CB RADIO – NEWS AND VIEWS INSIDE

Hobby Electronics

November '80

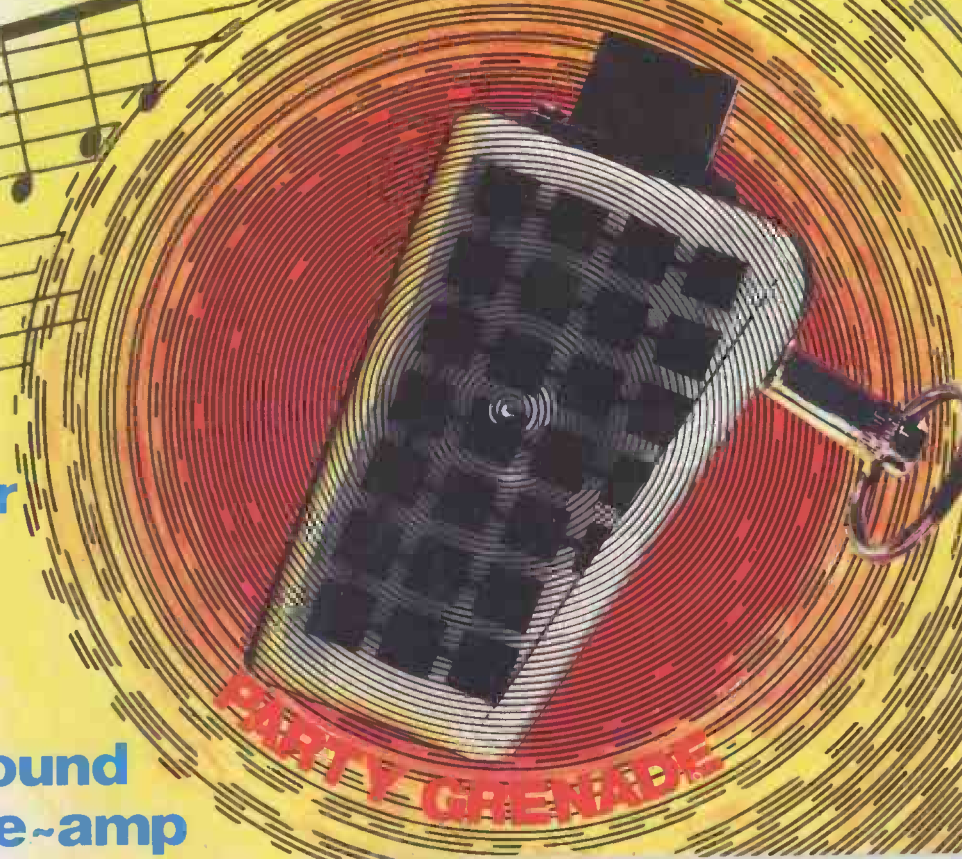
ISSN 0142-6192

55p

BUILD OUR £30 SYNTHESISER

EASILY CONSTRUCTED

REMEMBERS THE TUNES



Sort Out The Good From The Dud With Our DIY Transistor Tester

Save ££££'s With Our Simple Battery Eliminator

Boost Your Guitar Sound With Our Built-in Pre-amp

WE'VE COME A LONG WAY...
and it didn't take very long either. Electronics have evolved faster than anything else. From Marconi's first crackling morse transmissions to minichip in a lifetime. But space-age technology poses it's own problems to dealers anywhere. The days you strung your own aerial with a length of copper wire bought just around the corner are over. Nowadays, if you want the best you'll probably have to go to the States, or Japan, or Denmark ... or you can contact us. We're not just around the corner, but very nearly so. Located just about an hour from London, near Schiphol airport in Holland we have one of Europe's largest collections of aerials, CB equipment, accessories, electronics etc. from all over the world. Whether it's Danish, Japanese, American or anything else, we've got all the top names at bottom prices.
So, plug into the mains and contact
WINTJOY Ltd. 103 High Street, Shepperton, Middlesex TW17 9BL, England Tel. Walton-on-Thames (STD 09322) 48145
Or just simply call us.
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ELECTRONICS HAVE GROWN UP
WHY DON'T YOU, TOO

Hobby Electronics

NOVEMBER 1980
Vol.3 No. 1

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NEWS & INFO

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ILP

SIMPLY AHEAD and staying there

The range grows bigger...better...

New Profile Amplifiers - Two New Series

MOSFET

CHOOSE AN I.L.P MOSFET POWER AMP when it is advantageous to have a faster slew rate, lower distortion at higher frequencies, enhanced thermal stability, the ability to work with complex loads without difficulty and complete absence of cross-over distortion. I.L.P's exclusive encapsulation technique within fully adequate heatsinks has been taken a stage further with specially developed computer-verified 'New Profile' extrusions. These ensure optimum operating efficiency from our new MOSFETS, and are easier to mount. Connection is via five pins on the underside. **I.L.P MOSFETS ARE IDENTICAL IN PERFORMANCE TO THE COSTLIEST AMPLIFIERS IN THIS EXCITING NEW CATEGORY BUT ARE ONLY A FRACTION OF PRICES CHARGED ELSEWHERE.**

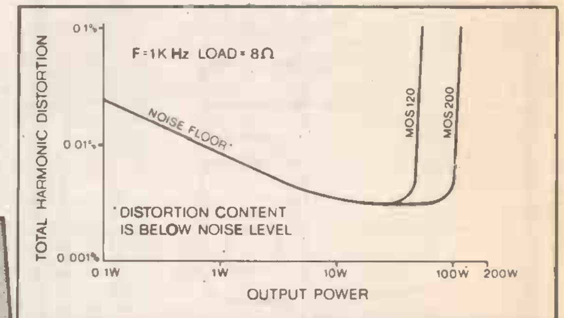
Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

BIPOLAR

CHOOSE AN I.L.P BIPOLAR POWER AMP where power and price are first consideration while maintaining optimum performance with hi-fi quality and wide choice of models. From domestic hi-fi to disco and P.A., for instrument amplification, there is an I.L.P Bipolar to fill the bill, and as with our new Mosfets, we have encapsulated Bipolars within our New Profile extrusions with their computer-verified thermal efficiency and improved mounting lugs. Connections are simple, via five pins on the underside and with our newest pre-amps and power supply units, it becomes easier than ever to have a system layout housed the way you want it.

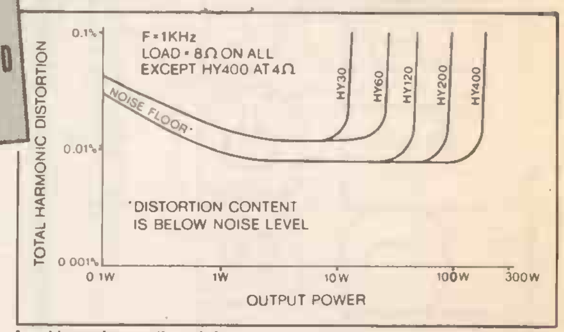
Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£6.34 + 95p
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.24 + £1.09
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£15.20 + £2.28
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£18.44 + £2.77
HY400	240W into 4Ω	0.01%	15V/μs	5μs	100dB	£27.68 + £4.15

ILP POWER AMPS ARE ENCAPSULATED FOR THERMAL STABILITY AND LONGER LIFE



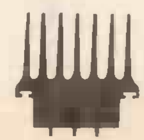
Load impedance both models 4Ω-∞ Input sensitivity both models 500mV

Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB



Load impedance all models 4Ω-∞ Input sensitivity all models 500mV

Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



THE NEW PROFILE EXTRUSIONS

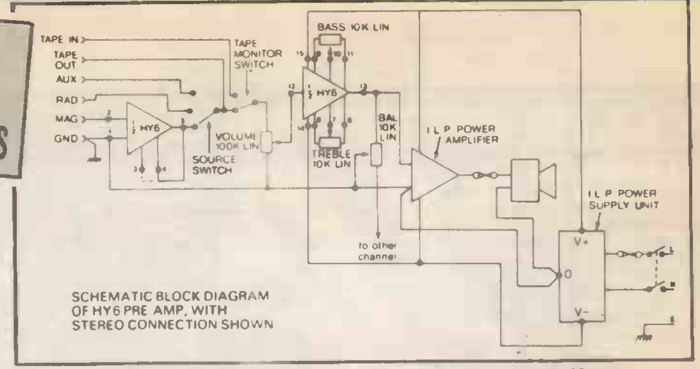
The introduction of standard heatsink extrusion for all I.L.P power amplifiers achieves many advantages:– Research shows they provide optimum thermal dissipation and stability. Slotted shoulders allow easy mounting; standardisation enables us to keep our prices competitive. Surfaces are matt black, anodised for lower thermal conductivity. Extrusions vary in size according to module number.

NEW PRE-AMPS

HY6 (mono) and **HY66** (stereo) are new to I.L.P's range of advanced audio modules. Their improved characteristics and styling ensure their being compatible with all I.L.P power-amps both MOSFET and BIPOLAR, giving you chance to get the best possible reproduction from your equipment. HY6 and HY66 pre-amps are protected against short circuit and wrong polarity. Full assembly instructions are provided. Mounting boards are available as below.
Sizes – **HY6** – 45 x 20 x 40 mm. **HY66** – 90 x 20 x 40 mm.
Active Tone Control circuits provide ±12dB cut and boost.
Inputs Sensitivity – Mag. PU. –3mV: Mic – selectable 1-12mV: All others 100mV. **Tape O/P** – 100mV: **Main O/P** – 500mV: **Frequency response** – D.C. to 100KHz – 3dB.

HY6 mono £5.60 + 84p VAT Connectors included
HY66 stereo £10.60 + £1.59 VAT Connectors included
B6 Mounting Board for one HY6 78p + 12p VAT
B66 Mounting Board for one HY66 99p + 15p VAT

COMPATIBLE WITH ALL ILP MODULES



SCHEMATIC BLOCK DIAGRAM OF HY6 PRE AMP, WITH STEREO CONNECTION SHOWN

- **DISTORTION TYPICALLY 0.005%**
- **S/N RATIO – 90dB (Mag. P.U. – 68 dB)**
- **38 dB overload margin on Mag. P.U.**
- **LATEST HIGH QUALITY CONNECTORS**
- **ONLY POTS, SWITCHES AND PLUGS/SOCKETS NEED ADDING**
- **NEEDS ONLY UNREGULATED POWER SUPPLY ± 15 to ± 60v**

NEW POWER SUPPLY UNITS

IN A RANGE OF 11 MODELS USING LATEST TOROIDAL TRANSFORMERS

Of the eleven power supply units which comprise our current range, nine have toroidal transformers made in our own factory. Thus these I.L.P power supply units are space-saving, more efficient and their better overall design helps enormously when assembly building. All models in the range are compatible with all I.L.P amps and pre-amps with types to match whatever I.L.P power amps you choose.

PSU30 ± 15V at 100mA to drive up to 12 x HY6 or 6 x HY66	£4.50 + 0.68p VAT
THE FOLLOWING WILL ALSO DRIVE I.L.P PRE-AMPS	
PSU36 for 1 or 2 HY30's	£8.10 + £1.22 VAT
PSU50 with toroidal transformer for 1 or 2 HY60's	£9.75 + £1.46 VAT
PSU60 with toroidal transformer for 1 HY120	£9.75 + £1.46 VAT
PSU65 with toroidal transformer for 1 MOS120	£9.75 + £1.46 VAT
PSU70 with toroidal transformer for 1 or 2 HY120's	£13.61 + £2.04 VAT
PSU75 with toroidal transformer for 1 or 2 **MOS120**	£13.61 + £2.04 VAT
PSU90 with toroidal transformer for 1 HY200	£13.61 + £2.04 VAT
PSU95 with toroidal transformer for 1 **MOS200**	£14.75 + £2.21 VAT
PSU180 with toroidal transformer for 1 HY400 or 2 HY200	£23.02 + £3.45 VAT
PSU185 with toroidal transformer for 1 or 2 **MOS200**	£24.20 + £3.63 VAT

1971-1980
TEN YEARS OF PLANNED PROGRESS

When, as a young man in 1971, Ian L. Potts founded his now world-famous company, he realised the need for a different and more rational approach to exploiting to the maximum, the potential of modular construction. New thinking was badly needed. The result was a range of modules completely revolutionary in concept. The rightness of Ian Potts' thinking is shown in the size of the company today, its new factory, its vast exports, its acceptance by constructors as *the* modules to build with. The range grows bigger and better. New lines (in no way replacing existing ones) are well past drawing board stage. This is why I.L.P are simply ahead and staying there – we don't rest on our laurels.

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Monitor

Cellular Construction

How many times have you been faced with a suspect 'dud' battery with no way of testing it? There's absolutely no excuse any more with this ingenious battery/cell tester/charger/bulb and fuse checker. No, it won't make the tea but that is about the only omission we can see. As you can see from the picture it will accept any cell or battery from the largest to the smallest (including watch and calculator batteries). The bulb tester section will happily accommodate any size of torch or instrument bulb and the test leads can check fuses and filaments for continuity. With the addition of a simple battery eliminator the unit will charge virtually the whole range of Ni-Cad cells and batteries. By now you should be asking the price of this marvel. You won't be disappointed because it will only cost £11.95 (plus VAT). It should be in the better electrical and electronics shops about now, ask for the X10 Battery Tester/Charger. If you have any difficulty then contact the importers who are: Northern Technical & Chemical Services Ltd of Liverpool.

Déjà Vu

Just as the sun rises each morning you can predict with equal certainty that somebody would try and copy the incredibly successful Sony Stowaway stereo cassette player.

A couple of months ago we told you how the Stowaway was becoming a craze, even at £99.00! Sony couldn't make enough of them. Now, entering stage left is the Binatone Company with its Hipfi. We had to look at it very closely indeed to make sure it was not a Stowaway with different makings, they're as similar as that! At the time of writing we haven't had a chance to cast a critical ear to the device but at only £59.95 it's bound to be a winner. It may even persuade Sony to drop its price. All of the features of the Stowaway are there, even a 'Talk Line' which bears more than a passing resemblance to the Sony 'Hot Line'. (This is a facility which will allow you to listen to the tape and nearby conversation via the built-in microphone.) The only real difference is the headphones: obviously Binatone couldn't use the amazing MDR3s from Sony. Instead they have developed their own lookalikes which we'll report on in the next issue. Meanwhile if you want to try them out for yourself then get along to Selfridges in Oxford Street. Binatone may be contacted direct at: Binatone House, 1 Beresford Avenue, Wembley, Middlesex HA0 1YX.

Notes From Casio

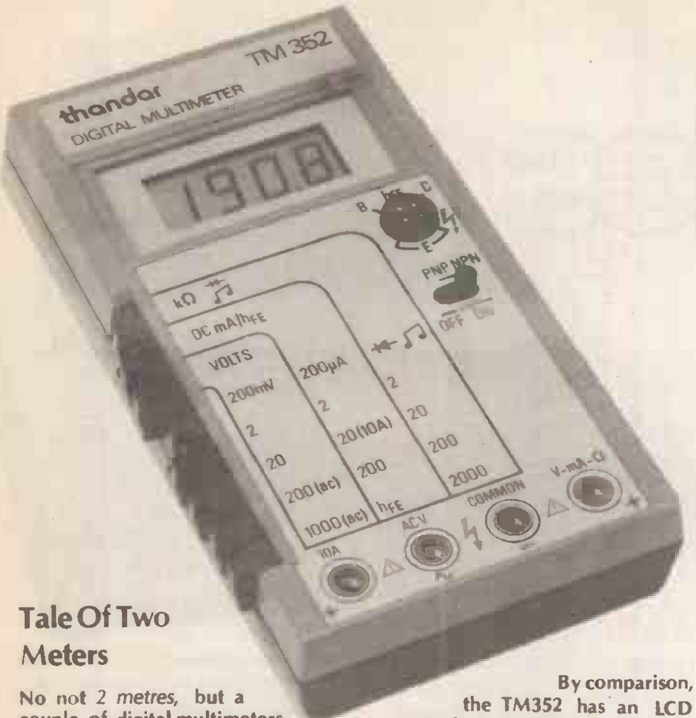
Our friends at Casio are back with a vengeance this month with no less than three singing and dancing boxes full of electronic wizardry.

First (and smallest) is an interesting new calculator that not only plays tunes but boasts a devastating and compulsive game that you just cannot put down. The MG-880 is fairly conventional in the calculator department with memory and percentage etc. Numerical keys are all designated with a musical note (do, re, me etc.) so even the most mundane calculations become a musical experience. The game is really clever. You control a 'laser' weapon that must destroy the alien hoards that attempt to cross the LCD screen from right to left. Each alien is represented by a single digit. To destroy the alien you must match the digit with your aim button which steps through the numbers 0-9 sequentially. When the correct digit has been selected the fire button will eliminate the monster. As you might expect the game starts relatively slowly and speeds up to a superfast speed that is virtually impossible to defeat.

So much for the brainy stuff, the other offerings from Casio are much less demanding. They are a pair of very good-looking electronic organs. The smaller of the two is called the Casiotone M-10. It is a fully polyphonic musical instrument offering 2½ octaves via 32 keys. Four effect keys give piano, violin, flute and organ voices. The M-10s larger brother is called the Casiotone 201 and covers four octaves. There are something like 30 different voices and effects that should keep the neighbours annoyed for weeks.

Now for the important bit (all bank managers please avert their eyes at this point). The MG-880 game can be yours for just £10.95. The M-10 is a very reasonable £69.00 and the 201; a paltry £245.00. All these prices are inclusive of VAT and P & P from our good friends Tempus. Find them at: 164-167 East Road, Cambridge CB1 1DB.

News from the Electronics World



Tale Of Two Meters

No not *2 metres*, but a couple of digital multimeters, the TS1000 from Eagle International, and the TM352 from Thandar.

Taking the TS1000 first, it has a 3½-digit LED display (8 mm characters) and provides 16 ranges covering DC and AC voltage, DC current and resistance. Features include h_{FE} and diode test. Despite having an LED display, the four HP7 batteries, claims Eagle, last between 150 and 200 hours. It can also be powered from an external 9 V DC supply. The TS1000 has a two-year guarantee and costs around £60 including VAT.

By comparison, the TM352 has an LCD display (12.5 mm characters). It also has 16 ranges, but in addition to h_{FE} and diode tests it includes a continuity check, where a buzzer sounds if measured resistance is less than 130R ± 50R. Life of the 9 V PP3 battery is claimed to be in excess of 150 hours. The TM352 has a one-year warranty and costs around £50.

Both meters incorporate overload protection and are supplied with test leads. A brief, and almost identical, specification for each is given below. Lower figures (such as 100 uV from 100 uV to 1 kV) apply to limits of lowest ranges.

	TS1000	TM352
Input impedance	10MR	10MR
DC voltage	200 mV to 1 kV	200 mV to 1 kV
AC voltage	200 V to 1 kV	200 V to 1 kV
DC current	200 uA to 10 A	200 uA to 10 A
Resistance	2kR to 2MR	2kR to 2MR
Accuracy	±1.2% ±2 digits all ranges	±1% on 10 A and resistance ranges, < ±1% on all other ranges

Mobile Mayhem

Now be honest with yourself, how much money have you spent on pub Space Invader machines? At ten pee a go you would have been able to buy your very own Space Invader game after only 220 plays. Admittedly this new hand-held version isn't exactly the same as the pub game but it is easily the best portable machine we've seen. It's called Electronic Space Invaders and comes from a company called Entex. The Entex version has two columns of aliens, two laser bases and the obligatory flying saucer, worth 10, 20 or 30 points when hit. Two levels of play are available. Our best score to date is 450 on the 'Pro' level. As the top score is 999 you can see we've a long way to go. The only real criticism of the game is the lack of brightness on the display. When we first tried it out we thought the batteries were dead, a new set proved us wrong. It only becomes a nuisance in strong light but it is a minus point on an otherwise excellent game. Space Invaders is available from our old friend NIC for £21.95. Keep a look out for more Entex games: we've had some samples in the office and can say with confidence that this is one games company with a lot of original ideas.

Just In Case

Project housings continue to look more and more like commercial boxes — here is a prime example from Vero. It is called simply the Pocket-Size, Hand-Held Box, and measures about 80 x 110 mm. The cut-out in the top will happily accommodate an LED display or switch panel. In the underside, Vero have sectioned off a battery compartment just right for PP3s or Ni-cads. The slide-off cover allows for easy battery replacement. Inside the case there is room for a PCB measuring up to 71 x 107 mm in the bottom section whilst the top half can take another board up to 56 x 105 mm. The top and bottom sections are held together by four self-tapping screws. For more information on this box and Vero's extensive range of attractive casings contact them at: Vero Electronics Ltd. Industrial Estate, Chandlers' Ford, Eastleigh, Hampshire SO5 3ZR.

Tip Top Shape

Announcing the latest four-hour VHS video tape from JVC. Until now the best you could get was a mere three hours recording time. This new tape, designated the E240 will be undergoing a market trial in the next few months. What am I bid for the Betamix system, do I hear five hours.

Ancient Audio

Way back in the September issue we told you all about the Vintage Wireless Company's interesting publication. Well, if you are interested in vintage radios then you may like to subscribe to the Vintage Wireless Company's newsletter. This is available for just £2.50 per year (£4.00 overseas) from: The Vintage Wireless Company, 64 Broad Street, Staple Hill, Bristol BS16 5NL.

Clever Clock

Have you noticed the new clock on BBC 2 lately? Chances are you haven't because it looks quite ordinary. Actually it's not what it seems, it is generated electronically, totally solid-state and of course very accurate. Next time it comes on your screen have a close look, it really is ingenious.

Errata

Guess what. There is no Errata this month. We actually got it right. Is this the shape of things to come?

TH. NEXT MONTH. NEXT MONTH. NEXT MONTH. NEXT MONTH. NEX

Hobby Electronics

ON SALE NOVEMBER 14th

Video Disc Systems

Just as video cassette machines are becoming firmly established next to the family TV, a relatively new method of video *playback* has been announced. We look at what it is, how it works and what it is likely to cost.

Audio Power Meter

Is your hi-fi amp LOUD enough for the neighbours? Our stereo bar-graph power meter shows you at a glance your watts-per-channel. It can be calibrated either in watts or nuisance units.

Dynamic Digital Speedo

Would you like your dashboard to look like that of an Aston Martin Lagonda? (Unless you've already *got* a Lagonda, that is.) Well, at least you can make a start with our digital speedo. If you get the calibration right you should keep closer to the legal speed limits. (No, it's not electronically coupled to the throttle.)

Model Train Controller

'Not *another* train controller!' you may say, but wait and see — this one's different. It uses pulsed control to give you a s-m-o-o-t-h chug response rather than the unrealistic lurch produced by some conventional controllers.

We are also planning another train modellers' project for the New Year which will work in conjunction with the HE train controller.

Battery Charge Indicator

Let's face it, not *every* car has an ammeter, voltmeter or other indication of battery state. But many motorist-readers will have suffered problems with their generators, alternators, regulators, or, of course, batteries. With this second HE car project for the December issue you can have a clear visual display of battery voltage.

Jack Lead Tester

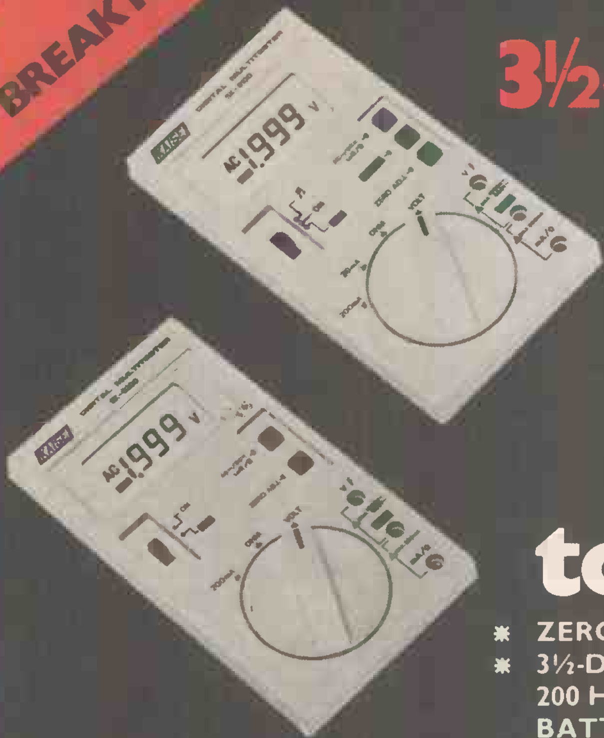
Ever been let down on the job? Ever been stuck with a faulty jack plug lead? Many a musician has, that's for sure. The HE jack lead tester is pocket-sized and tells you instantly what the fault is. Not only that, it only costs around £2.

AS ADVERTISED ON LOCAL RADIO

TH. NEXT MONTH. NEXT MONTH. NEXT MONTH. NEXT MONTH. NEXT MO

items mentioned here are those planned, but unforseeen circumstances may affect the actual contents.

DMM BREAKTHROUGH



If you want an Autoranging 3½-digit LCD DMM For only £39.95 (inc VAT)

We've got to hand it to you!

* ZERO ADJUSTMENT
* 3½-DIGIT LCD WITH 200 HRS CONTINUOUS BATTERY LIFE
* AUTO 'BATT' WARNING
* FULL AUTORANGING
* AUTO UNIT DISPLAY
* CONTINUITY TEST (6110 and 6100 only)
* 10 AMP AC/DC (6110 and 6220 only)

Introducing the latest professional state-of-the-art 3½-digit DMM – at really old-fashioned prices! From just an unbelievable £39.95 inc. VAT, plus £1.15 p&p!

	6100	6110	6200	6220
RESOLUTION	1mV, 10µA, 0.1Ω on all models			
FULL AUTO RANGING	✓	✓	✓	✓
RANGE HOLD	✓	✓		
UNITS OF MEASUREMENT DISPLAYED	mV, V, mA	mV, V, mA, A	mV, V, mA	mV V mA A
FUNCTIONS DISPLAYED	Ω, KΩ, AUTO, BATT, ADJ, LO, – and AC			
MEASURES DC VOLTAGE TO	1000V	1000V	1000V	1000V
MEASURES AC VOLTAGE TO	750V	750V	750V	750V
MEASURES AC DC CURRENT TO:	200mA	10A	200mA	10A
ZERO ADJUSTMENT	Zeros out minute test-lead resistances for precise measurements			
ACCURACY	0.5%	0.5%	0.8%	0.8%
LOW POWER OHM RANGES	For in-circuit resistance measurements on all models			
BUZZER – Continuity Test	✓	✓		
BUZZER – Over Range Indicator	✓	✓		
COMPLETE WITH	Batteries, pair of Test Leads, Spare Fuse, One Year's Guarantee			
PRICE	ONLY £64.95	ONLY £74.95	ONLY £39.95	ONLY £49.95
p&p	£1.15	£1.15	£1.15	£1.15

Why such a low, low price? Because the A/D converter and display are custom built! This is a genuihe top-spec DMM. Check these features for *unbeatable* value – you won't find a hand-held DMM with these features at these prices again!

I believe you! Please send me the DMM/s as marked.

_____6200 @ **£41.10** each, inc. VAT, p&p. Total price £______
_____6220 @ **£51.10** each, inc. VAT, p&p. Total price £______
_____6100 @ **£66.10** each, inc. VAT, p&p. Total price £______
_____6110 @ **£76.10** each, inc. VAT, p&p. Total price £______

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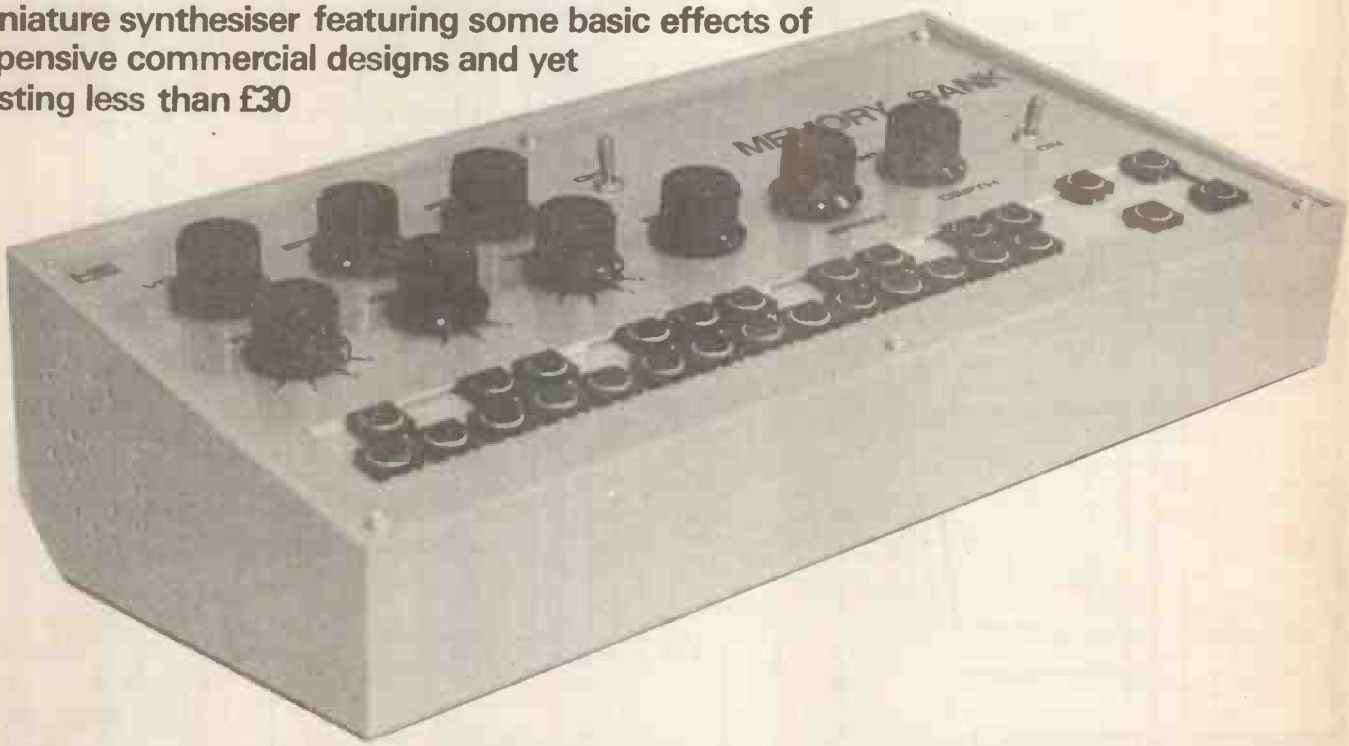
Mini Synth With Memory

Ideal for the music enthusiast, Memory Bank is a single chip miniature synthesiser featuring some basic effects of expensive commercial designs and yet costing less than £30



WELL, WE'VE GOT to admit it! When we first set about producing this project for £30 we didn't think it was going to be possible. We immediately had visions of banks of circuits each producing a different effect and hundreds of ICs — just how were we going to break this £30 price barrier? Not to be deterred, we sent out feelers to our many contacts in the electronics market. Finally, word began filtering through of a new IC which would do; not only most of the job itself, but it also had an accessible memory from which to record and recall notes in a sequencial fashion. The name Memory Bank stems from this function — the chip stores a 32 beat-length sequence of notes and spaces and, upon recall, replays the sequences at one of four switched tempos.

The IC in question is of the same family as the doorbell chip — you know, the one which produces 4000603½ tunes simply by pressing one button! But — and this is important — *not exactly the same one*. They are all known under the family number of TMS 1000N and are produced by Texas Instruments. Officially, they are 'dedicated micro-processors' which means that they are, in essence, small *computers* designed and programmed for one purpose.

Many of the features of Memory Bank stem directly from the chip, as it is so versatile but one or two features are additional, hence the use of a number of components around the IC.

Effective Effects

The main oscillator provides two squarewave output signals an octave apart. Effects pot RV4 allows a controlled variable mix of these two frequencies so that the overall output is not necessarily a pure square wave and consequently more pleasant to the ear. The frequency of the oscillator can be varied by RV3, the pitch control. Incidentally, a control voltage can be fed to the wiper of this potentiometer to give a VCO (voltage controlled oscillator) function seen in expensive commercial synthesisers.

The envelope control gives a variable attack and decay to each individual note — from a quick staccato effect to a long slow increase and decrease in volume. For instance, set at the longest attack and decay, Memory Bank produces a sound akin to a phased echo. This is perhaps one of the most interesting effects.

Vibrato is a standard effect where by the pitch of the main oscillator is frequency-modulated; that is, the centre frequency of the oscillator is raised and lowered slightly at a variable depth at a variable rate between about 1 to 10 Hz.

Other switched controls allow a

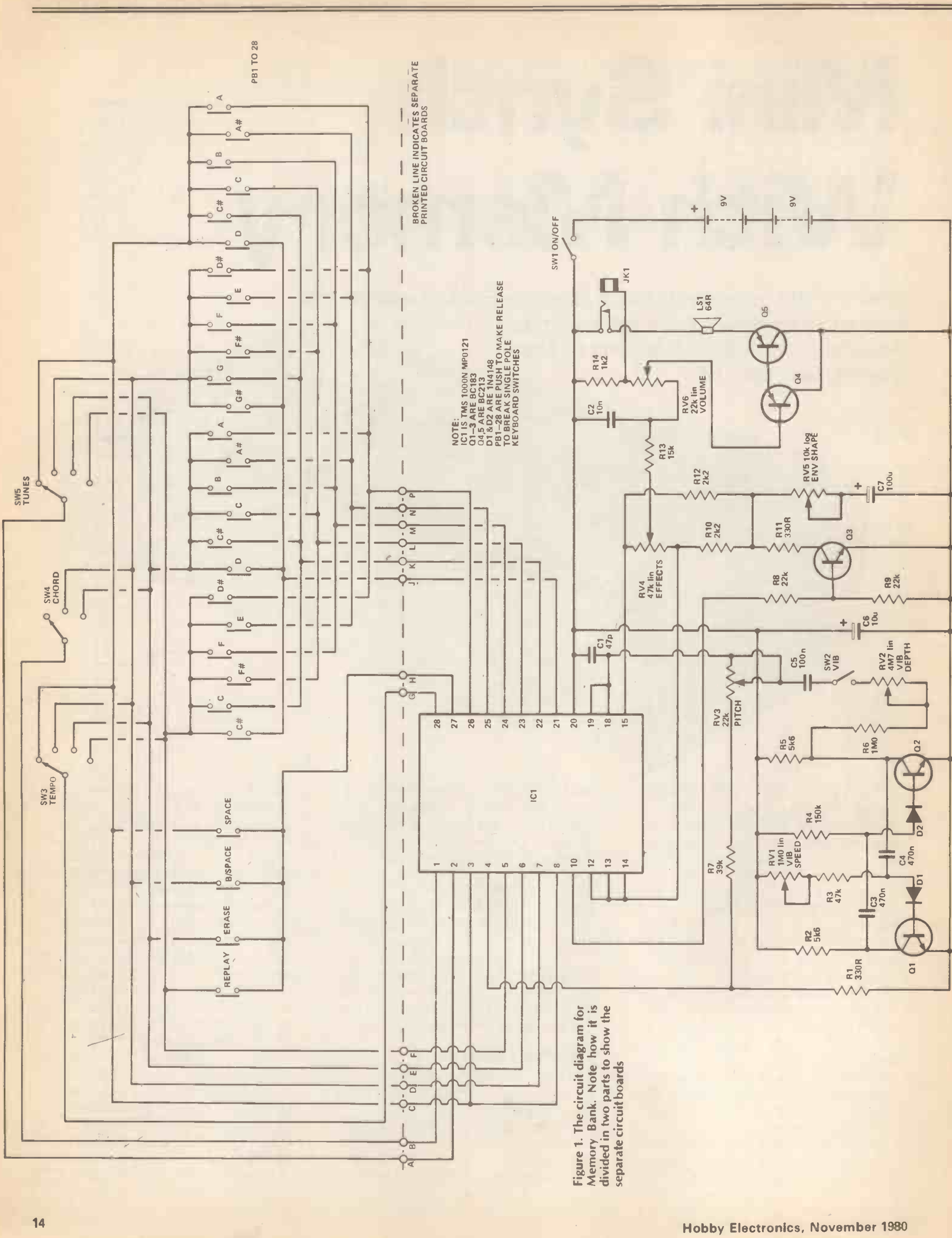


Figure 1. The circuit diagram for Memory Bank. Note how it is divided in two parts to show the separate circuit boards

How it Works

IC1 is the heart of the project. Being a dedicated device it does much of the donkey work, acting simply as a control device between the switched keyboard inputs and the audio circuit outputs. Pressing a key on the keyboard indicates to the TMS 1000N what is required: it then generates the correct response or set of responses. A more detailed description of the circuit follows.

About half way up the circuit diagram is a broken line indicating the two separate PCBs of the project and the 14 connections which are needed between them. The upper board contains the keyboard with 28 push-button switches — 24 notes and four controls — and three rotary switches. The connections, although looking complex, are actually straightforward. Pins 21 to 26 of IC1 are the 'NOTE' outputs which feed directly, via inter-board connections J, K, L, M, N, P to the note keypad. The keys are arranged in six groups of four.

The 'RETURN' inputs of IC1 (pins 5 to 8) are taken via inter-board connections C, D, E, F to the other side of the keys in four groups of six. Whenever a key is pressed, a NOTE output is connected to a corresponding RETURN input. In this way, one of 24 (that is, 6 × 4) different connections can be made, by pressing one keyswitch. A two-octave capability is possible with 24 notes, and we have arranged the keys from note A to G sharp, two octaves up.

The RETURN inputs are also used via PB1 to 4 and SW3 to 5 as returns for the memory (pin 27), tempo (pin 28), chord (pin 1) and tunes (pin 2) outputs of the integrated circuit, in the same manner as detailed above.

Capacitor C1, which charges up through R7 and RV3, determines the main oscillator frequency. Altering the position of RV3 thus alters the charge rate and the output frequency changes accordingly. The output of the main oscillator is divided down inside the IC to one of 24 output note frequencies. Pressing one of the note keyswitches will produce the corresponding note at pin 14. A frequency of half the pin-14 frequency is obtained at pin 15, providing the basis of a useful effect. The two outputs are connected directly across RV4 and so the wiper of this pot gives a straight mix dependent on position, which is amplified by Q4 and Q5 then fed to the miniature loudspeaker.

A pulsed output is given from pin 10 of the IC every time a note is played. We have used this facility to trigger a variable envelope shaper built around Q3 and its associated components. The charge and discharge rate of C7 defines the slope on the envelope of output sound, and so varying RV5 to alter this rate controls the attack and decay of each note. This pin 10 output could also be used to trigger voltage controlled amplifiers (VCAs) filters (VCFs), etc. in a more complex synthesiser circuit.

Finally, Q1 and Q2 are connected as an astable multivibrator with a variable frequency of between about 1 Hz and 10 Hz. Potentiometer RV1 controls frequency. The output of the astable is taken via RV2 (depth) to the main oscillator pot (RV3 - pitch), thus modulating the frequency of the main oscillator in a vibrato manner.

Parts List

RESISTORS (All ¼ W, 5%)	
R1,11	330R
R2,5	5k6
R3	47k
R4	150k
R6	1M
R7	39k
R8,9	22k
R10,12	2k2
R13	15k
R14	1k2

POTENTIOMETERS	
RV1	1M lin
RV2	4M7 lin
RV3,6	22k lin
RV4	47k lin
RV5	10k log

CAPACITORS	
C1	47p polystyrene
C2	10n polyester
C3,4	470n polyester
C5	100n polyester
C6	10u 25V electrolytic
C7	100u 16V electrolytic

SEMICONDUCTORS	
IC1	TMS1000N MP0121
Q1,2,3	BC183 NPN transistor
Q4,5	BC213 PNP transistor
D1,2	1N4148 diode

MISCELLANEOUS	
PB1 to 28	push-to-make, release-to-break, single-pole keyboard switches
SW1,2	single-pole, single-throw toggle switches
SW3,5	4-way rotary switches
SW4	3-way rotary switches
JK1	Stereo ¼ in. jack socket
2 × PP3 type batteries and clips	
Case to suit	
9 × knobs	
64R miniature loudspeaker	

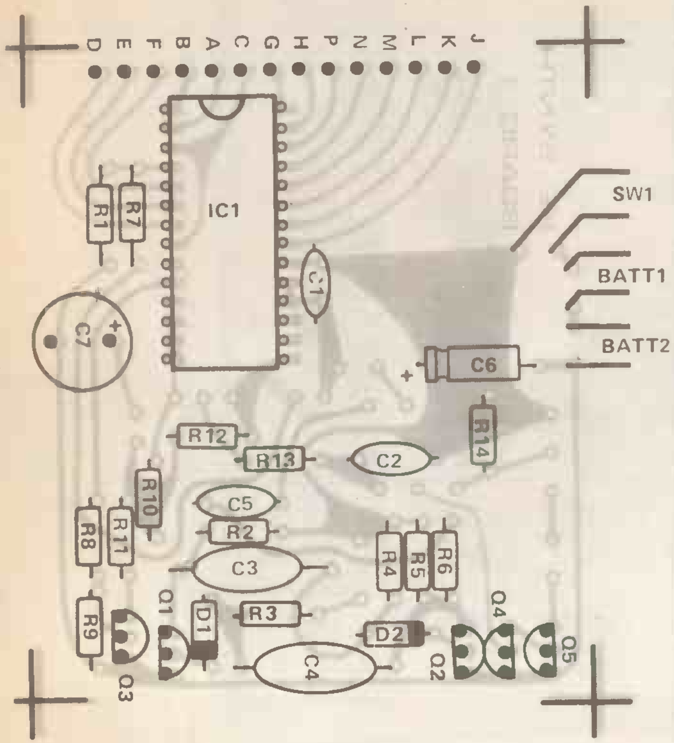
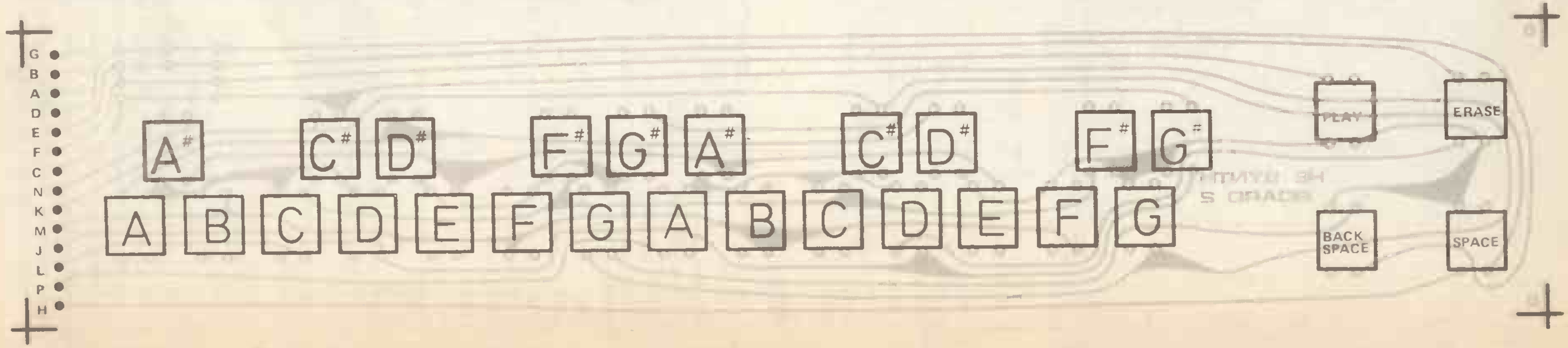


Figure 2. Overlay of the main circuit board. Make sure you insert all polarised components the correct way round

Figure 3. Below, is the overlay of the keyboard PCB. It is shown at about 65% reduction



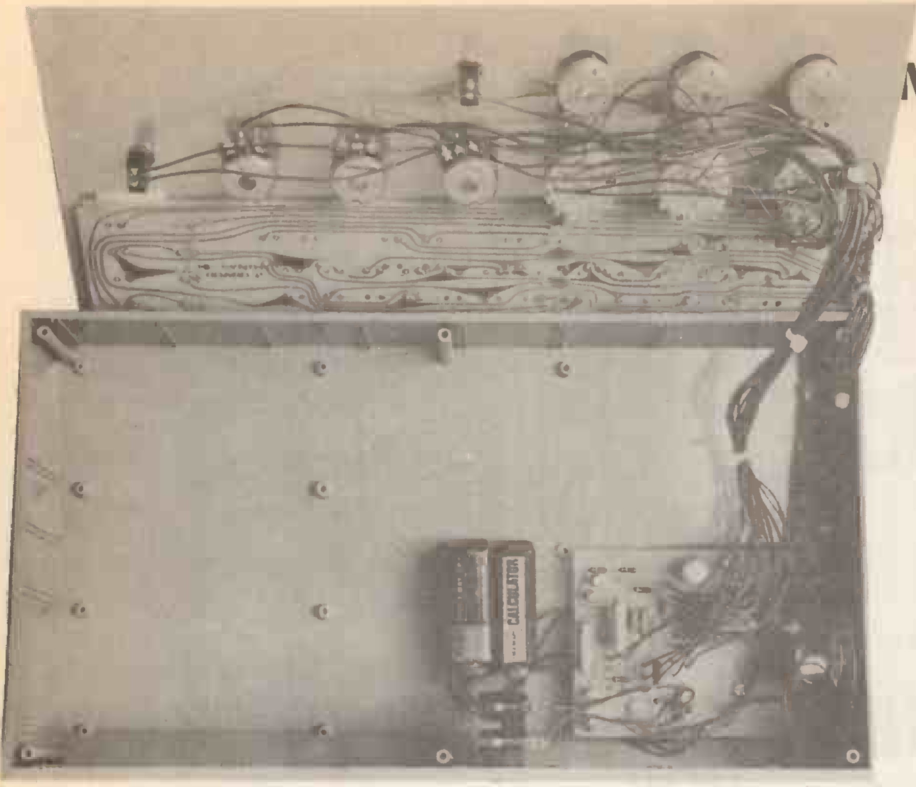


Figure 4. Lots and lots of interwiring, isn't there? Wait till next month before you commence wiring and we'll tell you the best way to do it

variety of extra facilities such as an echo where every note played is automatically repeated three times, or a chorded sequence where the played note produces the three harmonic notes of a basic chord in rapid succession.

All Keyed Up

Obviously we couldn't produce the project with a standard piano-type keyboard — that alone would cost more than the price limit of £30 — hence the use of push-button switches. But a musical-style layout with 24 buttons from A to G sharp two octaves above was maintained with all tones and semitones in between. An extra four switches to the right of this keypad control the 'record into memory' functions:

Erase — erases the present contents of memory
Space — records a single note-length space
Backspace — cancels the previous note recorded (useful if a mistake has been made)
Replay — recalls and plays the whole recorded sequence.

Upon switch-on, one of four switched tunes stored in the chip's permanent internal memory is automatically recorded into the accessible memory, after which it can be replayed or erased if desired. These tunes are: Oranges and lemons; When the Saints go marching in; Yankee doodle; and Holahi. Jack socket JK1 allows you to play through an external amplifier for extra volume. Insertion of a ¼ inch jack plug will cut off the internal speaker and provide a low level signal to the external amplifier.

Now what else can Memory Bank do? Oh yes, we almost forgot! After a few minutes of not being used — if it hasn't been switched off — the IC produces a warning tone for a few seconds to tell you that you haven't turned off the power. This helps prolong battery life.

Memory Bank Construction

Construction procedure this month consists of making up the two PCBs from the overlay diagrams shown. Neither board should cause much difficulty, but there are one or two points to note.

On the main board all resistors and capacitors are best inserted first, being careful to polarise C6 and C7 correctly. An IC socket is advisable for IC1 and this should be put in next. Don't insert the IC yet, however, leave it till last. Semiconductors D1, D2 and Q1 to Q5 can be soldered into position now. Note that there are two varieties of transistor — take care not to mix them up. To insert the transistors, align their flat side to correspond to the flat on the overlay diagram: the transistor will then fit neatly into its correct position on the board. Finally, IC1 should be carefully inserted into its socket. This is quite an expensive device so take your time to prevent possible damage through breaking off any pins.

Construction of the keyboard is simply a matter of inserting the 28 push-button switches. Make sure they are all perfectly flush to the board — this makes no difference to electrical connections, it simply looks better if they are visually lined up.

The second and final part of this article next month continues with constructional details of Memory Bank and includes full interconnection procedures along with case details.

Buylines

A full kit of parts for HE Memory Bank has been produced by Magenta Electronics, who advertise with us, on page 38 this month. All parts (excluding as usual the case, but including the PCBs and IC socket) will cost you only £28.50 including p&p and VAT.

If you wish to house your Memory Bank in the same case as we did, Magenta can supply one (when ordered with the kit) for an extra £5.80 including p&p and VAT.

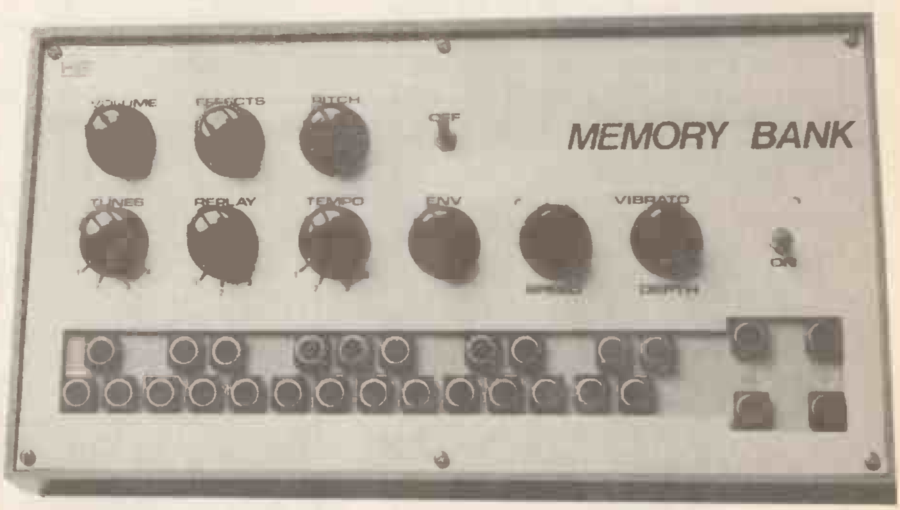


Figure 5. Showing front panel layout and lettering. Note the hole which needs to be cut out for the keyboard push buttons

HE

Story Behind Stereo

We have become complacent over the past few years. Technological developments come so quickly that we rarely pause to consider how they were developed. Ian Sinclair looks into the (surprisingly) long history of stereo and where future research may lead

NOW THAT we have the technical ability to process almost anything with electronics, it's interesting to note how many ideas which have been around for a long time are now being used at last. Stereo sound was one of the first of these ideas to be picked up, particularly when transistors became cheap enough to allow two amplifiers to be built for a price which previously bought only one. In this article, we'll try to trace the shaky beginnings of today's stereo.

Musicians have, of course, played with different arrangements of choirs and orchestras for centuries, and in many cathedrals, carefully chosen seating arrangements for the choristers were found by trial and error to give much clearer sound over a large space. By contrast, many composers preferred to write for small groups of players, deliberately avoiding the large spread of sound of the full orchestra.

The effect of the arrangement and spacing of sound sources which was well known to musicians was not lost on the physicists either, though it took some time before their knowledge of sound waves was sufficient to match up to the needs of analysing something so complex. Much of our knowledge of sound waves was laid down by the great physicist Helmholtz, and carried on by Lord Rayleigh of Terling, Essex. Rayleigh's Theory of Sound, published in 1896, is still the sourcebook for anyone investigating sound waves, and his work is the real starting point of the stereo systems which were developed after that time.

Rayleigh conducted a large number of experiments to find what factors determined how the human hearing system could 'localise' sound; that is, discover where the source of a sound appeared to be. One of his classic experiments involved fitting a listener with a pair of tubes, one to each ear, and sounding identical tuning forks at the end of each tube. He used this scheme for tuning forks with a wide variety of pitches, and found that the listener, who was blindfolded, imagined that the sound was directly in front of him when the higher-frequency tuning forks were used. This illusion did not persist when low frequencies were used, and could be restored only when a single fork was used and its sound taken through tubes of equal lengths to both ears.

Phased Forks

Rayleigh's conclusions were that the information on sound direction which we obtain arises in different ways at different frequencies. At low frequencies, it is phase differences between waves which carry the sensations of direction. Since he could not ensure that two tuning forks stayed in phase, the listener was unable to locate the source of low notes from two separate forks. At high frequencies, phase differences seemed less important, and the most important factor was the intensity of the sound; the direction of the sound always seemed to be towards the louder sound.

Rayleigh's experiments and theory weren't at all ahead of technology. Some fourteen years *earlier*, a telephone engineer in Paris had patented a system for enabling latecomers to a theatre to hear a realistic performance. His ideas was to use two microphones, one on each side of the stage. Each listener had also two earphones, left and right, so that the effect was that of headphone stereo. Since no amplification was needed, the system was quite practicable, and was, in fact, exhibited in action in 1881.

The lack of amplification in all early sound systems forced inventors to concentrate on headphone systems. Now, though headphones produce interesting effects, there is a vast difference between the sound heard on headphones, with its artificial separation, and the sound you hear live, or through loudspeakers. A good description of the difference is that headphone sound always makes your ears feel fifty feet apart, and this must be caused by the complete separation of signals which doesn't happen under normal listening conditions.

Early attempts at providing some form of loudspeaker stereo had to use the horn gramophone, and some of these were actually made. There is a photograph in the Science Museum of the 'Columbia Multiplex Grand', a cylinder gramophone with three pickups and horns, playing a cylinder with three separate tracks. Unfortunately, we can't tell now whether these were three tracks in the sense we would use now; ie, if they were simply three tracks of different instruments, using the horns as a form of mixer. These attempts came to nothing.

Two Channel Radio

World War I turned inventor's minds to less harmless pastimes, and at the end of the conflict, the new possibilities which were opened up by radio broadcasting began to excite considerable interest. One scheme which was tried in 1925 was the separate broadcasting of two channels on different wavelengths. The medium-wave bands were not so crowded then as they are now — you didn't get the call-sign of Radio Bohemia continually coming over the station you wanted in those days!

In Berlin, stereo experiments were carried out using 430 and 505 metre transmitters, and at New Haven, Connecticut, station WPAJ won a place in history as a stereo transmitter using 270 metres and 227 metres. Details of the Berlin system are lost, but the New Haven system is quite well documented. At the studio, the microphones were seven inches apart, a distance which had been picked by trial and error.

Station WPAJ had to bow to its listeners, though. Most listeners, still using headphones, didn't like the effect, which in any case was available only to listeners with two receivers. For the less well off, the reception of only one of two stereo channels was not a particularly good deal, and the scheme was abandoned.

For The Record

Curiously enough, disc stereo was not in such an advanced state. It's curious because all the information that was needed was already present. The early cylinder recordings had used what was known as 'hill and dale' recording (**Fig.1**) — the sound waves were recorded as a pattern of vertical bumps on the cylinder. Emil Berliner's flat discs of 1888 used lateral recording, the familiar groove which waves from side to side. It must surely have occurred to many inventors that it should be possible to record one programme on a vertical recording and another on a lateral recording in the same groove — and yet there's no trace of it.

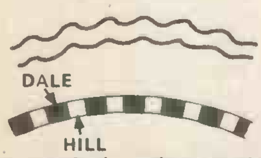


Figure 1. In the early years of this century, both lateral (side-to-side) and vertical (hill and dale) recordings could be bought. No one seems to have seen that both types of cut could be made on a single track.

Stereo as we know it has its roots in the work of one man — Alan Blumlein of EMI. Blumlein was probably the ultimate virtuoso of electronics; his patents cover all aspects ranging from stereo sound through most of television to radar. What he might have eventually accomplished is something we can only guess at, because he was killed in an air crash, during radar tests, in the early days of World War II.

His work at EMI started in 1929, and by 1931 he had taken out the patent which forms the foundations for most of today's stereo systems. This patent, number 394325 if you want to look it up, outlines all the requirements that we use today, and suggests in particular, the use of sum and difference rather than straightforward L and R sound channels. The important point about a sum-and-difference system (**Fig.2**) is that the sum signal is a normal mono signal, which can be used by mono equipment, and the difference signal is of comparatively small amplitude, easier to transmit. The sum-and-difference system has survived in FM stereo, though it was not used for either tape or disc stereo systems after World War II. The principles were revived, however, for most of the so-called 'quad' systems.

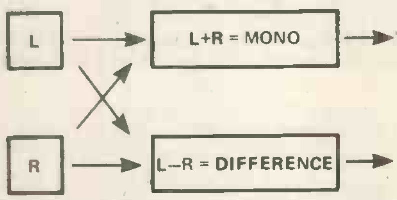


Figure 2. Blumlein's sum-and-difference method. The important point is that the sum signal is the normal mono signal, and the difference signal is at a much lower amplitude.

By 1932, Blumlein had turned his attention to the problem of coding two separate signals onto discs. The obvious method, stemming from gramophone history was to use both lateral and hill and dale recording on the same groove. This isn't entirely satisfactory, because one of the reasons for abandoning hill and dale recording was that the pickup could not follow the dales at high frequencies; it simply slipped from one hill to the next. Blumlein suggested that the two walls of the disc, set at 90° to each other (and at 45° to the vertical) could be separately modulated, and this is the scheme which was eventually used.

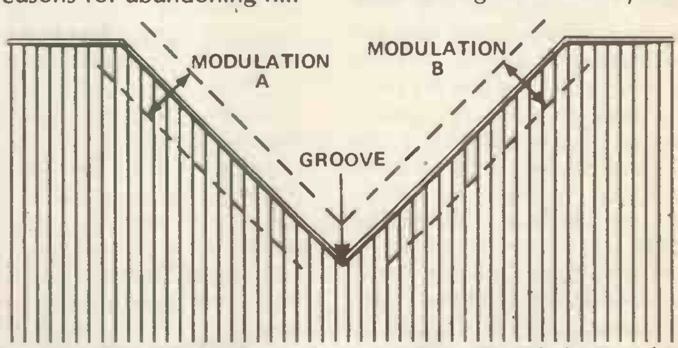


Figure 3. Groove cross-section — the walls are at 90° to each other, 45° to the horizontal. Each wall is separately recorded on by a hill-and-dale method.

Degrees Of Stereo

Now earnest students of 'O' level physics will have realised what the significance of 90° is in all this, but everyone else deserves some sort of explanation. Without going into a lot of detail, any motion in a straight line can be imagined as being caused by two movements at right angles to each other.

For example, if you pull on the two strings illustrated in **Fig.4**, then the block moves in the straight line which is shown. These two motions at right angles to each other are quite independent — changing one does not affect the other. Translating this into something closer to our applications now, imagine a device which consists of a miniature railway track with a plunger touching the surface of a plate between the rails (**Fig.5**). If the plate is shaped like a wave, the plunger will be forced to move up and down as the 'truck' is moved along. The up-and-down movement, however, does not cause the truck to move from side to side. Similarly, if the plate is flat, but the 'railway track' is a set of Z bends, the truck and the plunger with it will zig-zag without causing the plunger to move up or down. The two separate motions do not interfere with each other, provided that their directions are always at 90° to each other. We can now imagine that both sets of motions exist, with a wave shaped plate and Z-bends in the track, causing the end of the plunger to move in both directions simultaneously — this is as close as we can come to showing what takes place on a stereo recording. Imagine now that the whole caboodle is tilted through 45° — and you're there!

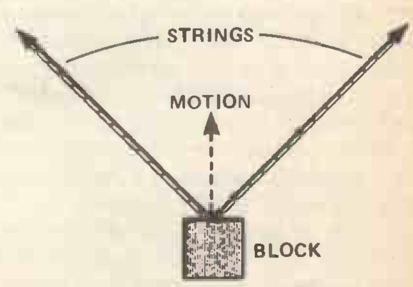


Figure 4. How forces at 90° to each other can produce movement at 45° to each force.

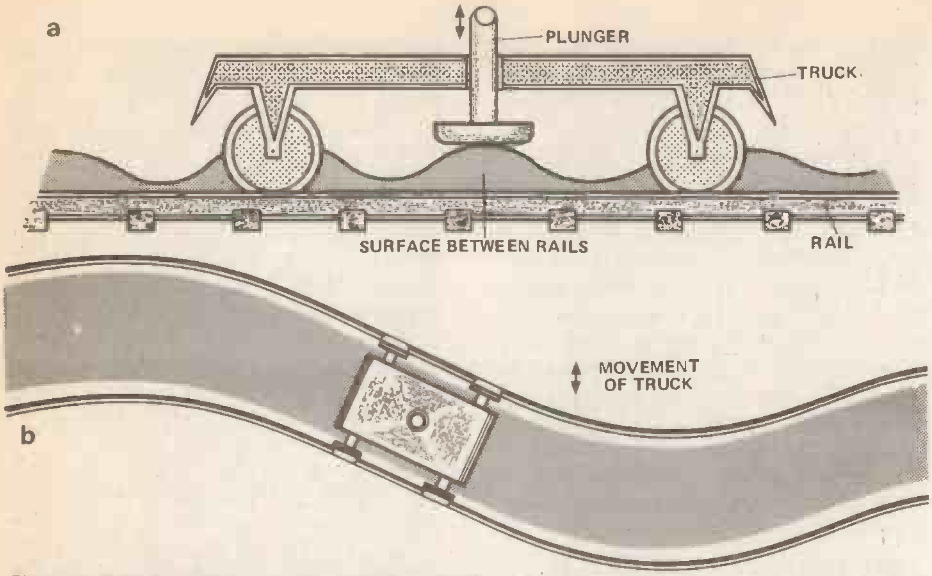


Figure 5. Independent movements which do not affect each other. The vertical motion in (a) is quite separate from the horizontal motion of (b), but if the two are combined, the plunger will have both types of motion simultaneously.

Fantasy Sounds

By the early thirties, all of the methods for obtaining and transmitting stereo had been worked out. The sum-and-difference coding for radio had been contributed by Blumlein, the 45°/45° disc was his work as well, and the third system, separate channels on tape was still waiting for further development of tape recorders.

There, for some reason, it rested. It was as if people couldn't take any more novelties, or perhaps that everyone sensed a coming war. Whatever happened, stereo sound didn't change, at least as far as the home user was concerned. Where it all started to happen was where there was money to play with, in the film world. The historic date was 1935, when the Bell Telephone Laboratories demonstrated before the Society of Motion Picture Engineers (SMPTE now, the T standing for Television) a stereo sound system for films, using twin tracks of the conventional type. It made some impression, but only on a few dedicated engineers. The big breakthrough came only in 1941 when Walt Disney Studios made Fantasia, a film of such remarkable originality that it still goes the rounds today. The theme of Fantasia is the fitting of cartoons to music, and Disney's engineers, who had heard the demonstrations in 1935, were convinced that a very large step forward in cinema sound was desirable. They certainly achieved it, after umpteen experiments and as many as ten full scale attempts, they ended up with an eight channel recording system. Their idea, later expressed in an article, was that if this improvement in sound was to catch the attention of the public it must be a dramatic improvement — there was no point in spending a million dollars in making something just slightly better. It's a principle that a lot of inventors ought to remember!

Fantasia certainly made its mark in the USA. No cinema carried the equipment necessary to reproduce the sound tracks, so the Disney Studios devised travelling sound systems, which had to be carted to each cinema and set up where a copy of the film was playing.

Coils And Cutters

By the mid '50s everyone was waiting for stereo to happen, and there were countless proposals, ranging from the well-researched to the simply silly, lined up. As usual someone had to break the ice and take the first step into the water. The someone in this case was that champion of all the innovating companies in electronics, RCA. At that time, virtually all the disc cutting heads were made by one company, Westrex, a branch of Westinghouse. In 1957 RCA instructed Westrex to make them a 45°/45° stereo cutting head — with the option that if they didn't, RCA would start manufacturing the heads themselves. It was an offer Westrex couldn't refuse, because several other companies were already in the business of developing such cutters, notably Telefunken in Germany, Decca in Britain and Orotofon in Denmark. Westrex went ahead to develop a type of cutting head which, with later refinements, is still in use today.

The Westrex head uses two separate moving coil assemblies. The moving-coil principle is an old and well known one in the history of disc cutting and reproduction, and is illustrated in **Fig.6.** A coil is driven with signals, and its magnetic field, which increases and decreases in step with the signal current, causes variable forces on an iron core. If the coil is suspended on springs, it will move in sympathy with the variations in magnetism, so producing a mechanical movement which keeps in step with the waveform of the signal. This is the motion which is used to operate the cutting stylus, and the Westrex arrangement consisted of two moving coil drives (or motors, as they are called) set at 90° **(Fig.6).**

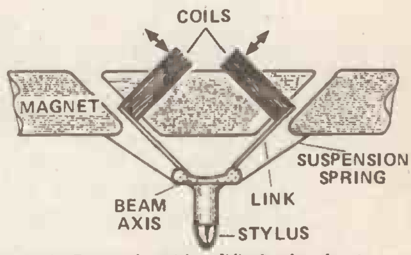


Figure 6. Front view (simplified) of a classic type of stereo cutter. The two coils are driven in directions at 90° to each other, so producing a 90° cut by the stylus.

Once the Westrex stereo cutter went into production, the manufacturing of stereo discs became possible. By that time, the microgroove long-play disc had been developed also, and the modern stereo disc became a reality.

Through The Air

Stereo radio, as we've seen earlier, actually started much earlier than stereo discs, though the systems which used separate channels broadcast on separate wavelengths were not compatible. Compatibility is always a problem which tends to prevent new systems from being developed for any established process. The argument is that the customer already has equipment which mustn't be made out of date. The fact that advertising is continually trying to tell the same customer that his equipment *is* out of date is conveniently ignored. The compatibility problem has affected two systems in particular — stereo radio and colour TV. The argument in each case was that the existing owner of radio or TV should continue to be able to receive the same transmissions. This was a reasonable argument in the USA, where millions of customers had mono radio and black/white TV, but it looked a bit less plausible in Britain where few people had FM radio, and the colour TV was to be broadcast on UHF, on a new standard which required new receivers anyway!

The two-transmitter method of

transmitting stereo is therefore a dead-duck as far as compatibility is concerned, and any scheme for transmitting what should be high quality signals on medium wave is a lost cause anyway. It's ironic that the only music on BBC medium-wave, which needs a reasonable bandwidth and quiet background, has just been shifted to the most unsuitable of all the wavelengths, 247 metres. Perhaps they don't really care any more!

As it happened, the first FM transmitter had been built by the beginning of World War II, by Edwin Armstrong, inventor of frequency modulation, and in the post-war years, FM transmitters multiplied rapidly in the USA. The users of FM tended to be listeners who were interested in higher quality reproduction of music, so the FM transmitters were seen as the natural medium for stereo transmissions. The bandwidth of an FM broadcast is much greater than that of medium wave, however, and this, along with the compatibility problem, rules out the use of transmitting each channel on a separate frequency.

Transmission Systems

Once again, the field was open to inventors to devise methods of modulating the two channels onto one single carrier in such a way that an existing one million radios would continue to receive an acceptable signal, but a specially adapted stereo radio would be able to separate the two channels. A large number of proposals were put forward mostly hinging on the use of a subcarrier. A subcarrier is a sinewave which can be modulated by a signal, and which is then, in turn, modulated on to a main carrier along with other signals. This time, the systems had to pass the scrutiny of the Federal Communications Commission, the body which controls broadcasting technical standards, and it showed! The FCC had previously insisted (1953) that any colour system should be compatible, and it certainly wasn't going to make its rules any easier for half-baked schemes to provide FM stereo.

The system which was eventually chosen was the Zenith Radio, General-Electric joint submission. This is the stereo system which, unlike the NTSC colour system, is used world-wide with only minor modifications, and a brief reminder of its principles might be useful.

The Zenith GE system (**Fig.7**) relies on Blumlein's principle of sum and difference signals, L + R and L − R. The sum signal, L + R is frequency modulated onto the main carrier in the usual way, so that the user of mono equipment has the same signal input to his receiver as he had before. The carrier is also modulated with two other signals. One of them starts as a subcarrier at 38 kHz, which is amplitude modulated by the difference signal, L − R. The subcarrier is then removed, leaving only the modulated sidebands, mainly low amplitude, to be modulated onto the main carrier. The third signal which is modulated onto the main carrier is a low amplitude sinewave at 19 kHz, which is obtained at the transmitter by dividing down the 38 kHz subcarrier frequency.

At the receiver, these signals can be separated without much difficulty (**Fig.8**). A mono receiver detects only the sum signal, with its normal de-emphasis circuits (low pass filter) removing the 19 kHz sinewave (the 'pilot tone') and the sidebands of the sub-carrier. A stereo receiver uses no filtering immediately after the demodulator, so that the pilot tone can be detected, amplified and frequency doubled to 38 kHz again. This newly regenerated carrier frequency can now be used to demodulate the subcarrier sidebands (a method called synchronous demodulation is used) to recover the L − R signals. The L + R and L − R signals can be combined to provide the L and R signals which are the stereo channel signals.

On Tape

Tape recorders? Oddly enough, though stereo on tape was used comparatively early by the manufacturers of discs, stereo tape for the home user came a lot later. The use of tape was only ever a minority interest in any case, apart from the brief craze for tape-recording in the early sixties, until tape became capable of providing better quality sound at reasonable prices. Though stereo tape recorders eventually became available, with such excellent machines as the Revox providing considerable competition to the best of discs, tape stereo still remained a minority pursuit. Things stayed this way until the cassette developed four channels and efforts were made to sort out the miserably poor signal-to-noise ratio.

Because commercially-made stereo cassettes could be bought, unlike stereo tapes, stereo on cassette flourished despite its technical shortcomings. Rapid development ensured that whatever stereo equipment you bought one year would be out of date by the next year, so keeping manufacturers keenly interested in research. In some cases, the research simply resulted in more shiny cases with less inside them, but some very important advances were made in tape material, in circuit techniques (such as Dolby and dbx), and in convenience (such as being able to set up the recorder easily for different types of tape). Because cassette stereo was the most recently developed stereo system, it's still developing, trying to reach nearer perfection before the next big breakthrough.

The next one? There are digital tapes, laser-read discs, and presumably, laser-read tapes all being developed, all with the promise of high packing density (lots of music in a small space) and very low noise levels. That doesn't mean that manufacturers have learned from early mistakes — there are as many systems competing now as ever were, some with such obvious flaws that it's difficult to imagine they were being seriously put forward except as a way of keeping a place in a queue. All we can do is wait and hear! **HE**

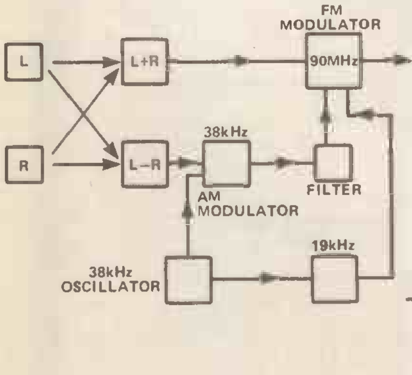


Figure 7. Stereo transmission. Three signals are modulated on to the main VHF carrier. One is the usual (mono) L + R audio signal, one is the sidebands of the subcarrier (carrying L-R), and the third is a low-amplitude 19kHz sinewave which is used for decoding at the receiver.

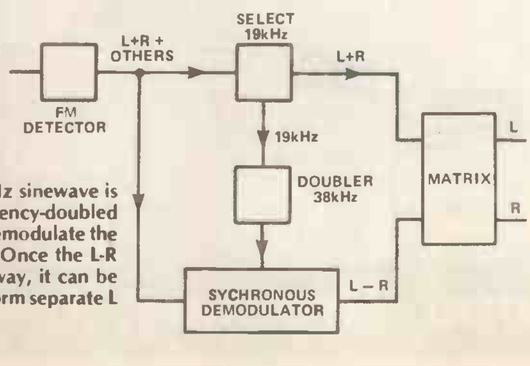


Figure 8. At the receiver, the 19kHz sinewave is selected by filtering, and then frequency-doubled to 38kHz so that it can be used to demodulate the sidebands of the subcarrier signal. Once the L-R signal has been recovered in this way, it can be combined with the L + R signal to form separate L and R signals.

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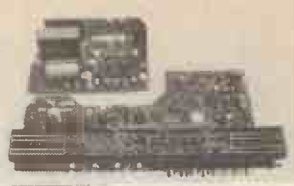

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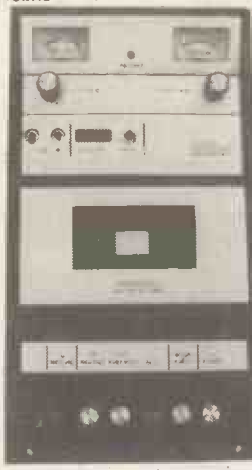

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5 pin 180	13p	11p	16p
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BC109C	12p	BFX29	25p	2N3702	9p
BC147	9p	BFX84	26p	2N3703	9p
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CA3046	70p	LM382	120p	TBA800	80p
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CA3130	100p	LM387	120p	TDA1022	630p
CA3140	60p	LM1458	40p	TL081	45p
LF347	170p	LM1830	180p	TL082	85p
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4006	95p	4042	85p	4510	90p
4007	25p	4046	110p	4511	100p
4011	30p	4047	95p	4518	90p
4013	50p	4049	50p	4520	110p
4015	85p	4050	50p	4527	165p
4016	48p	4052	80p	4528	100p
4017	90p	4060	120p	4532	125p
4018	90p	4066	63p	4543	170p
4020	110p	4068	25p	4583	80p
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4023	25p	4070	25p		
4024	80p	4071	25p		

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16pin	12p	28pin	26p
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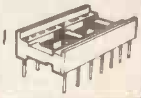

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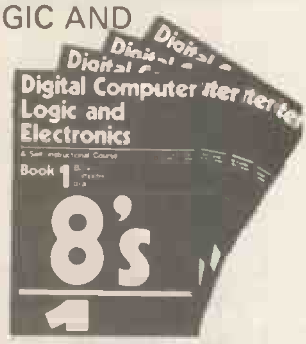

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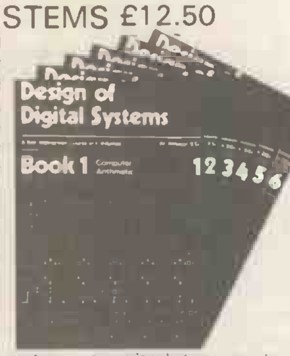

This course takes the reader to real proficiency. Written in a similar question and answer style to Digital Computer Logic and Electronics, this course moves at a much faster pace and goes into the subject in greater depth. Ideally suited for scientists or engineers wanting to know more about digital electronics, its six A4 volumes lead step by step through number systems and Boolean algebra to memories, counters and arithmetic circuits and finally to an understanding of calculator and computer design.

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Book 3 Half adders and full adders; subtractors; serial and parallel adders; processors and arithmetic logic units (ALUs); multiplication and division systems.
Book 4 Flip flops; shift registers; asynchronous and synchronous counters; ring, Johnson and exclusive—OR feedback counters; random access memories (RAMs) and read only memories (ROMs).
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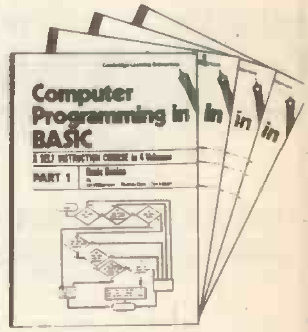

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Battery Eliminator

Don't let the soaring price of batteries worry you. Save your hard earned pocket money with the help of this simple project

IF YOU HAVE battery-powered equipment or projects and seem to be constantly buying cells, then the HE Battery Eliminator is just the job for you. The project gives a variety of switched output voltages — 5, 9 and 12 V, on our prototype — with a maximum output current of over 1 A, from mains 240 V AC. A single IC gives exceptionally good regulation to the required voltage and makes the project short-circuit proof — it virtually cannot be damaged, provided all components are inserted correctly. The use of this IC, the LM317T, makes the circuit extremely simple to build and operate. Output voltage is set by the value of only two resistors, so a wider range of voltages can be obtained, if you wish, simply by susbstituting different resistor values in their place. Connection to your battery-powered equipment is made with a suitable length of two-core flex with the correct plug on the end. If, like us, you intend to use the Battery Eliminator with a variety of equipment then a 4-way power plug, which gives a choice of different connections, is an advantage.

Construction

The HE Battery Eliminator is built on Veroboard, so you should take the usual steps when constructing the circuit. Follow the overlay diagram carefully, making all links before you insert any components.

Mark and drill the case for all switches, grommets etc., and be careful when wiring up the project because of the 240 VAC mains connection. Although the low voltage, secondary side of the circuit is isolated by the transformer, the primary side is potentially dangerous. Cover all connections with heat-shrink sleeving to give protection.

Follow the connection diagram carefully and use grommets and cable ties, thus preventing the mains cable from being pulled out or shorted to the case. Remember to fasten the mains earth to the transformer mounting bolt using a solder tag so that the whole metal case of the project is at earth potential. Note how IC1 is fastened to the case. A mica insulating washer must be used to provide electrical isolation with good heat conduction. A spot of heat sink compound wouldn't go amiss here, if you have any — but it's not essential.

Finally, once you have finished wiring up and have thoroughly checked the project through you can switch on and test it.

How it Works

The secondary output of T1 provides an AC voltage of approximately 12 V. This is full-wave rectified by BR1, a bridge rectifier, to DC and capacitor C1 smooths the voltage to a fairly constant level of about 16 VDC.

IC1. is a device known as a voltage regulator, which provides a very constant output voltage, regardless of its input voltage (bearing in mind that the input voltage should always be higher than the required output). The IC develops a reference voltage of 1.25 V between its output and adjustment terminals, ie across resistor R1. The value of R1 is 270R, hence from Ohm's Law:

$$I = \frac{1.25}{270} = 4.6 \text{ mA}$$

This current also flows through one of the three switched resistors R2, 3 or 4, depending on the position of switch SW2. Again from Ohm's Law the voltage across, for example, the resistor R2 is given by:

$$V_{R_2} = 4.6 \text{ mA} \times 820 = 3.77 \text{ V}$$

Therefore, the total voltage from the 0V line to the +V line (the output voltage) is:

$$3.77 + 1.25 = 5.022 \text{ V}$$

The calculations for the other two resistors are similar.

Any other voltage within the range 1.25 to 14 VDC can be supplied by IC1 (given that its input voltage is always more than its output) with the appropriate resistors in circuit.

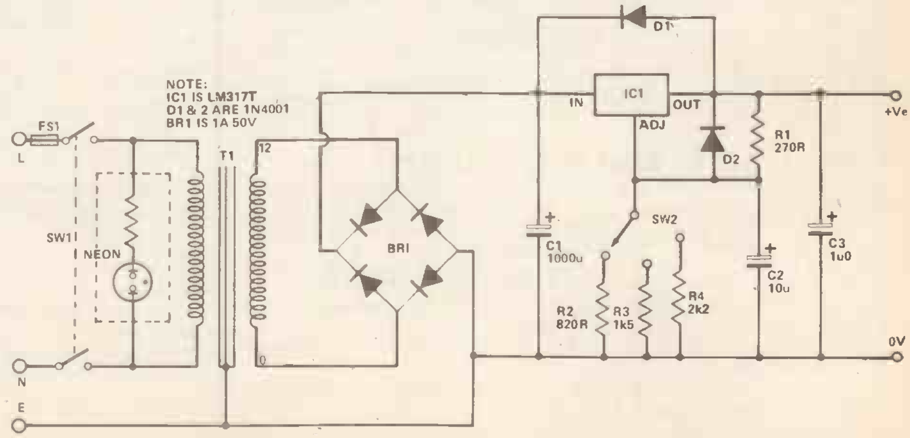


Figure 1. The Battery Eliminator circuit diagram. IC1 keeps the circuit simple yet gives good regulation

Buylines

IC1 is the only component which you may have problems finding from your local supplier. Mail order companies who advertise with us should be able to help. The total cost of components (excluding case) will be approximately £8.

The case we used is one of a range obtainable from Tandy. The stock number is 270-251 and the range is well worth a look, being very good value for money.

Parts List

RESISTORS (All ¼W, 5%)
- R1 — 270R
- R2 — 820R
- R3 — 1k5
- R4 — 2k2

CAPACITORS
- C1 — 1000u 25V printed circuit mounting electrolytic
- C2 — 10u 16V tantalum
- C3 — 1u 16V tantalum

SEMICONDUCTORS
- IC1 — LM317T
- BR1 — 1A 50V bridge rectifier
- D1,2 — 1N4001 1A diode

MISCELLANEOUS
- FS1 — 1A fuse + holder
- SW1 — double-pole, double-throw toggle switch
- SW2 — 1-pole, 3-way rotary switch
- T1 — 240/12V, 6VA transformer
- case to suit (see Buylines)
- mains neon
- grommets, cable ties, insulating washer
- knob to suit
- 10 strip x 24 hole Veroboard

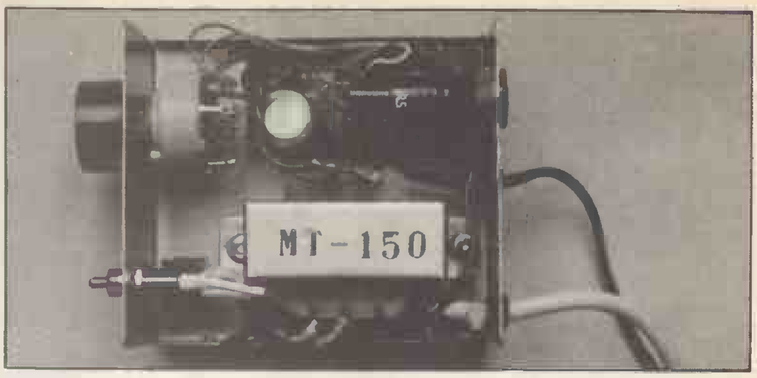
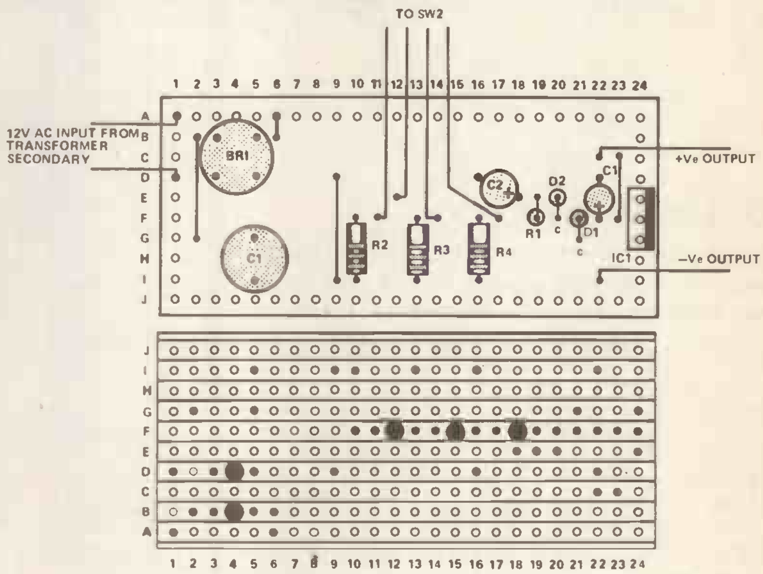


Figure 2. You can see how tightly packed the project is

Figure 3. Veroboard layout of the HE Battery Eliminator. The diagram of the underside shows where the breaks in track should be



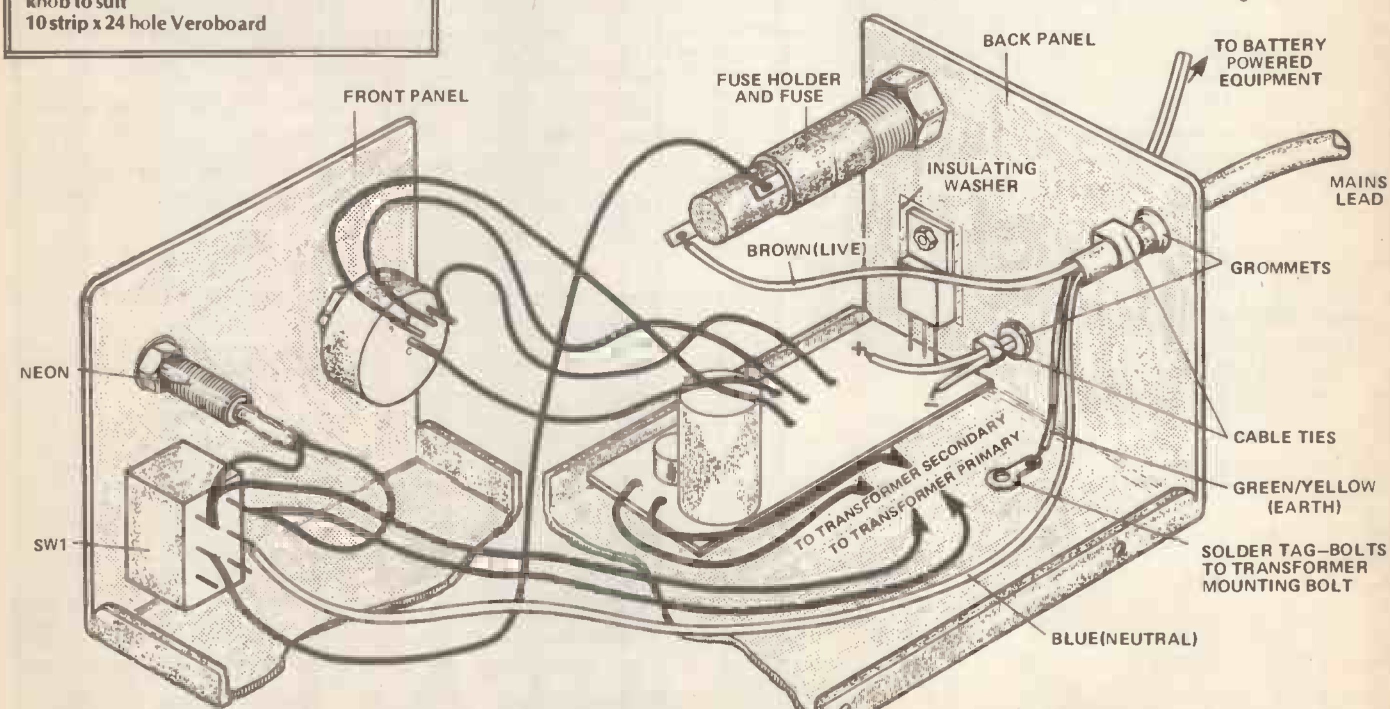
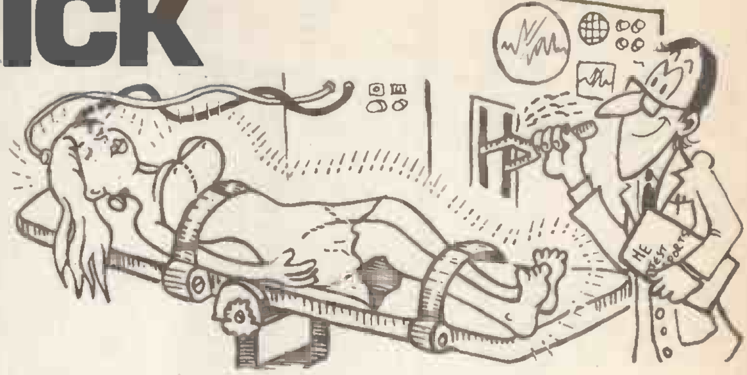


Figure 4. Connection details. Take care with the mains side of the circuit — heat-shrink sleeving is a good idea

HE

Clever Dick



Do you know why ICs are usually black? Clever Dick thinks he does. Find out the answer to this and many other really burning questions

I GET ASKED some very silly questions each month: 'where can I buy a PP3?' or 'what does an IC do?'. So you can imagine what we thought when M Turner innocently asked 'why is an IC black?'. It was I who felt silly when I tried to find the answer.

Dear CD,
Has it not occurred to you that Integrated Circuits would be a lot easier to identify if the plastic with which they are covered were made in different colours. CMOS for instance would for instance be a different colour to TTL, linear different to digital and so on. Apart from anything else it would make the boards a lot more colourful, why do they have to be black?
PS. How about a binder for this super fantastic idea?
M Turner
Bristol

I started by asking all the incredibly intelligent people that work in the office (the HE staff don't actually work but the cleaners were most helpful). After a decent amount of head scratching, no-one seemed to have any realistic (or printable) ideas. The next step was to phone up some IC manufacturers, and so we chose the big three: Mullard, Texas and National. As you might have expected we got three different reasons,

a) it aids heat dissipation
b) it keeps out the light which can upset the operation of the circuit
c) the epoxy resin that is used for IC encapsulation is cheaper to produce in black.

If anyone else has any ideas then please let us know: a binder to M Turner for a very tricky question.

We seem to have gained a reputation for finding addresses for manufacturers of obscure and foreign equipment, and here is this months plea.

Dear Clever Dick,
I have recently acquired a desk type calculator, made in Sweden by a company called FACIT. I wonder if you could give me an address for the company so that I can obtain some spare parts and possibly a circuit diagram. I would be very grateful if you could help me.
G Acreman
Somerset

This was a relatively easy one to track down. A quick call to the Swedish Embassy's trade commission produced two addresses. In this country you can call: Facit Addo Ltd., Maidstone Road, Rochester, Kent. Or if they cannot help you the Swedish Head Office is at: Facit AB Ltd., S-59700, Atvidaberg, Sweden.

Now for something a little closer to home.

Dear CD,
Just two questions: Concerning the Auto Probe in September '80, my wife's pill comes in a bubble pack, would something like an Aspirin container do instead?
Secondly, in your sister magazine ETI in the June issue they featured a project that could send audio signals down the mains. There was also a feature concerning house wiring that mentioned that the mains could also be used for transmitting control signals. How about a similar circuit (especially the remote control) sometime in HE for lazy people like myself?
Finally, thanks for a great mag, I've bought every one since you started in November '78 (isn't that loyal of me?). Now all I need is a binder to put them all in . . .
PS. I think you are the tea boy (or girl).
Dave Hart
Ongar, Essex.

You would need the Aspirin for your headache if you tried to get the circuit into the little hole that most Aspirin bottles have. Perhaps we'll have a project in a bubble-pack soon, you'll just have to 'control' yourself and wait to see!

What on earth is the point of printing a super difficult circuit like that when our sister mag ETI does it all the time? By the way, the circuit for a mains control system will be appearing in ETI in the next month or three — watch out for it. Now about that binder. They are available from our offices for the paltry sum of £3.95 all inclusive. Keep guessing about my identity, you're getting warmer.

Time now for some quick ones.

. . . Is it against the law to operate a radio control jamming transmitter? I want to stop someone who flies his models over my house at six o'clock in the morning.
MTF
London

Yes it is and don't do it, you'll kill someone.

. . . Can the frequency of a radio receiver be changed by altering the channel selector assembly?
J McEvoy
Merseyside

Sorry, not unless you really know what you're doing and even then it's doubtful

And finally . . . .

Where can I buy PCBs for Hobby Electronics projects?
Richard Long
Norfolk

No problem, just look at some of the advertising in this issue. Most of the companies who supply kits for our projects will be happy to oblige. See you next month, and please keep those letters short. **HE**

Into Digital Electronics

Dust off your Eurobreadboard, we have some practical circuits for you to try out using the theory we covered last month

USEFUL THINGS, gate circuits. In case you've forgotten last month's work, we can make any sort of gate circuit which has a 1 at the output for whatever pattern of 1s we want at the inputs. Even if these were the only kind of digital circuits we could make, they would still be useful, but NAND gates can be used to make an even *more useful* type of circuit, called a sequential circuit or flip-flop.

Practice before theory, this time. Build the circuit which is shown in **Fig.3.1.** The Eurobreadboard switches and LEDs are in their usual places, and the quad NAND gate 74132 has been inserted with its pin 1 in line 19A and its pin 14 in line 19B. The connections are as shown on the diagram. Looks familiar? Yes, if you've built multivibrators with transistors you should recognise this as one of the great multivibrator family. There are no capacitors, though, so this is a form of bistable; and all the resistors are inside the ICs. What makes this important is that it is a simple example of a circuit which, although it's made out of gates, doesn't behave like any of the gate circuits you've built so far.

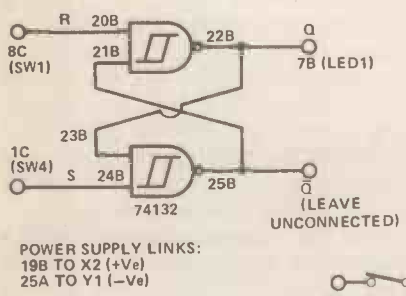


Fig.3.1 The circuit for the R-S flip-flop, showing the Eurobreadboard link numbers.

Figure 3.2 is a blank truth table for this circuit. Make sure you go through this table in the order which is given, otherwise you may miss the important feature of this circuit. There's nothing accidental about the fact that we have two lines in the truth table for which the inputs, R and S, are both at logic 1.

R (SW1)	S (SW2)	Q
1	0	
1	1	
0	1	
1	1	

Fig.3.2 Blank truth table for the R-S flip-flop. Make sure that you go through the truth table in the order which is shown.

See the difference? With R = 1, S = 1, the output which is monitored by the LED can be 1 or 0. What does it depend on? Look at the table again. What decides the value of the output Q is the value it had *before* the inputs changed to R = 1, S = 1. Now this is quite different from the circuit which we used in Part Two. In these 'combinational' circuits, the output from the gate circuit was decided completely by the combination of inputs. If we had a gate circuit with two inputs and one output, the output would always be the same when the inputs were both 1s. The circuit we're looking at now doesn't do this. What counts here is the *sequence* of signals at the inputs, and the output for R = 1, S = 1 depends on this sequence — the signals which were there at the inputs just before this state. If we had R = 1, S = 0 before R = 1, S = 1, then Q is 0. If we had R = 0, S = 1 before R = 1, S = 1, then Q is 1. Sequence, not combination, is what matters, so that circuits of this type are called *sequential* logic circuits.

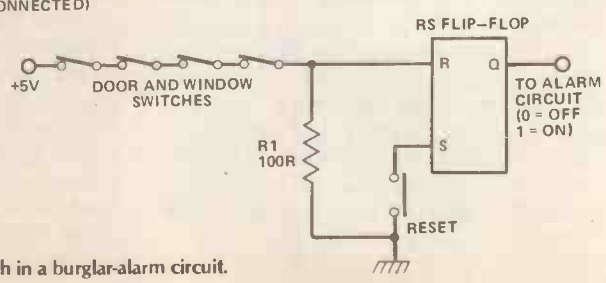


Fig.3.3 Using an R-S latch in a burglar-alarm circuit.

The R - S Flip Flop

This particular one is called the R - S flip-flop, with R and S meaning Reset (putting Q to 0) and Set (putting Q to 1). It's the simplest type of sequential circuit, but it's not used very much because of two problems. Problem 1 is that we have to leave out R = 0, S = 0 on the truth table. Why? Well, with that input, the Q output is 1, and the other output, marked Q is also 1. Now if we used only Q, this might not be too serious, although it's still a nuisance, having another state which causes Q = 1. For a lot of flip-flop applications, however, we use $\overline{Q}$ to provide the inverse of Q (so if Q = 1, $\overline{Q}$ = 0 and if Q = 0, $\overline{Q}$ = 1), saving another inverter. With R = 0, S = 0, $\overline{Q}$ is not the inverse of Q, so our logic goes bananas. Problem number 2 is that the output changes almost instantly when either input is taken to logic 0. For a number of reasons which we'll look at later, we'd like some control over this.

When the R - S flip-flop is used, it's used as a latch. A latch is our name for a circuit which will hold a bit (binary digit) unchanged for a time, a sort of temporary memory. We can set the R - S latch by making R = 0, S = 1 and reset it by making R = 1, S = 0, and we can store the result by keeping both R and S at logic 1. The outputs Q and $\overline{Q}$ will stay as they are as long as power is applied and R = 1, S = 1; this is the latching condition.

How about an example? Imagine the R - S latch is connected to operate a burglar alarm (**Fig.3.3**). The reset button has been pressed, making S = 0, R = 1 momentarily, so that the output Q is at logic 0. When the button is released, R = 1, S = 1 for as long as the door and window switches remain intact. Breaking contact on any one of these switches, even momentarily, will cause the input R = 0 because of the 'pull-down' resistor R1. This makes Q = 1, and this condition will remain latched even when R = 1, causing the alarm to sound until the switches are all closed and the reset button pressed. The 'pull-down' resistor is needed because without it a TTL input will remain at logic 1 if the connections to it are broken. Another way in which the R - S flip-flop is used is to control a gate in a counting circuit — the gate can be 'opened' by a push button which sets the output of the flip-flop, and closed by an 'end-of-count' pulse. The important point is that the R - S flip-flop can be changed over by a very brief pulse at one input, and the output can then be held in its new state.

D-lightful D-ifference

So much for the R - S flip-flop. Incidentally, there seems to be no particular rhyme or reason about how the inputs are labelled. Some texts show the R input to the gate whose output is Q (the scheme we've used here), others show the R input to the gate whose output is $\bar{Q}$. It doesn't really matter which way round it is, so long as you know the action — a zero at one input will cause a change at the output, and when the inputs are both at logic 1, the output is held latched. An R - S made from NOR gates, by the way, has just the opposite action, latching when R = 0, S = 0 and changing when either input goes to logic 1. Just as well we don't make much use of them!

We make a lot more use of the next chip, a D-type flip-flop. The example we have is a 7474, and it involves us in a lot of new ideas, one of which is clocking. Start by setting up the circuit in **Fig.3.4.**

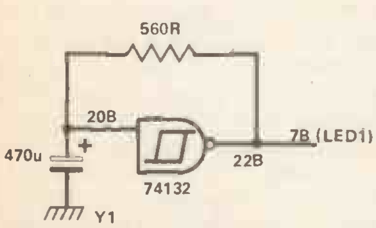


Fig.3.4 A pulse generator which makes use of the 74LS132 IC. Don't be tempted to use larger resistance values.

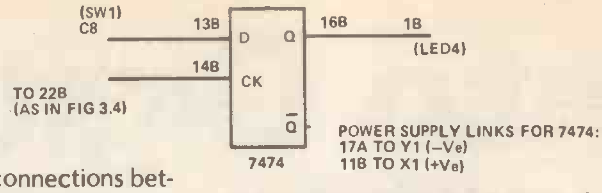


Fig.3.5 Using the D-type flip-flop 74LS74. The 74LS132 which is already on the board provides the clock pulses.

We have removed the connections between the 74132 and the switches, and substituted the 560R feedback resistor, and 470uF capacitor. Please note, you can't use this circuit with just any old gates. Only the 74132 NAND gate, the 7413 (also NAND) and the 7414 (hex inverter) can be used this way, because they are all of a type called Schmitt gates — more of that later.

Now switch on, and see what LED 1 is doing. If you are so lucky as to get a quick flash at intervals, that's it! The output of this circuit is a pulse, a change from logic 0 — to 1 — to 0 which recurs at regular intervals. Because it ticks away so regularly, we call it a clock pulse.

For any sort of sequential circuit beyond the simple R - S type, a clock pulse is essential. The reason is that the clock pulse can be made to control each step in the sequence, so that any changes which take place will always take place at some particular part of the clock pulse, either the leading edge (the start of the pulse) or the trailing edge (the end of the pulse). This avoids a lot of problems which can arise because of time delays in gate circuits. A single NAND gate will usually manage to respond to an input in about 30 nanoseconds (that's 0.03uS). That's fast, but suppose you have a circuit which uses two signals, one of which has come from one single NAND gate and the other of which has passed through about ten NAND gates. No prizes for guessing which signal gets to the circuit first, but suppose we need to wait until both of them are present? A circuit which operates from clock pulses (a clocked circuit) has a built-in time delay, the time between the clock pulses. We could arrange the circuit so that the signals were held in latches until both were present, and then gate them into our circuit by a clock pulse. The next clock pulse then resets the latches, ready for the next lot of signals. Circuits which make use of clock pulses avoid all the problems which time delays can cause in simple gate circuits, and also give us an automatic method of resetting latches. Clock pulses put the sequence into sequential circuits, and allow us to carry out very complicated actions in a surprisingly simple way, because we do only one step at a time. This idea is the germ from which the microprocessor has grown.

Going back to the board, you now have a clock pulse generator ticking away merrily at a nice slow pace. This pace isn't typical, most clock pulses go a lot faster, 100 kHz or more, but by slowing it down we can see what is going on by watching the LEDs. Switch off now, keep the clock pulse generator in place and put a 7475 on the board, with its pin 1 on line 11A and its pin 14 on line 11B. The power supply connections are shown in **Fig.3.5** with line 17A connected to line Y1 and line 11B connected to line X1. This also shows the symbol for a D-type flip-flop; there are two such flip-flops in the 7475.

Now for your actual flip-flop. Connect up as shown in **Fig.3.5.** The clock input of one D-type flip-flop is connected to the output of our clock pulse generator. The clock pulse generator circuit hasn't been shown here, only the connections. The D-type input (D for datum — one bit is datum, two or more is data) is obtained from one switch, SW1, and the Q output is connected to LED 1. We can now use SW1 to switch the D input to 0 or 1, and watch the output LED change — but when does it change? Does it change at the exact instant when you change over the switch?

That's the action. It might not seem very spectacular, but watch this space. What happens is that whatever logic level (0 or 1) is present at the D input when the leading edge of the clock pulse occurs is latched into the output **(Fig.3.6).** Notice that it's *latched* — if you stop the clock pulses, the Q output will remain as it is, no matter how the voltage at the D input changes. The other important point is that the leading edge of the clock pulse starts the latching — and this leading edge takes very little time, a few nanoseconds. The $\bar{Q}$ output is, as its symbol suggests, always the inverse of the Q output.

Now the interesting point about the D-type is that we can actually make use of the time delay between the leading edge of the clock and the appearance of the output. The clock pulse has its effect only while the voltage is rising, not at 0 nor at 1, and the output reaches its final state some time *after* the clock pulse voltage has reached 1. We can

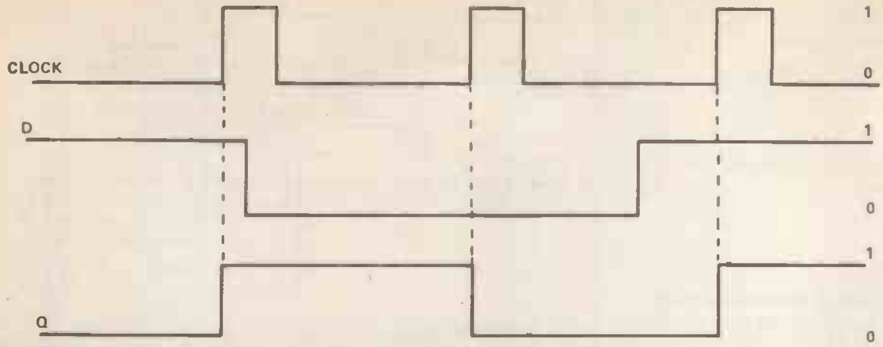


Fig.3.6 D-type action. The Q-output switches over at the leading edge of each clock pulses to a value equal to the logic level at the D-input.

therefore connect up the crazy-looking circuit of **Fig.3.7**. Try it, and watch the two LEDs. Led 4 is operated by the Q output of the 7474, and LED 1 is operated by the clock pulse. Notice anything about the flashing rate of LED 4?

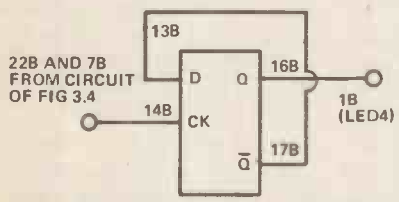


Fig.3.7 Toggling a D-type flip-flop. This connection makes the D-type give one output pulse for each two in, but only if the clock pulses have very fast rising leading edges.

It is indeed half of the flashing rate of LED 1, so that the output is a set of pulses at half the frequency of the clock pulses. The circuit is variously known as a toggle circuit, divide-by-two, scale-of-two, binary divider or bistable. The sixty-four thousand dollar question is, how does it work? The key to it is this business of time delays.

Imagine that the output of Q is logic 1, so that the output at $\overline{Q}$ is logic 0. Because $\overline{Q}$ is connected to D, the D input is also at logic 0, but this doesn't have any effect until a clock pulse comes along. When the clock pulse appears, its leading edge starts the changeover action, but the clock voltage has reached logic 1 before Q has had time to change from 1 to 0. That's the important point, because when the change takes place, it's too late to have any effect on D until the *next* clock pulse arrives. A timing diagram will make this a bit clearer. **Fig.3.8** shows the times, not to scale. You can see that by the time Q and $\overline{Q}$ change, the D input is 'locked out' — because the leading edge of the clock pulse has passed, the voltage at the D input has no effect on the output.

The result is the toggling action, with the voltage at Q changing at each clock pulse leading edge, causing an output

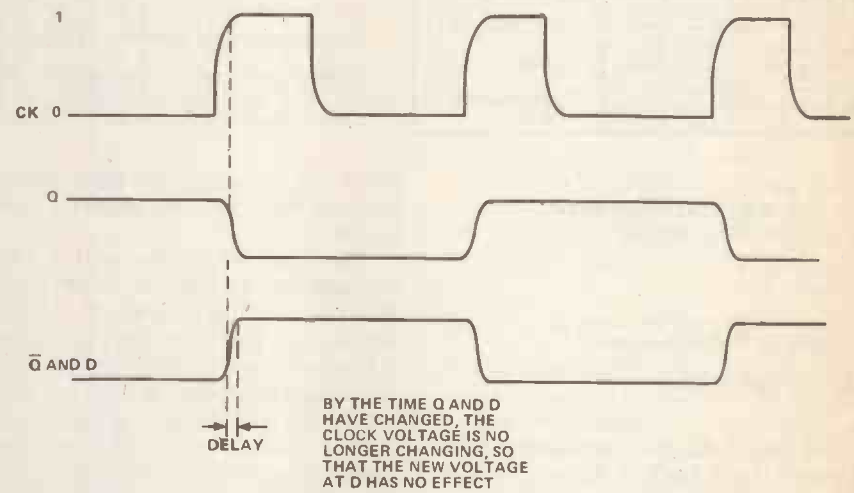


Fig.3.8 The time delays which cause the toggling action of the D-type.

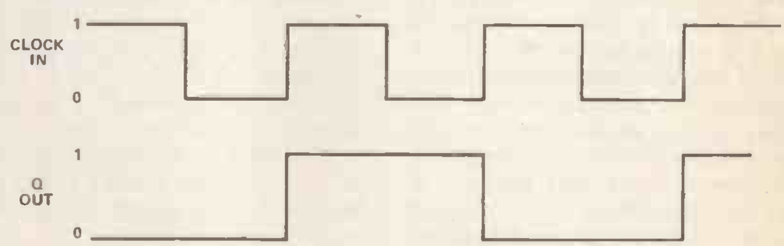


Fig.3.9 The divide-by-two action of a toggling circuit.

pulse at half the rate of the input (**Fig.3.9**). This toggling action is important because it is the method that a lot of counting circuits use — more of that later.

All Right, J - K?

D-type flip-flops have their uses, but the toggling action is reliable only if the rise-time of the clock pulse is very short. A much more versatile flip-flop has been evolved over the years, one which doesn't rely on this rise time or on the delay in the circuit. Its full name is Master-slave J - K flip-flop; just to keep your tongue from rattling too much we'll call it the J - K. It's not the sort of circuit you'd want to make up from separate transistors; even if you made it from IC NAND gates you'd need eight of them, but it can be made reasonably easily and cheaply in IC form. The one we'll use has the type number 7476, and this particular IC has two J - Ks in its 16-pin package.

The symbol for a J - K is shown in **Fig.3.10.** It looks a lot more complicated than the flip-flop we've used so far, and it is. The reason is that the J - K can replace any other type, and ever since J - Ks have been made at reasonable prices, other types have not been needed to anything like the same amount.

Going over the connections to a single J - K in detail, the outputs are the

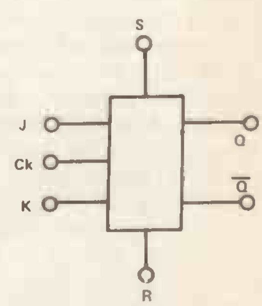


Fig.3.10 J-K flip-flop symbol.

familiar Q and $\overline{Q}$ which we're used to by now. Three of the inputs are also familiar — the clock and the R and S inputs. A clock pulse is taken to the clock input of the J - K, and the action of the J - K very much depends on this clock pulse. The R and S inputs are used to set ($Q = 1$) or reset ($Q = 0$) the output at any time — there's no need to wait for a clock pulse. These inputs are called the asynchronous inputs — they are not synchronised to the clock.

The other two inputs are labelled J and K, and they are used to 'program' the flip-flop. The voltages we set at these inputs will decide what the J - K does at each clock pulse. **Table 1** summarises what happens.

J	K	Q BEFORE CLOCK PULSE	Q AFTER CLOCK PULSE	
0	0	0	0	NO EFFECT
0	0	1	1	
1	0	0	1	FORCES Q = 1
1	0	1	1	
0	1	0	0	FORCES Q = 0
0	1	1	0	
1	1	0	1	CHANGES Q OVER
1	1	1	0	

S AND R
(CHANGES TAKE PLACE WHEN S OR R TAKEN TO LOGIC 0)

S = 0, Q = 1
R = 0, Q = 0

S AND R MUST NOT BE TAKEN TO LOGIC 0 AT THE SAME TIME

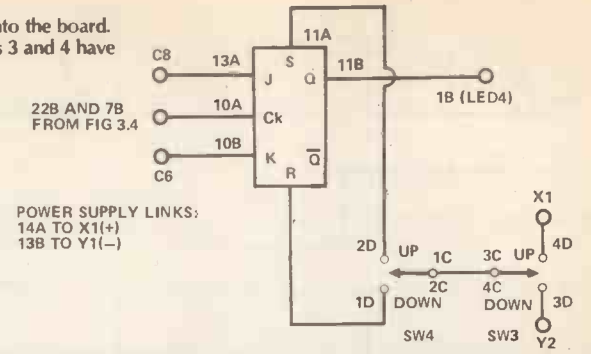
Table 1. J-K flip-flop action

The important thing now is to try it for yourself and **Fig.3.11** shows a circuit diagram. We've kept the clock generator in place, but the 7476 plugged in, with its pin 1 on line 10A and its pin 16 on line 10B. Remember that this one is a 16-pin IC! We also need to make some changes to one switch. Switch 4 is altered as shown, so that there are connections to the R and S inputs, with the switch selecting which of the two is taken low. Taking the R input to logic 0 will reset the J - K (Q = 0), and taking the S input to logic 0 will set the J - K (Q = 1). With the wiring shown, the J - K will be reset with SW4 down and set with SW4 up. SW3 is used to control the voltage used for R and S, so that we can leave them both isolated (switch 3 up) or have one of these inputs operated (switch 3 down). **Table 2** summarises the action of switches 3 and 4 in this circuit.

Switches 1 and 2 are used to control the J and K inputs. These switches are wired in the same way as they were when we started, up for logic 1, down for logic 0. Switch 1 controls J, and switch 2 controls K. LED 4 indicates the state of Q.

Start with J = 0, K = 0 (SW1 and SW2 both down) and reset the J - K by having switch 3 down and switch 4 down. With these settings, the clock pulse (watch LED 1) should have no effect on Q (watch LED 4). If you now push SW3 up just after a clock pulse,

Fig.3.11 Connecting the J-K flip-flop into the board. Note that the connections to switches 3 and 4 have been changed.



NOTE: SOME SAMPLES OF 74LS76 MAY NEED 'PULLUP' RESISTORS. IF YOU ENCOUNTER INCONSISTENT RESULTS, CONNECT 10k RESISTORS BETWEEN 2D & X1 AND BETWEEN 1D & X1.

Table 2. Action of switches SW3 and SW4 in Fig.3.11.

	UP	DOWN
SW3	NO ACTION	ACTIVATES S OR R
SW4	SET SELECTED	RESET SELECTED

the R and S inputs are released, and whatever happens is caused by J = 0, K = 0.

Nothing? Don't panic — that's what is supposed to happen. With J = 0, K = 0, the J - K is isolated. It saves having to add a gate if we can cut off the J - K like this. Just to confirm the action, try again, but this time set switch 4 up, so that Q is set (LED 4 glows) before isolating with SW3 (up). This time the Q output remains set; the clock pulses have no effect.

What we're doing is to hold the output set or reset by using the R or S inputs, and then releasing these inputs by pushing SW3 to give logic 1. Since the set/reset inputs need a logic 0 to operate, this prevents them from acting, so that the J - K is then programmed by its J - K inputs only. With J = 0, K = 0, the state of the Q output is unaffected by the clock pulse.

Now set the switches so that J = 0, K = 1 (switch 1 down, switch 2 up). Go through the same routine again, with switches 3 and 4 down so that Q is reset, then flick switch 3 up. Is there any effect on LED 4? Try again, starting with switch 4 up this time so that Q is set. Does the clock pulse cause any change after SW2 has been pushed up?

When J = 0, K = 1, the next clock pulse will cause the output to go to logic 0. If the output was already at 0, of course, the change will not be noticeable, but if the output was at 1, then the changeover occurs at the clock pulse.

Now try again, with J = 1, K = 0 (SW1 up, SW2 down). This time you'll find that the clock pulse has the effect of setting the output to 1 after the R,S inputs have been released.

Finally, try J = 1, K = 1, and leave SW3 up. What effect do the clock pulses have on the output now? J = 1, K = 1 is the toggling connection for the J - K flip-flop. No external feedback links are needed to accomplish this (compare the D-type) and the action does not depend on having a clock pulse with a very fast rise time.

The reason for this advantage is the master-slave principle. The J - K consists of two sets of flip-flops, the master, which is affected by the J, K inputs and the slave which is driven by the master and which in turn provides the outputs. Both of these flip-flops are operated by the same clock pulse, but the master operates on the leading edge of the clock, and the slave operates on the trailing edge. This guarantees a time difference between inputs and outputs, a time difference equal to the time of the clock pulse. At the leading edge of the clock pulse, the master flip-flop is set or reset by the J, K inputs, and its outputs are connected to the inputs of the slave. The slave does not operate, however, until the trailing edge of the clock pulse comes along, and that's when the outputs of the J - K change. By that time, no changes in the inputs can have any effect.

The J - K is such a versatile flip-flop, with so many useful operating conditions that it's seldom worthwhile using any other type. The usual TTL operating conditions apply — any unconnected input will 'float' to logic 1, and it's important not to have both set and reset inputs low at the same time, which is the reason for the connections to switches 3 and 4 in **Fig.3.11.** These inputs are also known by the names of preset (for set) and clear (for reset).

Quick Flips And Slow Bounces

And now for something entirely different — just to tidy up a few odd points. You'll remember the clock pulse oscillator circuit of **Fig.3.4** which needed to use a form of NAND gate called a Schmitt gate — here's why. Most NAND /NOR gates are simply based on inverting amplifiers with a very high gain.

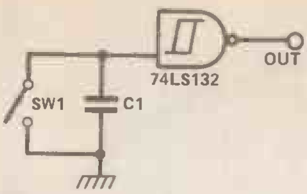


Fig.3.12 Debouncing a switch, using the 74LS132.

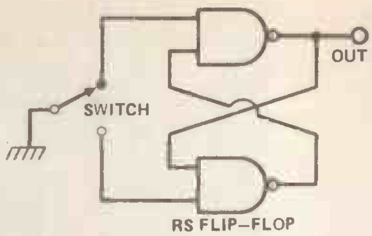


Fig.3.13 Using the R-S flip-flop to debounce a switch.

Like any other high gain amplifier, these will oscillate if they are suitably biased, and in the course of changing between logic 0 and logic 1 (or 1 to 0) they pass through a suitable bias voltage. Now if the input pulses are so fast that the gates don't have time to oscillate, that's fine. You can't always guarantee this, though, especially when the input comes from other circuits, particularly operational amplifiers (slow little devils, these). A Schmitt trigger input to a gate has a snap-over action which never allows the gate circuit to oscillate. No matter how slowly the input voltage of a Schmitt gate changes, the output will snap over at a really high speed, and there's a fair difference in the voltage which is needed at the input to switch the output high and the voltage which is needed to switch low. This quantity is called the voltage hysteresis. Whenever a signal has to be fed into a digital circuit from circuits which are not digital circuits, Schmitt trigger gates should be used. The symbol which is used to distinguish these gates is a miniature version of the shape of the V out/V in graph.

How does a gate like this oscillate? Imagine that the output in **Fig.3.4** is at logic 1, and the input is at 0. The current flowing through R charges up capacitor C, and when the voltage at the input reaches about 2.4 V, the output switches to logic 0. Capacitor C now discharges through R, until the input voltage reaches its other switching voltage at 0.8 V. At this voltage, the output goes high again and the action starts all over again.

We can use the Schmitt trigger gate also for 'debouncing' a switch. Whenever a switch is closed, the contacts will bounce, so that the switch closes and opens a few times before finally closing. If you're trying to generate one single pulse, this isn't very good, and some method of 'debouncing' the switch is needed. **Fig.3.12** shows one circuit, making use of the Schmitt trigger NAND gate 74132. The idea is that if the switch bounces open, the voltage at the input of the gate will not change fast enough to allow the voltage to get high enough to operate the gate — the capacitor C1 ensures that. When the switch is closed, C1 is discharged.

Another method of debouncing a switch is the use of the R - S flip-flop (**Fig.3.13**). If the switch has touched its contact, the flip-flop will switch-over, and any bounce simply leaves the R and S inputs both at logic 1. As you know by now, having both inputs of the R - S at logic 1 leaves the output unaffected, so the switch bounce has no effect on the output. We'll have a look at these debounced switches when we start on binary counters next time. **HE**

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Guitar Pre-amp

Got a guitar? Here's a way of improving its frequency response and cutting down noise and interference. This may seem too good to be true, but the HE Guitar Preamp can do all these things and a few more

WHY SHOULD YOU need to build a circuit like the HE Guitar Preamp into your guitar? I mean, who wants to take hacksaw, mallet, chisel and Black-and-Decker to their favourite Les Paul, simply to stick in some classy tone controls? Well, (believe it or not) there *is* a good reason why: you see, the trouble is that guitar pickups produce only a very low-level signal, usually just a few millivolts. And it's amazing just exactly what this signal has to put up with before it comes blasting out of the speaker at 4000 MW audio power.

First this feeble little signal has to fight its way through the passive tone networks and volume control on the guitar. After this, it reaches the outside world through the jack socket on the guitar body. But here it finds itself confronted with a long tunnel — about 20 feet (6 metres) of screened cable. Exhausted, it arrives at its destination, the amplifier. Up to this point the signal receives no amplification at all. Instead it relies on the high-gain preamplifier in the main amp to do all the work.

This arrangement, although popular for decades, has some serious pitfalls:

- passive tone controls — they do the job but don't allow for a great deal of tonal change in the sound. Active controls are much better
- a low-level signal in a long lead — very susceptible to noise and interference pickup. This can be understood more easily as a ratio of signal-to-noise. For instance, consider a noise or interference pulse, with an amplitude of 10 mV introduced along the lead. Your guitar produces a signal of, say 100 mV, so the signal-to-noise ratio is 10 to 1. The result will be an audible click. If, however, the guitar signal is amplified at source to say 5 V, then the ratio becomes 500 to 1. Because the noise amplitude remains the same it will be totally masked by the signal. Remember, once the noise or interference has been introduced it becomes extremely difficult to eliminate — amplifying the signal at the end of the lead only amplifies the noise too!
- A high-gain preamp is prone to interference itself — and unfortunately a power amplifier is a very good producer of interference (because of the high currents roaming around inside it). It is better to keep the preamp and power amplifier as far apart as possible.

Inserting the preamplifier inside the body of the guitar immediately reduces all these effects and gives an improvement in guitar sound. This is the method we have adopted for the HE Guitar Preamp. The preamp is as close to the signal source as possible and the resultant quality just has to be heard to be believed.

Construction

Although the circuit is rather compact, using Veroboard, its construction is still remarkably easy. Remember to break the copper strips of the board in the correct places before inserting components. Either the correct tool or an ⅛ in. drill bit — carefully hand-held — can be used for this job. Press lightly down on the correct hole and gently twist the tool or drill bit clockwise until the track is broken. Make sure no bridges have been formed between adjacent tracks by loose copper swarf.

The components can now be inserted following the overlay diagram of the circuit. An IC socket is advised for IC1 but not essential. Make sure that all polarised components, C4, C7 and IC1, are the right way round.

After checking that you have no solder bridges across copper tracks, you can commence wiring up the board to pots, battery and jack socket — and final housing.

As you can see in the photographs we housed our circuit inside the body of the guitar, directly underneath the pickup. This is the most advantageous position. However, if you don't want to carve up the inside of your Gibson, Guild or Gretsch, build it in a small box outside the guitar: the improvement in performance will still be worth the effort.

You will find it easier to mount all three pots and the jack socket on the front panel before commencing wiring. Solder longer-than-necessary leads on the pots (screened lead need only be used on the volume pot). Mark them and loosely mount the panel, taking the leads along inside the body of the guitar to wherever the circuit board and battery are mounted. The connection diagram shows where all connections from the pots to the board go. Remember C10 (we ran out of room on the board!) mounts on the volume pot. Cut the leads to the required length before soldering, and when all connections have been made, the group of leads, nine in all, can be held together with cable ties to form a neat cable. Finally, earth all pot bodies with one length of wire. You may have to lightly file the body of each pot to clean up the surface before it will solder.

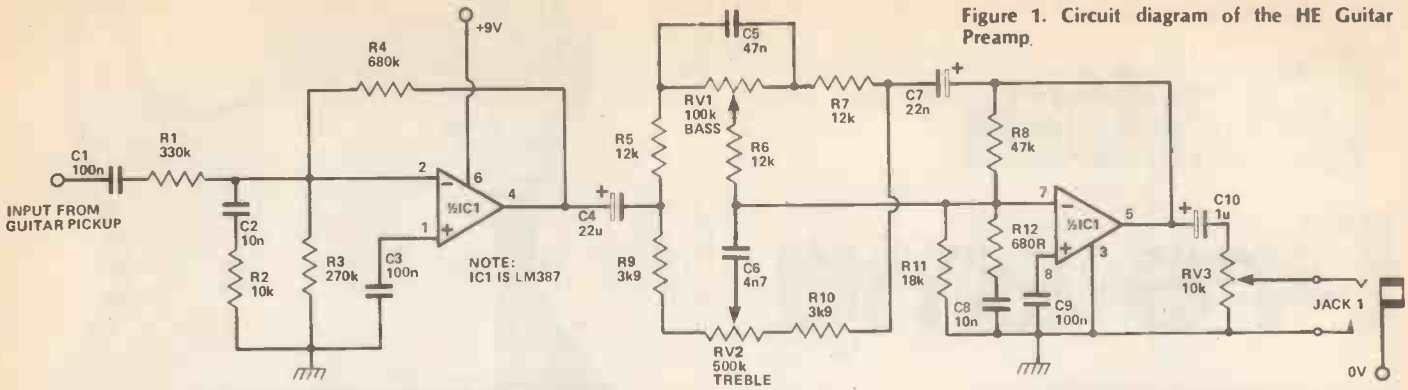


Figure 1. Circuit diagram of the HE Guitar Preamp.

How it Works

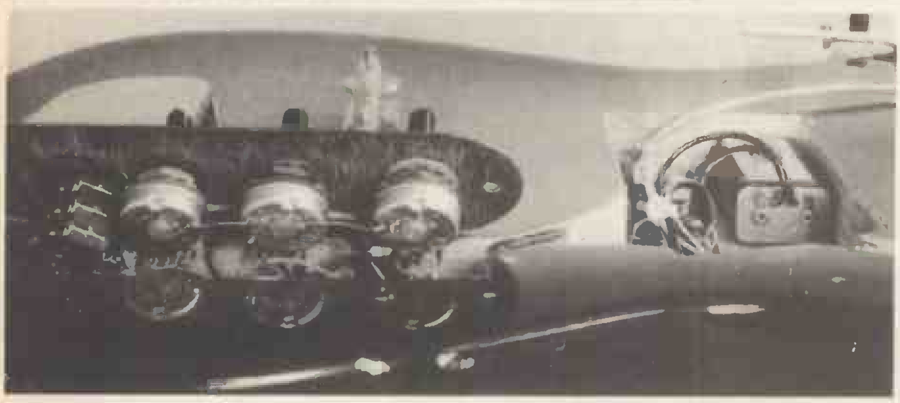
The main component, IC1 consists of two separate preamplifiers housed in the same 8-pin DIL body connected only by a common power supply of between 8 and 30 VDC. Both preamps are identical and are ideally suited for single 9 V-battery operation — current consumption is low, meaning that a PP3-sized cell can be used and has a reasonable life.

The first preamplifier (pins 1, 2 and 4) acts as a fixed gain, flat response circuit, meaning that all frequencies within the audio band are amplified equally. The gain factor of this stage is determined by the ratio of R4 to R1. If further gain is required, R1 should be reduced in value. Conversely, if gain has to be reduced, R1's value should be increased. This facility need only be used if the output from your guitar pickup is either less than, or larger than, average. We used a medium-output amplitude pickup and so our value for R1 provides a good starting point.

The input impedance of this preamplifier is such that the guitar pickup will not be loaded at all.

The second stage is designed around the second half of IC1 (pins 7, 8 and 5) and forms an active two-band tone control block. Bass and treble potentiometers are inserted in the feedback loop of this preamplifier, and provide very good control over the desired frequency response.

Potentiometer RV3 can be adjusted for volume. Because the output signal amplitude of the whole circuit is in the region of 2 volts it should be more than adequate for most requirements. A stereo jack socket is used for the output connections — this provides a useful means of on/off switch for power. When a normal mono jack plug is inserted into the stereo socket, the first two connections are shorted by the jack. Thus, if the battery 0 V connection is taken to the circuit via these two connections, power will only be supplied when a plug is in. You must, however, remember to take out the lead, when not using the guitar, to switch off the circuit and save your batteries.



Parts List

RESISTORS (All ¼ W, 5%)

R1	330k
R2	10k
R3	270k
R4	680k
R5,6,7	12k
R8	47k
R9,10	3k9
R11	18k
R12	680R

POTENTIOMETERS

RV1	100k lin
RV2	500k lin
RV3	10k log

CAPACITORS

C1,3,9	100n polyester or ceramic
C2,8	10n polyester or ceramic
C4,7	22u 10 V tantalum
C5	47n polyester or ceramic
C6	4n7 polyester or ceramic
C10	1u 10 V electrolytic

SEMICONDUCTORS

IC1	LM387 dual preamp

MISCELLANEOUS

10 strip x 24 hole Veroboard
stereo jack socket, battery and clip,
knobs to suit

Buylines

The approximate cost of all components for this project should be in the region of £6. No case or PCB is involved. All components should be freely available from most of the larger mail-order companies.

And that's it! You can check the whole thing before putting the guitar back together by plugging the unit into an amplifier — remember the guitar will now work with an amplifer without a pre-amplifier — and set all controls at about mid-position. Dangle anything metallic, — a bunch of keys will do — close to the pickup. The result will be a raucous noise from the speaker, proving that everything is OK. Check that all controls function correctly and if so you can now replace all guitar panels and play to your heart's content — with hifi sound.

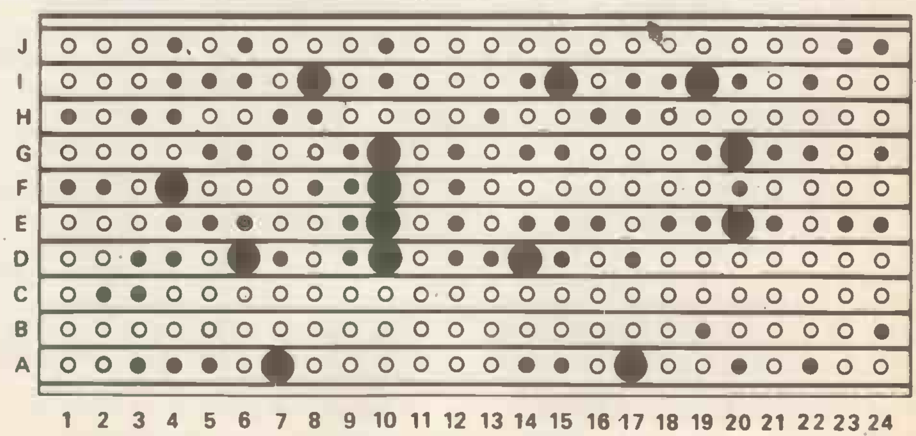


Figure 2. Veroboard component position and track cutting diagram

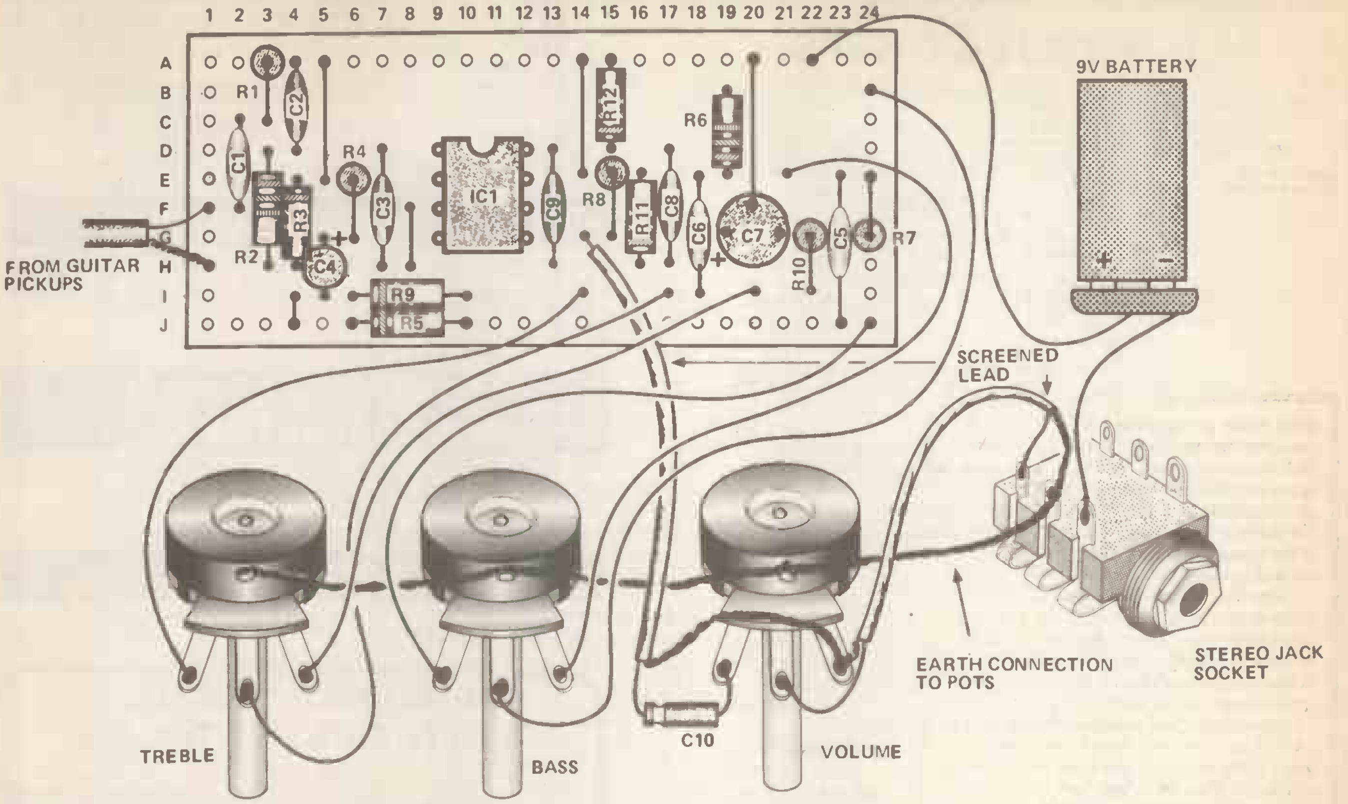


Figure 3. Interwiring and overlay diagram for the HE Guitar preamp

HE

What's In A Name

The transistor was the mainstay of modern electronics for three decades. Only during the past couple of years has it become clear that it too will follow the thermionic valve into history. Rick Maybury looks at the history of the transistor

REMEMBER VALVES? They were those glass tubes filled with high voltages and glowing filaments. Way back in 1948, just after World War II a lot of research was being carried out by the Bell Telephone Laboratories in the USA to produce an amplifier that didn't use valves. Research during the early 1900s suggested that materials called semiconductors (see September What's In A Name) could be worth investigating. A team of three men, John Bardeen, Walter H Brattain and William Shockley were looking at the possibility of semiconductor materials changing their resistance when subjected to an electric field. Most of their experiments resulted in dismal failure. (They were actually doing the groundwork for the Field Effect Transistor which didn't appear until 1963.) Their failure to observe the predicted changes in resistance led the team to carry out further experiments on the surface characteristics of certain semiconductor crystals. This involved placing two fine tungsten wires onto the surface of a slice of Germanium crystal.

Current Affairs

They found that a current change in one of the wires caused a current change approximately five times larger in one of the other wires, the transfer resistor or as we call it now, the Transistor was born!

The first devices became known as the 'point contact transistors' and led to the first practical, commercial device becoming available in 1950. The limitations of the point contact device soon became apparent, the first transistors were largely hand-made. High noise levels generated within the device and difficulty with quantity production led to further research which culminated in 1951 with the filing of a patent by William Shockley for the Junction transistor.

The Junction Transistor

In the point contact transistor the NPN or PNP structure was formed by using a single P or N type base, each of the other two junctions were formed at the point of contact by the fine tungsten wires. Apart from the noise problem the structure limited the power handling capability to a fraction of a watt. The almost microscopic junction was replaced by a slab of either P or N type semiconductor material fused to the base. By making the central base region thinner than the collector or emitter, the power handling, gain and noise figures improved dramatically, it also enabled the growing number of companies manufacturing semiconductor devices to produce transistors in their millions.

The next advance came during the early fifties with the Alloyed Junction Transistors. They used two pellets of Indium placed on either side of a slice of N-type semiconductor germanium. This was put into an oven and heated to 500°C. The two pellets partially dissolved into the germanium. After connecting the three leadout wires the assembly was then encapsulated into a glass or metal envelope. The famous OC71 was its name, ask your grandad about it sometime.

The Silicon Story

Developments followed thick and fast and the late fifties saw the introduction of silicon as a semiconductor material. Silicon offered several important advantages over germanium as it could withstand higher temperatures and had far lower leakage currents as well as having lower noise characteristics.

The Planar process revolutionised transistor manufacture. For the first time the semiconductor manufacturers could design their product to a given specification. The Planar process is essentially a photographic one. The thicknesses of the semiconductor layers can be finely controlled. The principle of the process relies on the diffusion of impurities into areas of the substrate defined by exposure of the silicon to a photographic mask. This process is the basis of modern IC manufacture.

In 1962 a further refinement to the Planar process was introduced, this was known as the Planar Epitaxial Transistor process. This involved the use of highly refined silicon designed to have all its component crystals in one plane.

By now the earlier research carried out by the Bell team was beginning to bear fruit. Advances in manufacturing techniques led to the Field Effect Transistor (FET) which made its debut in 1963.

This was the first real departure from conventional semiconductor operation for over a decade. Conventional transistors are commonly known as current amplifiers. You put a small current into the base and it will control a much larger current flowing through the collector and emitter. The FET is basically voltage-operated, similar in many respects to the thermionic valve. (There was even a suggestion some years ago that valves could be directly replaced with FETs with little or no modification to the circuit.)

The FET has become the basic building block for most of the ICs we use today. Their excellent switching characteristics and inherent simplicity make them ideal for logic gates.

As with many scientific developments the wheel turns full circle. The original research work that led to the transistor was in fact looking at FETs which are themselves similar to the valve for which the scientists were trying to find a replacement. The FET didn't appear until 1963, some 15 years after the original research was abandoned, and now it looks as though the FET (in its many guises) will replace the conventional transistor. What next we ask? **HE**

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AC178	£0.29	BC177	£0.18	BD135	£0.44	MPSA06	£0.23	2N2193	£0.44
AC179	£0.29	BC178	£0.18	BD136	£0.40	MPSA55	£0.23	2N2194	£0.44
AC180	£0.23	BC179	£0.18	BD137	£0.40	MPSA56	£0.23	2N2217	£0.25
AC180K	£0.32	BC180	£0.29	BD138	£0.41	OC22	£1.73	2N2218	£0.25
AC181	£0.23	BC181	£0.10	BD138	£0.41	OC23	£1.73	2N2218A	£0.23
AC181K	£0.32	BC182L	£0.10	BD140	£0.41	OC24	£1.55	2N2219	£0.23
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7412	£0.17	7445	£0.75	7490	£0.37	74153	£0.55	74192	£0.69
7413	£0.28	7446	£0.69	7491	£0.74	74154	£0.94	74193	£0.67
7414	£0.58	7447	£0.55	7492	£0.40	74155	£0.58	74194	£0.71
7416	£0.26	7448	£0.64	7493	£0.35	74156	£0.58	74195	£0.69
7417	£0.26	7450	£0.13	7494	£0.86	74157	£0.58	74196	£1.21
7420	£0.13	7451	£0.13	7495	£0.58	74160	£0.67	74197	£1.21
7421	£0.23	7453	£0.13	7496	£0.58	74161	£0.71	74198	£2.13
7422	£0.18	7454	£0.13	74100	£0.98	74162	£0.71	74199	£2.13
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CD4001	£0.22	CD4013	£0.48	CD4023	£0.22	CD4035	£1.38	CD4047	£1.00
CD4002	£0.18	CD4015	£0.94	CD4024	£0.75	CD4037	£1.09	CD4049	£0.55
CD4006	£1.06	CD4016	£0.49	CD4025	£0.22	CD4040	£1.01	CD4050	£0.55
CD4007	£0.20	CD4017	£0.94	CD4026	£1.70	CD4041	£0.87	CD4054	£1.27
CD4008	£1.06	CD4018	£0.98	CD4027	£0.58	CD4042	£0.83	CD4014	£0.92
CD4009	£0.52	CD4019	£0.48	CD4028	£0.78	CD4043	£1.01	CD4055	£1.15
CD4010	£0.55	CD4020	£1.04	CD4029	£0.98	CD4044	£0.94	CD4056	£1.55
CD4011	£0.22	CD4021	£0.94	CD4030	£0.55	CD4045	£1.61	CD4069	£0.20

LINEAR

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	£1.13	CA3130	£1.07	MC1496	£1.04	UA723C	£0.52	TAA550B	£0.40
CA3014	£1.55	CA3140	£0.81	NE536	£3.06	72723	£0.52	TAA621A	£2.30
CA3018	£0.75	LM301	£0.33	NE550	£1.09	UA741C	£0.28	TAA621B	£2.88
CA3020	£1.96	LM304	£1.84	NE555	£0.28	72741	£0.28	TAA661	£1.73
CA3028	£0.92	LM308	£1.15	NE556	£0.69	741P	£0.23	TAD100	£1.50
CA3035	£1.61	LM309	£1.73	NE565	£1.38	UA747C	£0.69	TBA540	£2.42
CA3036	£1.15	LM380	£0.98	NE566	£1.73	72747	£0.69	TBA810S	£0.86
CA3042	£1.73	LM381	£1.67	NE567	£1.96	UA748	£0.40	TBA810	£1.13
CA3043	£2.13	LM3900	£0.67	UA702C	£0.53	748P	£0.40	TBA820	£0.81
CA3046	£0.81	LM3914	£2.45	72702	£0.53	SN76013N	£2.01	TBA9200	£2.88
CA3052	£1.84	LM3915	£2.45	UA703	£0.29	SN76023N	£2.01	TCA270S	£2.30
CA3054	£1.27	MC1304	£2.19	72709	£0.53	SN76110	£1.73	TBA800	£0.92
CA3075	£1.73	MC1310	£1.09	UA710C	£0.46	SN76115	£2.19	TBA120	£0.60
CA3081	£1.73	MC1312	£2.19	72710	£0.35	SN76660	£0.86	TBA641A	£1.84
CA3089	£2.30	MC1350	£1.38	UA711C	£0.37			ZN414	£1.15
CA3090	£4.14	MC1352	£1.61	72711	£0.37				
CA3123	£2.19	MC1469	£3.39						

THYRISTORS

Volts No	Price	Volts	Price
10 THY600ma/10v	£0.17	50 THY7A/50	£0.55
20 THY600ma/20v	£0.18	100 THY7A/100	£0.58
30 THY600ma/30v	£0.23	200 THY7A/200	£0.65
50 THY600ma/50v	£0.25	400 THY7A/400	£0.71
100 THY600ma/100v	£0.29	600 THY7A/600	£0.89
200 THY600ma/200v	£0.44	800 THY7A/800	£0.05
400 THY600ma/400v	£0.51		
Volts No	**Price**	**Volts No**	**Price**
50 THY1A/50	£0.30	50 THY10A/50	£0.58
100 THY1A/100	£0.32	100 THY10A/100	£0.65
200 THY1A/200	£0.37	200 THY10A/200	£0.71
400 THY1A/400	£0.44	400 THY10A/400	£0.80
600 THY1A/600	£0.52	600 THY10A/600	£1.13
800 THY1A/800	£0.67	800 THY10A/800	£1.40
Volts	**Price**	**Volts No**	**Price**
50 THY3A/50	£0.32	50 THY16A/50	£0.62
100 THY3A/100	£0.35	100 THY16A/100	£0.66
200 THY3A/400	£0.37	200 THY16A/200	£0.71
400 THY3A/400	£0.48	400 THY16A/400	£0.88
600 THY3A/600	£0.58	600 THY16A/600	£1.03
800 THY3A/800	£0.75	800 THY16A/800	£1.59
Volts No	**Price**	**Volts No.**	**Price**
50 THY5A/50	£0.41	50 THY30A/50v	£1.36
100 THY5A/100	£0.51	100 THY30A/100v	£1.64
200 THY5A/200	£0.57	200 THY30A/200v	£1.87
400 THY5A/400	£0.65	400 THY30A/400v	£2.06
600 THY5A/600	£0.79	500 THY30A/600v	£4.03
800 THY5A/800	£0.93		

SILICON RECTIFIERS

200MA		**10 Amp**	
IS920 50v	£0.07	IS10/50 50v	£0.21
IS921 100v	£0.08	IS10/100 100v	£0.24
IS922 150v	£0.09	IS10/200 200v	£0.26
IS923 200v	£0.10	IS10/400 400v	£0.40
IS924 300v	£0.11	IS10/600 600v	£0.48
1 Amp		IS10/800 800v	£0.58
IN4001 50v	£0.05	IS10/1000 1000v	£0.69
IN4002 100v	£0.05	IS10/1200 1200v	£0.79
IN4003 200v	£0.07		
IN4004 400v	£0.08	**30 Amp**	
IN4005 600v	£0.09	IS30/50 50v	£0.64
IN4006 800v	£0.10	IS30/100 100v	£0.79
IN4007 1000v	£0.11	IS30/200 200v	£1.06
1.5 Amp		IS30/400 400v	£1.43
IS015 50v	£0.10	IS30/600 600v	£2.02
IS020 100v	£0.11	IS30/800 800v	£2.23
IS021 200v	£0.12	IS30/1000 1000v	£2.65
IS023 400v	£0.14	IS30/1200 1200v	£3.31
IS025 600v	£0.16		
IS027 800v	£0.18	**60 Amp**	
IS029 1000v	£0.23	IS70/50 50v	£0.86
IS031 1200v	£0.28	IS70/100 100v	£0.96
3 Amp		IS70/200 200v	£1.38
IN5400 50v	£0.16	IS70/400 400v	£2.01
IN5401 100v	£0.17	IS70/600 600v	£2.58
IN5402 200v	£0.18	IS70/800 800v	£2.87
IN5404 400v	£0.19	IS70/1000 1000v	£3.45
IN5406 600v	£0.24		
IN5407 800v	£0.28		
IN5408 1000v	£0.34		

TRIACS & DIACS

2 amp TO5 case		**10 amp**	
volts No	Price	volts	
100 TR12A/100	£0.36	100 TR110A/100	£0.88
200 TR12A/200	£0.59	200 TR110A/200	£1.06
400 TR12A/400	£0.82	400 TR110A/400	£1.29
		10 amp Plastic	
6 amp		volts	
volts		400 TR110A/400P	£1.29
100 TR16A/100	£0.59		
200 TR16A/200	£0.70	**DIACS**	
400 TR16A/400	£0.88	BR100 £0.23 032	£0.23

BRIDGE RECTIFIERS

Type	No.	Price	Type	No.	Price
SILICON 1 amp			**SILICON 2 amp**		
50v RMS	BR1/50	£0.23	50v RMS	BR2/50	£0.52
100v RMS	BR1/100	£0.25	100v RMS	BR2/100	£0.55
200v RMS	BR1/200	£0.29	200v RMS	BR2/200	£0.60
400v RMS	BR1/400	£0.41	400v RMS	BR2/400	£0.67
SILICON 10 amp			**SILICON 25 amp**		
50v RMS	BR10/50	£1.73	50v RMS	BR25/50	£2.19
200v RMS	BR10/200	£1.96	200v RMS	BR25/200	£2.53

DIODES

Type	Price	Type	Price	Type	Price	Type	Price
AA110	£0.09	BY100	£0.25	BYZ11	£0.52	OA90	£0.12
AA120	£0.09	BY101	£0.25	BYZ12	£0.46	OA91	£0.12
AA129	£0.09	BY105	£0.25	BYZ13	£0.46	OA95	£0.12
AAY30	£0.10	BY114	£0.25	BYZ16	£0.47	OA182	£0.15
AAZ13	£0.17	BY124	£0.25	BYZ17	£0.41	OA200	£0.09
BA100	£0.12	BY126	£0.17	BYZ18	£0.41	OA202	£0.09
BA102	£0.37	BY127	£0.18	BYZ19	£0.41	SD10	£0.07
BA148	£0.17	BY128	£0.18	OA5	£0.69	SD19	£0.07
BA154	£0.14	BY130	£0.20	OA10	£0.40	IN34	£0.08
BA155	£0.16	BY133	£0.24	OA47	£0.09	IN34A	£0.08
BA173	£0.17	BY164	£0.58	OA70	£0.09	IN914	£0.07
BB104	£0.46	BY176	£0.86	OA79	£0.12	IN916	£0.07
BAX13	£0.08	BY206	£0.34	OA81	£0.12	IN4148	£0.07
BAX16	£0.09	BYZ10	£0.52	OA85	£0.12	IS44	£0.06
						IS920	£0.07

LEDs

O/no	Size	Colour	Price
1501	125	RED	£0.10
1502	125	GREEN	£0.16
1503	125	YELLOW	£0.16
1504	2	RED	£0.10
1505	2	GREEN	£0.16
1506	2	YELLOW	£0.16
1509	2	CLEAR (Ill Red)	£0.12
SUPER 'Hi'Brite' Type			
1521	125	RED	£0.11
1522	2	RED	£0.11
1514	ORP 12 Light dependent resistor		£0.70
1520	OCP71 Photo transistor		£0.40

CLIPS

1508/125	pack of 5	125 clips	£0.17
1508/2	pack of 5	2 clips	£0.20

DISPLAYS

DL307 + segment D.P. felt (0.3" height) common anode single digit — O/NO 1523 £0.80

DL707 RED. 7 segment D P left (0.3" height) common anode single digit — O/NO 1510 £0.92

DL727 RED. 7 segment D.P. right (0.5" height) anode. Two-digit-reflector — O/NO 1524 £1.95

DL727 RED. 7 segment D.P. right (0.5" height) common anode Two-digit light pipe — O/NO 1521 £2.53

DL747 RED. 7 segment D.P. left (0.6" height) common anode Single-digit light pipe — O/NO 1511 £1.72

OPTO-ISOLATORS

Isolation Breakdown — Voltage 1500 — continuous two current 100mA

CIL74 Single-channel 6 pin DIP standard type — optically coupled pair with infra-red LED emitter and NPN silicon photo transistor — O/NO 1497 £0.57

CILD74. Multi-channel 8 pin DIP two isolated channels — O/NO 1498 £1.15

CILQ74. Multi-channel 16 pin DIP four isolated channels — O/NO 1499 £2.53

SECOND GRADE LED PACK

A pack of 10 standard sizes and colours which fail to perform to their rigid specification but which are ideal for amateurs who do not require the full spec.
O/NO 1507 £1.04

SOCKETS

1611	8 pin DIL	£0.09	1615	28 pin DIL	£0.26
1612	14 pin DIL	£0.11	1723	40 pin DIL	£0.34
1613	16 pin DIL	£0.12	1616	TO18 transistor	£0.13
1720	18 pin DIL	£0.18	1617	TO3 transistor	£0.37
1721	20 pin DIL	£0.20	16117	TO5 transistor	£0.13
1722	22 pin DIL	£0.22	1724	14 pin DIL Wire wrap gold plated Cambion	£0.25
1614	24 pin DIL	£0.24			

G.P. SWITCHING TRANSISTORS

TO18sim to 2N706 /3 SY27 28 95A. All useable devices, no open and shorts ALSO available in PNP sim to 2N290 BCY70 20 for **67p**; 50 for **£1.15**; 100 for **£2.07**; 500 for **£9.20**; 1,000 for **£16.10**. When ordering state NP/PNP

G.P. SILICON DIODES

300mW 40PIV (min) sub min. FULLY TESTED. Ideal for Organ builders
30 for **57p**; 100 for **£1.72**; 500 for **£5.75**; 1,000 for **£10.35**

VOLTAGE REGULATORS

Positive Case	Price		
uA7805 TO220	£0.75	uA7912 TO220	£0.85
uA7812 TO220	£0.75	uA7915 TO220	£0.85
uA7815 TO220	£0.75	uA7924 TO220	£0.85
uA7824 TO220	£0.75	uA7918 TO220	£0.85
uA7818 TO220	£0.75	72723 14 pin DN	£0.52
		uA723C TO99	£0.52
Negative Case	**Price**	LM309K TO3	£1.72
uA7905 TO220	£0.85	ZTK 338	£0.12

ZENER DIODES

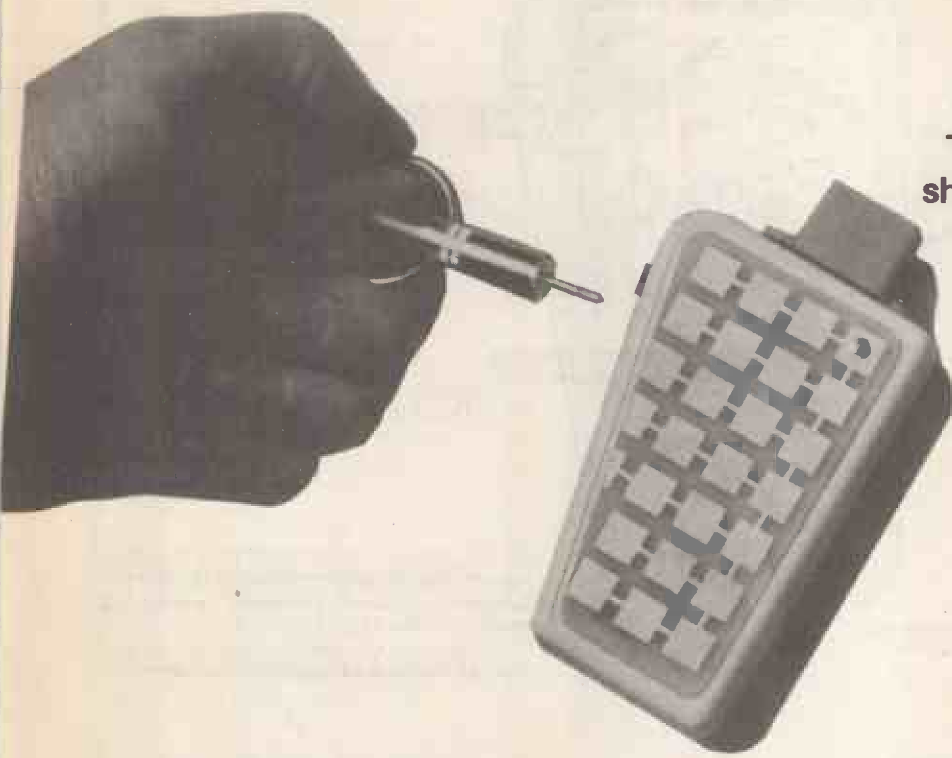
400 mw (Bzy88) 007 Glass encapsulated range of voltages available 1 3v 2 2v 2 7v 3 3v. 3 9v 4 3v. 4 7v 5 1v 5 6v 6 2v 6 8v 7 5v 8 2v 9 1v 10v. 11v 12v :3v 15v 16v 18v 20v 22v 24v 27v 30v 33v 39v **No. Z4 10p**

1w-1 5w Plastic and metal encapsulated Range of voltages available 1 3v 2 2v 2 7v 3 3v 3 9v 4 3v. 4 7v 5 1v 5 6v 6 2v 6 8v 7 5v 8 2v 9 1v 10v 11v 12v 13v 15v 16v 18v 20v. 22v 24v 27v 30v 33v 43v 47v 51v 68v 72v 75v 82v 91v 100v **No. Z13 18p**

10w metal stud type SJ10 case Range of voltages available as above **No. Z110 44p**

All prices include VAT Add 50p post per order — Just quote your Access or Barclaycard number
Terms: Cash with order, cheques, POs, payable to Bi-Pak at above address
Access and Barclaycard also accepted
GIRO A/C No. 388 7006

Party Grenade



This Christmas, we think that you should give your kids (and yourself) a treat and build something with no useful purpose — something just for fun. Designed by Jonathon Scott

IF YOU HAVE kids (or can borrow some), they make a great excuse for building this project! Don't think that it's purely for children; though — judging from the reactions we saw from adults (especially our staff!), the game is just as good for anyone young at heart.

The basic idea started from the old 'hot potato' game in which an object — the hot potato — is passed from person to person until some cue occurs, such as the music stopping, as in musical chairs. The holder of the object is then out of the game and it proceeds with one person less. Eventually, all but one person is excluded and he or she wins the game.

In this new version (which the office wag dubbed 'Irish Roulette') the tossed object is a grenade. Once the 'pin' (a shorted 2.5 mm jack plug) is removed, the grenade becomes active. After that, making touch contact between the two PCB plates on the outside of the box causes a capacitor to charge. When it has charged to a preset level, which is the same as saying that the grenade has been handled by the people in the game for the required time, the buzzer goes off — with no damage to life or limb!

The grenade will go off while a particular person is holding it. It is highly unlikely to go off in mid-air (though very wet hands can leave enough moisture to set it off). The faster your reaction and the quicker you get rid of the grenade the less likely you are to get 'blown up'. The grenade times at a rate independent of damp hands or strength of grip, and is reset by putting the pin back in.

Construction

The first job to undertake is the construction of the PCB. Take care that the diode, capacitor, transistor and the IC are inserted the right way round. As usual we recommend the use of an IC socket.

Mark and drill whatever case you are using to allow for the jack socket, buzzer and two touch contact-plates. The touch contacts are made from shaped pieces of PCB, etched in the pattern shown in the photographs, to imitate the visual appearance of a grenade and are simply glued to the side of the case.

Drill holes in the box underneath the places where the PCB touch contact board wires are to run. It is best to drill the small holes in the boards first to enable you to mark the positions of the holes to be made in the box. One touch contact can be glued on the outside of the case now, but the one which must cover the screws will obviously need to be left till last.

You can mount your PCB on the inside of the case using nuts and bolts if you wish but we preferred to hold ours down using one of the proprietary brands of double sided, adhesive pads available.

Interconnect the board, buzzer, battery and jack socket as in the diagram, mount the battery using double sided pads or jam it in place with some foam rubber and screw on the lid. Finally, the second touch contact is glued on the remaining side of the case. We found that a few small drops of cyanoacrylate adhesive was best, as it maintains good adhesion during normal use, but the board can be prised sharply off when the time comes to change the battery. Remember to follow the manufacturers' instructions when using the adhesive, it can be dangerous.

The pin is made by simply shorting the two connections together. Then if you drill a small hole through the cover of the plug a key ring can be used as a finger pull.

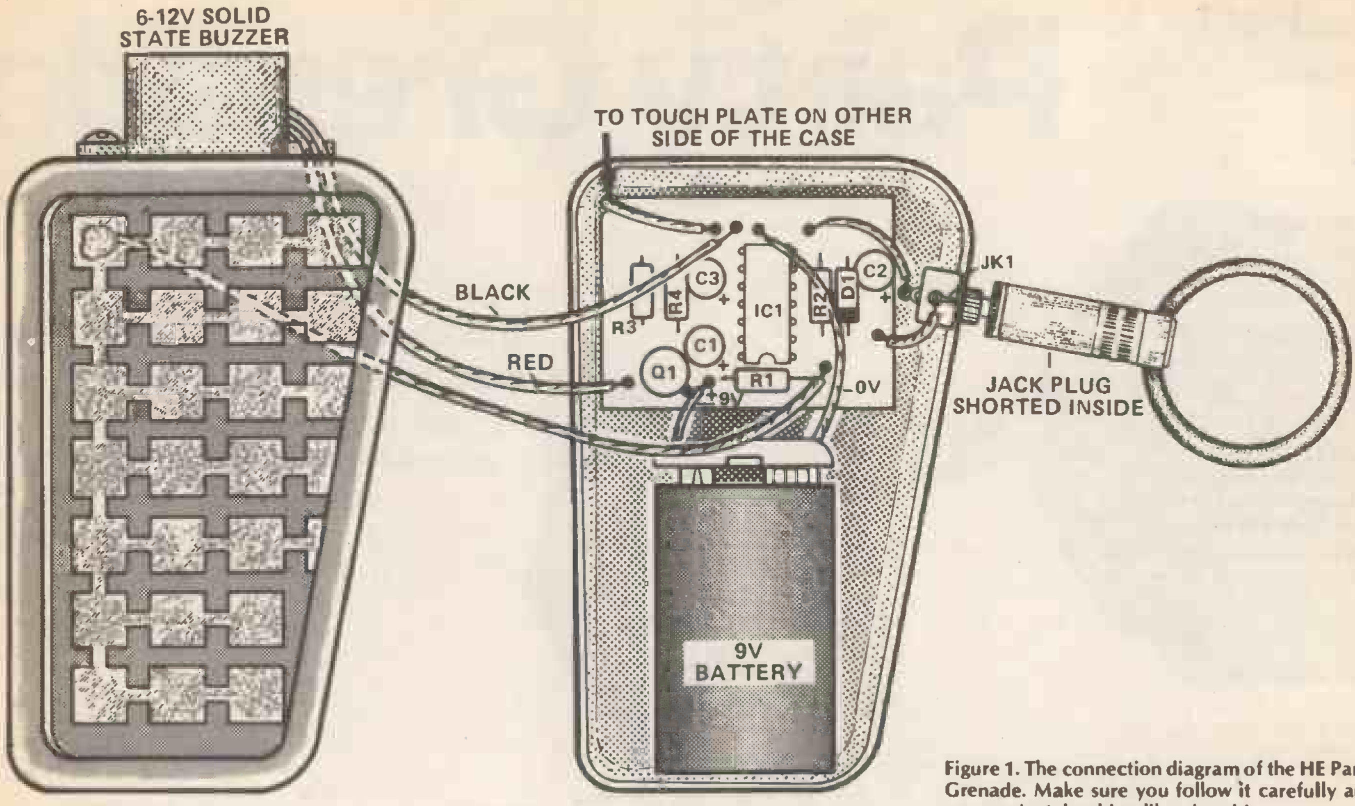


Figure 1. The connection diagram of the HE Party Grenade. Make sure you follow it carefully and your project should go like a bomb!

Figure 2. The circuit diagram is shown below

How it Works

The circuit counts the period of time that the grenade is held after the 'pin' has been pulled and operates the buzzer when this period reaches several seconds.

Initially, a shorted plug (the 'pin') is inserted in JK1, shorting C2. Resistor R1 holds the inputs of IC1a high. Its output is therefore low, so no current flows through R2/D1 (No relation to R2-D2!)

The output of IC1d is high, so that Q1 is biased off and the output of IC1c is held low. Quiescent current flowing in this state is negligible — less than 0.5 uA.

If the device is picked up and the skin resistance of a hand placed across the touch contacts, the output of IC1a goes high and a small current flows through R2, but C2 remains shorted out by the pin.

When the pin has been removed, however, holding the device causes C2 to charge. D1 prevents rapid discharging when the touch is removed by preventing current flowing back through R2.

When C2 charges to the threshold of IC1b, its output goes low and a monostable formed by IC1c and IC1d turns Q1, and thus the buzzer, on for about a second.

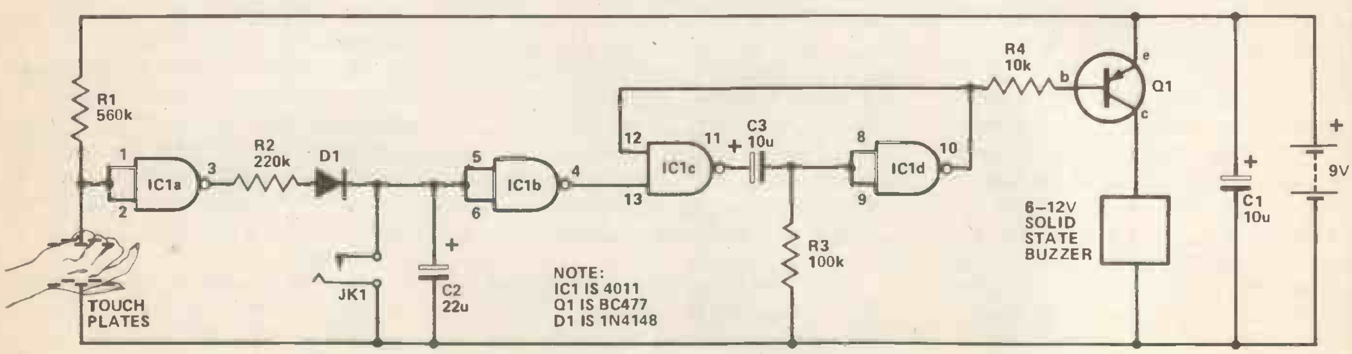
The pin is then replaced to reset the circuit, ready for another attack.

Buylines

The solid state buzzer is about the only component which may be difficult to find. Any of the usual mail order companies should be able to help.

The box is made by Vero and their code number for it is 202-21026G.

Approximate price for the HE Grenade should only be about £3. As usual this does not include case or PCB.



Parts List

RESISTORS (All ¼ W, 5%)

R1	560k
R2	220k
R3	100k
R4	10k

CAPACITORS

C1,3	10u 16 V tantalum
C2	22u 16 V tantalum

SEMICONDUCTORS

D1	1N4148
Q1	BC477
IC1	4011

MISCELLANEOUS

6 to 12 V solid state buzzer
2.5 mm jack plug and socket
case to suit (see Buylines)

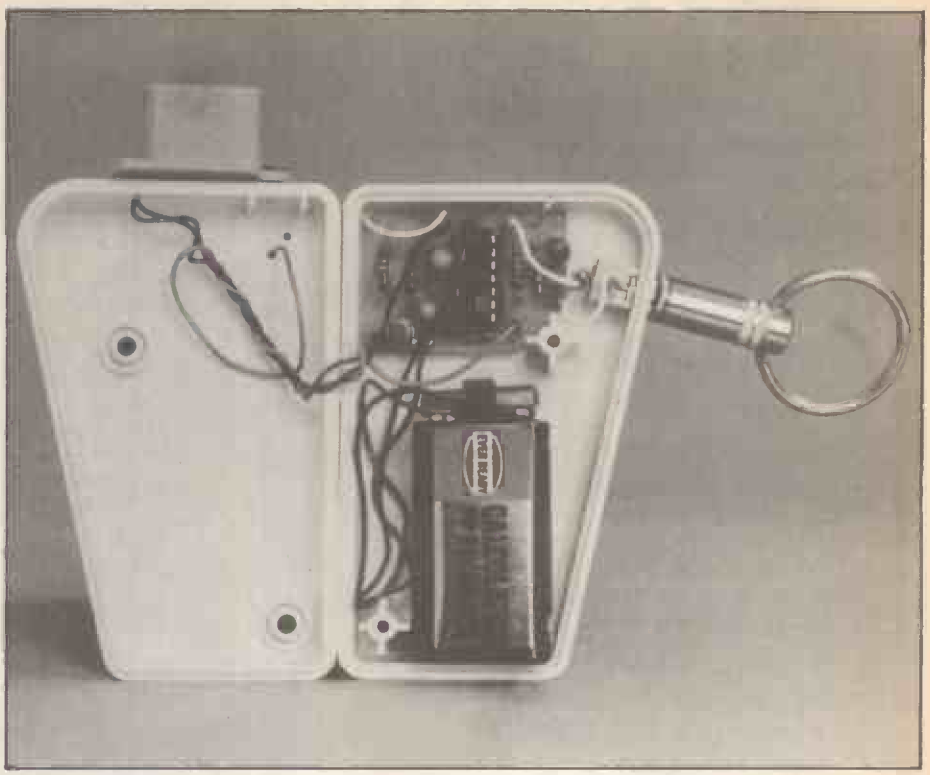
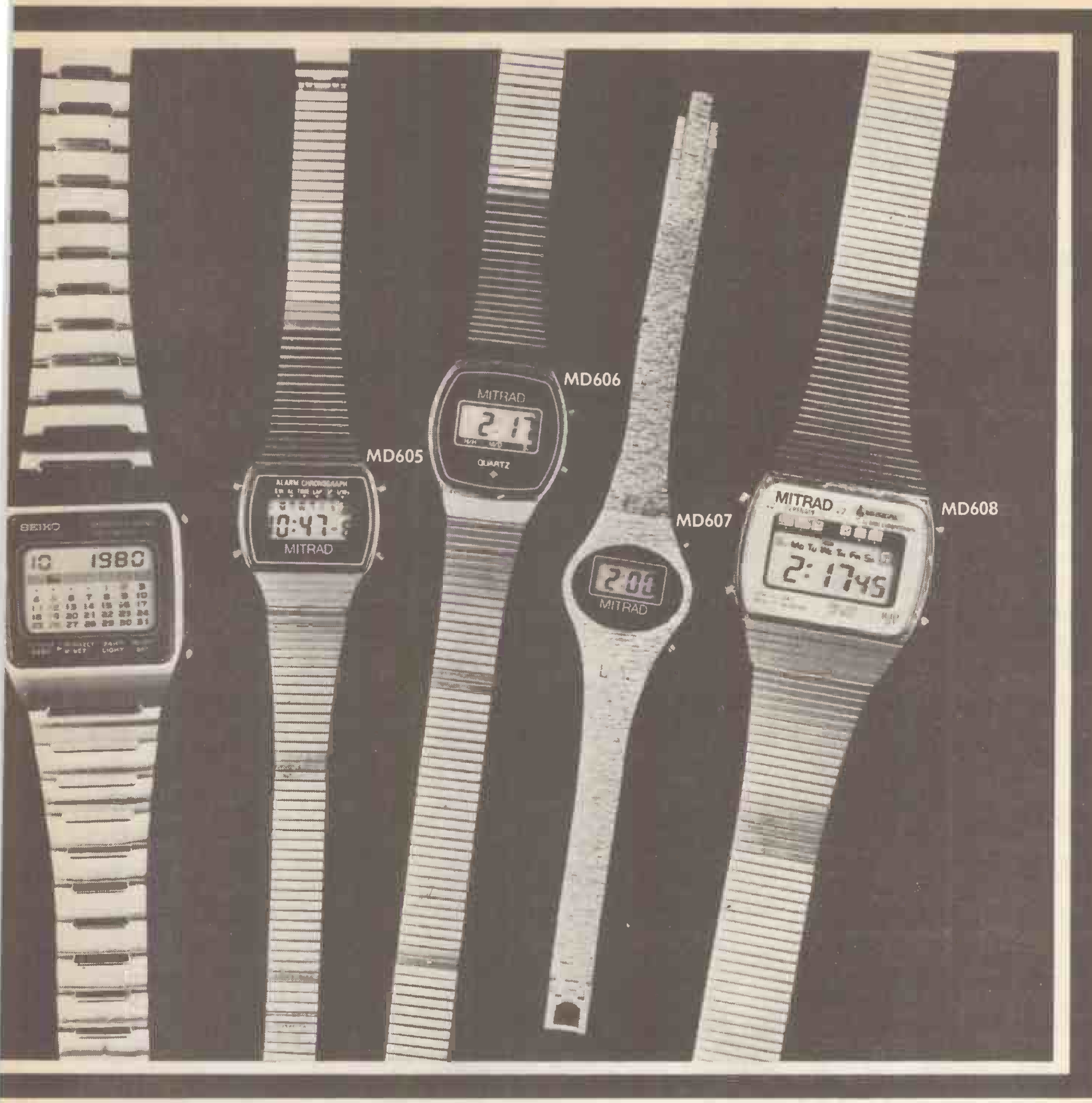


Figure 4. The inside of the case. There's not a lot of room left, is there?

HE



MD609 Gentleman's **super slim** flag date alarm. Only 4mm case thickness. Continuous display of hours, minutes, seconds and day; optional display of date, month, year. 24 hour alarm, alarm mode indication. Back light. Infinitely adjustable stainless steel strap. Very latest technology.
£10.95 + 85p p&p

MD610 Gentleman's dual time melody alarm chrono. Only 5mm case thickness. Continuous display of hours, minutes, seconds plus date and mode indications. 'Running horse' chrono to 1/10 sec, 12 hour alarm plays 30 seconds of 'Yellow Rose of Texas'. Infinitely adjustable stainless steel strap.
£16.95 + 85p p&p

MD605 Ladies musical alarm chrono. Continuous display of hours, minutes, seconds; optional display of day, date, month. Auto calendar. Chronograph with lap timing facilities, to 1/10 sec. 24 hour alarm plays 30 seconds of Beethoven's 'Fur Elise'. Back light. Infinitely adjustable stainless steel strap.
£11.95 + 85p p&p

MD606 Ladies five function fashion LCD watch with 3 year battery. Continuous display of hours and minutes, with month/date and date/seconds available. Auto calendar. Only 6mm case thickness. Back light. Infinitely adjustable stainless steel strap.
£9.95 + 85p p&p

MD607 Ladies slim 'sugar coated' dress watch. Continuous display of hours and minutes; optional display of month and date. Auto calendar. Back light. Integral watch and strap. In gold or silver finish.
£9.95 + 85p p&p

MD608 Gentleman's musical alarm chrono. Continuous display of hours, minutes, seconds, plus day indication. Also month and date. Chronograph with lap timing facilities, to 1/10 sec. 24 hour alarm plays 30 seconds of Beethoven's 'Fur Elise' or can be set to awaken to a single note. Back light. Infinitely adjustable stainless steel strap.
£15.50 + 85p p&p

Building Site

Do you want to know all about printed circuit boards? Are they as difficult to make as they seem? Keith Brindley explains how easy they really are

OVER THE LAST month or two I have received several requests by readers, to give all the gen about printed circuit boards (PCBs) — why do we use them and how does the hobbyist set about making them him-self (or herself)?

Well, the answer to the first question is simple — we use them because they provide the most convenient and foolproof way of making connections between components, without the danger of short circuits and without the use of a large number of interconnecting wires. In **Figure 1** you can see photographs of the top and bottom of a typical PCB showing the copper track attached to the surface of the insulating board. It doesn't take much imagination to picture the project if all connections had to be made with wires. Nothing can beat the neatness of a PCB in project construction and this is the reason why HE and our sister publication ETI have *always* used PCBs in projects — for your benefit.

As for the second question, there is no mystique to home-made PCBs (the real art is in the foil pattern design). The process is a straightforward, scaled-down version of commercial processes and is suited to the hobbyist in both ease and expenditure. There is no need for elaborate equipment which would be out of the home constructor's price range and likewise you don't have to be an expert. Just a few simple hints should be all that's required to enable anyone to do-it-themselves.

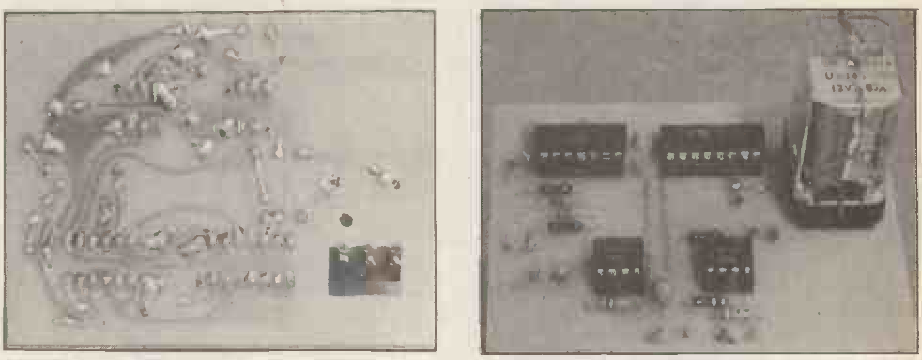


Figure 1: Photographs of the bottom and top of a typical printed circuit board

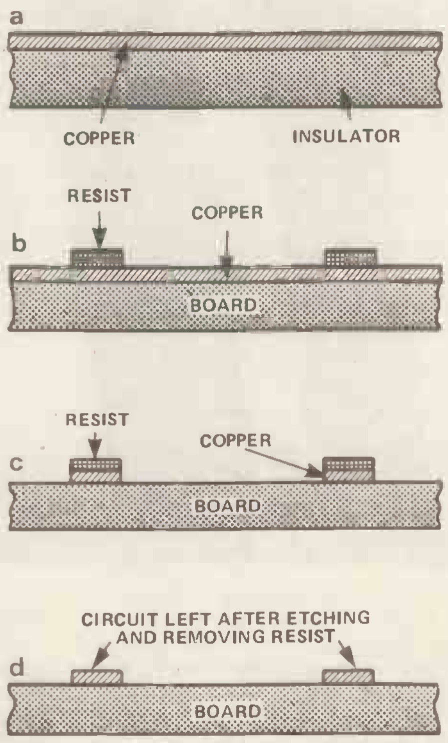
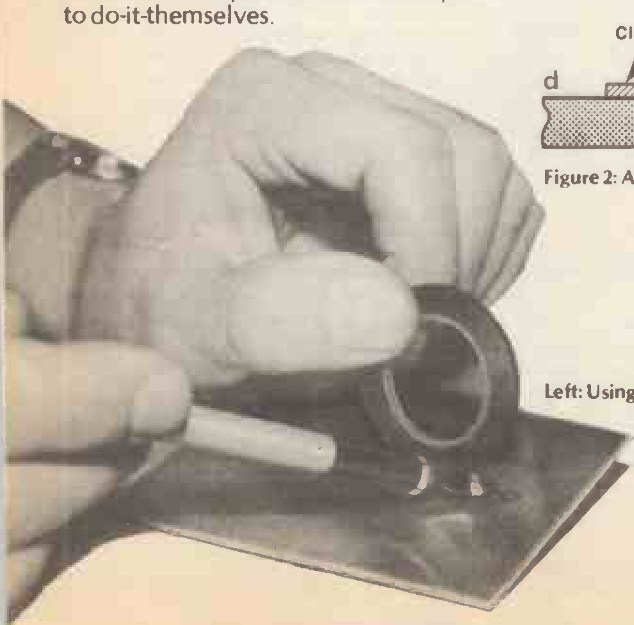


Figure 2: Above four stages in the life of a PCB



Left: Using the 'dots and tape' method of resist

Brass Tacks And Copper Tracks

PCBs start off in life as copper-clad board, the general construction of which can be seen in **Figure 2a**. The idea is that unwanted areas of copper are removed by a copper-dissolving or etching agent (normally ferric chloride), leaving behind the wanted areas of copper (the foil pattern). It is this pattern that is used to make all the interconnections between components. The foil pattern obviously needs to be protected from the etchant whilst the board is in the etching bath, and this is done with the use of an etch-resistant material usually known as the 'resist'. **Figure 2b** shows this. The resist can be any one of several materials — even common-or-garden household paint can be used as long as it is etch resistant. **Figure 2c** shows the board after it has been etched; the unwanted copper areas have been removed, leaving only the foil pattern which is known as the track. Lastly the resist is removed and the board is ready for drilling and use.

Which Method To Choose

There are at least three main ways in which readers can make their own PCBs in the above manner at a reasonably low cost.

The first is the tracing method. Provided that you have the foil pattern in front of you, it is a simple matter to transfer the outline to a sheet of tracing paper using a soft pencil. Once the pattern has been drawn, turn it upside-

Using **HOBBYPRINTS** as a resist. A burnisher can be used as in the photograph or alternatively a soft pencil works equally as well.

down and copy it on the reverse side. Place this over a clean piece of copper sheet and rub it over with the pencil. When the design has been transferred to the copper sheet fill in the track outlines with a fine brush with either enamel or cellulose paint. When the paint is dry the board is ready for etching.

The next method should be used when making boards which have ICs on them. The important point to remember is that the holes for the IC pins must be correctly aligned. This can be achieved by taping the board (copper-side up) to the underside of the traced pattern (for an HE project, tape the board to the underside of the page where the foil pattern appears). Now, with a sharp pointed scriber or similar tool, carefully mark through, onto the board, every hole position indicated on the paper. Remove the board and apply a resist to fill in the tracks around the holes according to the original pattern. Paint can be used as suggested above but this does require a steady hand. Alternatively etch-resistant transfers (for component holes) and tape (for the track) can be used. These can be bought from any good drawing office supplier although, inevitably they cost slightly more than paint. Their advantage however, is that they can make a neater PCB.

The remaining method of PCB construction for the hobbyist is the use of our own HOBBYPRINTS. Month by month, HOBBYPRINTS provide a rub-down transfer method of reproducing on to PCB the whole etch-resistant foil pattern for immediate etching use. The photograph shows its use. You'll find an advertisement for HOBBY-PRINTS close to the foil pattern page every month and they are well worth the measly sum involved in their purchase.

Take Care

Etching a PCB need not be tricky but it can be messy if you don't take care. The etchant is usually Ferric Chloride, which can be bought at most chemists or chemical wholesalers. Now this stuff is nasty. If you get it on your clothes they can literally fall apart. Use a plastic tray or an old food container for the etching bath and be careful how you pour it — try not to splash — if you do, wash immediately with cold running water. A good, fresh, strong solution of the stuff will etch your PCB in only a few minutes. A point to bear in mind at this stage is that as the reaction takes place a blackish deposit forms on the surface of the copper. If this is not removed then further reaction is slowed down. The deposit must be removed by either agitating the etching bath slowly backwards and forwards (extremely carefully) during the process or by making use of the surface tension of the fluid and floating the board copper-side-down on the surface. The deposit falls to the bottom of the bath leaving a constantly fresh copper surface for the reaction to occur. The only disadvantage is that you can't see the surface of the board to judge when the reaction has been completed.

Wash the board thoroughly after it has been etched and clean off the resist (using wire wool or sandpaper) to give a shiny clean copper surface. Finally, all component holes have to be drilled. One of the commercially-available, modellers' drills can be usedfor this, fitted with a 1 mm bit Such drills cost around £10 but this is money well spent if you are going to construct more than just a couple of PCBs a year. Making your own boards will work out much cheaper than buying them ready-made.

And that's it! The next stage is the insertion of components to complete your project. Nothing to it really is there? — when you know how. **HE**

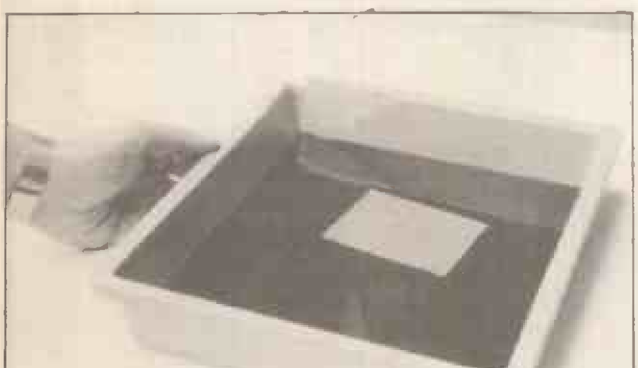


Figure 3. Etching a PCB by floating the board on the surface of the ferric chloride.

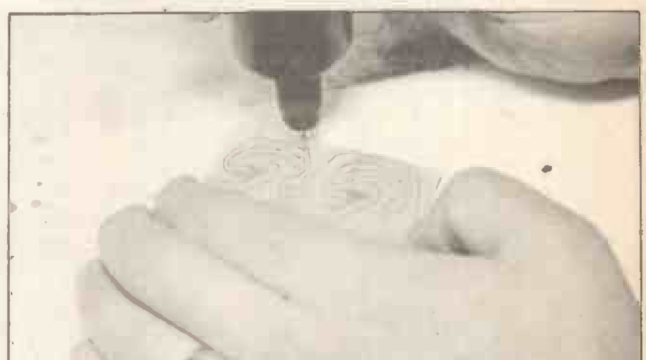


Figure 4. A modeller's drill fitted with a 1 mm bit can be used to drill all component holes.

O Level Q & A

Now for some actual components. Nick Walton looks at the most basic building blocks of electronic circuits — Resistors and Capacitors

THIS MONTH we look at two fundamental electronic components; the resistor and the capacitor.

In electronics books and magazines hardly a page goes by without resistance rearing its little ohms sign, because any circuit will offer some sort of resistance to the flow of current. It is defined in terms of our two basic quantities, the ampere (flow of charge, or current) and the volt (the push giving energy to make the charge flow) dealt with last month. Logically the unit of resistance, the ohm, is defined as the resistance that allows a current of one amp to flow when a voltage of one volt is provided. Georg Simon Ohm's law states that current is directly proportional to voltage for steady temperature; that is, treble the voltage gives treble the current and so-on. This relationship was actually discovered by an Englishman, Henry Cavendish, who never bothered to publish his work. Perhaps just as well because when Ohm did so, it was so severely criticised that he lost his job as a school teacher in Germany.

Mathematically, Ohm's law says that:

$$\frac{\text{volt}}{\text{amps}} = \text{a constant value (the resistance in ohms)}$$

which is the same as:

$$\text{volts} = \text{amps} \times \text{resistance},$$

and

$$\text{amps} = \frac{\text{volts}}{\text{resistance}}$$

all of which can be summarised in the form shown in **Fig.1**.

Another helpful way of looking at resistance coming from the volts/amps idea is to regard, say, five ohms as five volts per amp; that is, a resistor which needs five volts to produce a current of one amp. Of course this assumes things do not get hot — which is fair enough in theory but not in practice. By the time you are thinking of a 12kR resistor as 12,000 volts for its statutory one amp current the poor little thing is probably sizzling quietly away — red-hot or better!

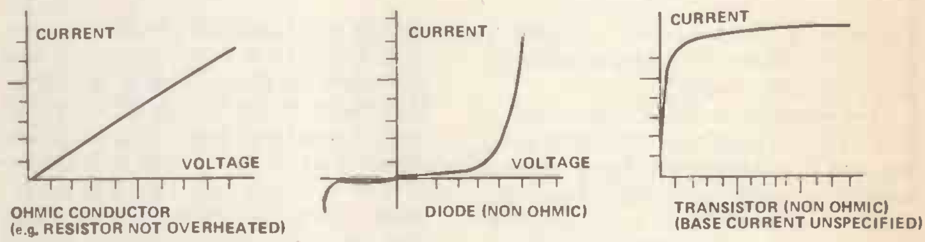


Figure 2. Ohmic and Non-Ohmic conductors

Few conductors obey Ohm's law with 100% obedience, but it is still an incredibly useful generalisation. Conductors which show a total disregard for it are called non-ohmic and include many electronic devices like diodes and transistors. A current-voltage graph of a well-behaved ohmic conductor shows a steadily rising straight line in keeping with the 'treble voltage, treble current' proportionality idea. **Fig.2** shows this as well as diode deviations and transistor transgressions.

Sometimes, you have two or more resistors together; they may be in series, as indicated in **Fig.3**. Here, to get the total resistance you simply add them up, giving $R_{total} = R1 + R2$.

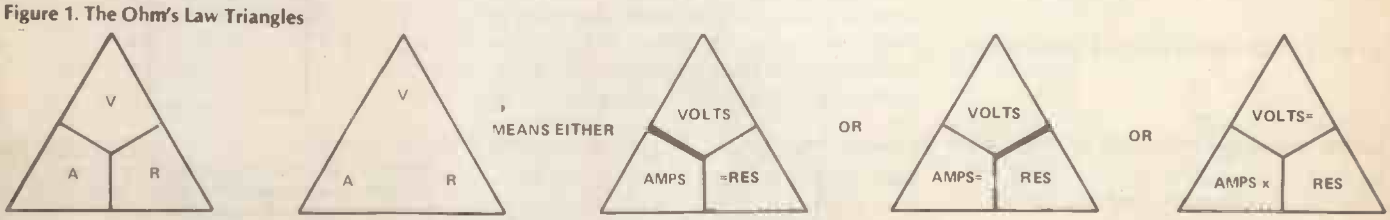
The other way of combining them is to 'branch' the circuit as in **Fig.4**, where the resistors are connected in parallel. The resistance of the combination, R_{AB}, is contained in the formula:

This can be shown by realising that the total current i_{AB} must be the sum of what is flowing in R1 and R2 ($i_{AB} = i_{R1} + i_{R2}$) and then by using the Ohm's low triangle to express current in terms of resistance and voltage. (Remember that the voltages across AB, R1 and R2 are all the same.) It is useful to bear in mind that with resistors in parallel the resistance of the combination is always less than the value of any individual one.

Figure 3. Two resistors R1 and R2 in series

Such talk of changing resistance leads to thoughts of how a variable resistor might be used. Variable resistors or potentiometers consist of a length (AB) of resistance material, sometimes straight, sometimes curved, constructed so that you can use all

Figure 1. The Ohm's Law Triangles



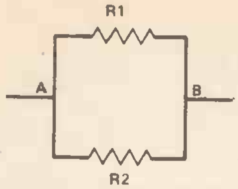


Figure 4. Two resistors R1 and R2 in parallel

or only a part of it (see **Fig.5**).

Now, if you put a fixed voltage (say 3 volts or 3V) across AB then you can tap off any value of output voltage up to 3V depending on the position of the slider. For example, with our 3V across AB we can get one volt if the slider is a third of

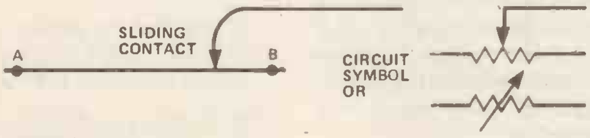


Figure 5. Variable resistance principle

the way up from B. This is called a potential divider or potentiometer or just 'pot' (quite legal!).

The variable resistor is also used in a series control system — the sort of thing you use to control the volume of your radio. You might, for example, have one stage of an amplifier in series with the next stage, and you control how much voltage is fed to the second stage by the variable resistor.

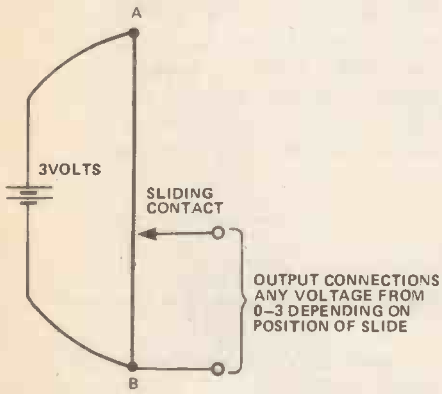


Figure 6. The voltage divider or potentiometer

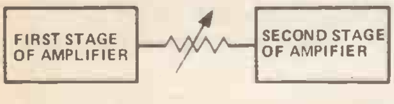


Figure 7. Variable resistor used as a series control

Colourful Codes

Finally, a colourful ending: a resistor's value is not written but denoted by three coloured bands. Each figure 0 to 9 has its own colour thus:

0 is Black	**5 is Green**
1 is Brown	**6 is Blue**
2 is Red	**7 is Violet**
3 is Orange	**8 is Grey**
4 is Yellow	**9 is White**

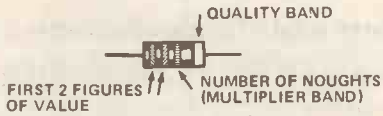


Figure 8. Secrets of the resistor colour code

The first two bands give the first two figures and the third band the number of noughts, as indicated in **Fig.8.** For instance a value of 47 000 R would have the first two bands yellow (4) and violet (7) and then an orange band to tell you that there are three noughts to follow. The fourth band is a quality band is most frequently silver or gold. Silver means that its actual value is within 10% of what it should be. Gold is 5%. Three other colours of quality band may be encountered: salmon pink is 20%, red is 2% and brown is 1%.

Capacitors

The capacitor (old name condenser, ancient name Leyden jar) is a very different little fellow and can best be regarded as being two metal plates, close together but insulated from each other. If you put, say, negative charge (that is, electrons) on one plate, these will repel electrons from the other plate and you end up with an equal amount of positive charge on the other plate. Negative charge on one plate and positive charge on the other is equivalent to saying that you have a voltage across them, because if they were now connected to a resistor a brief current would flow until the charges had evened themselves out again (called discharging a capacitor). So connecting a capacitor to a battery as shown in **Fig.9** charges up the capacitor.

There has been a brief flow of current as charge flowed from the battery onto the capacitor plates. It builds up until there is a voltage which exactly opposes the voltage the battery has to offer, at which stage there is no further current. This is why a capacitor can be used to block direct currents — a function known as a DC block. If we suddently reversed the battery, the capacitor would discharge and then charge up the opposite way round (**Figs. 10a and 10b**).

Continually doing this is none other than alternating voltage and the little squirt of current that results each time is

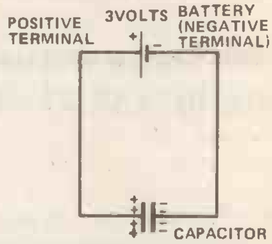


Figure 9. A capacitor being charged by a battery

our old friend *alternating current*. So while a capacitor will block direct current it is happy to let AC pass. Indeed it even has its own Ohms rating (called reactance) given by:

where = 3.14 as in circles, f is the AC frequency and C is the value of capacitance, to be dealt with next.

Different-sized capacitors clearly need different amounts of charge to produce one volt between their plates. So a capacitor is rated by the number of coulombs of charge it needs to produce 1 V across it. This is expressed in coulombs per volt and one coulomb per volt is known as one Farad.

A one Farad (1F) capacitor would need one whole coulomb to produce one volt across its plates. Thus:

Farads = coulombs

or

(where C is capacitance in Farads, Q is charge in coulombs and V is voltage in volts).

Actually a Farad is an inconvenient-

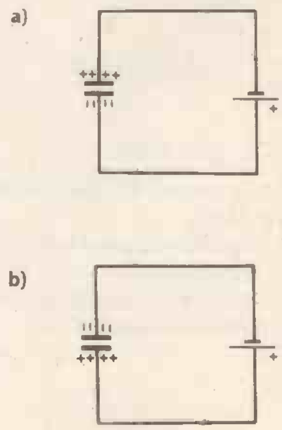


Figure 10. Discharging a capacitor by reversing the battery a) Just after the battery terminals have been reversed. b) Finally fully charged the other way

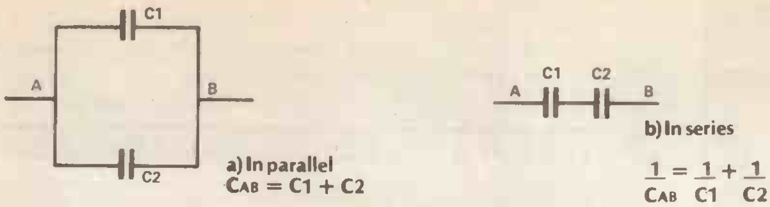


Figure 11. Combinations of capacitors a) In parallel b) In series (Note that this is the opposite to resistors)

ly large unit — the plates would have to be a few square miles in area — so the most common unit is a millionth (10^{6}) of a Farad, a microfarad or uR (muff). Sometimes this is still too large and a millionth of a microfarad is used, called a picofarad (10^{12} F, pF or puff). You occasionally see nanofarads (nF) used, and that's intermediate between muffs and puffs at 10^{9} Farads. Nuff said.

Like resistors you can arraange capacitors in series or *parallel:* you add together the individual capacitances to get the total combination. When they are in series you have to add their reciprocals to get the reciprocal of the combination (see **Fig.11**).

We are now ready to consider RC circuits; that is, a resistor and capacitor together in the same circuit. A charged capacitor allowed to discharge through

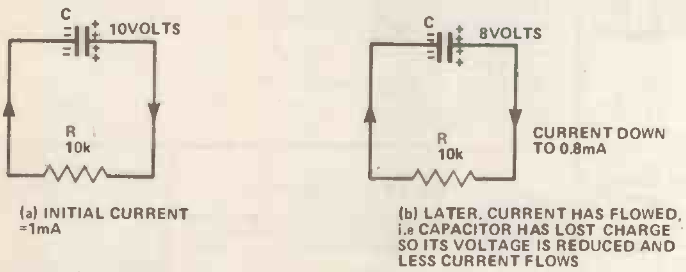


Figure 12. Capacitor discharge through a resistance

a resistor produces a fascinating chicken-and-egg situation on careful examination. Suppose a capacitor, charged to 10 V, starts to discharge across a 10 000 R (10kR) resistor (**Fig.12a**). By Ohm's law the initial current is one milliamp (1mA). But as the charge starts to flow off the capacitor, less charge on the plates means less voltage across them and hence across the resistor. So the current flowing in the resistor drops (**see Fig.12b**). A graph showing how current decreases as time goes by will look like the one in **Fig.13.** In fact if the current took, say, ten seconds to drop to half the original value, it would take another ten seconds to drop to half that; thus halving its value every ten seconds. Such a slowing down is called an exponential decrease and is found to pop up all over the scientific scene, especially in radioactive decay and chemical reactions.

If you want to alter how long the capacitor took to discharge in such a circuit you could do so in two ways. You could either get a larger resistance in which case the charge would flow off the capacitor more slowly. (that is, smaller current), or you could begin with a much larger original capacitance which, for its voltage, was carrying a much larger charge. Indeed if you multiply together the R and C values (ohms x farads) you get what is called the 'time constant' of the circuit.

A careful (incredibly intelligent) look at the units of ohms multiplied by farads will reveal that they turn out to be seconds. So the time constant of a circuit with a 1000uF capacitor (10^{3}F) and a 20kR resistor will be 20 seconds (20s). This is the time for the charge (or current) to drop to between a half and a third — to be precise to 2.718 — though the significance of this weird number, 'e' to its friends, is quite another story.

Capacitor Construction

So far as construction goes, capacitors come in many different shapes and sizes, and with many practical capacitors the plates are rolled up Swiss-roll fashion. Try unrolling a paper capacitor some time. My daughters have discovered, that they make very smart dolly's loo rolls!

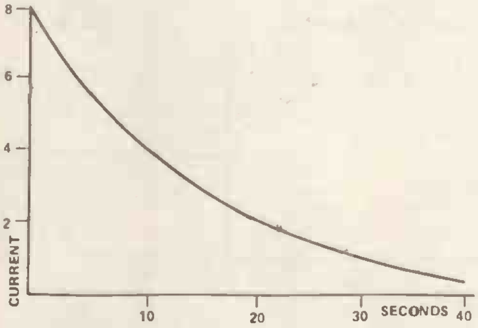
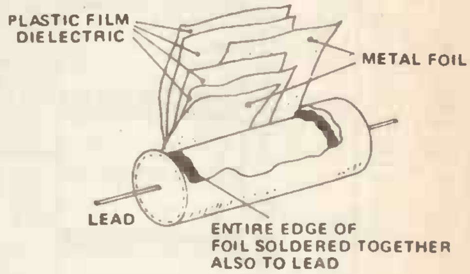


Figure 13. Current from a capacitor through a resistor. An exponential curve

The plates can be very thin aluminium foil or a thin silver layer deposited on a plastic such as polystyrene, polyester or terylene.



Construction of a polystyrene capacitor

For high values, about 1 uF to 10 000 uF electrolytic capacitors ('elcos') are used. These consist of two sheets of aluminium foil separated by paper impregnated with an electrolyte like aluminium borate. A small current forms a very high-resistance aluminium oxide film on the surface of the plates and it is this which acts as the insulator between the plates. Connecting an electrolytic the wrong way round or exceeding the rated voltage can destroy the film. Result? Bang! Wochit!

A selection of capacitors

If you are still awake and totally confused, never mind —that's the lot for this month. Make sure you read Ian Sinclair on the digital bit, because that's all part of our course and I will not be duplicating it, though later I shall point out exactly what our course requires digitally. One other thing — start thinking about a project to build and about a case study on a topic you find interesting. Its all go! Watch those electrolytics — take care and see you next month.

HE

Transistor Tester

Test NPN or PNP transistors quickly and easily with this cheap and simple-to-build project for beginners

OVERKILL: Have you ever heard that word? It means taking a design too far, pushing it from the sublime to the ridiculous by making it too complex when there is a much easier and more economical answer.

Well nobody can accuse our designers of 'over-killing' the HE Transistor Tester. If you take a close look at the circuit diagram you will see that the design is simplicity itself. Only 11 components make up the circuit. That doesn't mean that the HE Transistor Tester is too simple or that it can't be as good as more complicated designs. Far from it — our circuit is all that's necessary to make a good, reliable piece of test gear which is easy to build and exceptionally useful. Now you can test your transistors before use, making sure that they are fully operational. Think how many hours of fault-finding you can save yourself when building projects!

The circuit is built around a two-transistor circuit and uses LEDs to indicate when the transistor under test is operational. A simple potentiometer compensates for different transistor characteristics and its position can be calibrated to give a visual readout of the transistor's current gain.

To test a transistor, start with RV1 at maximum resistance, connect the transistor, and rotate RV1 just far enough to cause the appropriate LED to light. The approximate gain can then be determined from RV1's scale. If the LED remains either switched on or off (regardless of RV1's setting), the test device is almost certainly a dud.

How it Works

To simplify the NPN/PNP switching, the unit has separate circuits for testing the two types of device, and this is an economically sound approach because of the simplicity of each section.

If we consider the unit in the NPN mode first, a base current is fed to the test device via SW1, R1, and RV1. By means of RV1 this current can be varied over an approximate range of 0.4 mA at minimum resistance to 0.004 mA at maximum resistance. The current flowing in the collector circuit of the test device coupled to SK1 will be equal to the base current multiplied by the current gain of the device. If this current is about 4 mA or more, the voltage developed across R2 becomes higher than the base threshold voltage of Q1, biasing the latter into conduction and causing LED1 to light.

In practice RV1 is adjusted for the lowest current that causes LED1 to light, and thus for a nominal 4 mA collector current. The setting of RV1 is then directly related to the current gain of the test device, with minimum resistance corresponding to a gain of 10 (4 mA ÷ 0.4 mA = 10) and maximum resistance to a gain of about 1000 (4 mA ÷ 0.004 mA = 1000). Potentiometer RV1 can be fitted with a scale so that current gain can be directly read off.

The PNP test circuit is much the same, but a few changes obviously have to be made to accommodate the change in polarity. Resistor R6 ensures that an excessive current cannot flow if RV1 is adjusted for minimum resistance with a very high-gain device in circuit.

Construction

Figure 2 shows the Veroboard layout and wiring of the tester, and this is all quite straightforward. Follow standard practice when using the Veroboard. If you're not too sure or your memory's a bit hazy, refer to the Construction section of the Guitar Preamp, where its use is detailed.

It is advisable to fit RV1 with a large control knob as its scaling is not linear, and becomes cramped at lower gain settings. With the aid of a multimeter used on a resistance range the scale of

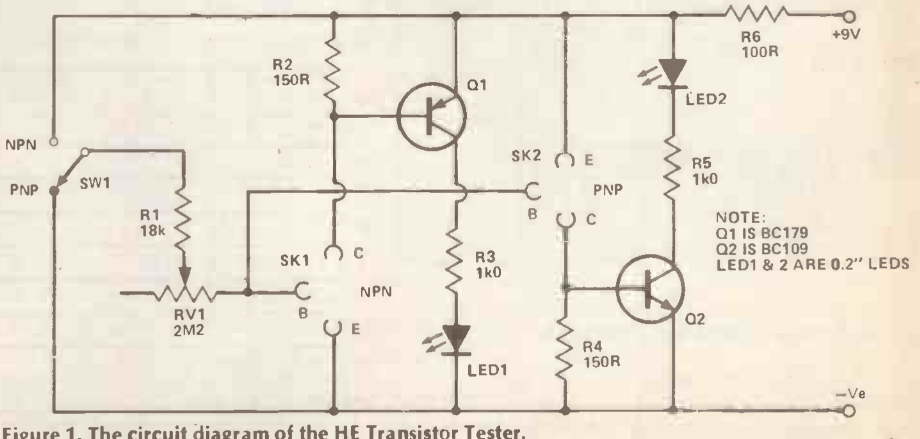


Figure 1. The circuit diagram of the HE Transistor Tester.

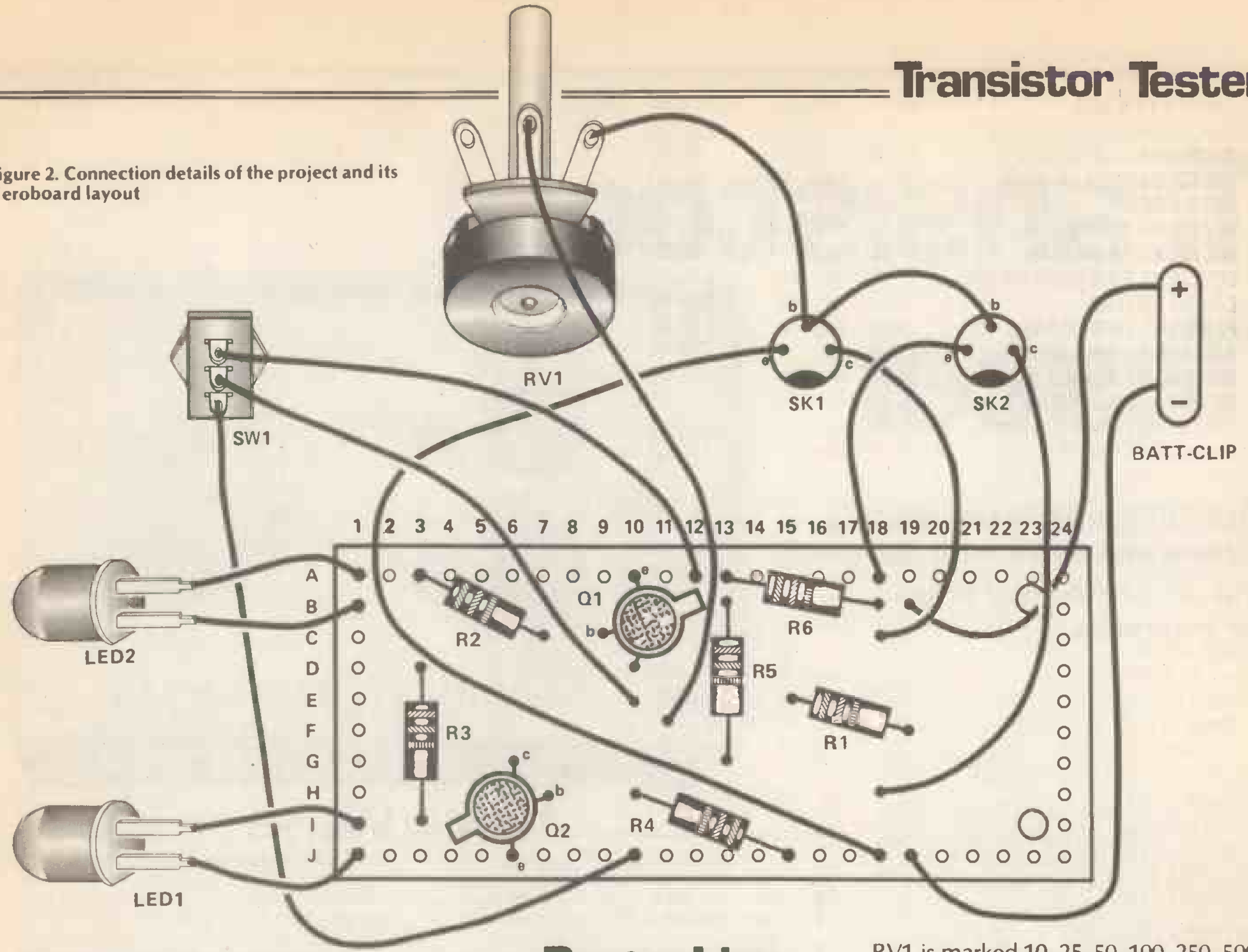


Figure 2. Connection details of the project and its Veroboard layout

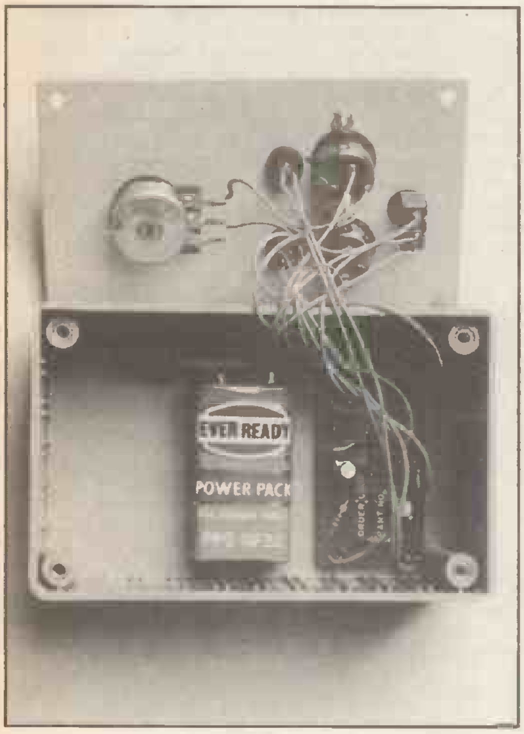


Figure 3. Above. Internal case photograph

Parts List

RESISTORS (All ¼W,5%)

R1	18k
R2,4	150R
R3,5	1k0
R6	100R

POTENTIOMETERS

RV1	2M2 lin

SEMICONDUCTORS

Q1	BC179 PNP transistor
Q2	BC109 NPN transistor
LED 1,2	0.2 in LEDs

MISCELLANEOUS

SW1	single-pole, double-throw, toggle switch
SK1,2	3 way DIN sockets

10 strip x 24 hole Veroboard
pointer knob
case to suit
battery and clip

RV1 is marked 10, 25, 50, 100, 250, 500 and 1000 at settings which give a total resistance of 20k, 50k, 100k, 200k, 500k, 1M and 2M across R1 and RV1.

Many transistors will readily plug directly into the appropriate test socket (but be careful to connect the test devices correctly). A set of test leads can be made up so that less-cooperative devices can be checked. All that is required is a 3-way DIN plug connected to three crocodile clips by three short insulated leads of different colour. **HE**

Buylines

You shouldn't have any problems in obtaining components for this project and the price for the bits and pieces (excluding the case, of course) will be about £5.

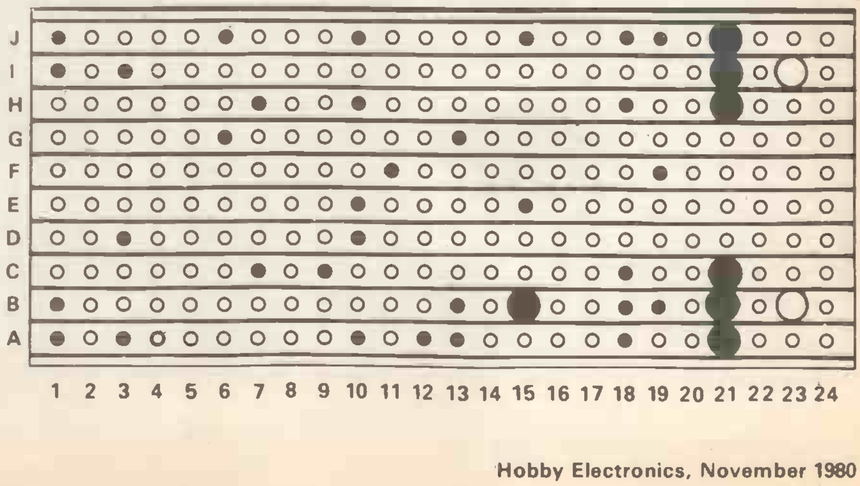


Figure 4.
Right. Underside details of the Veroboard showing track breaks. Make these before inserting the components

GUITAR PHASER	ZD85	Sept. '80	£9.60
BENCH POWER SUPPLY UNIT	ZD87	Sept. '80	£25.00
DEVELOPMENT TIMER	ZD86	Sept. '80	£8.75
TOUCH SWITCH (on Vero)	ZD84	Sept. '80	£4.50
AUTO PROBE	ZD83	Sept. '80	£3.00
REACTION TIMER	ZD82	Sept. '80	£26.50
MICROMIXER (on Vero)	ZD81	Sept. '80	£8.50
EQUITONE CAR EQUALISER	ZD52	Aug. '80	£13.30
GAS DETECTOR	ZD55	Aug. '80	£22.00
PASS THE LOOP GAME	ZD56	Aug. '80	£12.00
RADIO TIMER (on Vero)	ZD57	Aug. '80	£5.50
MOVEMENT ALARM (on Vero)	ZD54	Aug. '80	£5.00
OP. AMP CHECKER (on Vero)	ZD53	Aug. '80	£4.00
CAR BOOSTER (no speakers)	ZD50	July '80	£18.00
HAZARD FLASHER	ZD48	July '80	£10.50
★PUSH-BUTTON VOLUME CONTROL	ZD47	July '80	£19.50
SOUND FLASH TRIGGER (on Vero)	ZD49	July '80	£3.50
2 WATT AMPLIFIER (on Vero)	ZD46	June '80	£3.90
METRONOME (on Vero)	ZD51	June '80	£3.50
MICROBE R/C SYSTEM (less Servos)	ZD45	June '80	£17.50
FOG HORN	ZD44	June '80	£4.50
★EGG TIMER	ZD43	June '80	£6.50
MINI CLOCK	ZD10	May '80	£26.00
5080 PRE-AMP	ZD11	May '80	£32.00
TRACK CLEANER	ZD12	May '80	£7.75
★R/C SPEED CONTROLLER	ZD3	April '80	£9.60
HOBBY COM	ZD8	April '80	£28.60
ELECTRONIC IGNITION	ZD2	April '80	£18.25
DIGITAL FREQUENCY METER	ZD9	April '80	£27.75
SHORT WAVE RADIO	ZD80	March '80	£19.50
TOUCH SWITCH	ZD79	March '80	£5.00
5080 PSU MODULE	ZD78	March '80	£29.50
SYSTEM 5080A	ZD77	March '80	£15.00
PASSION METER	ZD6	Feb. '80	£5.00
WIN INDICATOR	ZD42	Feb. '80	£9.00
INFR RED REMOTE CONTROL	ZD7	Feb. '80	£19.35
SCALEXTRIC CONTROLLER	ZD41	Jan. '80	£52.50
CROSSHATCH GENERATOR	ZD4	Jan. '80	£11.25
DIGI-DIE	ZD5	Jan. '80	£5.50
RING MODULATOR	ZD1	Dec. '79	£8.50
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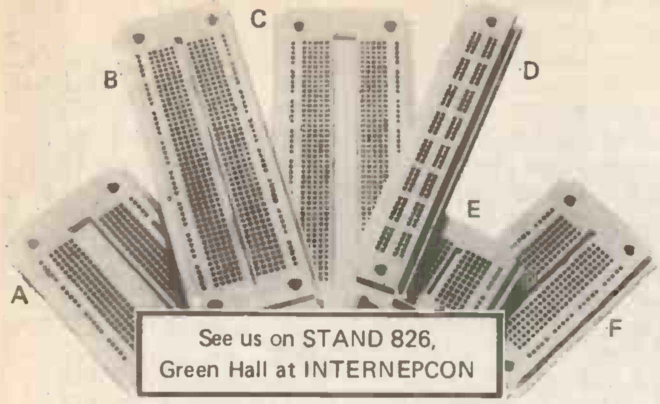

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Talking Design

We've covered PWM theory: now for something practical. This month's article describes a high-quality PWM audio amplifier you can build

LAST MONTH I described a simple pulse width modulator which was capable of driving small DC motors and lamps. At the time I hinted that this technique was likely to become of major importance in audio amplifiers. This month, as a follow-up, a digital audio amplifier circuit is presented.

PWM amps are not new. Sinclair marketed a 10 W version in the sixties. What has precipitated the recent interest is the advent of digital recording techniques, and the increasing availability of fast switching transistors, especially the VFET.

To refresh your memories, a pulse width modulator is basically a square wave oscillator whose output mark-space ratio can be altered by an external voltage. If this voltage is an audio signal and the output frequency is sufficiently high, the average output voltage of the oscillator will be the audio signal. The obvious question is how high does the frequency have to be to encode the full audio band from 20 Hz to 20 kHz? Surprisingly, thanks to the work of Nyquist, the answer is only 40 kHz. Nyquist showed that a signal, in the form of modulation on a carrier wave, could be fully recovered as long as the carrier was at least twice the maximum frequency of the modulating signal.

Given that information it should be possible to produce a PWM amp with a beefy output stage running at well over 40 kHz that can deliver a signal to a normal loudspeaker. Such a digital amplifier has lots of advantages in terms of performance. If a push-pull output stage is employed, the power devices dissipate very little heat since they are either in saturation or in cut-off.

As long as the signal is linearly transferred into digital form no audio distortion can occur. Similarly, there is no crossover distortion or noise added to the signal. What has prevented all audio amplifiers from being built this way is the problem caused by the electromagnetic radiation at carrier frequency from the speaker leads. A second problem has been the shortage of devices.

When Sinclair marketed his PWM amp in the sixties, silicon transistors and logic ICs were expensive novelties. Nowadays there is a proliferation of ICs and transistors capable of being employed in such circuits.

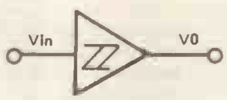
The problem of carrier radiation is a vexed one. According to the Post Office, it is quite in order to send 200 kHz FM signals through mains wiring. In fact most domestic appliances produce RF radiation, as can be confirmed by anyone whose hi-fi equipment is upset by switching 'thumps'. The simplest way over this problem is to place a low-pass filter between the amp's output and the load. Using screened lead with the screen connected to earth is another precaution. With the amp described here RF radiation is not a real problem as long as the filter is incorporated.

Last month's circuit employed a comparator to produce PWM. This time the same result is obtained by using the audio signal to alter the switching thresholds of a Schmitt trigger. This trigger is a device that has two switching thresholds, let's call them t1 and t2 (**Fig.1**). When the input voltage is less than t1 the output is low. As soon as the voltage exceeds t1 it goes high.

Low Down Volts

If the voltage is now reduced, nothing happens until it falls below t2. At this point the output goes low again. (Note that the two threshold voltages t1 and t2 are not equal.) This characteristic is known as hysteresis. The ZZ indicates a Schmitt device or function and these triggers are usually employed in digital circuits to convert slowly rising and falling waveforms to pulse trains suitable for logic systems. A Schmitt trigger can be made from an op-amp or comparator. **Figure 1** also shows an astable similar to one employed last month but this time it is built around an op-amp.

On switch-on, capacitor C1 is discharged, holding the inverting input



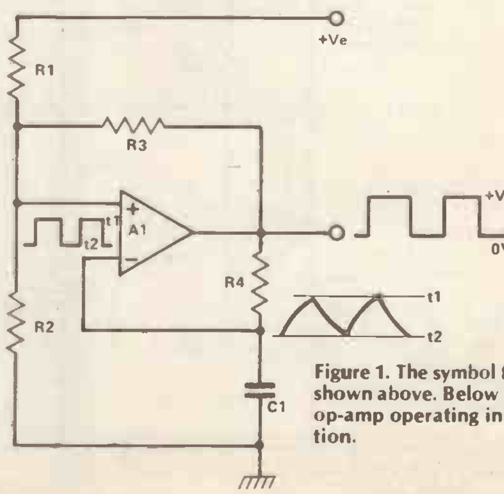


Figure 1. The symbol for a Schmitt trigger is shown above. Below is an astable using an op-amp operating in a Schmitt trigger action.

of A1 low relative to the non-inverting input. Since this is so, the output will be high. Now, if we make R1, R2 and R3 equal in value, then the non-inverting input will be held at ⅔ Vcc, because R3 is effectively in parallel with R1. In consequence, C1 will rapidly charge through R4 until the voltage at the inverting input exceeds ⅔ Vcc. At this point A1's output will start going negative. Positive feedback through R3 makes the output's transition from high to low extremely rapid.

A second stable voltage will now be found at the non-inverting input, equal to ⅓ Vcc. This time, R3 is effectively in parallel with R2. Capacitor C1 will now discharge via R4 and A1's output stage until the voltage on the inverting input falls below ⅓ Vcc. The output again goes high and the cycle repeats itself indefinitely.

Because of the influence of R3, A1 acts as a Schmitt trigger, t1 and t2 being ⅔ Vcc and ⅓ Vcc.

Figure 2 shows how this simple circuit can be modified to encode an audio signal into PWM. The audio is simply imposed upon the non-inverting input, thus altering the threshold switching voltages. Resistor R5 prevents interaction between the audio signal and carrier as does R6. Capacitor C2 isolates DC voltages from the astable. Unfortunately, C1 charges exponentially via R4 so somewhat less hysteresis is applied by making R3 much larger than either R1 or R2. This has the effect of making the switching thresholds very close together and linearising the triangular waveform across C1 resulting from it being charged through R4.

To produce a good square wave at high frequencies an LF351 op-amp is used. This is a VFET device which features a high slewing rate, that is 13 V/uS.

The full circuit of the digital amplifier is shown in **Figure 3**. Here, the op-amp drives a pair of transistors in a push-pull output stage. These transistors, a BC142 and BC143, are rated at 1 A collector current. As you can see they are connected, without base bias, as emitter-followers. When the output of the op-amp is high, Q2 is in saturation and provides current to the load via the low-pass filter L1, C5 and the output coupling capacitor C6. Incidentally, in class B amps the latter component is often of a lower value. This is a pity since the lower −3 dB point is defined by the size of this capacitor.

As you will remember, the impedance Z of a capacitor is given by:

$$Z = \frac{1}{2\ \pi\ FC}$$

where C is in farads and Z is in ohms.

Negative Feedback

The astable has a unity gain and so, to improve the sensitivity, an audio preamplifier stage has been added. This is built around Q1 which is used in the common-emitter mode. Negative feedback, however, is applied from the collector via R3. A collector current of 1 mA has been chosen to allow adequate drive. Resistor R7, therefore, drops 1 V whilst C3 decouples line ripple to ground. For linear drive the collector is operated at 17 V/2 $\simeq$ 8 V. The value of R4, therefore, is given by 8 V/10^{-3} A = 8k, the nearest value being 8k2.

A BC149 is used for Q1 and this has a gain of 200 minimum at 1 mA. Base current I_B is therefore equal to:

$$\frac{10^{-3}\ A}{2 \times 10^2} = 5uA$$

Figure 2. An astable used to encode an audio signal applied at its input into PWM.

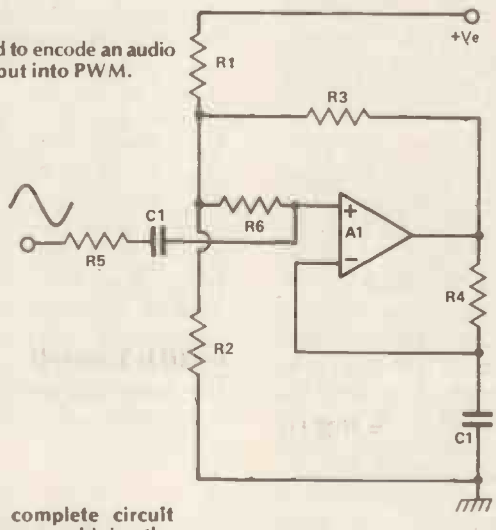
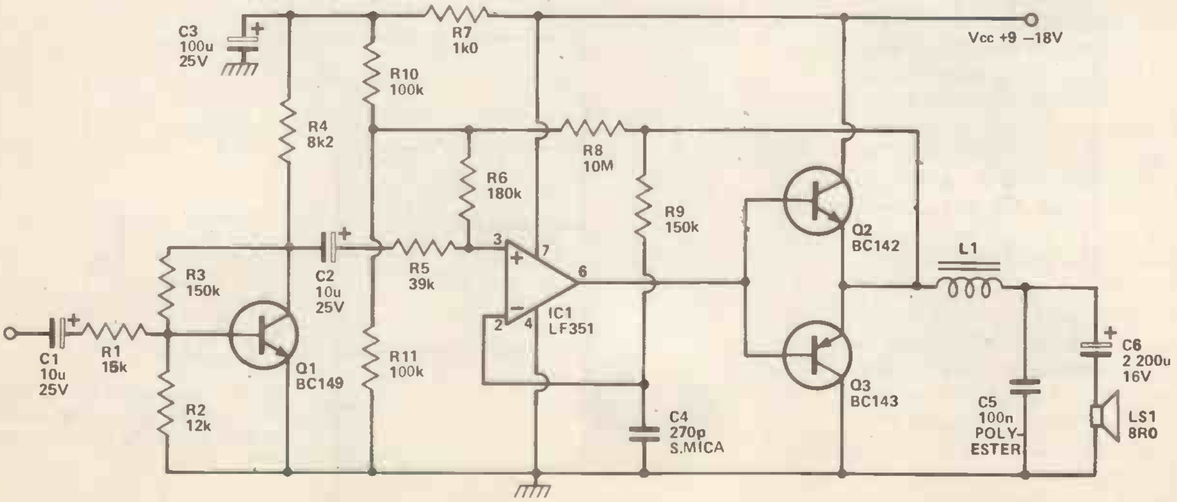


Figure 3 below. The complete circuit diagram of the PWM amp combining the astable circuit of figure 2 with a push-pull output stage.



The base will be 0.65 V above ground and, taking 10 x I_B through R2 and R3, the value of R3 is given by:

$$\frac{0.65}{5\times10^{-5}} = 1.3\times10^4 R,$$

12k being the nearest value.

Similarly, the value of R2 will be equal to the collector voltage minus the base voltage divided by 50uA, given by:

$$R2 = \frac{8 - 0.65}{5\times10^{-5}A}$$

$$= 147k,$$

150k being the nearest value.

Virtual Earth

Using a transistor in this way, with feedback from collector to base forms a 'virtual earth amplifier'. This is because the feedback reduces the input impedance. The gain of the stage is set by the ratio of R3 to R1. For a gain of 10, sensitivity 900 mV, a value of 15k was chosen. Capacitor C1 simply isolates the input from DC from previous stages. A suitable Veroboard layout is shown in **Fig.4.** In the circuit shown in **Fig.3** we have a classic high-pass filter formed by the speaker impedance Z and C. The lower −3 dB point can be calculated by rearranging the equation for f1 given by:

$$\frac{1}{2\pi CZ}$$

substituting:

$$f1 = \frac{1}{2\times3.14\times2.2\times10^{-3}\times8} = 9.05\text{ Hz}$$

The minimum gain of the output transistors Q2 and Q3 is 30 at 1 A. In practice this is the absolute minimum likely to be encountered. The op-amp output can source or sink 25 mA. It follows that the worst-case minimum current that can be fed into the speaker is:

$$\pm 25\text{ mA} \times 30 = 750\text{ mA}.$$

Since the speaker impedance is 8R, the peak voltage under these conditions is equal to IR; that is, 750 mA x 8R = 6 V, or 12 V peak-to-peak. Since the power output is given by V^2/R, one could be forgiven for thinking that the output power would be (12 x 12)/8 = 18W. Unfortunately, you would be wrong!

The output power is the RMS voltage divided by the load. Assuming our output is a sinewave of 12 V peak-to-peak, the RMS value is found by dividing Vpk-pk by 2.8.

The output power (minimum) is therefore given by:

$$\left(\frac{12}{2.8}\right)^2/8R = 2.29\text{W RMS}.$$

Because of the small voltage drop that occurs across a saturated transistor, the output will be slightly less than this, namely 2 W.

Going back to our astable, the operating frequency has been set at 300 kHz. This gives a full power bandwidth of 10 Hz to 150 kHz.

Build It Yourself

The construction is quite straightforward and requires little comment except that it is necessary to ensure that all the semiconductors are correctly orientated and the breaks in the Veroboard tracks are not forgotten.

Although the circuit will operate from 9 V, batteries are not really suitable and any mains PSU offering an output voltage in the range indicated is better.

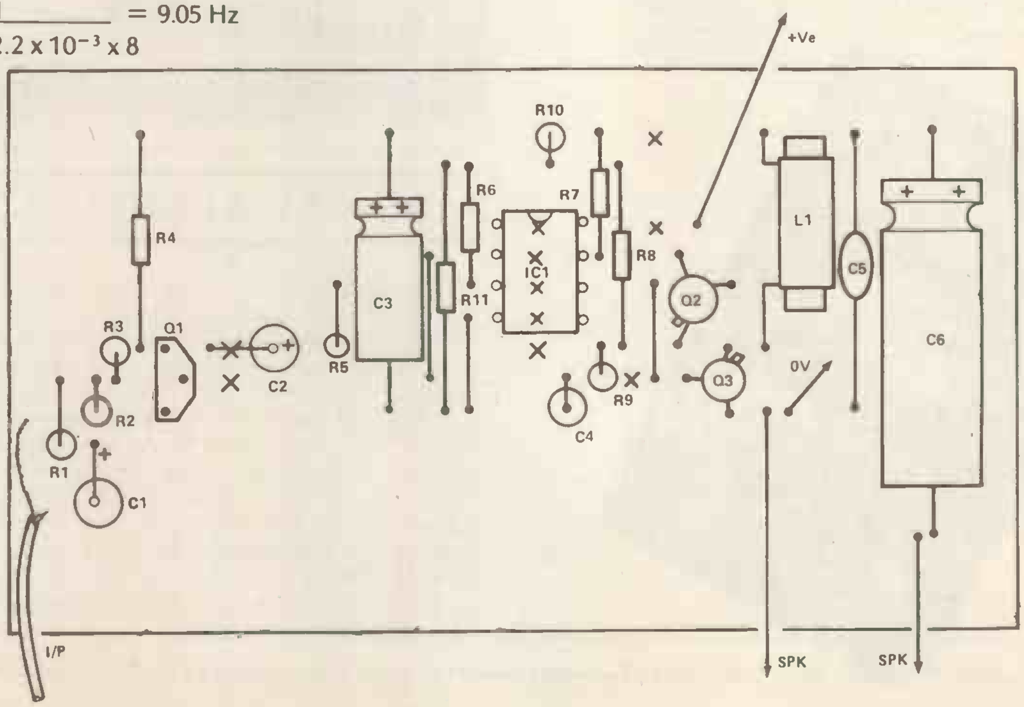
L1 consists of 60 turns of 0.56mm enamelled copper wire, pile-wound on a 1 in length of ⅜ in diameter ferrite rod.

When construction is completed, no adjustments need to be made to the circuit. All that is required is an input signal and a speaker.

Our regular monthly feature 'Talking Design' is not aimed at the absolute beginner. Before you tackle any of these projects you should be reasonably familiar with circuit construction techniques.

For a really comprehensive introduction to electronics why not read our special publication 'Into Electronics Plus'. You'll find details of this and all of our other 'Specials' elsewhere in this issue.

Figure 4. The Veroboard layout of the PWM amp. The small crosses (x) indicate breaks in the copper track underneath the board.



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electronics today INTERNATIONAL

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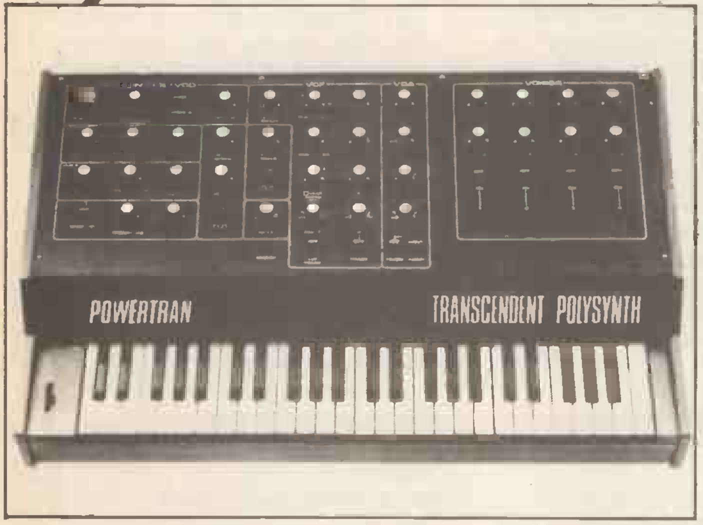

TRANSCENDENT POLYSYNTH

Transcendent, a name familiar to ETI readers, turns up next month in the shape of our latest keyboard instrument project. The Transcendent Polysynth, designed by Tim Orr, is a polyphonic music synthesiser. It can be operated with one, two, four and even eight voices. Each voice is a synthesiser in itself, containing two VCOs, two ADSR units, one VCA and one VCF. The design features all the usual synthesiser functions — pitch bend, portamento, noise source, modulation oscillators, etc.

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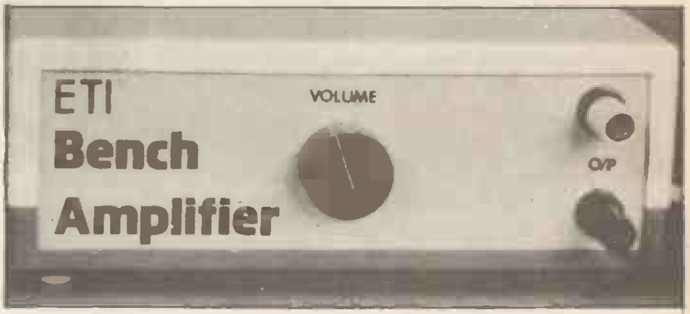

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Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in a recent issue of Radio Constructor. Complete kit, includes case materials, six transistors, and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy, if you have an amplifier to connect it to on a pair of high resistance headphones. Price **£11.95.**

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0.25 MA coil made for the G.P.O. A very useful instrument especially when panel space is limited. **£2.90.**

BLACK LIGHT. Can add a touch of novelty to a party or disco. We have in stock the Atlas 175 watt U.V. Lamps. These plug straight into a lampholder and need no control or starter gear. This is a black lamp about the size of the old-fashioned 200 watt lamp. **Price £10.35.**

PANEL METER 0.1mA
Japanese made full vision perspex front, flush mounting. Price **£3.45.**

SHORT WAVE CRYSTAL RADIO
All the parts to make up the beginner's model. **Price £2.30. Crystal** earpiece **65p.** High resistance headphones (give best results) **£3.75.** Kit includes chassis and front but not case.

RADIO STETHOSCOPE
Easy to fault find — start at the aerial and work towards the speaker — when signal stops you have found the fault. **Complete kit £4.95.**

INTERRUPTED BEAM KIT
This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components — relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price **£2.30.**

PUNCHED TAPE EQUIPMENT for controlling machine tools, etc., motorised 8-bit punch with matching tape reader. Ex computers believed in good working order, any not so would be exchanged. **£15** the pair. Carriage **£3.**

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DESOLDERING PUMP
Ideal for removing components from computer boards as well as for service work generally. Price **£6.35.**

4-CORE FLEX CABLE
White pvc for telephone extensions, disco lights, etc. 10 metres **£2,** 100 metres **£15.** Other multicore cable in stock.

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A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. **£2.50** complete kit.

HUMIDITY SWITCH
American made by Honeywell. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch. Very sensitive breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Only **£1.15.**

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Mains quick connector will save you valuable time. Features include quick spring connectors, heavy plastic case and auto on and off switch. Complete kit **£1.95.**

V3 MICROSWITCHES
Over 50,000 in stock all 250 AC working, with **3** silver contacts for c/o circuits — 10 amp **25p** each or **£20** per 100, 15 amp **35p** each or £30 per 100.

MAINS ADAPTORS
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- **Altai** gives 6v 7.5 or 9v - 300mA — **£3.95**
- **Crown** give 6v at 300 mA — **£2.95**
- **Nixie** give 12v - 750 mA — **£3.95**

These are all made up complete with mains lead in plastic cases. We can also supply Mains Transistor Power Pack Kit for Voltage output anything from 3v to 16v up to 300mA — complete kit with double insulated mains transformer and full instructions — **£1.95.**

MULLARD UNILEX

A mains-operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone. In easy-to-assemble modular form this should sell at about **£30**—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£16** including V.A.T. and postage.

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VENNER TIME SWITCH mains operated with 20-amp switch, one on and one off per 24 hours repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95.** These are new but without case, but we can supply plastic cases (base and cover) **£1.75** or metal case with window **£2.95.** Also available is adaptor kit to convert this into a normal 24-hour time switch but with the added advantage of up to 12 on/offs per 24 hours. This makes an ideal controller for the immersion heater. Price of adaptor kit is **£2.30.**

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45.**
Made-up model **£1** extra.

DELAY SWITCH

Mains operated—delay can be accurately set with pointers knob for periods of up to 2½ hours. 2 contacts suitable to switch 10 amps—second contact opens a few minutes after 1st contact. **£1.50.**

NEW KITS

SUB-MIN MICROPHONE
Size only ½" × ¾" × 3/16" so small enough for a bugging device, ex-hearing-aids but guaranteed. Price **£1.50.**

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RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. **£6.90.**

EXTRACTOR FANS

Ex-Computer made by Woods of Colchester; ideal also as blower; central heating systems, fume extraction, etc. Easy fixing through panel, very powerful 2,500 r.p.m. but quiet running. Choice of 2 sizes, 5" £5.50, 6" £6.50; post £1 per fan.

3-CHANNEL SOUND TO LIGHT KIT

Complete kit of parts for a three-channel sound to light unit controlling over 2,000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for Disco work.
The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Special snip price is **£13.50** in kit form or **£16.50** assembled and tested.

THIS MONTH'S SNIP

Here's a super bargain for you. 100 twist drills; regular toolshop price over £50, yours for only **£10** including V.A.T. and post. With these you will be able to drill from the tiniest holes in p.c.b. right up to ¼" for switches, etc. Don't miss this snip — send your order today.

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TERMS: Cash with order—but orders under £10 must add 50p to offset packing, etc.
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IT'S FREE
Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived—often bargains which sell out before our advertisement can appear—it's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

SUPER BREAKDOWN PARCEL with free gift of a desoldering pump, perhaps the most useful break-down parcel we have ever offered. Consists of 50 nearly all different computer panels on which you will find: over 300 ICs, over 300 diodes, over 200 transistors and many hundred other parts, resistors, condensers, multi turn pots, rectifiers, SCR etc. etc. for only **£8.50**, which when you deduct the value of the desoldering pump, works out to just a little over 4p per panel, **+£1.27 VAT +£2** post (it's a big parcel).

AUTUMN IS ALMOST WITH US and if the year lives up to its reputation, we will have chilly evenings — so don't put off those heating jobs any longer. While stocks last, we will supply the tangential heater units at last season's prices, namely **£5.95 +** £1.50 post for the 2KW and **£6.95 +** £1.50 post for the 3KW. These prices include VAT but not the control switch, which is the three interlocked rocker type for the 2KW, price **0.65p** and the four interlocked rocker type for the 3KW, price **95p.**

12v MOTOR BY CROUZET — a powerful motor virtually impossible to stop by hand, size approx 2¼in long and 2½in dia, this is a permanent magnet field type so is reversible simply by changing polarity and has a relatively constant speed with or without load. Fitted with a splined shaft which could directly engage a toothed gear wheel or to which a pulley could be attached. Ideal for large models, or small machines etc. **Price £3.95.**

12v MOTOR BY SMITHS INDUSTRIAL made for use in cars, these are series wound and become more powerful as load increases — they will in fact burn themselves out if over-loaded to stopping point — not polarity reversible — but if you are prepared to do a little unsoldering and rewiring then they will reverse at the flick of a switch. Being series wound they will also work off a.c. mains through a step down transformer and if you use a variable voltage type then the motor speed can be varied by the voltage. Size approx 3½in long by 3in dia these have a good length of ¼in dia spindle — **price £3.50.** Ditto out double ended **£4.**

MAINS OPERATED LOW SPEED MOTORS 2 watts type as fitted into time switches, machine controllers etc. We have a good selection and can offer the following final speeds: 1 r 24 hrs, 1 r 8 hrs, 1 r 4 h, 1 r h, 2 r h, 3 r h, 4 r h, 12 r h, 20 r h, 30 r h, 1 rm, 2rm, 4 rm, 8 rm, 15 rm, 200 rm, all at **£2.85.**

SPIT MOTORS. These are powerful mains operated induction motors with gearbox attached the final shaft is a ½in rod with square hole, so you have alternative coupling methods — final speed is approx. 5 revs per min, price **£5.25** post 60p — similar motors but with final speed 110 rpm and 80 rpm same price.

WALL MOUNTING THERMOSTAT by Danfoss has a really pretty two tone grey case with circular white scale and dial. Setting temperature from 0-30c — 13 amp 250v contacts. **Price £4.60.**

EXTENSION SPEAKER CABINETS. Teak look black front, size 11in x 8in x 4½in approx. **Price £2.00.** Post £1.00. (We have larger ones). If you can call and collect these these cabinets you can save yourself the quite considerable postage and you only have to buy a few to get a discount as well. The quantity discount for these is a special rate of 25% if you buy ten or more. Note these cabinets are very good quality (made for Rank Audio Systems) the grill material is Dacron.

MERCURY BATTERIES. Bank of 7 mercury cells type 625 which are approximately ⅝in dia. in plastic tube, giving a total voltage of 10.7. Being a plastic tube it is very easy to break up the battery into separate cells which could be used for radio control and similar equipment. Carton of 25 batteries **£1.15 + 85p** post.

HALF-PRICE CABLE OFFERS. We have good stocks of:

Size mm	Type	Price 100 metres	Carriage
1.5	Single	£4.00	£1.75
1.5	Flat twin	£6.50	£2.75
1.5	Flat 3-core & E	£9.75	£3.50
4	Single	£7.50	
4	Flat twin	£11.50	£4.00
6	Flat 3-core	£32.50	£5.00
16	Twin & E	£79.00	£10.00

ONCE AGAIN IN STOCK ex-G.P.O. resistance bridge. It is in fact an electronic megger, which tests at a voltage of around 250, thus revealing any leaky points. These must have cost at least £150 each to make. In a portable light weight case, size approx 9in x 9in x 9in with a carrying handle. Has two moving coil panel meters which give clear readings of resistance from fractions of an ohm right up to 100 megs and then to infinity. We have two versions of these instruments 1) is as good as new and checked and tested before despatch price £22.50 + £3.38, post £2.50. 2) Secondhand models complete and believed to be in working order but not checked nor guaranteed, £12.50 + £1.87, post £2.50

MAKING A CONVECTOR HEATER? We can offer a bank of four 1 KW metal clad elements all mounted on a 3in square iron plate. By comparatively simple switching 8 heat outputs ranging from approximately 250 watts to 4000 watts can be achieved. The elements which have push on tag connectors, extend to a length of approx 17in from their mounting plate, so a relatively compact simple convector heater could be made using this. **Price £2.37 +** post £1.50.

G.P.O HIGH GAIN AMP/SIGNAL TRACER. In case measuring only 5¼in x 3¼in x 1¼in is an extremely high gain (70DB) solid state amplifier designed for use as a signal tracer on GPO cables etc. With a radio it functions very well as a signal tracer. By connecting a simple coil to the input socket a useful mains cable tracer can be made. Runs on standard 4½v battery and has input, output sockets and on-off volume control, mounted flush on the top. Many other uses include general purpose amp, cueing amp etc. **An absolute bargain at only £1.85.** Suitable 80 ohm earpiece 69p.

OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. **Price £11.50 +** £2.50 post.

MOUTH OPERATED SWITCH. Made for washing machines to control water level etc. this is a sensitive low pressure device which operates three 1 pole changeover switches at different levels of pressure but all within a normal persons blowing capacity — blow gently into it and No. 1 switch operates, blow a little stronger and No. 2 operates, blow harder still and No 3 operates. The switch is airtight so the weight of water or other fluid substance could operate it. Undoubtedly a switch with very many applications. Disc type construction, this is approx 3¼in dia x 1⅜in thick — the air entry is a pipe approx 3/16in dia — electrical contacts we estimate a 10 amp c/o a 230 volt — connection by push on tags. Order ref. RS.4. **Price £2.88**

BE PREPARED. For possible blackouts and interruptions in electricity supply this winter. Have some emergency lighting nearby. We still have the fluorescent outfits for operating 12in or 21in tubes from 12V car battery and the price is **£4.65** 80p post complete with tube, please state which.

BLEEPERS 6 or 12v battery or transformer operated, ideal for using in most alarm circuits but for car and motor cycle alarms. These give a loud shrill note. American made by Delta Alarm. **Price** 87p. Large quantities available

MOTORIZED LIGHT FLASHER. Christmas is coming, so you've got to think about your decorative lighting, to make this flash we can offer two motorized units both capable to 2000 watts of light. One ½ second flasher changes every ½ second and the 2 second flasher changes every 2 seconds. **Either type £6.90.**


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Double Dice

Chance your luck with HE's latest game of fortune — for those readers who can't find the energy to shake'em — here's a pair you only have to touch

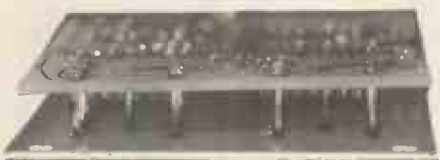
THE TIME OF YEAR approaches when more games are bought and played than at any other. A large percentage of these games need some system whereby a random number between 1 and 12 can be quickly and easily generated — the usual way of doing this is with a pair of dice. A good electronic dice project hasn't materialised in any of the hobbyist magazines recently and so we thought that the time was right for HE to produce a dice to beat all dice. Although quite ingenious in operation, the HE Double Dice is simplicity itself to build — apart from the display there are only 18 other components, and all parts mount on a small PCB.

The display is formed from individual LEDs, seven in each die, grouped together into the well-known dice formation. Five ICs perform all logic, control, counting and driving functions of the circuit and both die displays are completely random and non-synchronised.

The device is touch-controlled: simply placing a finger over the two contacts starts operation of the dice. The LEDs light up and are seen to flash at a fast rate (showing that the 1 to 6 sequence is in operation.) Upon removing the finger, the LEDs stop flashing and hold the last number displayed.

After a short time, all the LEDs extinguish, showing that the dice is ready for its next cycle of touching and displaying. The display period is defined, mainly, by the value of capacitor C1, and using the value shown a period of about 5 seconds is obtained. Increasing its value lengthens illumination time and vice versa.

LEDs need a fair amount of current to give a reasonable illumination and if they remained on at all times, battery life would be severely limited. The self-cancelling function reduces the *average* current consumption of the circuit and therefore prolongs battery life.



Side view of the HE Double Dice showing the position of the LEDs

Buylines

You shouldn't have any trouble in obtaining the components for this project.

Approximate price (excluding case and PCB) will be around £7.

Construction

Start construction by inserting the six links into the PCB as shown in the overlay diagram of **Fig.2.** It is helpful to use a pair of long-nosed pliers to bend the link wires before insertion. Resistors, capacitors and IC sockets if used, should be put in now but leave the ICs till last.

Next, insert LEDs 1 to 14 into the board in the double dice formation. Mount them about 10 to 15 mm above the PCB so that they stand above the maximum height of the other components. Connect the switch, battery and touch contacts (two wires will do for test purposes), plug in the five ICs, switch on and test the project.

Housing the PCB in a case should not be a problem. Suggestions are: either mount your board on the underside of the case lid, drilling holes for the LEDs to mount into, or make a panel out of coloured transparent plastic (or similar) through which the LEDs will be visible.

You can make your touch contacts out of virtually any small pieces of electrical conductor — touch plates are available commercially, of course. We chose to use the heads of metal drawing pins inserted through the case lid. Soldered connections can be made underneath the lid to the board. If you do the same, remember that a metallic lid conducts and the contacts will have to be insulated from it.

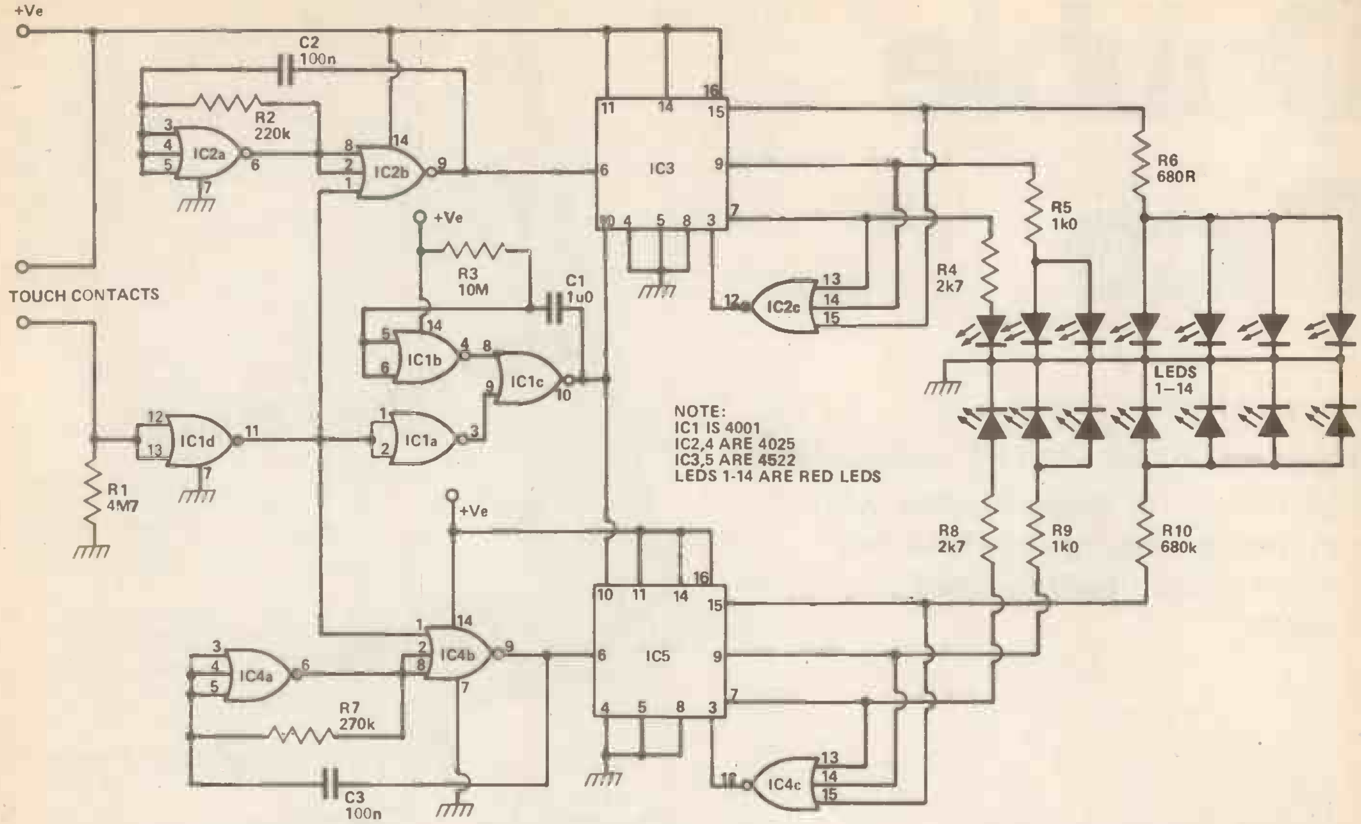


Figure 1. Circuit diagram of the amazing Hobby Electronics Double Dice

How it Works

The circuit of the HE Double Dice can be seen in Fig.1. By cross-referring to it, the operation of the dice may be more easily understood. Most of the circuit is duplicated for each dice (IC2, 3 and common components) — the action of the other dice is identical (using IC4 and 5 instead).

A	B	C	NUMBER DISPLAYED
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6

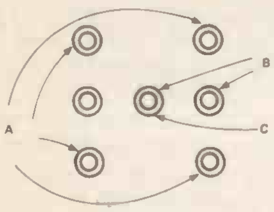


Figure 3.

The LEDs are formed on the PCB to a standard dice configuration as in Fig.3. In this diagram the individual points have been grouped together into three categories A, B and C. By looking at the numbers on a dice in turn, a table can be drawn up, as in Fig.3 to show that all LEDs in any one category must be either on or off at the same time. Therefore, we can consider the groups as single logical levels in a set code. It just happens that the set code is required is part of the binary code, of which the part of interest is shown in Fig.4 against the corresponding denary, or ordinary number value.

DENARY NUMBER	BINARY NUMBER
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

THE PART OF THE BINARY CODE WHICH IS OF INTEREST

Figure 4.

ICs which count in binary are readily available and the 4522 (IC3) does just that. It is a *down* counter, meaning that it starts its cycle at binary 15 and counts down to 0. On the next count after 0 it would (normally) reset to 15 and start the cycle over again. However, we have taken advantage of the fact that the 4522 is a programmable counter which can, on a command pulse, be programmed or set to a particular number in its cycle. In our circuit this number is 6 (represented by the logic levels at pins 14, 11 and 5, that is 1, 1, 0). The command pulse is obtained from the output of IC2c, which is at logic 1 only when its three inputs are 0. These inputs are in parallel with the LED drive outputs of IC3 so that as the number 0 is displayed by the LEDs the counter automatically jumps to the number 6. The interval between the count to 0 and the display of 6 is so small that to the human eye it appears that the counter progresses naturally from 1 to 6.

IC2a and b form a simple astable multivibrator which produces a square wave of about 100 Hz and which clocks the counter whenever pin 1 of IC2 is at logic 0.

The part of the circuit which is common to both sides is that of IC1. Pins 12 and 13 of this IC are held normally low by R1, a very high resistance. The output of IC1d is therefore normally high (the gate is acting as an inverter). If a finger is placed on the touch contacts, skin resistance takes the input to this gate high, and the output, pin 11, goes low. This pin is connected to pin 1 of the astable which as detailed above, clocks the counter.

As well as enabling the astable, pin 11 is connected to the input of a monostable multivibrator with an 'on' period of about 5 seconds so that as a finger is put on the touch contacts the monostable enters its 'on' state. The output of the monostable is connected to pin 10 of the counter so that during the 'on' state the LED display is allowed to function. At the end of the 5 second on-period the monostable switches off and the display is disabled (the LEDs are held off) thus saving unnecessary battery wastage.

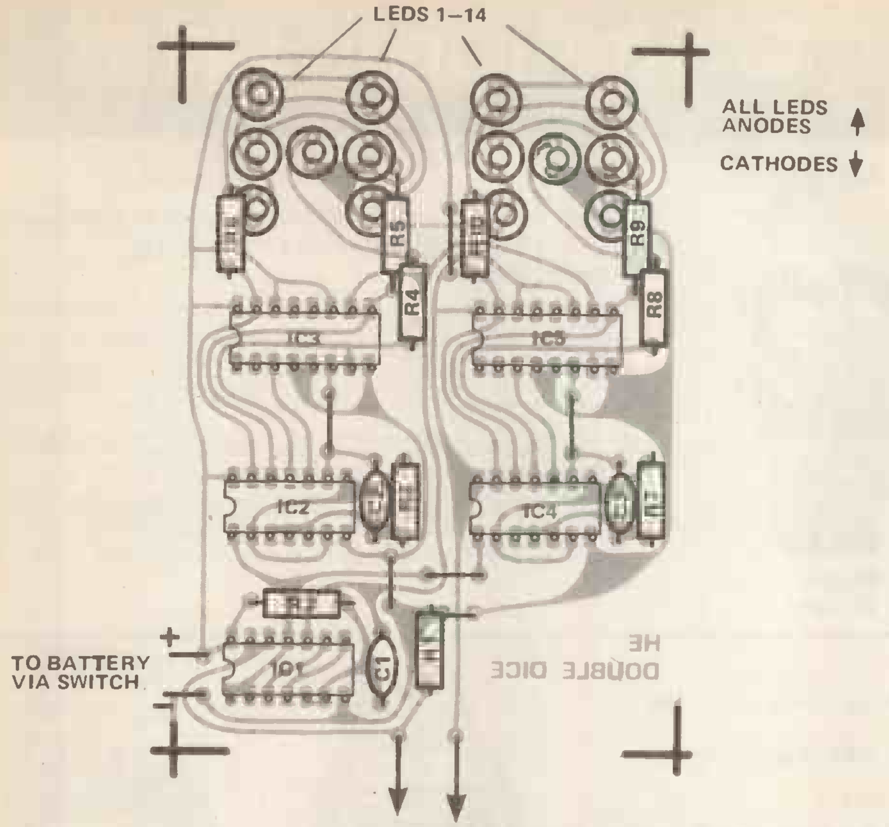


Figure 2. Overlay diagram for the HE Double Dice

Parts List

RESISTORS (All ¼W, 5%)

R1	4M7
R2	220k
R3	10M
R4,8	2k7
R5,9	1k0
R6,10	680R
R7	270k

CAPACITORS

C1	1u0 polycarbonate
C2,3	100n polyester

SEMICONDUCTORS

IC1	4001 quad, 2-input NOR
IC2,4	4025 triple, 3-input NOR
IC3,5	4522 programmable BCD counter
LED1-14	miniature red LEDs

MISCELLANEOUS

single-pole, single-throw toggle switch
battery clip
case to suit
touch contacts

HE

See opposite page for ordering details

CB Breaker One Four

Send any news, comments or information you have to: Breaker One Four, Hobby Electronics, 145 Charing Cross Road, London WC2H 0EE

There's not much happening on the legalisation scene this month but elsewhere CB accessory shops are opening almost daily. Rick Maybury has details

THIS HAS BEEN one of the quietest months for a long time. Although our spies tell us that 27 megs is busier than ever (all 40 channels full some nights!) the campaign has slowed down to a crawl. We contacted the Home Office to see how the Green Paper was faring. The gentleman we spoke to didn't want to commit himself to actual numbers but he did say that if he saw another letter about CB in the next ten years it would be too soon. By all accounts the HO are being inundated with responses, keep it up, we're sure they're getting the idea.

Usually we get to hear of a fair number of 'busts' during the month and even these seem to have tailed off: are the PO and HO giving it a rest?

The media are finally realising that CB is here to stay, and this is amply demonstrated by the sudden proliferation of CB magazines on the bookstalls. Everyone seems to be getting on the band wagon (pun intended). We welcome all these new magazines (with one doubtful exception), they are all doing a splendid job.

The accessory scene is also livening up, two new shops in the London area having been opened within a week or so of each other. The first is A Aerials in St James Street, Walthamstow. We hope to be getting down there in the next few weeks — look out for a report next month. The biggest shop to open for a long time was undoubtedly the Citizens Band Radio Centre in Harrow, and we were invited down to the opening — more about that later.

Cheap Rigs

We had two surprises this month in the shape of catalogues from companies advertising actual, genuine CB rigs for 27 MHz. In all fairness both companies stressed that these devices were not available in the UK but both openly admit that they do sell their wares over the counter in the Irish Republic. The first company is called BIS Electronics. They quote a price of just £28 for the Sharp 2460 basic 40 channel rig in lots of 20. This is a trade price so add about 33% for the retail price. The second company is none other than Tandy, who have included about half a dozen rigs in their new catalogue. There are no prices for the rigs but again they are freely available in the Irish Republic. The catalogue does, however, give prices on Tandy's very creditable range of accessories including antennas, mikes and connectors etc.

The whole point of this is to show you just how much the equipment really does cost. A year ago we told you how our roving reporter was offered standard 40 channel rigs, brand new in their boxes, for just £3.00 each. Admittedly this was in the States but you get the idea. If the Government goes ahead with Open Channel on 928 MHz and limits the number of licences to just 150,000 in the first year, then no manufacturer will be able to make the gear for less than £200.00. If, say, half a dozen companies manufacture the rigs, then with a production run of just 25,000 each they cannot hope to bring the price down to a realistic level. After all, that number is barely more than a pre-production prototype run. Some Japanese companies can make that number of radios in a weekend: they couldn't justify the expense of setting up production lines for such a limited market. Oh well, back to more pleasant matters.

Midlands Radio Fair And Mass Eyeball

A group of businessmen in the Nottingham and Derby area are organising an event called the 'Midlands Radio Fair & Mass Eyeball'. This will be held on Sunday 9th November. The organisers tell us that it will be run along the lines of an Antique fair with trade stands, a bar (that sounds interesting!) and

catering facilities. The Nottingham/Derby area is one of the most active in terms of CB interest so the organisers expect a good turn out. You may even see the odd refugee from HE wandering about (probably near the bar) so why not pop along and see what's happening.

The venue will be the Festival Inn in Trowell Nottinghamshire. This is situated on the main Ilkeston-Nottingham road, (A609) about 6 miles from Nottingham, approximately 4 miles from Junction 25 on the M1 motorway. The Fair opens at 10am and will stay open till 5pm. If you want any more information then you can contact the organisers at:

TVC Ltd., Station Road, Long Eaton, Nottingham (Phone Long Eaton 62247).

CB Handbook and National Directory of Handles

This is what you've all been waiting for. The Hobby Electronics CB HANDBOOK AND NATIONAL DIRECTORY OF HANDLES is finally ready. After months of computerised compilation we have collated together thousands and thousands of registered handles into alphabetical and geographical categories. Each handle has been assigned a unique identification code consisting of numbers and letters so there shouldn't be any confusion in future over who was first. Included in the handbook section are features on CB law, all of the currently-used codes, addresses of all the local and national CB clubs and details of the National CB organisations. Most important of all is the registration form, enabling you to register your handle in the next edition which will be appearing in the next few months. Remember, registration is absolutely free: all you have to do is to get hold of a copy of the CB HANDBOOK AND NATIONAL DIRECTORY OF HANDLES. This special publication is available only from us, it will cost just £1.00 including post and packing or, if you can get along to the HE offices, only 85p. We will of course be happy to quote a discount for bulk orders. Get your copy early to avoid disappointment. Please allow 21 days for postal delivery.

Club Call

There can't be many areas without some form of CB club now but we're still getting news of new clubs. As always we're willing to give your club a mention if you just jot down a few details. Don't forget the address and a word or two about your membership and meeting place. Here is this month's selection.

Clog Town Breakers Club
Secretary: CBC
C/O Astley Bridge,
Bolton BL1 6PY
(Phone 0204 50046)

East Antrim CB Club
PO Box 4
Antrim
Northern Ireland

Grampian Breakers Club
Secretary: R.T. Strachan
59 Jasmine Terrace,
Aberdeen,
Scotland

Please note:
Open Channel CB Club.
F.W. McKeown is no longer the Chairman of the above club. The new Chairman is Mr S.J. Battersby. All correspondence should now be addressed to: The Secretary, OCCBC, 17 Coronation Street, Blackburn BB1 1BS.

Harrow has Jaws

As proof of the ever-increasing interest in CB, yet another accessory shop has been opened — Citizens' Band Radio Centre — at 331/7 Kenton Road, Harrow, Middlesex. It is a family business, run by David, Anita and Irving Jacobs.

David Jacobs spoke about some of the products: most interesting was the Jaws 2 transceiver. This is supplied in kit form (assembled PCB, case, knobs, brackets, screws, etc.). When assembled, it operates only as a receiver thus, it was claimed, meeting the requirements of the law. A full set of components, however, are available for this rig and it costs around £70. Prospective buyers are warned by staff of the legal position concerning CB.

According to David, sixty different types of aerial are on offer, including Avanti, PAL-Firestik and Shakespear. The linear amplifier range covers 25 W to 1kW. Most popular of these amps seemed to be the Lazer 1000 (switchable for 25, 50, 75 and 100W). Mikes included the popular K40, and Dacron and Alinca were among power supplies on show. It is planned to have a monitor receiver, model 733C, available 'before Christmas'. This will cover AM, FM (56 to 108 MHz) and CB (26.965 to 27.405 MHz) and is likely to cost around £15.

Stocked for service — view inside Citizens' Band Radio Centre during the press reception.

Bold display of CITIZENS' BAND is counterpoised with OPEN CHANNEL outside the shop.

CB VIPS

Mura

Three for the price of one this month — our roving reporter has been to Mura Ltd where Elliot Kahan, David Gross and Ged Crow are running one of the most successful CB accessory shops in the country.

Mura started some two years ago, after Elliot and Ged had returned from a visit to the States. Naturally the lack of CB in this country inspired them to do something about it, they actually started operations with just three antennas! They adopted the name Mura from an American company of the same name, Mura Corporation, one of the largest manufacturers of CB accessories in the USA. Just after Christmas this year they opened their now famous shop in Church Road, Hendon. It didn't take long for them to build up a respectable retail business, mostly by word of mouth, customers now come from all over the country. Much of their business now originates from the nationwide chain of dealerships and few areas are without a Mura stockist. Indeed, whilst we were in the shop one gentleman was busily buying stock for a shop that he was about to open in North London. Some £2,000 changed hands in just under ten minutes. Although Elliot wouldn't be too specific, it would seem that they are enjoying a turnover in excess of this country's current balance of payment. CB must be one of the most successful growth industries in these troubled times.

From left to right: Ged Crow (seated) David Gross and Elliot Kahan.

If you can cast your minds back a couple of months you'll remember our first visit to Mura. At that time they were heavily into antennas (base station aerials a speciality). That is still very apparent, although they can now offer a very comprehensive range of mikes, SWR and test meters, mounting hardware and a rather interesting CB monitor. This particular model is one of the best we've seen: it even has a squelch and noise limiter control. At £14.95 it has got to be one of the best in terms of value for money, the only problem being that they only have a limited number of them so you'll have to hurry.

Getting back to the business, they has recently opened a small but worthwhile operation in Tottenham Court Road. That looks set to expand shortly, and Mura are currently thinking about opening another shop very soon.

We asked the lads what they thought about Open Channel. We needn't have bothered as they felt pretty much the same as everyone else. Though perhaps more shrewdly than most, they have already had some sample antennas for 928MHz. All they need now is some equipment to connect them too. As they pointed out at the time, that is one line that won't be selling too well for a long, long time.

A number of CB magazines were on sale. David said that amateur radio (RSGB) publications had been selling faster than those on CB. In his view, CB was often the first step for some into ham radio, and said: "One in 10 are showing an interest in moving in that direction."

The question of the sale of high-power linear amplifiers (burners) was raised. In David's view, those who bought these had serious intentions of working long distances and would be already using a beam antenna (especially radio hams on 10 metres). CBers, he felt, preferred to stick to a high-efficiency aerial rather than use a burner. They realised, he said, that using a high-quality aerial was better than putting '1kW into a coat hanger'.

He saw Open Channel as: 'a means of stalling on behalf of the Government and Government bodies'.

He also said that experiments into the use of aerials for 928 MHz (the proposed OC frequency) were being undertaken by one of the Centre's overseas suppliers.

Irving Jacobs had grave doubts about 928 MHz, and saw little hope for British rig manufacturers if this became the accepted band. We would have, he said, 'the best of the boot' if 27 MHz was legalised, reaping the benefits of US experience on this waveband.

An associate company — Open channel radio GB Ltd. — has been formed to invest in rig manufacturers — once the proposed OC network comes into being.

Teach Yourself CB

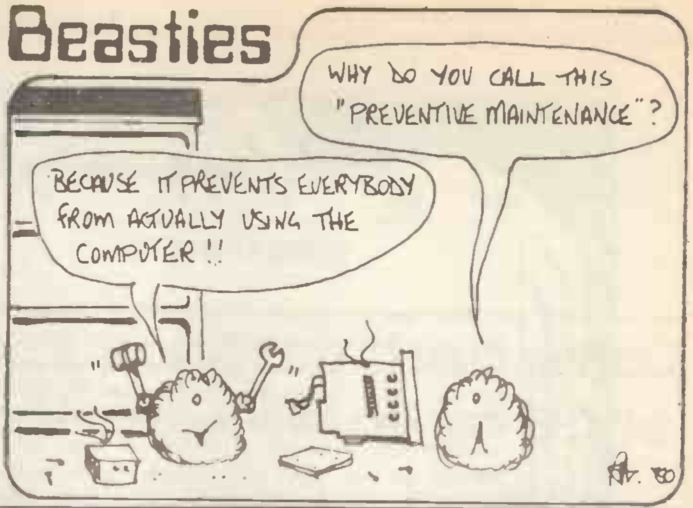
We received a cassette tape the other day from a company called Bridair Audio Promotions Ltd. These enterprising people have produced the very first guide to British CB with their tape called 'Teach Yourself CB'. After slapping it in the HE cassette player we must admit that it sounded rather odd at first. After all, American CB slang explained by someone with a BBC newscaster's accent does sound awkward, to say the least. Actually it did grow on us and after hearing it a couple of times we've got to say that we're impressed. It has been professionally produced and although the commentary is slightly shorter than we would have liked there is a good selection of Country & Western music (all CB songs) to listen to. All in all a good introduction to British CB, there are lots of helpful hints and tips and it should get a lot of people get acquainted with two-way radio. We will be offering this tape as a special offer in our forthcoming CB publications. If you just can't wait then you can contact Bridair at:

Basement Studios, 158 New Bridge Street, Newcastle on Tyne, NE1 2TE.

Each 40-minute cassette costs £2.99 plus post and packing from the above address.

Times up again for another month. Stay lucky and see you in four weeks.

HE



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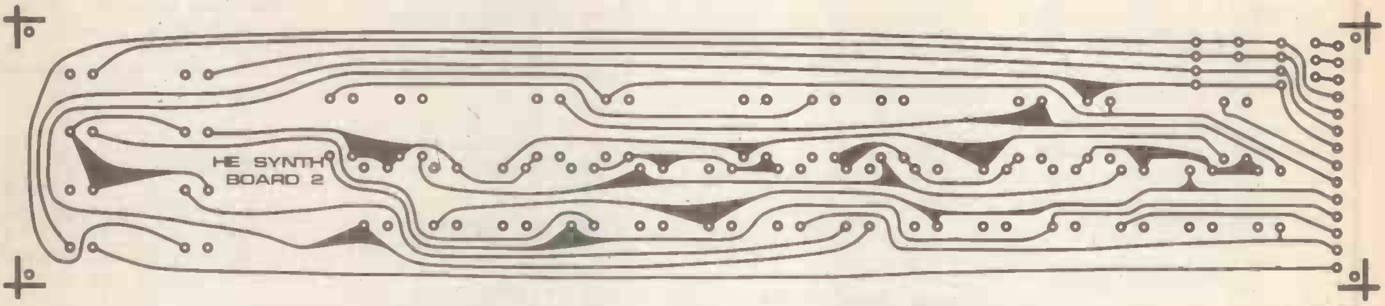
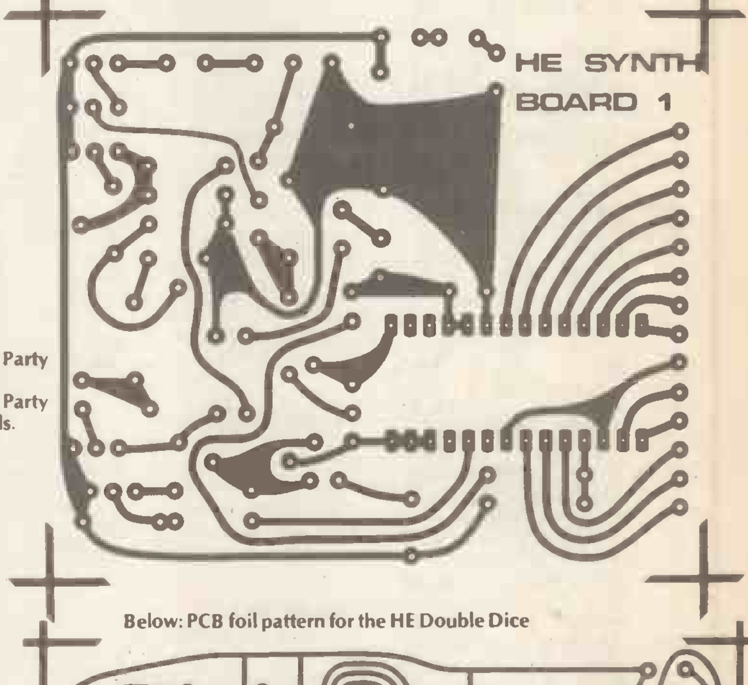
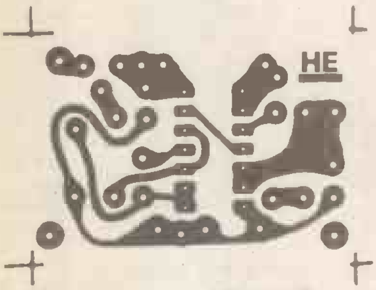
PCB Foil Patterns



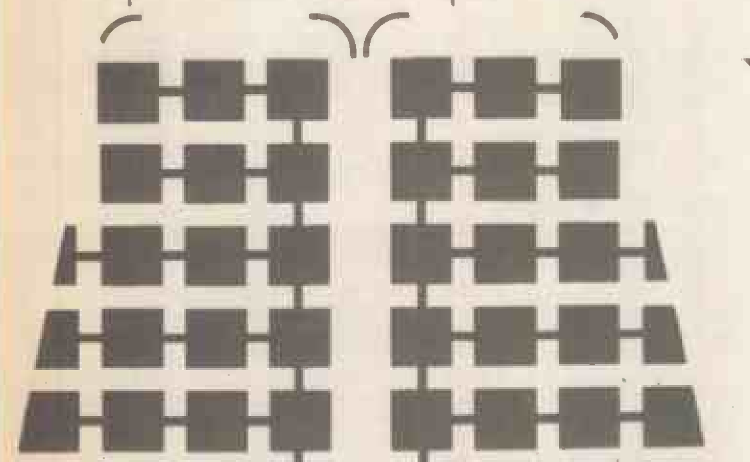
Mini synth keyboard (Note this is shown 60% full size)

Below: Main PCB for the Mini synth

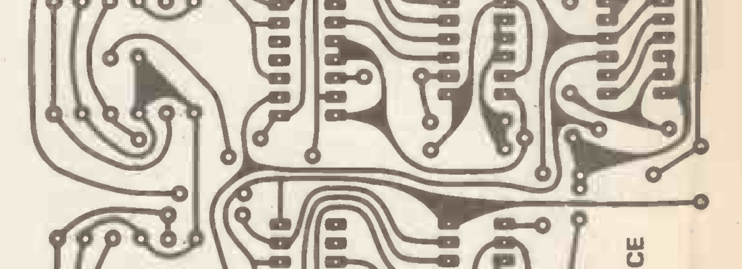




Left: PCB pattern for the Party Grenade.
Below: Foil pattern for the Party Grenade touch contact boards.



Below: PCB foil pattern for the HE Double Dice



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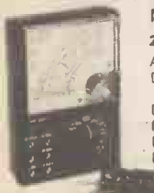

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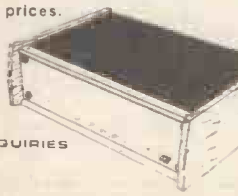

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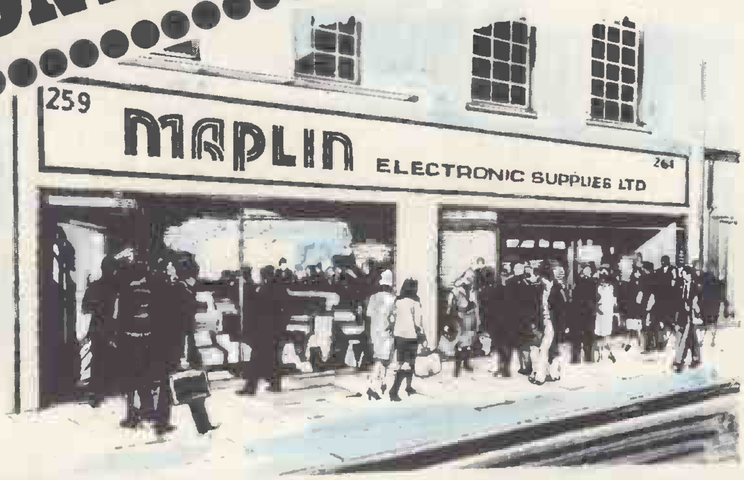

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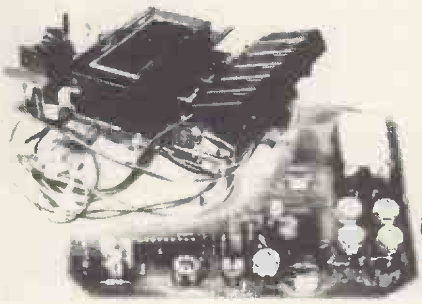

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