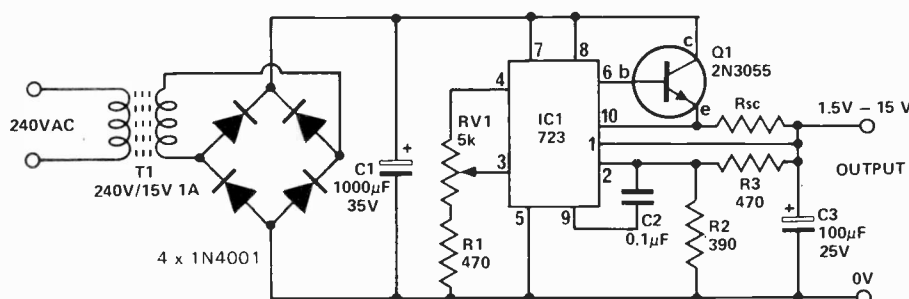


Fig. 9. This regulated supply, based on a µA723 IC, provides an output adjustable between 1.5 and 15 volts.

# Electronics by John Miller-Hirkpatrick Tomorrow

TWO of the country's largest Television Rental companies (they are *both* the largest according to their sales blurb) will not under any circumstances allow any internal modification to their sets, either by their own or by any other qualified TV service engineers. That's not strictly true because I rent my set from one of these companies and they did fit an extension speaker socket to my set, but unofficially and after a lot of persuasion. The other company did offer to rent me a set with some of the modifications that I required but it was a set designed for schools and was large, cumbersome and much more expensive. I have offered to pay for the modification and subsequent de-modification of the set, I have all of the circuit diagrams with the required modifications - all to no avail, they refuse to allow any internal modification to the set. What is this massive internal reorganisation that I want? Simply the provision of Video input and output sockets and line and frame sync signals. The total cost of components is about £3, conversion time about ½ an hour, and it is all safe from the user's point of view and from the companies'.

For those of you that do not know what I am going on about it is like putting a 'TAPE' input/output socket on a Hi-Fi system or adding an oil pressure gauge to a car. With add-on systems like CEEFAX/ORACLE and Video Cassette Recorders becoming popular the customer is left with the choice of an expensive external mod, buying your own TV and getting an internal mod or simply going without. If you rent a TV set enquire now about modifications for these systems - it could help for the future.

Having got that off my chest I will tell you what started it all. Two months ago I mentioned that I was waiting for data on a TV clock chip from National, well by twisting a few arms I received the data *and* the chips. I thought it would be a good idea to get the chips working before writing about them and that was the problem. The time is presented on

top of the programme that you are watching and thus has to be added to the programme video signal inside the set. To do this you need to interrupt the programme signal, combine it with the time signal and then continue with the combined signal. That is why I needed the Video input/output socket. In order for the time signal to be readable it must be told where to position itself on the screen relative to the top of the screen (frame sync) and relative from the left hand side of the screen (line sync). If the system is not given these reference points the result will tend to look like 'snow' on the top of the programme signal. As you may have gathered by now I have not yet been able to get the system working but I will still tell you what it is supposed to do as it may well be a standard feature on most TVs in the near future.

It all starts with the American idea of having several TV stations available to the average city viewer. With the advent of varicap tuners for UHF and VHF the rotary tuning shaft with a dial readout of channel number has started to disappear. An alternative method of showing channel number was required and as most of the American varicap tuner systems have a BCD readout of channel number the choice comes down to what sort of digits do you want and where do you want them? National Semiconductors came up with the idea of superimposing the data on top of the programme being watched so that every time you change channels the channel number is displayed in one corner of the screen for a few seconds. Why stop there, if you are going to all the bother of putting two digits on top of the programme why not put eight digits up and have the time displayed as well? In such a way was born the MM5841 encoder and the MM5318 clock chip. In this country we only have BBC1, BBC2 and ITV and thus in theory we do not need a channel number readout and thus the two digits that started it all can be

ignored or used for showing the temperature or humidity or the scores on a TV game. The system is split into two parts the first of which is the clock chip MM5318 which is basically our old friend the MM5311 with a few changes. The TV clock system works in a multiplexed mode but the multiplexing must be relative to the line and frame sync signals and so the MM5318 is a multiplex 'on demand' system. This means that instead of the chip giving BCD and/or seven segment data for one digit at a time and a digit strobe line to indicate the digit data being shown, the chip gives you the data for the digit you request. If the clock chip was free running then when the system wanted digit 1 the clock chip might be strobing digit 4, to ensure compatibility the clock chip still multiplexes the data but under the control of the encoder chip. The MM5318 still has multiplexed seven segment lines and six digit lines and so can be used both as a clock for readout on the screen as described and with LEDs.

The second part of the TV clock system is the MM5841 encoder chip. This is a CMOS chip designed to accept BCD time and channel data, sync reference data and display on/off signals and to produce a video output signal. The video signal can be used alone but is intended to be combined with a programme video signal for eventual display on a TV screen. The numbers displayed can be white on a black background or vice-versa, if the TV is a colour set then the numbers can be virtually any colour like green, purple or pink. The options available are channel only or channel and 4 digit time or channel and 6 digit time. The channel is displayed above the data and is leading zero suppressed; perhaps if no channel data is put in (channel 00) the data does not appear at all. The time data is presented as hours, colon, minutes, colon and seconds, all about 1 inch high on a 23" screen.

A circuit diagram of the system is shown in Fig. 1. For data and prices



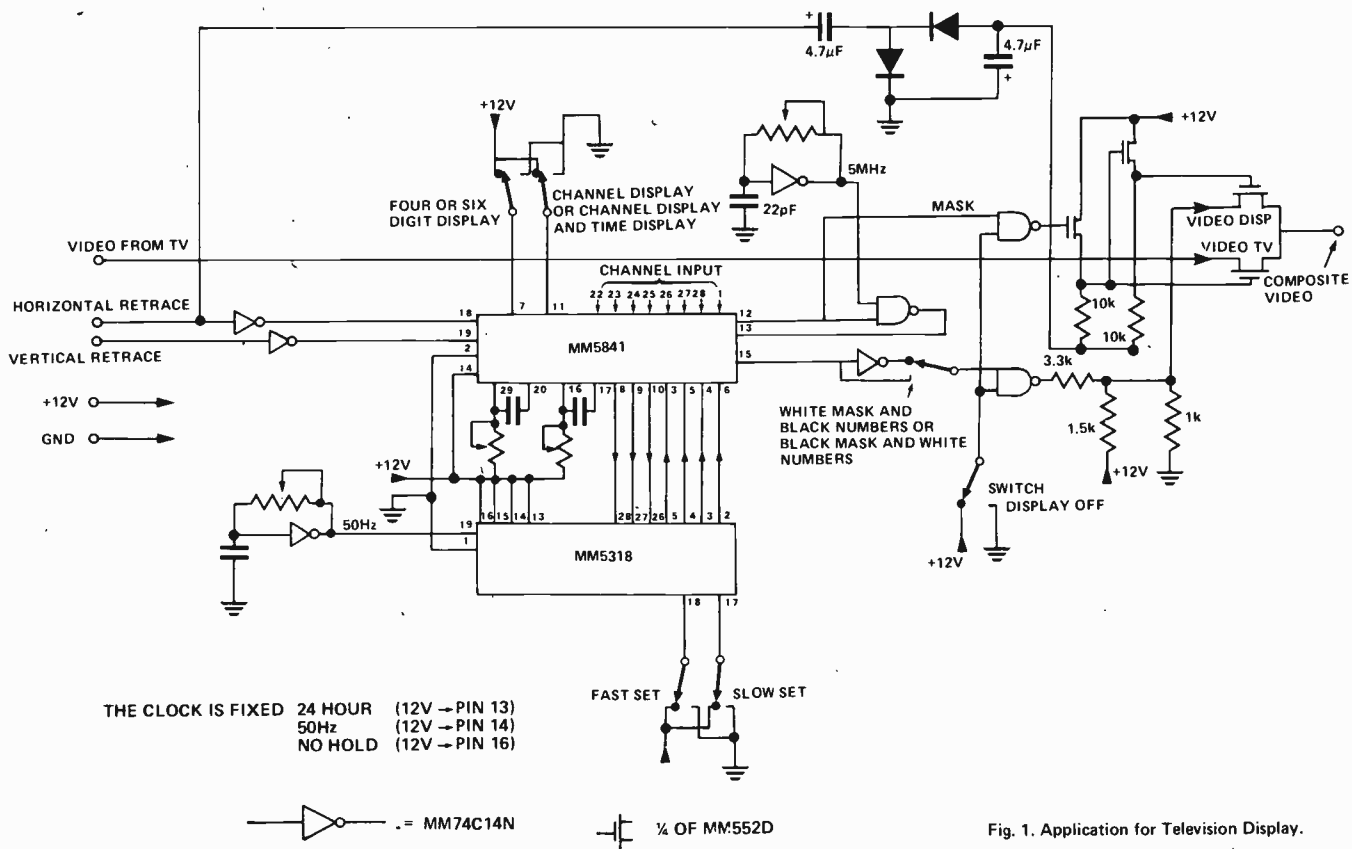


Fig. 1. Application for Television Display.

contact National Semiconductors (UK) Ltd, The Precinct, Broxbourne, Herts.

**THIS CALCULATOR MUST BE THE CHEAPEST!**

Another new National product is the MM5780 calculator chip. It is understood that a calculator using this chip will soon be available from NOVUS National's consumer manufacturing division, it will surely be one of the cheapest calculators on the market. For any of you who might be interested in building one of these calculators for yourself we are pleased to announce the complete parts list — Case—Plastic or any other material as required or available.  
 Keyboard—Simple 18 key layout, simple push switches can be used.  
 SW 1—On/Off switch spst.  
 Battery—9V PP3 or equivalent.  
 IC 1—MM5780 Calculator chip.  
 LED 1—Single LED lamp (Red).  
 LED 2—Single LED lamp (green).  
 Other—Asstd screws, nuts, bolts, glue, chewing gum, etc.  
 You will have notice that there are no

display drivers required for this calculator, this new saving in components and cost has been arranged by use of a revolutionary new display technology called TIO. TIO is a display system which uses no display interface drivers because the display is of the non-existent type, There Isn't One (TIO). This new calculator is designed to aid in the teaching of children, the idea is to enter a simple (or otherwise) mathematical problem into the keyboard together with the solution and then to press the 'TEST' key to check the answer. If the green 'Correct' light comes up then the answer was right, if the red light comes up lose one house point. The problem is entered in the usual format as you might find in a text book, e.g. —

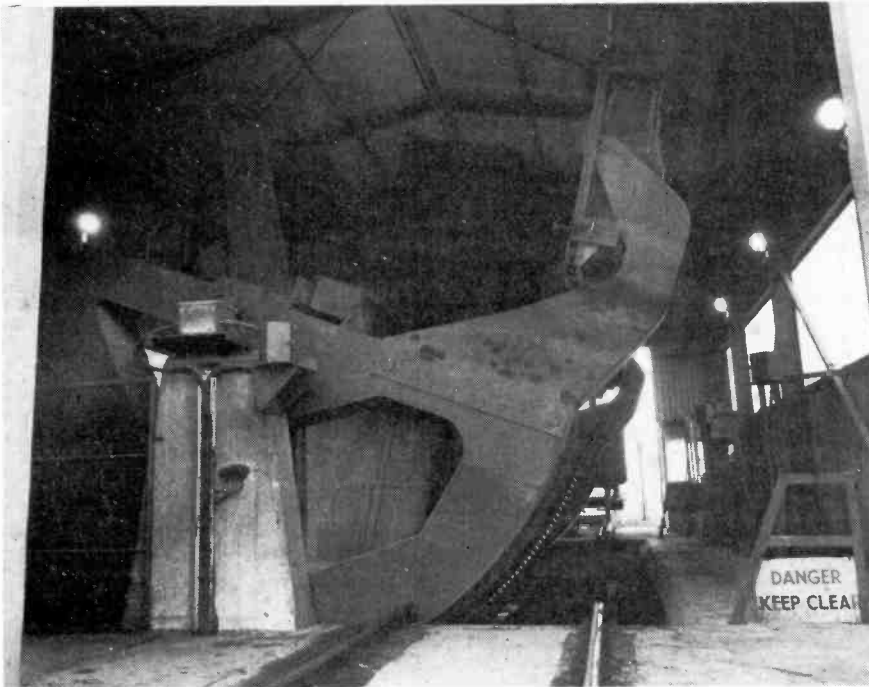
- 4 + 3 = 7 T (green)
- or 4 x 3 = 9 T (red)
- or 6 + 2 - 10 x 3 = - 6 T (green).

The internal logic is relatively simple, if you can find an algebraic calculator try this idea. Enter 6 + 2 - 10 x 3 -

- 6 =, the display should show 6, 8, -2, -6, 0. In other words instead of pressing the equals key and getting the correct answer subtract what you think is the correct answer and the result should be zero. If the correct answer should be negative as in our example then you have to subtract a negative number i.e. add the positive number. The inside of the 5780 has a test for zero check when the 'TEST' key is pressed, if the sum was correct then the display would contain zero and thus the green light comes on, if the result was not zero then the red lamp comes on.

The chip is not limited to simple problems, if the diameter of a circle is 5" is its area 24.674126 sq. ins? Try 5 + 2 x 3.1416 x 3.1416 = 24.674126 T.

This is not a belated April fool article, the device really does exist. The chip is soon to be available from National's distributors and the calculator may be in the shops soon. The rumour that the MKII will be without the green and red lamps and will dispense Smarties for correct and 1kV shocks for wrong is believed to be unfounded.



## ELECTRONICS FOR AUTOMATIC TIPPLER WEIGHBRIDGE

*A new tippler in action at the coke crushing plant at BSC Appleby-Frodingham. The integral weighbridge is an electronic (load-cell) machine supplied by Henry Pooley & Son. Of 50 tonnes capacity, it works on a fully automatic cycle interlocked with the tippler to ensure that tipping cannot take place until after gross weighing and that another wagon cannot be hauled onto the weigh platform while the preceding wagon is being weighed. Gross and tare weights are indicated digitally and printed out by tabulator together with a calculator net weight and wagon number.*

## BRITISH-MADE RECORDING HEADS

An agreement between Wolfgang Bogen GmbH of West Germany and Magnetic Components Limited (a UK company) will result in the development and production of a new range of quality cassette and cartridge heads, to be marketed under the trade name Bogen-MCL. At present Bogen make high quality expensive heads, whereas MCL go for high volume, low price products. The new

heads are to be midway between the present products, and the companies hope for a large slice of the Japanese dominated market. At least 90% of the production will be based in Penryn, Cornwall, where wage rates are more economical than in West Germany (thought to be only one third of the German rates).

An annual growth rate of 20% is expected in the cassette market and Bogen-MCL are aiming to take 5% of the world market and 50% or more in Europe.

## ALUMINIUM WAVEGUIDE

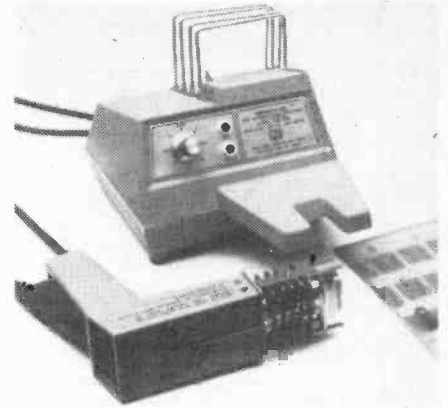
Siemens are now developing semirigid aluminium waveguides which can be bent and twisted and exhibit a very low reflection coefficient and low attenuation. Siemens expect these to be used in radio relay routes. Radio relay systems operate in the microwave range above 3 GHz. Repeater section lengths of about 5 km are normal for these frequencies. Previously the laying of the connecting lines between radio equipment and antenna has presented difficulties in adapting the rigid rectangular waveguide to meet local conditions.

## TELDEC VIDEO PLAYER ON SALE AT LAST

Telefunken-Teldec's video-disc playback system is finally on sale.

At present distribution is limited to West Germany, but the unit is now readily available there through most audio shops and major department stores. Cost is approximately £250. The programme discs sell for around £1.50. Each disc carries a 10 minute colour programme.

At present some 50 titles are available but about 400 titles should however be available by the end of the year.



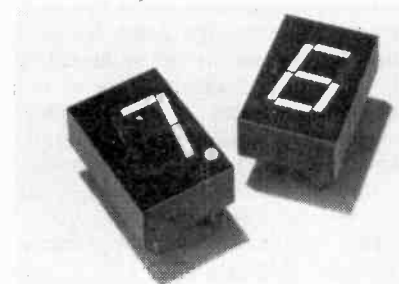
## IC REMOVER

A new automated de-soldering instrument specifically designed for the removal of DIL ICs from printed circuit boards has been introduced by Adcola Products Ltd. Known as the Removic, the unit de-solders and removes 14 and 16 pin IC's in seconds from both through-hole-plated and standard PCBs.

The unit consists of an operating 'gun' supplied through a variable temperature control box. The 'gun' is designed for ease of operation and precise positioning control. Twin spacers on either side of the pre-tinned heating blocks protect the PCB from any chance of direct contact and prevent discolouration or delamination.

In operation the 'gun' is placed over the IC to be removed from the PCB and an activator handle is pressed with the heel of the hand which positions the extractor claws and brings the heater blocks into contact with the IC leads. As the solder melts, the IC is extracted by hand pressure. The price is £138. Further details of the Removic may be obtained from Adcola Products Ltd., Adcola House, Gauden Road, London SW4.

## MOS-INTERFACING LED



A new, common cathode LED display interfaces directly with MOS clock circuits. The price of the Hewlett-Packard Model 5082-7760 is £2.60 from Celdis Ltd., 37-39 Loverock Road, Reading, Berkshire RG3 1ED. or from GDS Sales Ltd., Michaelmas House, Salt Hill, Bath Road, Slough, Berkshire SL1 3UZ.

**CLOCK KITS and ICs**

MK/704-4	4 digit Alarm Clock Kit (complete less case, transformer, switches, LS)	£14.95
MK/704-6	6 digit Alarm Clock Kit	£16.85
MK50250N	Alarm Clock IC	£5.60
AY-5-1224	4 digit Clock IC	£4.75

**DISPLAYS**

DL704 (Econ)	.3" Red Common Cathode LED display	95p
DL707	.3" Red Common Anode LED display	£1.70
DL747	.6" Red Common Anode LED display	£2.45
FND5000	.25" Red Fairchild Superdigit C.C.	£1.15
FND500	.5" Red Fairchild C.C.	£2.20
NSN33	12" Red 3 digits in DIP C.C.	£1.65
MAN3M	12" Red Common Cathode LED display	48p
SP352	.55" Orange Beckman 2 digit module	£4.00
5 LT01	.5" Green 4 dig Phos-diode Clock	£5.80

**SUPPORTING ICs, PCBs, HARDWARE, etc.**

32kHz	High accuracy/stability crystal from ITT	£3.60
50 cps	32 kHz Xtal plus CMOS to provide 50 cps	£5.84
75492	Hex Digit Driver IC—MOS to C. Cathode LED	£1.02
75491	Quad Seg Driver IC—MOS to C. Cathode LED	81p
7447	BCD to 7 seg decoder driver (C. Anode)	£1.05
7448	BCD to 7 seg decoder driver (C. Cathode)	85p
B704-6	PCB for clock display with 4 or 6 DL704	£1.35
MK-PCB	PCBs, IC socket, cable, stand-offs for MK50250N with common Cathode displays	£2.45

SOLDERCON PINS (in strips of 100) for	100+	50p/100
Low cost sockets for TTL, CMOS, displays, ICs.	1000+	40p/100
Nylon support samples with any pin order	3000+	35p/100
10w-C	10-way Colour Coded Flat Cable	60p per metre
20w-C	20-way Colour Coded Flat Cable	50p per 50cm

**MODULES**

LG110K	Logarithmic Voltage Controlled Oscillator	£5.25
FX1100	Low Frequency Function Generator	£4.95
SINTEL SOUND	LAB KIT LG110K plus FX1100	£9.95

**ET 13600.** All Semiconductors are being stocked for this project.

Other displays, ICs, etc., available — phone (9.30 a.m.-7 p.m.) or write.

Data, and circuits where appropriate, supplied with all orders, or available separately (send sae).

ADD VAT at 8% — 10p P&P on orders under £2

**CMOS** From the 2 leading manufacturers only, RCA and Motorola:  
At the new manufacturers' prices

Device	£	Description	Man
CD4000AE	0.21	Dual 3-Input NOR gate plus inverter	RCA
CD4001AE	0.21	Quad 2-Input NOR gate	RCA
CD4002AE	0.21	Dual 4-Input NOR gate	RCA
CD4006AE	1.47	18-Stage Static Shift Register	RCA
CD4007AE	0.21	Dual Complementary Pair Plus Inverter	RCA
CD4011AE	0.21	Quad 2-Input NAND gate	RCA
CD4012AE	0.21	Dual 4-Input NAND gate	RCA
CD4013AE	0.63	Dual "D" Flip-Flop with Set-Reset	RCA
CD4016AE	0.62	Quad Bilateral Switch	RCA
CD4017AE	1.63	Decade Counter/Divider	RCA
CD4019AE	0.73	Quad AND-OR Select Gate	RCA
CD4020AE	1.82	14-Stage Binary Ripple Counter	RCA
CD4022AE	1.69	Divide-by-8 Counter/Divider	RCA
CD4023AE	0.21	Triple 3-Input NAND Gate	RCA
CD4025AE	0.21	Triple 3-Input NOR Gate	RCA
CD4027AE	0.91	Dual J-K Master Slave Flip-Flop	RCA
CD4029AE	1.96	Pre-settable Up/Down Counter	RCA
CD4030AE	0.65	Quad Exclusive-Or Gate	RCA
CD4047AE	1.37	Monostable/Astable Multivibrator	RCA
CD4049AE	0.62	Hex Buffer/Converter (Inverting)	RCA
CD4050AE	0.62	Hex Buffer/Converter (Non-Inverting)	RCA
CD4068BE	0.26	8-Input NAND Gate	RCA
CD4069BE	0.26	Hex Inverter	RCA
CD4071BE	0.26	Quad 2-Input OR Gate	RCA
CD4073BE	0.26	Triple 3-Input AND Gate	RCA
MC14501CP	0.32	Triple Gate	MOT
MC14510CP	1.77	BCD Up/Down-Counter	MOT
MC14511CP	1.95	BCD to 7 Seg Latch/Decoder/Driver	MOT
MC14553CP	4.07	3-Digit Counter	MOT

We also have smaller stocks of most of the rest of the CMOS range — sae or phone for stock/price list.

**RCA 1975 CMOS Databook** (645 pages) £2.30 (No VAT) plus 37p P&P. Pin-outs, Data, CMOS use, Application notes and circuits.

ADD VAT at 8% — 10p P&P on orders under £2

**53a Aston Street, Oxford**  
**Tel. 0865 43203**

SINTEL

**Arbour Electronics Limited****CENTURION  
INSTRUMENT CASES**

Model No. 321F FLAT PACK front panel aluminium, rear panel and case, mild steel. Front panel finished in white gloss, other parts finished black, textured finish supplied with aluminium top and bottom trim.

D	W	H	PRICE
203mm	406mm	165mm	£6.20 each

Model Nos 119 & 121 two part aluminium construction base front & back unit finished in white gloss, hooded cover finished in blue hammer stove enamel.

MODEL	D	W	H	PRICE
119	152mm	127mm	89mm	£1.80 each
121	152mm	202mm	76mm	£2.20 each

Model Nos 221F & 222F Flat packs. Front & Rear panels aluminium case mild steel front panel finished in white gloss other parts finished in blue hammer stove enamel.

MODEL	D	W	H	PRICE
221F	152mm	203mm	152mm	£3.05 each
222F	197mm	254mm	159mm	£3.65 each

Prices include P & P U.K. only. Add 8% VAT U.K. only.  
Send S.A.E. for full brochure

**ARBOUR ELECTRONICS LIMITED**

Unit 13 East Hanningfield Industrial Estate, Nr. Chelmsford,  
Essex. CM3 5BG. Tel: Chelmsford (0245) 400700.  
Sheet metal work wiring assembly service available.

# Don't miss your copy of HENRY'S NEW 1975 CATALOGUE

only  
50p  
Plus 15p  
P&P



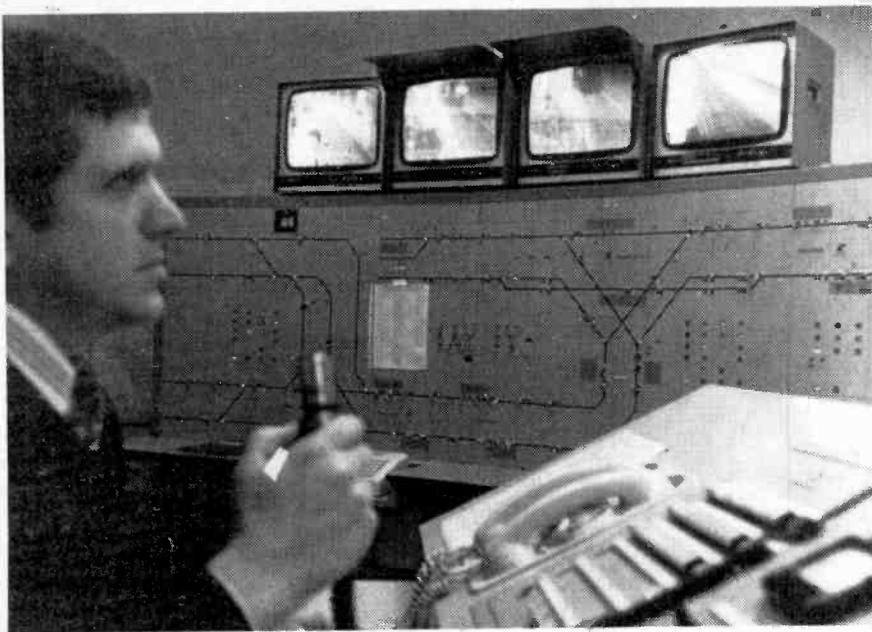
- ★ OVER 5,000 ITEMS — largest UK range of electronic components for home constructors.
- ★ 200 PAGES — every aspect of electronics and components for amateurs and hobbyists — kits, projects, test gear.
- ★ DOZENS of new lines and new ranges.
- ★ MANY price reductions throughout the new Catalogue.
- ★ A Discount Voucher with every copy, worth 50p.

**FREE** TO EDUCATIONAL ESTABLISHMENTS  
when ordered on official notepaper.

Write now for your copy, enclosing 65p remittance.

# HENRY'S

303 EDGWARE ROAD, LONDON W2.



## COMPUTER ON THE UNDERGROUND

The world's first computer-controlled train guidance system for an underground train was recently placed in service for the Cologne Public Transport Dept. The system, planned and supplied by Siemens, is built around two Type 320 process-control computers and controls all underground railway operations in an area extending to seven stations. With four radially converging lines, the Ebertsplatz underground station is a particularly important junction; up to 120 trains per hour pass through it.

## NEW CONTROL SYSTEM FOR SLR CAMERAS

Electronic shutter speed and exposure controls can now be built into single lens reflex cameras without mechanically modifying the camera bodies or lenses.

A new control system, developed by Matsushita Electrical Industrial Corporation, measures the light at a preset aperture (in less than two

milliseconds) and then sets exposure time accordingly. Control range varies from 0.0005 seconds to four seconds — dependent upon lens aperture and film speed.

Prior to the Matsushita development, it was necessary to have a light measuring device accommodated behind the main lens — calculating light intensity with the lens held wide open.

## RADIOPAGING — LONDON 1976

The GPO will operate a radiopaging service over 900 square miles of the London area. The boundaries will be Potters Bar, in the north, Caterham, in the south, Heathrow, in the west, and Dartford, in the east. Twenty thousand users will be catered for initially, with a maximum capacity of a hundred thousand.

For the last two years an experimental service has been running in the

Thames Valley. Now the GPO is looking at the possibility of a national paging service.

A call to a pager can be made from any telephone by dialling a ten-digit number. The first four digits are a common STD code to route the call to the computer terminal equipment. The GPO is thinking of having some pagers with two tones — so the user will know which of two contact numbers to phone.

## CALCULATOR CHIPS NOW LESS THAN £1

Calculator chips prices continue their inexorable fall in price. Latest prices in the USA for four function eight digit MOS chips are now as low as 40p

to 80p. Even the complex scientific calculator chips are down to £6 or less compared to £20 this time last year.

MOS Technology Corporation for instance are selling a single chip scientific unit for £7.

## OPTICAL AUTO-PILOT

Unlike electrical signals, light pulses don't get scrambled by static caused by lightning or other electrical interference. The Hughes Aircraft Corp., has developed a guidance system using optical waveguides to carry light pulses.

In conventional automatic pilot systems, each aspect of the plane's flight is constantly monitored by sensors which send continuous streams of information to a main flight control computer.

Switching to the optical waveguide system means going from continuous monitoring to systematic sampling. The computer calls up each sensor at regular intervals — from 25 to 400 times per second.

Pilots involved in tests said they noticed no difference between standard control systems and the new one operating at sampling rates of 100 per second or faster. Sampling rates of less than 100 per second resulted in flight corrections that were noticeable by the crew. This is undesirable because it indicates that unnecessary stresses are being placed on the aircraft.

The waveguides were supplied by the Corning Glass Works, NY, USA.

## VIDEOPLAYER USES STANDARD AUDIO CASSETTE

A video-tape system based on the standard Philips-type audio tape cassette has been developed by Japan's Matsushita Electric Corporation.

The system is currently being demonstrated in Tokyo using apparently standard Memorex cassettes.

At present the system appears to be designed for play-back only, competing with videodisc systems such as Teldec, Philips/MCA and RCA.

No further details of the Matsushita system were available at the time of closing for press.

A further videoplayer development is that BASF are believed to be developing a video version of their Uniset audio cassette. The latest version uses the standard Uniset cassette housing (which accepts ¼" width chromium dioxide tape).

## ERRATA

*Car Alarm, March ETI, page 24.*

*The circuit diagram does not show pin 4 connected to the positive supply. The pcb, however, is correct.*

*Some readers have had problems with the alarm triggering too easily. Increasing the value of R4 should cure this (up to 2M if necessary).*

*With some relays the IC will oscillate at RF unless pin 3 is decoupled with a capacitor of 6 to 10µF.*

# Join the Digital Revolution

## Teach yourself the latest techniques of digital electronics

Computers and calculators are only the beginning of the digital revolution in electronics. Telephones, wristwatches, TV, automobile instrumentation — these will be just some of the application areas in the next few years.

Are you prepared to cope with these developments?

This four volume course — each volume measuring 11 $\frac{3}{4}$ " x 8 $\frac{1}{4}$ " and containing 40 pages — guides you step-by-step with hundreds of diagrams and questions through number systems, Boolean algebra, truth tables, de Morgan's theorem, flipflops, registers, counters and adders. All from first principles. The only initial ability assumed is simple arithmetic.

At the end of the course you will have broadened your horizons, career prospects and your fundamental understanding of the changing world around you.

### Digital Computer Logic and Electronics

A Self-instructional Course

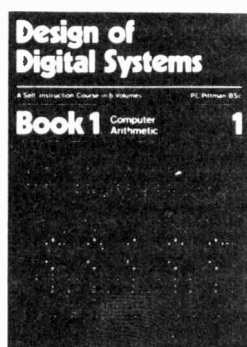
C. P. Gane MA (Cantab)  
A. W. Unwin BA (Cantab)

**Book 1** Basic computer logic

**Book 2** Logical circuit elements

**Book 3** Designing circuits to carry out logical functions

**Book 4** Flipflops and registers



**Design of Digital Systems**  
A Self-instructional Course in 6 volumes  
PC Primer 85c

**Book 1** Computer Arithmetic

**Also available — a more advanced course in 6 volumes:**

1. Computer Arithmetic
2. Boolean Logic
3. Arithmetic Circuits
4. Memories & Counters
5. Calculator Design
6. Computer Architecture

**Offer:** Order this together with Digital Computer Logic & Electronics for the bargain price of £9.25, plus 50p p&p.

**£5.95** plus 50p p&p

Design of Digital Systems contains over twice as much information in each volume as the simpler course. Digital Computer Logic and Electronics. All the information in the simpler course is covered as part of the first volumes of Design of Digital Systems which, as you can see from its contents, also covers many more advanced topics.



**£3.95**

plus 50p packing and surface mail anywhere in the world.

Quantity discounts available on request.

Payment may be made in foreign currencies.

VAT zero rated.

**Designer  
Manager  
Enthusiast  
Scientist  
Engineer  
Student**

These courses were written so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being quicker and more thorough than classroom learning. You work at your own speed and must respond by answering questions on each new piece of information before proceeding to the next.

**Guarantee — no risk to you**

If you are not entirely satisfied with Digital Computer Logic and Electronics or Design of Digital Systems, you may return them to us and your money will be refunded in full, no questions asked.

To: Cambridge Learning Enterprises,  
FREEPOST, St. Ives, Huntingdon, Cambs.  
PE17 4BR.

\*Please send me . . . set(s) of Digital Computer Logic & Electronics at £4.45 each, p&p included  
\*or . . . set(s) of Design of Digital Systems at £6.45 each, p&p included  
\*or . . . combined set(s) at £9.75 each, p&p included

Name . . . . .

Address . . . . .

. . . . .

. . . . .

\*delete as applicable  
No need to use a stamp — just print FREEPOST on the envelope.

TPB ET17









## MICRO ELECTRONIC TRANSMITTER

**FUN, SECURITY, ENTERTAINMENT, OR LISTENING TO BIRD SONG**

**Receive on a V.H.F. radio**

The smallest transmitter available in the U.K. Only 2in. x 1in. Fits in the palm of your hand. Can pick up and transmit voices and minute sound. Range 500 yards at least. Can be worn round the neck, held in the hand or operated in a drawer. Works almost anywhere. Uses PP3 battery (very long life). Simply switch on, no other connectors. Completely self contained. Transistorised, printed circuit. Used the world over. Many applications. Fully guaranteed. Latest model now despatched.

Transmitter £15.50. If required suitable radio for receiving transmitter £14.25.



## UHF - VHF CONVERTER

As most high level transmissions are now moving to UHF this unit enables their reception without the necessity of an expensive receiver.

The unit will receive frequencies in the range 420-470 MHz or to customers' requirements and allows any VHF radio to receive UHF transmissions.

To operate: Connect crocodile clip to any VHF radio aerial, in the down position, switch connector on, tune VHF radio to 100-108 MHz on dial and receive UHF communications band.

The converter is of rigid metal construction and housed in a strong plastic case. The circuitry uses tuned lines in oscillator and RF circuits facilities are made for peaking I.F. output between 100-108 Mc/s. Power supply is from an internal 9-volt battery.

Unit dimensions: App. 6" x 3" x 1"; aerial 6".

An interesting feature is that the converter can be used to feed several VHF radios enabling a number of UHF channels to be received simultaneously.

**CONVERTER, ready to use — £25.50**

Mail order and C.O.D. welcome. P&P 45p

**MULHALL ELECTRONICS (ET1)**

Ardglass, Co. Down, UK B730 7SF. Tel. 039 684 461

Licence not available in the U.K.

## Greenbank Electronics

**FREE!**

Data and circuit diagram for Digital Clock Chip AY-5-1224, Digital Alarm Clock Chip MK 50253, also data sheet for DL-747, DL-750 LED displays. (A stamped addressed envelope with enquiries would be a great help to us, but is not essential.)

### CLOCK CHIPS

AY-5-1224, 4 digit, 12/24 hr., 50/60 Hz, TTL compatible, zero reset, easy display interface, 16 pin package. **£3.66**

MK 50253, 4/6 digit alarm clock chip, 50 Hz, 12/24 hr., AM/PM and activity indication, 'snooze' feature, intensity control, simple time setting, 28 pin package. **£5.50**

### L.E.D. DISPLAYS

DL-747 0.6" (15mm) high, common anode **£2.04**  
DL-750 0.6" (15mm) high, common cathode **£2.25**

Add VAT to all prices, post, etc. 10p + VAT per order.

**GREENBANK ELECTRONICS (Dept. T6E)**  
94 New Chester Road  
New Ferry, Wirral, Merseyside L62 5AG  
Tel. 051-645 3391

## 1974-1975 TRANSISTOR COMPARISON TABLES

A true pocket book (5½"x4") which gives equivalents of over 2,500 types - several alternatives are given for each. Originally a German publication, this book gives the information in English, French, German and Italian. 24 pages are devoted to transistor lead connections and over 130 to the equivalents section giving basic construction, lead details and manufacturers.

Send a cheque or P.O. for £1.25 (includes postage) to ET1 to receive this truly up-to-date reference book.

TO: TRANSISTOR COMPARISON TABLES  
ET1,  
36 Ebury Street,  
London SW1W 0LW.

Please find enclosed my cheque/P.O. for £1.25.

NAME .....

ADDRESS .....

## HARDWARE

Screws, nuts, washers, etc.

Sheet aluminium cut to size or in standard packs, plain or punched / drilled to spec.

Printed circuit boards for published designs or individual requirements, one-off or small runs.

Fascia panels, dials, nameplates, etc., in etched aluminium. 6p for details.

**Ramar Constructor Services**  
29 Shelbourne Road  
Staford on Avon, Warwicks.

## QUARTZ CHRONOMETER KITS



The proven range of EST chronometers is now available to home and professional constructors.

Write or telephone for full details:  
049481 - (Penn) - 4661

Prices:

401-6 (Hours, minutes, seconds) ..... £35  
401-4 (Hours, minutes) ..... £31  
401-6-R (As 401-6 with Nicad battery pack) ..... £46  
401-4-R (As 401-4 with Nicad battery pack) ..... £42

Ready-built units add £7 plus 8% VAT. U.K. only

Overseas — Add 10% extra for Air-parcel Post, no VAT

**ADVANTAGES OF THIS SUPERB MODERN CHRONOMETER:**

- ★ One second per month accuracy at room temperature
- ★ 3MHz quartz crystal used for best temperature stability
- ★ Rugged mechanical design ensures reliability for mobile use
- ★ All components supplied including wire, screws and case
- ★ Professional quality parts, glass fibre PCB
- ★ Large, easy to read LED display
- ★ 220/240V mains or external battery operation
- ★ Attractive polycarbonate case, brushed aluminium panel
- ★ One pulse per second and external display outputs available if required
- ★ Optional self-contained Nicad battery for portable use
- ★ No-cost extras include precision-engineered black anodised adjustable stand and power unit/battery charger
- ★ 12-month guarantee for correctly assembled kits and ready-built Chronometers

**FULL INSTRUCTIONS SUPPLIED**

TO: **ELECTRO SYSTEMS AND TIMING CO**

48 Robinson Road, Loudwater, High Wycombe, Bucks HP13 7BJ,  
ENGLAND

PLEASE SUPPLY: (UK residents add 8% VAT)

401-6 kit(s) at £35     401-6-R kit(s) at £46     Ready-built unit(s)  
 401-4 kit(s) at £31     401-4-R kit(s) at £42    (specify code number)

NAME .....

ADDRESS .....

I ENCLOSE CHEQUE/PO FOR £ .....

- ★ ELECTRONIC PIANO KIT
- ★ SYNTHESISER KIT
- ★ ELECTRONIC ORGAN KITS



There are five superb Electronic Organ kits specially designed for the D-I-Y enthusiast. With the extreme flexibility allowed in design, you can build an organ to your requirements, which will compare with an organ commercially built costing double the price.

★ Portable organ with 4 octave keyboard, £145.29. ★ Console organ with 5 octave keyboard, £250.95 ★ Console organ with 2 x 4 octave keyboards and 13 note pedal board. £470.65. ★ Console organ with 2 x 5 octave keyboards and 32 note pedal board. £680. ★ Console organ with 3 x 5 octave keyboards and 32 note pedal board. £960. ★ W/W Sound Synthesiser Kit. £130. ★ W/W Touch Sensitive Electronic Piano. £100.

All components can be purchased separately, i.e., semi-conductor devices, M.O.S. master oscillators, coils, keyboards, pedal boards, stop tabs, draw bars, key-contacts, etc.

Send 50p for catalogue which includes 5 x 10p vouchers or send your own parts list, enclosing S.A.E. for quotation.

## ELVINS

ELECTRONIC MUSICAL INSTRUMENTS

Designers and component suppliers to the musical industry  
12 Brett Road, Hackney, London, E8 1JP. Tel. 01-986 8455

## INDEX TO ADVERTISERS

Ambit	57
Arbour	67
Axial Products	72
B.H. Components	70
BIET	75
Bi-Pak	4&5
Bi-Pre-Pak	21
Bywood	9
Cambridge Learning Enterprises	69
Chiltmead	51
Decon	23
EDA	9
Electro Systems & Timing	73
Elektor	70
Elvins	74
Greenbank Electronics	72
Henry's Radio	67
Maplin Electronic Supplies	76
Marco Trading	72
A. Marshall & Sons	23
Minikits	57
Mulhall Electronics	73
Sinclair (Calculators)	inside front
Sinclair (Project 80)	52&53
Sintel	67
Tamar Electronics	72
Technomatic	71
Trampus	71
Wilmslow Audio	57

PLEASE MENTION ETI WHEN REPLYING  
TO ADVERTISEMENTS

# You might have seen some of these before :



Chances are you won't have seen them all

There is only one sure way to get every copy of ETI when it is published:

Make friends with Valerie Fuller; send her £4.25 (payable to ETI).

Then she'll get a copy for you when they come in from the printers and will send it to your home. **Every** month for a year.

To Valerie Fuller  
Subs. Department, ETI Magazine  
36 Ebury Street, London SW1W 0LW.

I enclose £4.25 (£4.75 overseas) which includes postage, for the next twelve copies of ETI.

Name

Address

6/75

# FREE!

## Over 150 ways to engineer a better future

**HIGHER PAY**  
**A BETTER JOB**  
**SECURITY**

### find out how in just 2 minutes

That's how long it will take you to fill in the coupon. Mail it today and we'll send you full details and a free book. We have successfully trained thousands of men at home - equipped them for higher pay and better, more interesting jobs. We can do as much for YOU. A low-cost home study course gets results fast - makes learning easier and something to look forward to. There are no books to buy and you can pay-as-you-learn.

Why not do the thing that really interests you? Without losing a day's pay, you could quietly turn yourself into something of an expert. Complete the coupon (or write if you prefer not to cut the page). No obligation and nobody will call on you . . . but it could be the best thing you ever did.

#### Others have done it, so can you

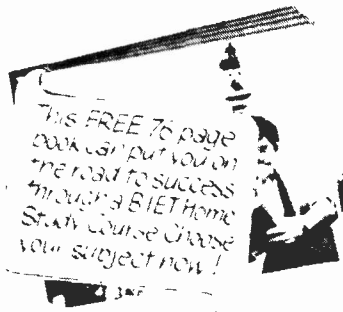
"Yesterday I received a letter from the institution informing that my application for Associate Membership had been approved. I can honestly say that this has been the best value for money I have ever obtained, a view echoed by two colleagues who recently commenced the course". - Student D.I.B., Yorks.  
"Completing your course, meant going from a job I detested to a job that I love, with unlimited prospects". - Student J.A.O. Dublin.  
"My training quickly changed my earning capacity and, in the next few years, my earnings increased fourfold". - Student C.C.P., Bucks.

#### FIND OUT FOR YOURSELF

These letters, and there are many more on file at Aldermaston College, speak of the rewards that come to the man who has given himself the specialised know-how employers seek. There's no surer way of getting ahead or of opening up new opportunities for yourself. It will cost you a stamp to find out how we can help you. Write to Aldermaston College, Dept. TET02, Reading RG7 4PF., Home of B.I.E.T.

Practical Radio & Electronics Certificate course includes a learn while you build **3 transistor radio kit.**

Everything you need to know about **Radio & Electronics** maintenance and repairs for a **spare time income** and a **career** for a better future.



**CUT OUT THIS COUPON**

Tick or state subject of interest. Post to address below.

- |  |   |
|--|---|
| <b>ELECTRICAL ENGINEERING</b><br>City & Guilds Wiring and Installations<br>C. G. Electrical Tech - Primary<br>Gen. Electrical Eng.   | <b>MECHANICAL ENGINEERING</b><br>Society of Engineers Inst. Engineers and Technicians<br>General Mechanical Eng. Welding<br>Maintenance Eng. General Diesel Eng.  |
| <b>AERONAUTICAL ENG.</b><br>Air Registration Board Certificates<br>Gen. Aero Engineering   | <b>DRAUGHTSMANSHIP</b><br>Institute of Engineering Draughtsmen & Designers<br>General Draughtsmanship<br>Architectural Draughtsmanship<br>Technical Drawing   |
| <b>AUTO ENGINEERING</b><br>City & Guilds Auto Engineering Practice<br>Inst. Motor Industry<br>M.A.A./I.M.I. Management Diploma<br>Gen. Auto Engineering<br>Auto Diesel Maintenance<br>Motor Mechanics<br>Service Station and Garage Management | <b>CONSTRUCTION &amp; BUILDING</b><br>Institute of Building<br>Construction Surveyor's Inst. Clerk of Works Diploma<br>C. & G. Building Quantities<br>General Building<br>General Civil Eng.<br>Heating, Ventilating & Air Conditioning<br>Carpentry & Joinery<br>Painting & Decorating<br>Plumbing |
| <b>TELECOMMUNICATIONS</b><br>City & Guilds Telecommunications  | C.E.I. (Part 1)<br>Inst. Cost & Management Accountants<br>Works management etc. etc.  |
| <b>RADIO &amp; TV</b><br>Gen. Radio and TV Eng.<br>Radio Servicing, Maintenance and Repairs<br>Practical Radio & Electronics (with self-build kit)<br>Radio Amateurs' Exam   | <b>ELECTRONIC ENGINEERING</b><br>Gen. Electronic Eng.<br>Practical Electronics (with kit)   |
| <b>AGRICULTURAL ENG.</b>   | <b>REFRIGERATOR SERVICING</b>   |

G.C.E. - 58 'O' & 'A' Level Subjects 1 over 10,000 Group Passes!

Coaching for many major exams. including ONC, C & G, etc.

## POST TODAY FOR A BETTER TOMORROW

To Aldermaston College, Dept. TET02, Reading RG7 4PF. TET02.

NAME .....  
Block Capitals Please  
ADDRESS .....

POSTCODE .....

OTHER SUBJECTS ..... AGE .....

Accredited by C.A.C.C. Member of A.B.C.C.

**HOME OF BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY**

# 3 GREAT PROJECTS

## FOR YOU TO BUILD

### \* AN EXCITING ELECTRONIC ORGAN



#### BUILD AN ORGAN TO YOUR OWN SPECIFICATION!

Full construction details in our leaflets.

Leaflet MES 51 price 15p, describes a fully polyphonic basic organ which can be used later as the basis of a large sophisticated instrument.

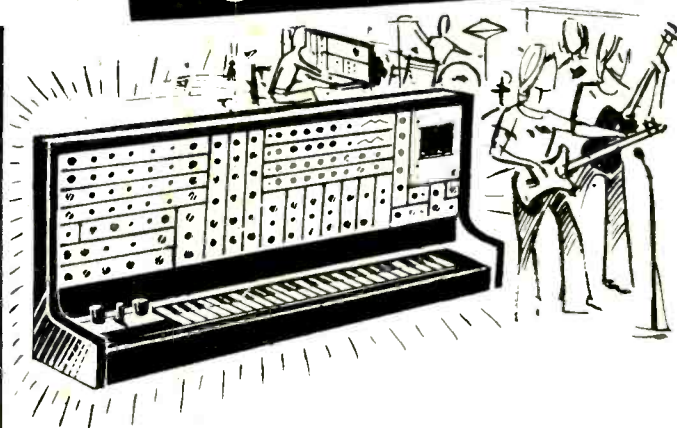
Further leaflets issued at approx. 3 monthly intervals describing; more footages, solid state switching, foot pedal board, many more stops, special effects, rhythm section, "Leslie" speaker etc.

At every stage in this organ we shall be using the very latest technology, to give you a really high quality instrument, that is not only on a par with, but probably in advance of most commercially available organs.

#### REDUCED COSTS!

Eventually you could be the owner of a highly sophisticated instrument, and parts of it will still be using the original components you bought for the basic organ. Of course this means greatly reduced costs and the satisfaction of having "built it yourself."

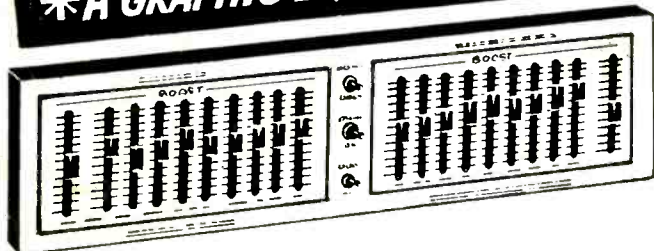
### \* THE INTERNATIONAL 4600 SYNTHESISER



We stock all the parts for this brilliantly designed synthesiser, including all the PCB's, metalwork and a drilled and printed front panel, giving a superb professional finish. Opinions of authority agree the ETI International Synthesiser is technically superior to most of today's models. Complete construction details available shortly in our booklet. S.a.e. please for specification and price lists.

\* We shall be stocking all parts for the International 3600 Synthesiser, to be published shortly.

### \* A GRAPHIC EQUALIZER for under £50!



A really superior high quality stereo graphic equaliser as described in Jan. 1975 issue of ETI. We stock all parts (except woodwork) including all the metal work drilled and printed as required to suit our components and PCB's. S.a.e. for price list.

GET A SUPERSONIC SAME-DAY-SERVICE  
WITH QUALITY COMPONENTS - FAST!

# MAPLIN ELECTRONIC SUPPLIES



Our fantastic 1975 Catalogue is much more than just a stock list. Inside its attractive glossy cover it is packed with; **CIRCUITS YOU CAN BUILD** . . . A 10 w stereo tuner-amp, a MW/LW radio, a high quality pre-amp, a 10w stereo power amp, a digital clock. Application circuits for our I.C's (e.g. a frequency doubler, audio amps and pre-amps, flip-flops power supplies, notch filter etc. etc. Detailed data on all our semiconductors. A comprehensive transistor equivalents list. Full data and hundreds of pictures of the thousands of lines we stock, including hundreds of new ones!

P.O. Box 3 · RAYLEIGH · ESSEX Telephone: Southend-on-Sea (0702) 44101  
VAT. Please add