PRACTICAL

ELECTRONICS

Australia $1.35 New Zealand $1.60 Malaysia $4.95 IR £1.14 (inc. VAT)

JULY 1982

75p

Audio Test Set

Also in this issue...

Model Railway Automatic Controls

Active Speaker System

Genesis S101

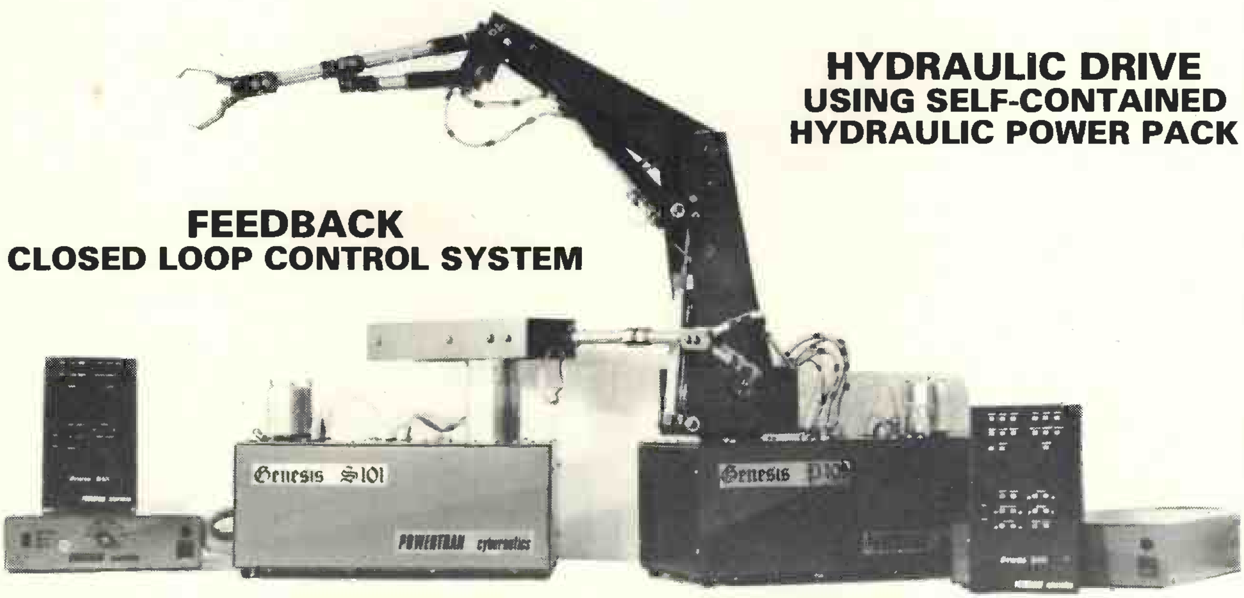
Genesis P101

POWERTRAN cybernetics

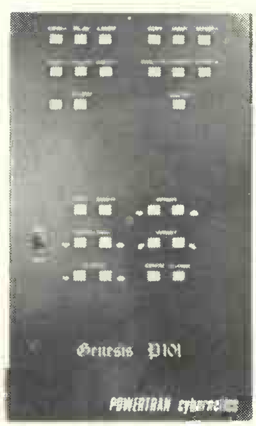
Hydraulic Powered Microprocessor Controlled Robots

HYDRAULIC DRIVE
USING SELF-CONTAINED HYDRAULIC POWER PACK

FEEDBACK
CLOSED LOOP CONTROL SYSTEM



With prices starting below £1,000 the Genesis range of general purpose robots provide a first rate introduction to robotics for both education and industry. Each has a self-contained hydraulic power source, which enables loads of several pounds to be smoothly handled. The system operates from a single phase 240 or 120V AC supply or a 12V DC supply. The machine can be supplied with up to 6 axes each of which is fully independent but capable of simultaneous operation. Position control is achieved by means of a closed-loop feedback system based around a dedicated microprocessor. Movement sequences can be entered, stored and replayed by use of a hand held controller, alternatively the systems can also be interfaced to an external computer via a standard RS 232C link.



P101 Hand Held Controller.

Example prices and specifications

Genesis S101

Base: 19.5″ × 11″ ×7.5″
Lifting capacity: 1500gm
Arm lift: 6.6″
Weight: 29Kg

4 axis model in kit form **£390**
5 axis model in kit form **£445**
5 axis model READY BUILT **£790**

Genesis P101

Base: 19.5″ × 11″ × 7.5″
Lifting capacity: 2000gm
Arm lengths between axles: 14.0″
Weight 34Kg

4 axis model in kit form **£495**
6 axis model in kit form **£595**
6 axis model READY BUILT **£950**

COMPLETE SYSTEMS AS SHOWN IN PHOTOGRAPH ABOVE

Genesis S101

4 axis system in kit form **£635.50**
5 axis system in kit form **£695.00**
5 axis system READY BUILT **£1355.00**

Genesis P101

4 axis system in kit form **£742.00**
6 axis system in kit form **£852.00**
6 axis system READY BUILT **£1525.00**

As featured in this journal November '81–April'82 issues.

For further details please contact:

POWERTRAN CYBERNETICS

PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3WN

Telephone: ANDOVER (0264) 64455


ZX Spectrum

Colour and sound...full-siz
16K or 48K RAM... high-res

Proven pedigree

Following the world-beating success of the Sinclair ZX80/ZX81 – over 400,000 sold so far – comes the Sinclair ZX Spectrum. The ZX81 is, and will continue to be, the ideal introduction to computing – with up to 16K RAM available, and the ZX Printer. The ZX Spectrum offers even more computing capability, with colour and sound, up to 48K RAM, and high-resolution graphics.

Professional power... more capacity...personal computer price!

The power of the Sinclair ZX Spectrum comes from a new 16K BASIC ROM. So, in addition to the features of the ZX81, the ZX Spectrum gives you a full 8 colours, a sound generator, high-resolution graphics and many other features – including the facility to support separate data files.

The storage capacity of any computer is governed by the amount of RAM. The ZX Spectrum comes in two versions – with 16K, or a really massive 48K, of RAM. Yet even the 48K RAM version costs only £175 – compared to £125 for the 16K RAM model.

Many people will opt for the full 48K RAM from the outset, but if you do decide to start with the 16K version, you will be able to return your ZX Spectrum for a 48K RAM upgrade at a later date – at a cost of around £60.

A growing system

Your ZX Spectrum comes with a mains adaptor, all the necessary leads to connect to most cassette recorders and TVs (colour or black and white), and *two* manuals. If you're new to computing, you'll find both manuals of immense help.

Together, they represent a course in BASIC programming from first principles to advanced techniques. But if you already have experience of computers, you can skip much of the ground-work, and move straight into the colourful world of ZX Spectrum professional-level computing.

Either way, you don't have to stop there. The ZX Printer – available now – is fully compatible with the ZX Spectrum. And later this year there will be Microdrives for massive extra on-line storage, plus an RS232/ network interface board.

The ZX Printer – available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set – including lower-case characters and high-resolution graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

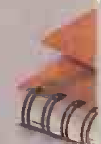
The ZX Printer connects to the rear of your ZX Spectrum and a roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.

RS232/network interface board

For around £20, this interface – available later this year – will enable you to connect your ZX Spectrum to a whole range of printers, terminals and other computers. The astonishingly low price is possible only because the operating systems are already designed into the ROM.

Sinclair ZX Spectrum

From only £125!



ze moving-key keyboard... solution graphics...

ZX Microdrive – coming soon

Designed exclusively for use with the ZX Spectrum, the new ZX Microdrives will revolutionise personal computing.

Each Microdrive can hold up to 100K bytes on a single interchangeable microfloppy – with a transfer rate of 16K bytes per second. And you'll be able to connect up to 8 ZX Microdrives to your ZX Spectrum – they're available later this year, for around £50.

Professional performance for only £125 – how's it done?

Quite simply, by commitment and design. Timex and ICL are adopting Sinclair technology and Sinclair BASIC under licence for future products. Sinclair is now world leader in personal computer production.

Key features of the Sinclair ZX Spectrum

Full colour – 8 colours each for foreground, background and border, plus flashing and brightness -intensity control.

Sound – BEEP command with variable pitch and duration.

Massive RAM – 16K or 48K.

Full-size moving-key keyboard – all keys at normal typewriter pitch, with repeat facility on each key.

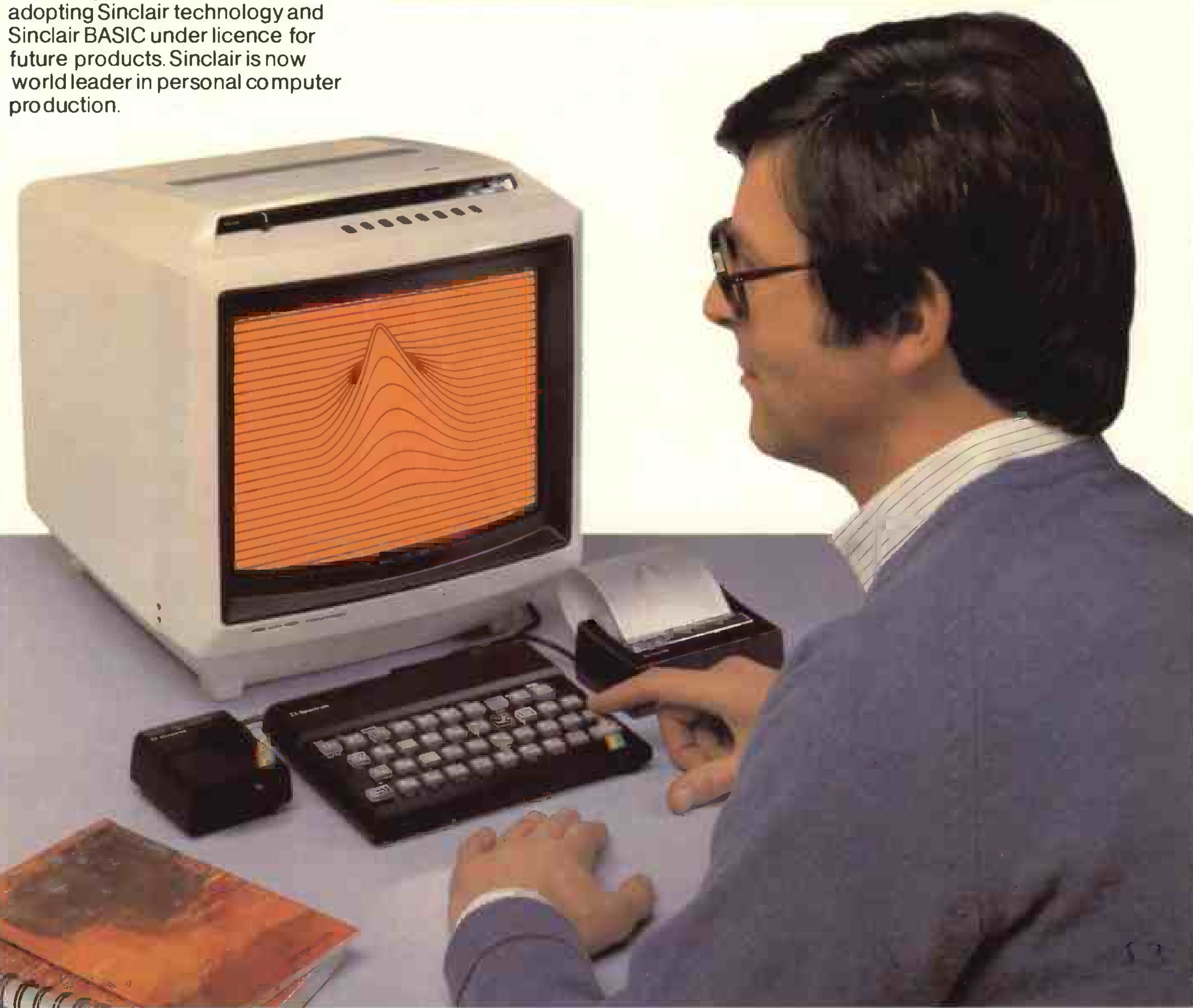
High resolution – 256 dots horizontally x 192 vertically, each individually addressable for true high-resolution graphics.

ASCII character set – with upper- and lower-case characters.

Teletext-compatible – user software can generate 40 characters per line or other settings.

High speed LOAD & SAVE – 16K in 100 seconds via cassette, with VERIFY and MERGE for programs and separate data files.

Sinclair 16K extended BASIC – incorporating unique 'one-touch' keyword entry, syntax check, and report codes.



Double-manual system for the ZX Spectrum – slim introductory manual takes beginners through to programming proficiency. Advanced manual smoothes the way through difficult, complex programs.

Connect up to eight ZX Microdrives to your ZX Spectrum. Each holds up to 100K bytes on any one microfloppy. Each can transfer at 16K bytes per second – with an average access time of 3·5 seconds.

The proven ZX printer – full ASCII character set, printing at 50 cps, with 32 cpl and 9 lines per vertical inch. Reproduces exactly what's on the screen at the touch of a button.

ZX Spectrum

Available only by mail order and only from

sinclair

Sinclair Research Ltd,
Stanhope Road, Camberley, Surrey, GU15 3PS.
Tel: Camberley (0276) 685311.

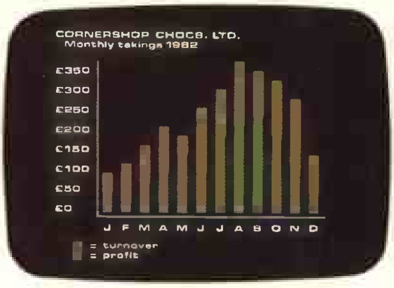
ZX Spectrum software: how good and how soon?

The ZX Spectrum uses an enhanced version of Sinclair BASIC, fast becoming a world standard, and unlikely to be superseded. Unique features, such as one-touch keyword entry and syntax check and report, are increasingly attracting software originators.

Building the software library is already far advanced, and a complete catalogue will be available in the next few months. Subjects will include sophisticated games, education, 'housekeeping', and business management. The more complex packages can, of course, be used to their best advantage with the full 48K RAM version of the ZX Spectrum.

The Sinclair ZX Spectrum can handle sophisticated games programs with high-resolution colour graphics and sound.

This major advance in computer technology maintains Britain's world-beating position in the field of personal computers.



A range of business software will soon be available, covering both specific applications (eg stock-control and payroll) and general business management systems (eg matrix models).

This second generation of Sinclair personal computers demonstrates continuing commitment. Advanced technology made the ZX80/81 family a price breakthrough: advanced technology makes the ZX Spectrum a breakthrough in price and performance.

How to order your ZX Spectrum

BY PHONE–Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST–use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY–please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt–and we have no doubt that you will be.

To: Sinclair Research, FREEPOST, Camberley, Surrey, GU15 3BR.

Qty	Item	Code	Item price £	Order Total £
	Sinclair ZX Spectrum – 16K RAM version	100	125.00	
	Sinclair ZX Spectrum – 48K RAM version	101	175.00	
	Sinclair ZX Printer	27	59.95	
	Printer paper (pack of 5 rolls)	16	11.95	
	Postage and packing: orders under £100	28	2.95	
	orders over £100	29	4.95	

TOTAL £________

Please tick if you require a VAT receipt ☐

*I enclose a cheque/postal order payable to Sinclair Research Ltd for £________

*Please charge to my Access/Barclaycard/Trustcard account no.

*Please delete/complete as applicable.

Please print.

Signature ________________

Name: Mr/Mrs/Miss

Address

PRE807

FREEPOST – no stamp needed. Prices apply to UK only. Export prices on application.

Sinclair ZX Spectrum–technical data.

Dimensions

Width	233 mm
Depth	144 mm
Height	30 mm

CPU/memory

Z80A microprocessor running at 3.5 MHz. 16K-byte ROM containing BASIC interpreter and operating system.

16K-byte RAM (plus optional 32K-byte RAM on internal expansion board) or 48K-byte RAM.

Keyboard

40-moving-key keyboard with full upper and lower case with capitals lock feature. All BASIC words obtained by single keys, plus 16 graphics characters, 22 colour control codes, and 21 user-definable graphics characters. All keys have auto repeat.

Display

Memory-mapped display of 256 pixels × 192 pixels; plus one attributes byte per character square, defining one of eight foreground colours, one of eight background colours, normal or extra brightness and flashing or steady. Screen border colour also settable to one of eight colours. Will drive a PAL UHF colour TV set, or black and white set (which will give a scale of grey), on channel 36.

Sound

Internal loudspeaker can be operated over more than 10 octaves (actually 130 semitones) via basic BEEP command. Jack sockets at the rear of computer allow connections to external amplifier/speaker.

Graphics

Point, line, circle and arc drawing commands in high-resolution graphics. 16 pre-defined graphics characters plus 21 user-definable graphics characters. Also functions to yield character at a given position, attribute at a given position (colours, brightness and flash) and whether a given pixel is set. Text may be written on the screen on 24 lines of 32 characters. Text and graphics may be freely mixed.

Colours

Foreground and background colours, brightness and flashing are set by BASIC INK, PAPER, BRIGHT and FLASH commands. OVER may also be set, which performs an exclusive-or operation to overwrite any printing or plotting that is already on the screen. INVERSE will give inverse video printing. These six commands may be set globally to cover all further PRINT, PLOT, DRAW or CIRCLE commands, or locally within these commands to cover only the results of that command. They may also be set locally to cover text printed by an INPUT statement. Colour-control codes, which may be accessed from the keyboard, may be inserted into text or program listing, and when displayed will override the globally set colours until another control code is encountered. Brightness and flashing codes may be inserted into program or text, similarly. Colour-control codes in a program listing have no effect on its execution. Border colour is set by a BORDER command. The eight colours available are black, blue, red, magenta, green, cyan, yellow and white. All eight colours may be present on the screen at once, with some areas flashing and others steady, and any area may be highlighted extra bright.

Screen

The screen is divided into two sections. The top section – normally the first 22 lines – displays the program listing or the results of program or command execution. The bottom section – normally the last 2 lines – shows the command or program line currently being entered, or the program line currently being edited. It also shows the report messages. Full editing facilities of cursor left, cursor right, insert and delete (with auto-repeat facility) are available over this line. The bottom section will expand to accept a current line of up to 22 lines.

Mathematical operations and functions

Arithmetic operations of +, −, ×, ÷, and raise to a power. Mathematical functions of sine, cosine, tangent and their inverses; natural logs and exponentials, sign function, absolute value function, and integer function; square root function, random number generator, and pi.

Numbers are stored as five bytes of floating point binary – giving a range of $+3 \times 10^{-39}$ to $+7 \times 10^{38}$ accurate to 9½ decimal digits.

Binary numbers may be entered directly with the BIN function. =, >, <, >=, <= and <> may be used to compare string or arithmetic values or variables to yield 0 (false) or 1 (true). Logical operators AND, OR and NOT yield boolean results but will accept 0 (false) and any number (true).

User-definable functions are defined using DEF FN, and called using FN. They may take up to 26 numeric and 26 string arguments, and may yield string or numeric results.

There is a full DATA mechanism, using the commands READ, DATA and RESTORE.

A real-time clock is obtainable.

String operations and functions

Strings can be concatenated with +. String variables or values may be comapred with =, >, <, >=, <=, <> to give boolean results. String functions are VAL, VAL$, STR$ and LEN. CHR$ and CODE convert numbers to characters and vice versa, using the ASCII code.

A very powerful string slicing mechanism exists, using the form a$ (x TO y).

Variable names

Numeric – any string starting with a letter (upper and lower case are not distinguished between, and spaces are ignored).

String – A$ to Z$.

FOR-NEXT loops – A-Z.

Numeric arrays – A-Z.

String arrays – A$ to Z$.

Simple variables and arrays with the same name are allowed and distinguished between.

Arrays

Arrays may be multi-dimensional, with subscripts starting at 1. String arrays, technically character arrays, may have their last subscript omitted, yielding a string.

Expression evaluator

A full expression evaluator is called during program execution whenever an expression, constant or variable is encountered. This allows the use of expressions as arguments to GOTO, GOSUB, etc.

It also operates on commands allowing the ZX Spectrum to operate as a calculator.

Cassette interface

The ZX Spectrum incorporates an advanced cassette interface. A tone leader is recorded before the information to overcome the automatic recording level fluctuations of some tape recorders, and a Schmitt trigger is used to remove noise on playback.

All saved information is started with a header containing information as to its type, title, length and address information. Program, screens, blocks of memory, string and character arrays may all be saved separately.

Programs, blocks of memory and arrays may be verified after saving to confirm successful saving.

Programs and arrays may be merged from tape to combine them with the existing contents of memory. Where two line numbers or variables names coincide, the old one is overwritten.

Programs may be saved with a line number, where execution will start immediately on loading.

The cassette interface runs at 1500 baud, through two 3.5 mm jack plugs.

Expansion port

This has the full data, address and control busses from the Z80A, and is used to interface to the ZX Printer, the RS232 and NET interfaces and the ZX Microdrives.

IN and OUT commands give the I/O port equivalents of PEEK and POKE.

ZX81 compatibility

ZX81 BASIC is essentially a subset of ZX Spectrum BASIC. The differences are as follows.

FAST and SLOW: the ZX Spectrum operates at the speed of the ZX81 in FAST mode with the steady display of SLOW mode, and does not include these commands.

SCROLL: the ZX Spectrum scrolls automatically, asking the operator "scroll?" every time a screen is filled.

UNPLOT: the ZX Spectrum can unplot a pixel using PLOT OVER, and thus achieves unplot.

Character set: the ZX Spectrum uses the ASCII character set, as opposed to the ZX81 non-standard set.

ZX81 programs may be typed into the ZX Spectrum with very little change, but may of course now be considerably improved. The ZX Spectrum is fully compatible with the ZX Printer, which can now print out a full upper and lower case character set, and the high resolution graphics; using LLIST, LPRINT and COPY. ZX81 software cassettes and the ZX 16K RAM pack will not operate with the ZX Spectrum.

sinclair

ZX Spectrum

Sinclair Research Ltd, Stanhope Road, Camberley, Surrey, GU15 3PS. Tel: Camberley (0276) 685311.

55

How the ZX Spectrum compares with other personal computers.

	ZX Spectrum	BBC micro model A	VIC 20	ATARI 400	TI 99/4A	TRS 80 Colour
Guide price – basic unit inc. VAT	£125	£300	£190	£300	£300	£450
Standard RAM	16K	16K	5K	16K	16K	16K
Standard RAM available using high-resolution graphics	9K	3K	N/A	7K	14K*	10K
Maximum RAM	48K	32K	29K	32K	48K	32K
Sound generator	✓	✓	✓	✓	✓	✓
Colours available	8	8	16	16	16	9
Maximum colours on screen at one time	8	4	16	5	16	8
FLASH	✓	✓				
BRIGHT – or equivalent	✓			✓		
High-resolution graphics (>40000 pixels) available for PLOT & DRAW	✓	✓		✓		✓
User-definable graphics characters	✓				✓	
Full upper/lower case ASCII	✓	✓		✓		✓
User-definable character set	✓	✓	✓	✓	✓	
Screen display (columns x rows)	32 x 24	40 x 25	22 x 23	40 x 24	32 x 24	32 x 16
Auto-repeat on all keys	✓	✓		✓	✓	
Cassette interface for all normal recorders	✓	✓			✓	✓
Baud (data transfer) rate	1500	1200	300	1200	450	1200
LOAD & SAVE	✓	✓	✓	✓	✓	✓
VERIFY	✓	✓	✓		✓	
MERGE	✓			✓		

**But PLOT & DRAW not available*

Elegant, effective, unique–the ZX Spectrum design.

'Less than half the price of its nearest competitor – and more powerful.

'These two pictures show how it's done. On the right is the PCB from the BBC Model A Microcomputer. On the left is the PCB from the ZX Spectrum.

'It's obvious at a glance that the design of the Spectrum is more elegant. What may not be so obvious is that it also provides more power.

'The ZX Spectrum has more usable RAM, and higher maximum RAM.

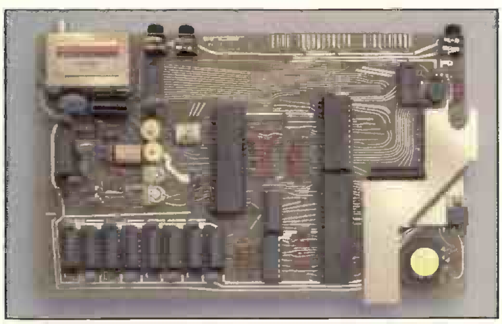
'It offers twice as many colours on the screen at any one time, plus a colour brightness control. It also offers user–definable graphics.

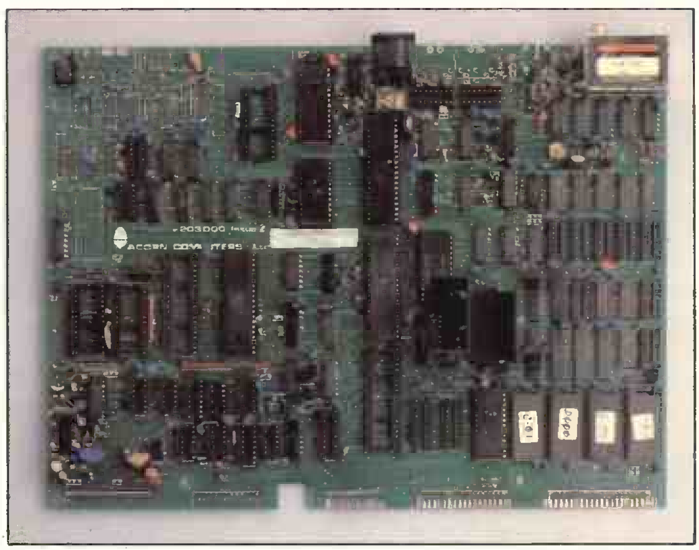
'It has data transfer rate 25% faster, supported by a VERIFY facility.

'And it employs a dialect of BASIC (Sinclair BASIC) already in use in over 400,000 computers worldwide.

'We believe the BBC make the world's best TV programmes – and that Sinclair make the world's best computers!'

– Clive Sinclair.





Above left: internal layout of Sinclair ZX Spectrum.

Right: internal layout of BBC Micro Model A.

The illustrations are to the same scale, and demonstrate the rate of advance in microcomputer design. The ZX Spectrum uses just 14 chips to provide more power and more user-available RAM.

PRACTICAL
ELECTRONICS

VOLUME 18 No. 7 JULY 1982

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

OUR AUGUST ISSUE WILL BE ON SALE FRIDAY, JULY 9th, 1982
(for details of contents see page 25)

WE WILL BEAT BY 5% ANY LOWER PRICE ADVERTISED BY COMPETITORS*

CASIO

100 METRE WATER RESISTANT

W-100	W-150C	W-150
Resin case/strap	S/S case, resin strap	All S/S
£19.95	**£21.95**	**£24.95**

Time and auto calendar. Alarm and hourly chimes. Countdown alarm timer with repeat memory function. Professional 1/100 second stopwatch. Time is always on display, regardless of display mode. Amazing 5 year lithium battery life. Superior to the W-250

50 METRE WATER RESISTANT

W-20	W-21	W-30
REsin case/strap	Resin S/S trim	All S/S
£12.95	**£14.95**	**£19.95**

12/24 hour time and auto calendar. Alarm and hourly chimes. Professional 1/100 second stopwatch to 12 hrs. Compact and slim cases, approx. 8mm thick. 5 year lithium battery.

OTHER MODELS

AX-210. The world's most versatile watch?

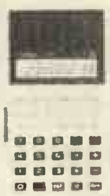
Analog Display
LC Display of hours and minutes
Digital Display
- Local time, 12 or 24 hour
- Full calendar display
- Dual time, 12 or 24 hour
- Countdown alarm timer with memory function
- Professional 1/100 second stopwatch

Hourly time signal. Daily alarm electronic buzzer or 3 selectable melodies. Rapid forward/back setting. 9.4 x 35.4 x 36mm
Usual price: £29.95
Lowest price elsewhere
● **£27.95**

*****NEW*****

CA95. Calculator, 4 alarms, hourly time signal, stopwatch Black resin case/strap £19.95.
CA951 Metal case/bracelet version of CA95 £29.95.
Other models. CA85 £19.95; CA851 £29.95; J100 £19.95; GM10 £19.95; SA50 £14.95; SA50G £19.95.

LOOK, NO BATTERIES



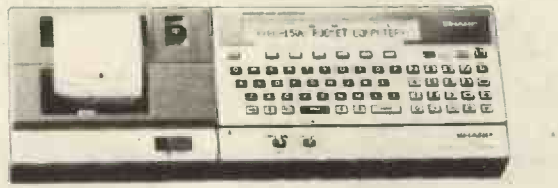
FX-950 SOLAR CELL SCIENTIFIC
Powered by almost any light. 50 scientific functions, with nesting of up to 15 parentheses at 5 levels. Hyperbolics, Standard Deviations, etc. 10 digit display. 5.4 x 73 x 129mm Supplied with wallet.
£22.50

FX-900 8-digit version with less functions £19.95

Sharp Portable Colour Computer for only £278 + VAT

The Revolutionary New PC-1500 and CE-150

PC-1500 Computer
£169.95
CE-150 4-colour Printer
£149.95
CE-151 4K Byte RAM
£49.95
CE-155 8K Byte RAM
£79.95

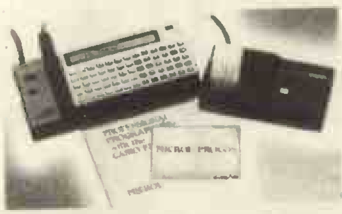


We are convinced that this is the world's most advanced PC-1500 software.

MICROL 1500 SOFTWARE SERIES
The Portable Computer Comes of Age with advanced ready-to-run software to meet the needs of management, science, engineering and the professions. Major features include: (1) 100% reliable performance for total dependability. (2) "User-friendly" commands and prompts. (3) Comprehensive "plain English" operating manuals. (4) No computer experience required. (5) Designed for easy personalisation. (6) Future-compatible, with full hardware and software add-on capability. Plus: Full colour print commands with Auto-Colour, Audit-Trail and Archive options, sophisticated user-error recovery systems and Database Integrity Protection option.
MICROL 1500 Software Series from £200 to under £20.
Brochure on request
Worldwide dealer network now being established
Dealer enquires welcome.

The PC-1500 approaches the Personal Computer in ability. 16K bytes of ROM and up to 11.5K bytes of RAM memory, with battery protection. Multiple program storage capacity. 'BASIC' program language with two dimensional arrays and variable strings. QWERTY keyboard with upper and lower case. (Word-processor software available soon.) Mini-graphic 7 x 156 dot matrix display. Line width 26 characters. The CE-150 4-colour Graphic Printer/Two Cassette Interface (for saving/loading) prints virtually any drawing, with complete control of up, down, left and right printing. Variable line length from 4 to 36 characters. With rechargeable battery and mains adaptor.
Dimensions: PC-1500 195 x 25.5 x 86mm. Wt 375g. CE-150 330 x 50 x 115mm. Wt 900g.
Available soon: RS-232C Interface. Software board to serve as input keys in graphics, or pictures, previously drawn on a template.
Brochure on request.

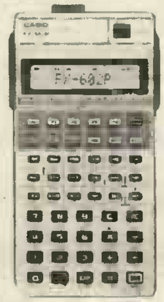
The Scientific Portable Computer



CASIO FX-702P Only £99.95
Plus FREE MICROL Professional Programming Pack (RRP £9.95) or we will beat any lower price by 5%.
The widest range of math, science and statistics, (55 in all, including Regression and Correlation). BASIC. Up to 1,680 program memory steps, up to 226 data memories. Subroutines, 10 levels; FOR:NEXT looping, 8 levels. Edit, debug and trace modes. 240hrs battery life.
17 x 165 x 82mm. Wt 176g.
MICROL 702 PROCOS Professional Computing Solutions on tape. Save up to 90% of programming time with this electronic equivalent of pen and paper. 'Visicalc-type' systems answers 'what if' questions and analyses trends. £24.95.
Peripherals for FX-702P, 602P, 601P and 502/501P
FA-2 Remote control Cassette interface £19.95
FP-10 Permanent hard copy printer. AC/DC £44.95

702 PACKAGE DEALS
Pack A: FX-702P + MICROL PPP £99.95
Pack B: 702 + FA-2 + PROCOS £139.95
Pack C: 702 + PPP + FP-10 + PROCOS £179.95

World's Fastest Programmable?



CASIO FX-602P
Only £74.95
With FREE MICROL Professional Programming Pack (RRP £9.95) or we will beat any lower price by 5%.
50 scientific functions. Up to 512 program steps, up to 88 memories, all protected when switched off. Programs; P0 to P9. GOTO up to 10 pairs. Up to 9 subroutines nestable to 9 levels. 33 brackets at 11 levels.
FA-2.......... £19.95
FP-10......... £24.95

CASIO FX-601P Now only £39.95
Similar to the FX-602P but with 128 program steps, 11 memories; 18 brackets, up to 6 levels; up to 9 subroutines, nestable up to 4 levels.

Other Scientifics
FX-3600P 38 program steps £22.95* Others £21.95*
FX-8100 With Clock, Alarms, Stopwatch......... £19.95
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PE VOLUME 18 No. 7 JULY 1982

ALARMING

It's quite alarming how crimes of theft have increased during the period of recession and this month we start PE's drive to assist crime prevention. Included in the issue are a *Burglar Deterrent* which will assist with that "house occupied" appearance, and a *Versatile Car Alarm* to protect your vehicle and its contents.

Both designs are relatively easy to build and install; above all both are inexpensive. They form a simple start to a number of different projects to be presented over the next couple of months.

THREE MORE

In the August issue we will carry three different alarm systems based on a single p.c.b. design. These systems use the latest technology and will cover a wide range of applications in and around all types of property. The three units are: an ultrasonic Doppler shift alarm operating at 32·7kHz, crystal controlled with sensitivity variable up to 8 metres; a radar Doppler shift alarm operating at 10·687GHz, based on a Mullard radar module and having a range of up to 30 metres; and an infra-red heat sensor system with a sensitivity peaking at human body temperature. The double pyroelectric infra-red sensor is mounted in a patented multifaceted mirror housing providing a range of 15 metres in six zones.

We will also be describing a simple *Automatic Photographer* project which could be used in a "burglar identification" role, although it was not designed primarily for this. As is our normal practice full details of each device will be published and full constructional information provided.

PLUS ONE

One further system will be published in a later issue—possibly October—it will provide a wired alarm system in addition to timed entry and exit delays and circuit test facilities.

ELECTRONIC HOBBIES FAIR

Unfortunately the Breadboard Exhibition no longer appears to be meeting the needs of exhibitors or public. In this booming area last year's Breadboard attendance was down by 23 per cent and dissatisfaction was expressed by both public and trade. In response, the three IPC electronic hobbies magazines P.E., P.W., and E.E. are proposing a new exhibition to meet the needs of hobbyists and suppliers.

With trade backing the new exhibition will provide much more than Breadboard has offered in the past; in addition to the usual stands there will be many special exhibits and demonstrations. We intend to make it a day out for the family to remember, not just a two-hour browsing or shopping trip—more news next month.

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Technical Queries

We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or international reply coupons, and each letter should relate to one published project only.

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p.

Binders

Binders for PE are available from the same address as back numbers at £4·60 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions

Copies of PE are available by post, inland or overseas, for £13·00 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...NEWS &

Edited by Jasper Scott

Shshsh - It's the ZX82!

Only one man is fast enough to eclipse a Sinclair microcomputer, and that's Clive Sinclair. First the ZX80, then the ZX81, and now the ZX82—to you and I the ZX Spectrum!

With high resolution colour graphics at 256 × 192 pixels, sound (10 octaves of bleeps), and a sanguine 16K of enhanced Sinclair BASIC with Syntax Check and Report Codes; the ZX Spectrum, with its 16K or 48K RAM option, compares as shown with other machines.

It was to the amusement of one journalist's colleagues at the machine's unveiling, that he was sternly corrected for quoting Clive Sinclair as having claimed that the Spectrum was as good as the BBC micro'. "No, no. I said it was *better* . . ." responded the man who perhaps seeks to demonstrate that the Beeb made the wrong choice.

There is certainly value for money in the ZX Spectrum with its two manuals, one for the absolute beginner, and the other a BASIC handbook. The 16K model is factory upgradable to 48K for around £60, and either version unleashes hitherto unexploited potentials in the ZX Printer. ZX81 software *will* run on the Spectrum "with minor alterations"—words not to be treated dismissively by the neophyte.

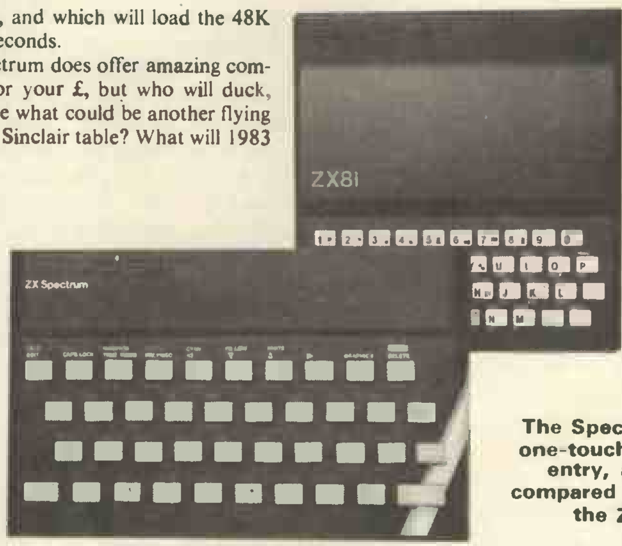
Awaiting a call to arms is a set of operating routines buried in ROM in this 14 chip design, to drive the RS232 interface (around £20) available later this year.

Now out of the membrane keypad class, the latest ZX computer uses a standard typewriter pitched keyboard, but sans conventional space bar, the manufacturer's confidence in the relationship which can be struck up between the machine and a touch-typist may not be shared. Business, research and education are all targets for the unit, measuring a mere 233 × 144 × 30 mm.

Mail order only, initially, the Spectrum will be supplied to run with a standard cassette player, and conventional PAL colour TV set—no VDU. A tone leader has been incorporated to overcome automatic record level fluctuations.

A network interface is planned which will allow many Spectrums to be linked together, *and* teletext compatibility. The interface will also support several Microdrives, the 100K byte micro-floppy system currently at working prototype stage, and which will load the 48K RAM in three seconds.

The ZX Spectrum does offer amazing computing power for your £, but who will duck, and who will bite what could be another flying crumb from the Sinclair table? What will 1983 bring?



The Spectrum has one-touch keyword entry, and is compared here with the ZX81

	ZX Spectrum	BBC Model A	VIC 20	ATARI 400
Guide price—basic unit inc. VAT	£125	£300	£190	£345
Standard RAM (max. RAM)	16K (48K)	16K (32K)	5K (29K)	16K (16K)
Standard RAM available using high-resolution graphics	9K	3K	N/A	7K
Sound generator	✓	✓	✓	✓
Max. colours on screen at once	8	4	16	4
FLASH	✓	✓		
BRIGHT—or equivalent	✓			✓
High-res. graphics (>40000 pixels) available for PLOT & DRAW	✓	✓		✓
User-definable graphics	✓			
Full upper/lower case ASCII	✓	✓		
User-definable character set	✓	✓	✓	
Screen display (columns x rows)	32 x 24	40 x 25	22 x 23	40 x 24
Auto-repeat on all keys	✓	✓		✓
Cass. interface for normal recorders	✓	✓		
Baud (data transfer) rate	1500	1200	300	1200
LOAD & SAVE	✓	✓	✓	✓
VERIFY	✓		✓	
MERGE	✓			

Information supplied by Sinclair

MARKET PLACE

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

Psst-It's the Sinclair rival!

In last month's News & Market Place, we mentioned a teaching computer known as the Micro-Professor MPF-I. We have now received details of a powerful personal colour computer from the same manufacturer, the MPF-II. It is expected to retail at around £115 and offers a formidable range of features.

Based around a 6502 CPU, the MPF-II provides 12K of ROM (including 8K BASIC interpreter compatible with Apple II), 16K of RAM, with built-in provision to expand on board memory by up to 32K. A software cartridge connector enables a wide range of games and educational programs to be run and also gives the option of operation in machine code languages. Programs can of course be loaded and stored via the cassette interface.

The MPF-II features a 40 × 24 screen format, 53760 dot character capacity, 16 colour graphics, inverse video, a 49-key alphanumeric keyboard and Centronics printer interface. It is available from Flight Electronics Ltd., Flight House, Quayside Road, Bitterne Manor, Southampton, Hants SO2 4AD (0703 34003).

The launch of the MPF-II means that Sinclair will have a formidable rival for the new ZX Spectrum. Adding the MPF-II to the comparison table opposite may prove very interesting when more details are available.

Briefly...

The first issue of the Beebug Newsletter which is published by the Independent National User Group for the BBC Microcomputer is now available. The Newsletter contains a review of the BBC machine as well as programs, letters, hints and tips.

Membership applications should be sent to Beebug Dept 1, 374 Wandsworth Road, London SW8 4TE (£4·50 for five issues).

● ● ● ●

Oracle, ITV's teletext service, has now expanded into classified advertising following their very successful experiments in Christmas and Valentine's Day messages.

The service, which is called 'Reasons to be Cheerful', enables viewers to broadcast their own personal messages via television to celebrate special occasions like birthdays and anniversaries.

The charge for the service is £6 for one line and £10 for two lines. Messages will stay on the air from 8.30 a.m. till closedown.

DROUGHT DOUBTS?

Farmers and gardening enthusiasts who wish to monitor rainfall with accuracy and convenience can now do so with the help of a device known as the Rain-o-Matic.

The Rain-o-Matic consists of two units—a rain collector, and a control box which houses a 3 digit l.e.d. display, reading and zero switches, memory circuitry, and a battery. Ten metres of cable are supplied, so that the control box may be placed in a convenient position indoors.

Manufactured in Denmark, the Rain-o-Matic is distributed in this country by R.E.N.S. Services, who say that the device should prove to be a valuable horticultural aid, as it enables the user to monitor rainfall over set periods, thus building up a comprehensive picture of local rainfall. The user can then determine the extent of irrigation necessary to ensure maximum yields.

The Rain-o-Matic is priced at £35 inclusive of VAT and p&p (but excluding a battery) and is available from R.E.N.S. Services, 21 Chestnut Grove, Gedling, Nottingham (0602 611903).

COMPACT KEYBOARD

Owners of the ubiquitous ZX81 will no doubt be aware of the baffling selection of add-on keyboards currently available to replace the ZX81's original membrane pad. This selection has now been added to by Kempston Electronics.

The Kempston Keyboard differs from its competitors in that it is a scaled down version of a traditional computer keyboard which fits directly in place of the ZX81's membrane, and thus represents a considerable space saving over full size add-on keyboards which have the added inconvenience of trailing ribbon cables. The keys have a positive 'click' effect when pressed, and are mounted on a single p.c.b. which is

finished in matt black to match the ZX81. Installation of the keyboard is said to be a simple operation. A set of legends, which are scaled down versions of the originals, is supplied with the keyboard which is sold in kit form and priced at £22·50 inclusive of VAT and p&p.

For those who would like more positive keyboard operation, but do not wish to sacrifice compactness, the Kempston keyboard would appear to offer an excellent compromise. Further details are available from Kempston Electronics, 60 Adamson Court, Hillgrounds Road, Kempston, Bedford.

MULTITRACKING WITHOUT TEARS

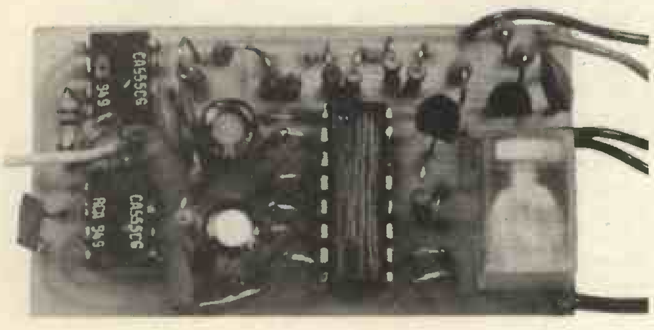
If you are a musician and have reached the stage of wanting to produce demo tapes, you may well have come across the Portastudio. Introduced by Teac (under the Tascam label) in 1980, the M144 Portastudio comprised a cassette based four-channel recorder/mixing package that was both comparatively inexpensive and simple to use, and offered the musician the chance of making DIY multitracking a reality.

Now the 144's successor, the 244 Portastudio (pictured above) has been launched. The 244 offers considerable improvements over the 144, most notably: dbx II noise reduction (giving a −90dB signal/noise ratio); parametric sweep instead of bass and treble controls—thus increasing flexibility of tone control; and a completely new transport system that gives smoother operation and improved tape handling. It is also possible with the 244 to select pre or post fader eq for the aux system.

The 244 underlines Teac's commitment to bring home multitracking within the reach of as many professional and amateur musicians as possible, and, as they consider the majority of musicians to have virtually no knowledge of the technical aspects of multitracking, the 244's design is such that you don't need to be a sound engineer to obtain professional results from it.

The Tascam M244 Portastudio is expected to retail at around £600, and is distributed in this country by Harman (Audio) UK Ltd, Mill Street, Slough, Berks SL2 5DD (0753 76911). Harman should be able to supply further details and a list of dealers.

THE HARMONIOUS BREAKER?



Dedicated CB enthusiasts who wish to 'personalise' their transmissions can now do so with the MM300 Tune Box from C.F. Shorto Electronic Services.

The MM300 is a sequential tone generator with an eight step sequence and a possibility of seven different tones or a blank in each step. This gives over 16,000,000 possible sequences. The unit is designed to operate at the end of each transmission—in the same way as a roger bleep. It may be wired so the tune can be monitored through the speaker of the set in which it is installed, or so that the tune is only heard by the receiver. Some readers may be relieved to hear that there is provision for an on/off switch to be added!

The MM300 is available either as a kit—price £7·00 inc. postage, or ready built—price £9·50 inc. postage. So, if you feel like bringing a little melody (?) to the airwaves, contact C.F. Shorto Electronic Services, 25 St Helens Road, Weymouth, Dorset DT4 9DY.

MARKET PLACE

POINTS ARISING . . .

MICROBUS (May 82)

The following corrections apply to "ZX81 Composes Music":

1) The capacitor on Fig. 8 is 100 nanofarad.
2) The program line 60 on Fig. 10 should be corrected as follows: 60 POKE 16515, PEEK (16521 + E).

The "Inverse Video" article for the ZX81 has given some readers problems. The author has pointed out that varying characteristics in the 4069 i.c. means that 100 Ohms is not always the optimum value for R1. His advice is to replace R1 with a 1k preset and adjust until the picture is well contrasted, yet stable. The author's prototype worked well on both mono and colour television sets.

FREQUENCY METER & PRESCALER (May '82)

The following Plessey i.c.s are available from Semiconductor Specialists of West Drayton, Middlesex (08954 46415): SP8629, SP8630 and SP8660. These are available ex-stock in ceramic, or plastic versions may be ordered. A £5 minimum order charge is imposed.

The Intersil 7216BIBI is available from Macro Marketing of Slough (062 86 4422). One-off price is circa £20—no minimum order surcharges etc. apply.

FREQUENCY METER (May '82)

Whilst the main 0–10MHz counter i.c. will drive the decimal point, its position becomes meaningless if a ÷100 prescaler is used. Normally, with a $\frac{1}{10}$ second gate the decimal point of D5 would be lit, with D6 and D7 switching on for the 1 sec. and 10 sec. gates respectively, but with a ÷100 prescaler D3, D4 and D5 decimal points must be utilised, so the d.p. output pin of the 7216 cannot be used. Thus the digit strobe lines (pins 7, 9, 10) have to be employed.

The multiplex rate of the display is 500Hz, and so each digit is switched on in turn very quickly, by having its CC pin grounded by the strobe line. This multiplex arrangement can be used to control the p.n.p. transistor TR1, which will switch on, allowing current to flow through the decimal point l.e.d., with R8 acting as a current limiting resistor to prevent damage. R7 ensures a clean switching action. (The resistor labelling is to avoid confusion with the other components on the frequency counter board.)

The spare pole of S2 is used to select either D3, D4 or D5, and should be connected according to Fig. 3.

If a wire link has been inserted between pin 23 IC3(V) and the d.p. pin on the display board, this should now be removed.

Note that because there is now no spare switching capability, the decimal point driver will remain activated when the 'External' range is selected, irrespective of whether the external input is prescaled or not.

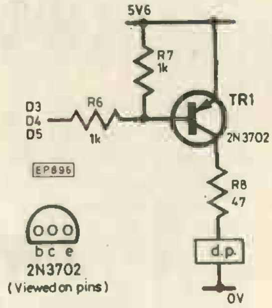


Fig. 1

Fig. 2

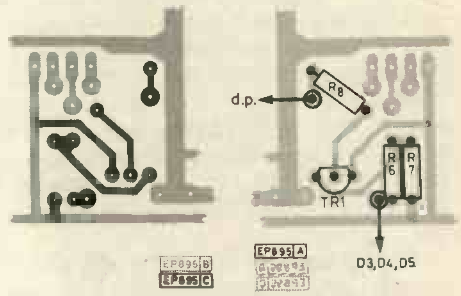
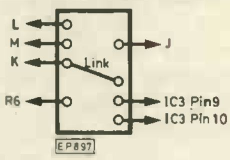


Fig. 3



Countdown . . .

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below.

Compec North June 23–25. Belle Vue Hotel, Manchester. **Z1**
Transducer/Tempcon Jun. 29–Jul. 1. Wembley Conf. Centre. **T**
BEX (Business Equipment) Croydon Jun. 30–Jul. 1. **K**
European Holography July 1–Sept. 26. Light Fantastic Gallery, Covent Gdn, London. **A8**
Leeds Electronics Show Jul. 6–8. University. **E**
Video Revolution (Symposium) July 12–15. Reading University. **G1**
Internoise July 13–15. 1983. Edinburgh University. **A7**
BAEC Amateur Electronics Jul. 17–25. Penarth Esplanade, S. Glamorgan. **B9**
BEX Manchester Sept. **K**
Personal Computer World Show Sept. 9–12. Barbican Centre, London. **M**
Laboratory London Sept. 14–16. Grosvenor Ho. Park Lane. **E**
Two Counties Fair Sep. 15–18. Plymouth Ex. Centre, Millbray, Plymouth, Devon. **T**
IBC Sept. 18–21. Metropole, Brighton. **N**
Microprocessors In Audiology Sept. 24 **A7**
Holographic Techniques Sept. 30–Nov. 28. Light Fantastic Gallery, Covent Gdn. **A8**
BEX Cardiff Oct. **K**
Viewdata Oct. 12–14. Wembley Conf. Centre. **O**
Video Show Oct. 16–18. West Cnt. Hotel. **Z1**
Computer Graphics Oct. 19–21. London. **O**
Testmex Oct. 26–28. Wembley Conf. Centre, London. **T**
Compec Nov. 16–19. Olympia, London. **Z1**
Brighton Electronics Exhibition March 1983. **T**
INSPEX March 21–25, 1983. NEC. **Z1**
HEVAC London Apr. 26–28 1983. Barbican. **I**
Semlab June 1983. Olympia, London. **I**

A7	Institute of Acoustics, ✆ 031-225 2143
A8	Holographic Exhibitions ✆ 01-836 6423
B9	BAEC, Penarth ✆ 0222-707813
E	Evan Steadman, Saffron Walden ✆ 0799 22612
G1	SERT, 8 Charing Cross Rd., London.
I	ITF, Solihull ✆ 021-705 6707
K	Douglas Temple, Bournemouth ✆ 0202 20533
M	Montbuild ✆ 01-486 1951
N	IEEE
O	Online, Northwood, Middx. ✆ 0822 4671
T	Trident Tavistock ✆ 0822 4671
Z1	IPC Exhibitions, Sutton ✆ 01-643 8040

Active Speaker System

J. Macaulay

DESPITE recent advances in turntable and pickup design the quality of a hi fi system is closely tied to that of the final link in the chain. Namely the speakers. One of the most recent innovations in this field is the active speaker system.

In a conventional passive system the audio signal from the power amplifier is fed to the various drive units in the system by a crossover network. The crossover is essentially a filter system of varying degrees of sophistication. The design of a conventional crossover is complicated by the fact that a speaker is not a pure resistive load. Indeed the theoretically perfect crossover often works poorly because of this.

Another problem is that the efficiencies of a woofer and a tweeter are rarely the same. In consequence one of the drivers, normally the tweeter, has to have a resistance in series with it to equalise sound levels.

Even when all this is done well there are further problems. In the days of valve amps an output power of 15W and above was only used for PA purposes. The reason for this is that the speaker cabinets were larger and the crossovers simpler. In consequence the efficiency of these systems was considerably higher. A complex crossover means a loss of power. Furthermore when a power amplifier goes into clipping large amounts of harmonics are generated and these find their way into the tweeter. The inevitable result is heavy distortion. If you look at the power versus frequency plot of musical signals you will see that most of the energy is concentrated in the lower mid range region, around 100-300Hz. The harmonics generated when an amp clips on these signals are far higher in amplitude than the natural harmonics of the signal and hence are not masked by the programme.

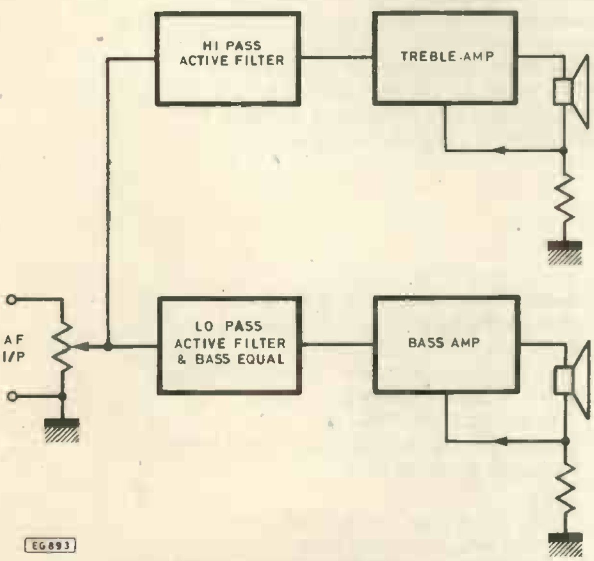


Fig. 1. Block diagram of the system

ACTIVE SPEAKER SYSTEM

Having described some of the drawbacks of the conventional approach we can now examine the active system and the way it avoids these problems (Fig. 1).

Essentially an active speaker system employs one power amplifier for each speaker used. The audio input signal is divided by an active network and fed to the speaker via the appropriate amplifier.

Since there are no passive components in series with the speaker there is no signal loss. The result is that a 6dB or so of extra sound level can be generated for the same input power. A fourfold increase!

Another advantage is that the full damping factor of the amplifiers is applied to the speakers thus mimimising spurious cone movement. The crossover can be designed without any reference to the electrical characteristics of the drive units and no inductors are required.

Furthermore if the bass amplifier clips, the harmonics are confined to the bass driver and have no influence on the tweeter.

As you can see there are a lot of advantages for the active system and these differences are clearly audible. However the only active systems on the market cost upwards of £500 and more often than not the buyers of this equipment end up with a special crossover module and an extra pair of stereo amplifiers!

Naturally this usually means that the existing power amp has to be scrapped in favour of the new equipment. With the design presented here the existing power amp is used as a source of signals for the speaker so that they can be simply added onto an existing system with the minimum of fuss.

An incidental advantage of this is that the loading on the existing power amp is so small that it will operate in class A reducing the distortion still further.

CIRCUIT DESCRIPTION

In order to simplify matters the complete circuit has been split into two parts. Fig. 2 shows the active filter circuit. Basically this can be further subdivided into three parts.

First the signal from the power amplifier is applied across R1 and VR1 which form a potential divider. The heart of the

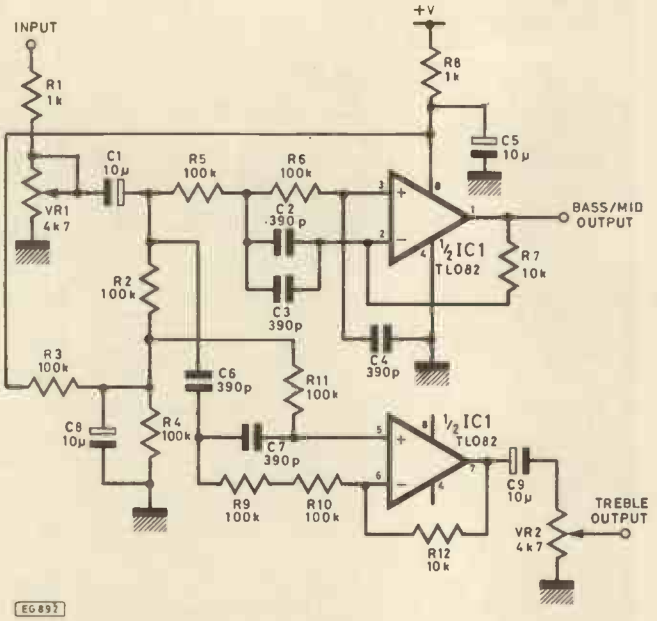


Fig. 2. Active filter circuit

filter section is the dual op amp the TL082. Because a dual power supply is not being employed here a half voltage reference is provided by the R3/R4 divider and C8 removes any noise by producing an a.c. short across R4. In order to work as a crossover network the audio input has to be split into two parts, bass and treble. This is achieved by means of Butterworth filters.

One of the most important decisions that has to be taken when designing a speaker system is the filter order to be used. To explain briefly; the steepness of a filter's response depends on two factors. Firstly the 'Q'; if a filter with a high Q is used you get a peak in the response at the cut-off frequency. This peak is undesirable because it would cause response anomalies. Another problem resulting from high Q filtering are unwanted phase shifts in the passband which can be audible.

Filters are classified according to their Q. Crossover filters have to be designed for the maximum roll-off combined with the greatest freedom from phase anomalies and this type is known as the Butterworth filter.

The filter order also has a profound effect on the rate of roll-off obtained. However for audio work there has to be a trade off. In the case of crossover filters this is the transient response of the system. In theory the greater the filter order the sharper the filter's roll-off. For this design the inevitable

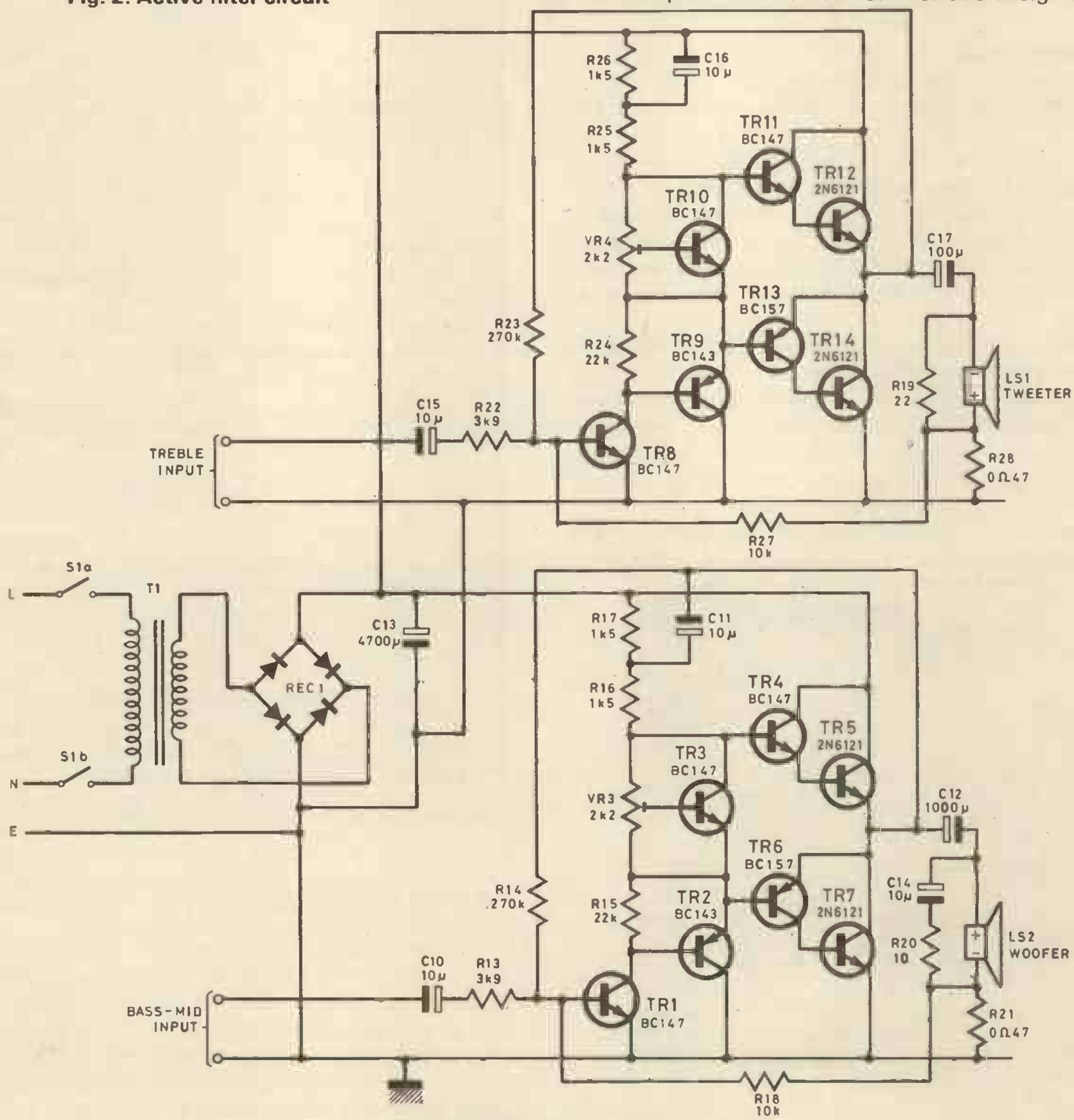


Fig. 3. Power amplifier circuit for one enclosure

design compromise has been made by adopting the second order filter.

The next problem is to set the crossover frequency of the system. Here we have to avoid the natural h.f. mechanical roll-off of the woofer and the natural resonant frequency of the tweeter.

This last factor is frequently overlooked. The Philips tweeter employed in this design has a natural 'bass' resonance at 1kHz. The woofer rolls off at about 3·5kHz. After some experimentation a crossover filter with a turnover at 2kHz was decided on. This gives sufficient attenuation to both drive units before problems arise. A further bonus is that the actual crossover occurs somewhat before the critical 3 to 5kHz region at which the ear is most sensitive.

To return to the circuit diagram the low pass filter is built around IC1. The resistors R5, R6 and the capacitors C2, C3 and C4 form the filter. The high pass filter is built around the second half of IC1. In this case the filter consists of C6, C7, R9, R10 and R11. Resistor R12 maintains stability.

Since the signals are fed into two identical power amplifiers some method has to be devised to equalise the power outputs from both speakers. This is achieved by feeding the treble signal across VR2 via the d.c. blocking capacitor C9. The signal is fed into the treble amp from the slider of VR2 which acts as an attenuator.

POWER AMPLIFIER

Fig. 3 shows the power amplifier's circuit. There are, of course two power amplifiers per enclosure and they are identical.

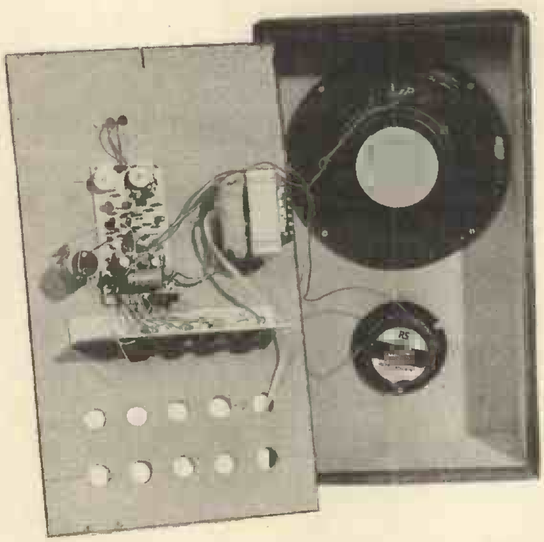
Before describing the circuit in greater detail it will be as well to consider the novel form of feedback used. It is conventional practice to use overall feedback from the output of the amplifier to its input. However in this circuit a method is employed which includes the drive unit within the feedback loop. To understand how and why this works we have to go back to basics.

Several concerns have marketed motional feedback systems in the past twenty or so years. The basic principle is to sense what the speaker cone is doing and use this signal to help correct any errors that the speaker may introduce. The most successful of these systems is the Philips system which obtains its feedback signal from a small ceramic transducer fitted to the woofer's cone.

Unfortunately this method, although successful, needs specially adapted speakers. The method used here obtains a feedback signal by sampling the current flow through the drive unit.

Any physics textbook will tell you that the acceleration of the cone is equal to the force on the cone divided by the cone's mass. This is Newton's second law. This can be written in the form F=ma. Where F is the force in Newtons, m the mass in kilos and a the acceleration in m/sec^{-2}.

There is however another useful relationship between the force exerted on the speaker cone and the flux of the magnet employed. It is, F=BLI, here B is the field strength in Tesla's,



COMPONENTS . . .

Resistors

R1, R8	1k (2 off)
R2, R3, R4, R5, R6, R9, R10, R11	100k (8 off)
R7, R12, R18, R27	10k (4 off)
R13, R22	3k9 (2 off)
R14, R23	270k (2 off)
R15, R24	22k (2 off)
R16, R17, R25, R26	1k5 (4 off)
R19	22
R20	10
R21, R28	0Ω47 2½W wirewound (2 off)

All resistors ¼W 5% carbon except where otherwise stated.

Potentiometers

VR1, VR2	4k7 log pot (2 off)
VR3, VR4	2k2 hor. preset (2 off)

Capacitors

C1, C5, C8, C9, C10, C11, C14, C15, C16	10μ 16V elect (9 off)
C2, C3, C4, C6, C7	390p ceramic plate (5 off)
C12	1000μ 25V elect
C13	4700μ 63V elect
C17	100μ 25V elect

Semiconductors

REC1	2A 100PIV rect
TR1, TR3, TR4, TR8, TR10, TR11	BC147 (6 off)
TR2, TR9	BC143 (2 off)
TR5, TR7, TR12, TR14	2N 6121 (4 off)
TR6, TR13	BC 157 (2 off)
IC1	TL082

Miscellaneous

T1 24V 1½A sec mains transformer
Woofer Audax H1F 20
Tweeter Philips
Heatsink 150 x 75 x 25mm 3mm dia. angle
TO66 mounting kits (4 off)
"Bostic" car damping panels
1 metre of BAF wadding
P.c.b.
Veropins
Control knobs (2 off)
Cabinet

The above components list is for one channel or enclosure. For stereo operation the list should be repeated.

Constructor's Note

A complete kit of parts (except for the "Bostic" damping panels) is available from **Bewbush Audio, 26 Hastings Road, Pound Hill, Crawley, West Sussex.**

L is the length of wire wound on the speech coil and I is the current in amps.

Combining these two equations we obtain BLI=ma. Rewriting this in terms of *a* we get, a=BLI/m. Since B,L and *m* are constants for any given drive unit it follows that the cone acceleration is directly proportional to the current flowing through the speech coil. All we need to obtain this signal is to connect a small value resistor in series with the speaker. The output current will now produce a voltage across the resistor which can be used to correct any anomalies of the cone's motion. The method works because a loudspeaker can be made to work as a generator simply by moving the cone. Thus if the cone moves differently to the input signal an error voltage is produced. The error is then reduced by the negative feedback loop.

In Fig. 3 TR1 provides all the voltage gain of the bottom amp and is used in the common emitter mode. TR2, the predriver is used in the emitter follower mode. There is a +0·6V drop across the base emitter junction to which R15 is connected. Since the signal at the emitter of TR2 is some 98 per cent of the signal at its base a d.c. positive feedback loop is formed which effectively increases the voltage gain of TR1.

TR3 is a Vbe multiplier which is used to set the bias necessary for the output stage to prevent crossover distortion.

The output stage proper consists of the two pairs of transistors TR4/TR5 and TR6/TR7. The upper pair (TR4/TR5) are connected as a Darlington pair which prevents loading on TR2 and offers a low output impedance. TR6/TR7 are a complementary feedback pair which acts in the same way as a p.n.p. Darlington pair.

The audio output from the amplifier is applied across the drive unit via the coupling capacitor C12. This has to be of sufficient size to allow bass signals to be effectively coupled since C12 and the speaker form a low-pass filter.

The function of R21 in series with the speaker has already been discussed. Overall d.c. feedback is of the shunt type as the amplifier is of the inverting type. The base of TR1 is biased from the output via R14 and R18/R21. Voltage gain is determined by the value of R13.

This component's value also defines the input impedance of the amp. The whole circuit is supplied by a conventional unregulated power supply consisting of T1, the bridge rectifier REC1 and the smoothing capacitor C13.

All that is left to describe is the RC network used with speakers. These components form what is known as a Zobel

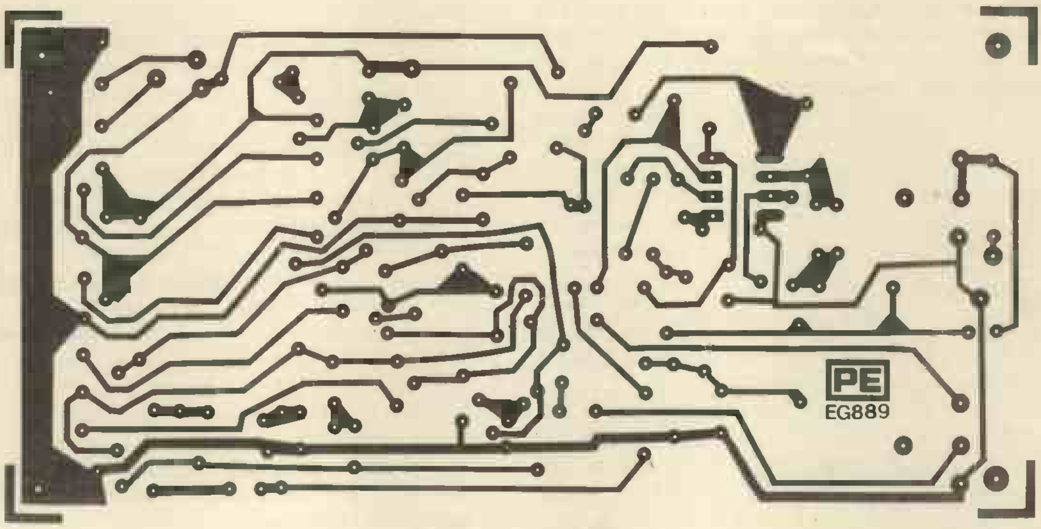


Fig. 4. P.c.b. design

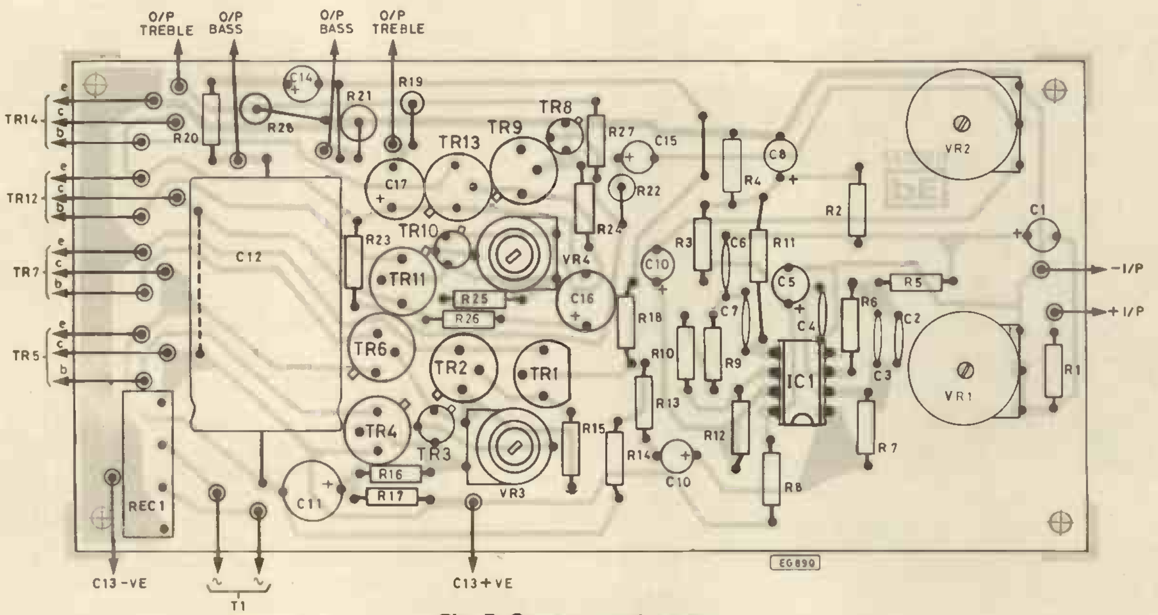


Fig. 5. Component layout

network which helps to protect the amplifiers by presenting, in conjunction with the speakers, a nearly pure resistive load to the output stage.

Unfortunately the drive units are not pure resistances and so some compensation is necessary to ensure stability. The component values are different for each speaker to effectively compensate for their respective impedances.

Having described how it works how worth while is it? Well the transient response is audibly better with less ringing and during the development of this project some tests were undertaken to see how effective the circuit was.

The cone comes to rest several times faster than with a conventional amplifier. Furthermore if an attempt is made to disturb the cone by pushing it the amplifier's output can be seen to move to correct it. The improvement is such that the circuit is subject to a patent application. There is of course no restriction on individuals using it for non commercial purposes.

CONSTRUCTION

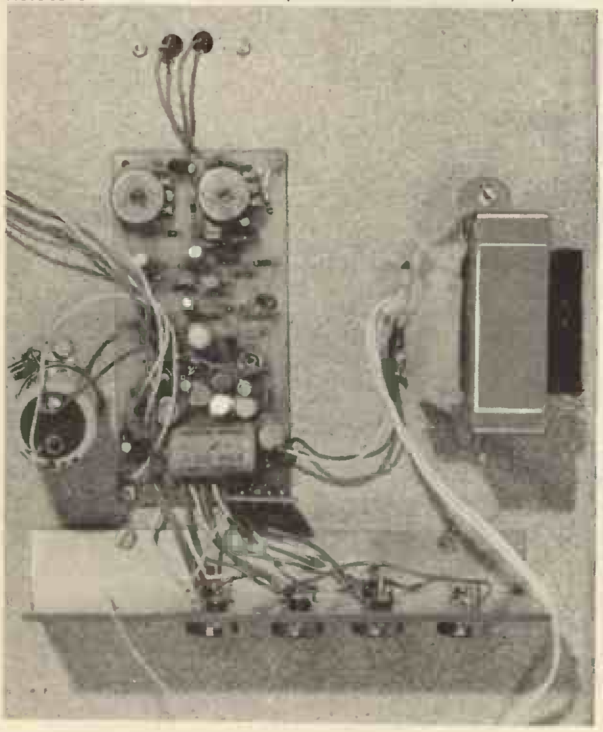
The construction of the project falls neatly into two stages, mechanical and electronic.

All the electronic components with the exception of the power transistors, the transformer and C13 are mounted upon the p.c.b. the design of which is shown in Fig. 4 with the component layout shown in Fig. 5.

It is probably most convenient to mount the components from R1 onwards. Be absolutely sure that all the electrolytics and semiconductors are correctly orientated. Lastly, but by no means least mount the p.c.b. pins. At this stage it is as well to set the presets VR3/VR4 so that the sliders are shorted to the collectors of TR3/TR10 as measured with a multimeter.

Having done this turn the board over and check that there are no blobs of solder shorting across any of the tracks. When you are satisfied that all is well the mechanical work can be accomplished.

All the components are mounted upon the back panel. Fig. 6 shows the dimensions and mounting hole positions for the various parts. First drill $\frac{1}{8}$" mounting holes for the output transistors. It is as well to position the holes by marking them through the transistor's own mounting holes. A fine felt tipped pen is invaluable here.



The power transistors are mounted on the usual mica insulating washers to provide electrical isolation from the heatsink. Thermal grease is not however required as long as the fixing screws are tightened. The transformer, heatsink, p.c.b. and input signal socket are all fixed into position with $\frac{1}{2}$" No 6 pan headed self tapping screws.

When this has been accomplished the interwiring is the next thing on the agenda. The last wires to be attached should be those intended for the speakers. These should be left at least 18" long to allow easy connection.

At this stage the panel can be set up. A multimeter set to read volts should be connected across the positive end of C12 and ground then switch on. Assuming all is well you should measure half the supply voltage across the capacitor. A variation of a volt or so either way is not significant.

Now check the voltage across C17 and ground. This should show the same reading as that across C12. Again a couple of volts either way is inconsequential. If however the voltages at both or either of these test points is too far out check your wiring, especially around the feedback loop.

This whole procedure should now be repeated for the other channel and attention can now be turned to the preparation of the cabinets. These are supplied with cutouts already in the front baffle to take the drive units.

So far we have dealt with the purely electronic circuitry and now attention must be focused on the cabinet. If you take a speaker unit and place it on a flat surface reproducing music you will notice a complete absence of bass.

In actual fact the speaker will be producing the bass but the signal radiating from the rear of the drive unit will cancel that from the front. The only practical way around this problem is to put the speaker in a cabinet. Unfortunately life isn't as simple as that. The larger the cabinet the better the bass response. This is due to the work that the drive unit has to do to compress and rarefy the air enclosed in the cabinet.

From the perspective of sound quality alone the speaker cabinets should be as large as possible.

The enclosures chosen have an internal volume of about 0·7 cu. ft. Now it is quite possible to use these cabinets as they stand but a better bass response can be obtained by reflexing the speaker.

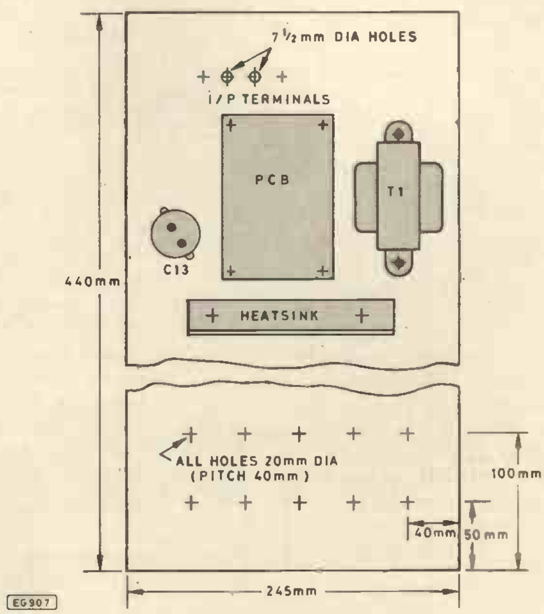


Fig. 6. Rear panel drilling details

There are various tricks of the trade that can be employed to extend the bass response of an enclosure. The most well known is the bass reflex in which a duct is inserted into the cabinet. As long as the dimensions have been correctly calculated the duct will radiate deep bass signals in phase with the drive unit thus extending the response.

A variation on this theme is the distributed port enclosure which is used here. This consists of a series of spaced holes which act as a duct with an acoustic resistance. The result is an extended bass with an excellent transient response, substantially better than that produced by the reflex. Another advantage of this form of loading is that it can be fabricated from a series of 20mm holes.

A problem with all speaker cabinets is that they are subject to internal resonances. These must be well damped or the sound will be coloured. In most high quality designs these days bituminous pads are used internally. They are used in this design to, but the panels recommended are sold for damping car panels and can be obtained from car accessory stockists. These are self adhesive and are applied, three layers thick to the inside walls. The back panel of the speaker is prone to vibration but this is reduced considerably when the electronics and power transformer are fitted. The distributed port is cut into the top half of the back panel and the speaker drive units are fitted from the rear of the front baffle with self tapping screws. The final stages of construction consists of setting the quiescent current in the power amps and filling the enclosure with wadding.

SETTING UP

First the power amps. The presets will already have been set for zero quiescent current in the output stages. Set both VR1 and VR2 to half travel and feed an audio signal into the input. Music at a reasonable level should emanate from the speakers. It will however sound distorted.

Disconnect one of the wires from the tweeter. Slowly adjust VR3 until the distortion *just* disappears. Turn the volume down until the signal is just audible. As you adjust the control downwards distortion should again become apparent. Once again slowly adjust VR3 until the distortion just disappears. When this has been accomplished one of the woofer's wires should be disconnected, the tweeter wire reconnected and the whole procedure repeated for the tweeter, adjusting VR4.

It is imperative that the presets are not adjusted any more than necessary or thermal runaway might occur in the power transistors.

Lastly before the back panels are attached a roll of BAF wadding, $\frac{1}{2}$ a metre long should be placed in the enclosure. The placement isn't too critical but the rear of the drive units should be covered.

Once the back panel has been attached the speakers are complete and ready to use. Because of the voltage gain provided by the internal power amps it will be found that VR1 will need to be set at a low setting to avoid amplifying the hum and noise being produced by the existing amplifier driving the speakers.

As with all speaker systems the best position must be found experimentally, though is not likely to be found too close to the walls as reflected sound will tend to destroy the stereo imagery of which these speakers are capable.

VR2 sets the balance between bass and treble output and should be adjusted to suit the acoustics of the listening room. This is not a daunting job and can be done most rapidly by listening to voice material. The control should be adjusted until the sound is as natural as possible. The best source of high quality voice signals appears to be Radio 4. ★

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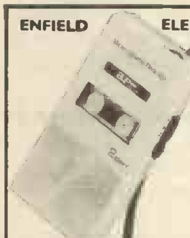

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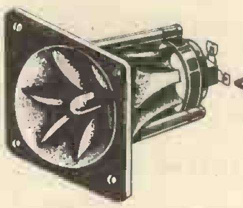

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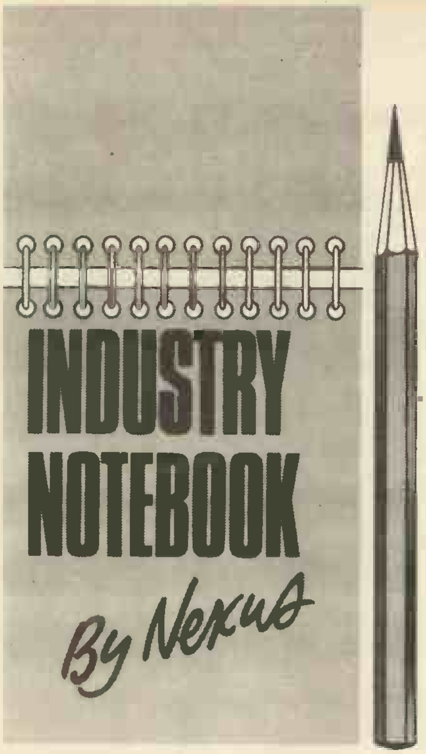


Perspective

International upheavals are no respecters of press deadlines. Thus, no sooner had last month's column gone to print than the Falkland Islands confrontation burst upon us, unfortunately too late for comment then and yet now still too early to judge its final and total effect on industry.

One result was to shift our perspective. All our preoccupations of earlier in the year faded into relative insignificance. How shabby and trivial the ASLEF strike against flexible rostering now seemed in comparison. Even unemployment, the hottest of political issues, found itself relegated to a poor second in emotional value. Long-running issues like abortion, smoking in public places, blood sports, always good for an airing, became also-rans in public concern.

Optimism on the economy, both before and after the budget, and its underlying strength were confirmed when, after an initial period of uncertainty, the stock exchange and the pound sterling first faltered and then stabilised at figures only fractionally below pre-crisis levels.

For the electronics industry South America has never been an easy or good market, being dominated by the United States. The trade embargo with Argentina will have had little impact.

In the longer term what might affect the industry is the re-surfacing of the moral issue of the supply of armaments. This topic is bound to be the subject of emotional and probably very confused public debate. It will be argued that we should never have supplied ships and missiles to the Argentine navy. These, of course were ordered long ago by previous Argentine governments, always regarded as friendly, and were licensed for export equally under Labour and Conservative administrations with no dissent from Liberals.

The supplying companies are politically neutral. Given a technical specification, a commercial contract and permission from our own government to supply, the goods are delivered in the usual business way including, if necessary, training in their use. It is no concern of individual suppliers to what political or military purpose they may or may not be used. This is the business of government and of political judgement and, of course, Britain is not the only supplier. The United States, Germany and France also equip the Argentine armed services and all must be judged equally innocent or guilty.

In an ideal world the demand that we should opt out of the arms trade altogether makes sense. In such a world there would be no need of arms, anyway. But in the real world in which we have to live, such a moral gesture might ease the collective conscience but only at the expense of further unemployment and much advanced research and development which spins off into products for peace as well as war.

LCD 'Scope

The contribution of military R and D to the advancement of the electronics art needs little stress. We need only think of radar or inertial navigation to get the point. Now the latest spin-off from military beginnings is a world-first for Britain in the shape of the tubeless storage oscilloscope.

When visiting the Royal Signals and Radar Establishment (RSRE) at Malvern I was intrigued by the work on electronic displays and particularly on those for field-portable radar for use in the front line by infantry units to detect and give range and direction of enemy vehicles and troops. And it is from that and similar work at RSRE that the idea of a flat l.c.d. screen has emerged, now engineered by Scopex into a battery-operated 'scope with a physical back-to-front dimension of less than 100mm.

The l.c.d. has a matrix of 128 by 256 'picture points' and it is the method of addressing all the points in rows and columns to build up the displayed waveform that is due to Dr I. Shanks and his team at RSRE.

The Scopex 'Voyager' is now in commercial production, supervised by Paul Holland, a collaborator of Dr Shanks at RSRE who has since joined Scopex. Because there is no CRT and therefore no high voltage supply one of the markets will be for intrinsically safe application as in coal mines and petrochemical plants. But the Voyager is expected to do well in the wider test market and is the first of a family of tubeless 'scopes with a full range of peripheral equipment and accessories.

US Eyes on UK

After Canada, the United Kingdom is the favourite country for overseas investment by manufacturers in the United States according to a recent survey. Industry Secretary Patrick Jenkins recently returned from the USA brimming with optimism.

US industrialists are particularly impressed by the way the British economy has improved with its falling inflation and increased productivity. Many American companies already here are expanding their facilities. Motorola and Hewlett-Packard are just two examples. But many companies new to Britain are making encouraging noises.

There is only one snag. It is more than probable that both the Labour and TUC conferences during the summer parliamentary recess will confirm resolutions demanding withdrawal from the European Common Market, even though some 40 per cent of trade is with our European partners. Could anything be more damaging? Or more discouraging to overseas investors? Or more disheartening to the unemployed?

Infosystems

The information 'explosion' of the 1970s is puny compared with what is to come and firms are already gearing up to cope with the demand. GEC is gathering all the loose information technology strands in its vast organisation and grouping them in a new subsidiary, GEC Information Systems.

The size of the information technology market is anyone's guess because there are many fringe activities but one estimate is that it could be worth a staggering £110 billion by 1985, only three years ahead.

Racal is investing heavily in the technology with, for example, a £750,000 R and D bill for their newly unveiled Planet local area private network. This works like a ring-main electricity supply except that it uses co-axial or fibre-optic cable and carries messages in digital form instead of electrical power. It can link up all the information requirements in a large office complex, computers, word processors, printers, electronic mail etc. Up to 500 separate devices can be connected to one system and it can carry digitised voice as well as data. A novel feature is that the microprocessor 'director' of Planet will automatically re-route data round a cable break or equipment failure. There is also a back-up 'director' so that the system is virtually self-healing. Planet originated in Racal-Milgo's Reading laboratories using LSI devices from Racal Micro-electronic Systems and was financially assisted by a Department of Industry grant. Planet production is at Racal's Warrington plant.

Another Racal company, Racal Recorders, is starting a major thrust in data recording with a number of new products due to appear this year. The company is now headed by David Kempson who joined Racal as a development engineer in 1963. Kempson sees one of the new products, the Storehorse, as opening up a new market measured in tens of millions of pounds.

Although portable, Storehorse has an enormous data capacity on its 15-inch spool of magnetic tape. Enough storage, it is claimed, to contain 147 years of issues of the Financial Times (or the equivalent in issues of Practical Electronics) not to mention all the signals from a radio transmitter 24 hours a day for 131 days. Storehorse has applications in R and D and performance monitoring in industry, in surveillance and in document storage and is expected to have 75 per cent of sales outside the UK, particularly in the United States.

Semiconductor UPDATE...

FEATURING MF10 CA3300D SA6000

R. W. Coles

MIRACLE FILTER

In the beginning, when a.f. filters were made with inductors and capacitors, filter construction was not for the timid since it involved the winding of innumerable coils with precise inductance values. Despite the complications that this caused however, a.f. filters *were* produced, and the mathematics of their design was well understood. A filter could be produced with almost any desired combination of bandwidth, cut-off slope, flatness within the pass-band, phase shift and Q factor. All that was needed was a smart mathematician and a coil winding set-up!

It had always been recognised that in theory, complex filters could be made with the much simpler combination of just resistors and capacitors, but this was rarely done because of the dreaded insertion-loss caused by the non-reactive impedance of the resistors. This attenuation could only be counteracted by the addition of gain stages within the filter, and that meant the use of expensive valves or transistors. Most designers stayed with their coil winders! When integrated circuit amplifiers came along in the late '60s the design of a.f. filters was changed almost overnight and the new era of the "Active Filter" using Rs, Cs, and op amps had arrived. Although many coil winders were consigned to the dustbin, mathematicians found their services still in demand since active filter design was as complex as ever and lots of new tricks were conceived to reduce the component count for any given filter function.

As far as hobbyists were concerned however, the word "filter" had now entered our vocabulary and many articles aimed at simplifying the design of active filters were published to make life easier for the would-be creators of sound-to-light units and audio spectrum analysers. Despite this progress however, the design of complex active filters is still a bit of a chore, and still requires the use of high precision resistors and capacitors if calculated performance is to be realised in practice.

If you have avoided being ambitious with active filters up to now, you may soon be converted by a new device from National coded MF10, a switched-capacitor active filter which completely dispenses with the need for any external capacitors. The MF10 is a CMOS device in a 20 pin skinny-d.i.p. package and it actually contains *two* second order filter stages each of which can provide allpass, lowpass, highpass, bandpass and notch functions with a Q value of up to 500 for centre frequencies of up to 20kHz.

The secret of the MF10 lies in the use of internal switching circuitry to control the charge and discharge of integrator circuits which use on-chip storage capacitors. The switching process is controlled by an external TTL or CMOS clock generator and the filter operating frequency is decided primarily by the frequency of this clock. The only external components required (apart from the clock, which can control any number of MF10s) are a few resistors to set the gain, Q factor, and the precise frequency of operation. The clock frequency can be set at either 50 or 100 times the desired operating frequency by a single pin section and tuning can be accomplished by varying the clock frequency or by resistor trimming. The MF10 is designed to work on plus and minus 5V supplies, but can be run from a single 10V rail if required. The price is low, its easy to use and it *is* available, so now all we need is an article by a National engineer to give us some help with the sums!

QUICK FLASH

Analogue to Digital converters such as the one in your trusty digital multimeter carry out a single conversion in about 40ms which is O.K. for slowly changing signals but no use at all if you want to digitise video or even audio signals. Perhaps you don't want to digitise such signals at the moment, but we are being told that the future is digital, that eventually all hi fi and video systems will use binary words rather than analogue voltages between their input and output terminals to facilitate fancy signal or image processing using a microprocessor, and so we must keep up to date!

The latest offering from RCA is a 6 bit A to D converter which can carry out a conversion in only 66 *nanoseconds*, fast enough to keep up with a 7MHz video signal! As if that wasn't news enough, the RCA CA 3300D is actually made using low power CMOS technology rather than the to-be-expected bipolar process.

The secret lies in the adoption of the Silicon On Sapphire (SOS) CMOS process and in the use of a parallel or "flash" conversion scheme with no less than 64 separate voltage comparators on the chip. Each comparator has a different reference voltage derived from an on-chip resistor chain, and the 64 comparator outputs are encoded using high speed logic to yield a binary equivalent.

Some readers may remember my PE DIGI-SCOPE design which used a matrix of 80 l.e.d.s to form an oscilloscope display. The input circuitry in that design used a string of comparators in a similar fashion to the CA 3300, but with only the equivalent of 3 bits of precision. If I was going to improve on DIGI-SCOPE I would certainly use one of these new RCA devices with a bigger display matrix to get not only more definition but also an improved bandwidth.

The CA 3300D comes in an 18 pin ceramic package and will run from a single 5 to 8 volt supply.

MICROWATT MICRO

I normally try to cover devices which are, at least potentially, useful for hobby projects. This item breaks that rule but is interesting nevertheless because it hints at the goodies we will be able to obtain in the shops before too long.

I refer to the ITT SA6000 microprocessor which is a CMOS single-chip device of diminutive proportions able to run from a 3V battery supply. From now on, any housing from the size of a wrist watch upwards, capable of accommodating a single lithium button cell, can have its very own dedicated microprocessor. The 4 bit SA6000 has 2·268K bytes of masked ROM, 96 nibbles of RAM and no less than 51 I/O lines. The standard clock frequency is 32·768kHz and the I/O pins can directly drive an 8 digit liquid crystal display, so the most obvious use for the SA6000 is in upmarket digital watches with lots of fancy extras such as calculators or bio-rhythm options.

Nothing new so far perhaps, watches like this are already available, but remember that the SA6000 is a true microprocessor so it can be programmed to do just about anything, unlike most existing watch chips. How about a heat monitor, or a cheque account balancer, or a miniature multimeter, or a space invaders game? All are possible with the SA6000. You don't need to keep changing the battery either since the ITT chip sips only 45 microamps from a 3V supply when active and only 15 microamps when idle. If you want to buy 100,000 of them, they'll set you back about £2·50 each!

AVAILABILITY

Devices featured in Semiconductor Update should, under normal circumstances, be available from good component retailers, but bear in mind that retailers will often not receive stocks of a device until some time after it has been featured in 'Update. However, when a high demand from hobbyists is not anticipated, you may need either to contact the manufacturer or a specialist distributor.

Next Month

Comprehensive HOME ALARM SYSTEM

Infra-Red · Radar · Ultrasonic

A choice of three alarm systems, all based on a single p.c.b. design: Infra-red heat sensor; Radar Doppler Shift (operating at 10·687 GHz); and Ultrasonic Doppler Shift (operating at 32·7 kHz)

Combo AMPLIFIER... Plus

100W of hi-fi power from a self-contained indestructible MOSFET drive amp with twin/mix preamps—*and* at half the usual cost!

MICRO-PROFESSOR REVIEW

PRACTICAL
ELECTRONICS

OUR AUGUST ISSUE WILL BE ON SALE FRIDAY, JULY 9th

AUDIO TEST SET PART ONE

MICHAEL TOOLEY B.A. & DAVID WHITFIELD M.A. M.Sc.

THE Audio Tester is a versatile multi-function test set intended primarily for the audio and hi-fi enthusiast, but which is suitable for a wider range of applications outside the audio field. The instrument combines a signal generator, analogue frequency meter, electronic a.c. voltmeter, and dummy loads in one lightweight portable unit which is capable of operating from either a.c. or d.c. supplies.

In addition to general fault finding, it can be used for performance checks; measurements of gain, frequency response and power output. It thus provides many of the facilities of the wide range of test equipment normally required in an audio workshop, but at a small fraction of the cost. The Audio Tester features single-p.c.b. construction, uses readily available components, and is suitable for the relatively experienced constructor.

SPECIFICATION

The signal generator provides sine and square wave outputs from 10Hz to 100kHz in four decade ranges. The output impedance is constant on all ranges and the maximum output is 2V pk-pk on both sine and square wave. Switched and continuously variable output attenuators are provided and amplitudes are identical for both waveshapes at all attenuator settings. Signal frequency and amplitude may be displayed using internal measuring facilities thus avoiding the need for the usual calibrated scales. Where a higher level of output is required, as would for example be the case when testing loudspeakers, use can be made of the internal monitor amplifier. This produces an output of up to 1W into an 8 ohm load. The minimum recommended load impedance is 3 ohm. The frequency response of the monitor amplifier is limited to 60Hz to 30kHz however this is adequate for most audio purposes. The monitor amplifier may also be used for signal tracing either in conjunction with headphones or with an external loudspeaker. It may also be used to provide monitoring facilities for either outgoing or incoming signals. This latter facility, in conjunction with either the a.c. volt meter or frequency meter, allows the user to listen to the signal which is being measured. This function is extremely useful when investigating signals which may be corrupted by hum or noise thus helping to avoid misleading and inaccurate measurements.

The a.c. voltmeter provides six ranges from 1V to 300V full-scale. The calibration may be in terms of root mean square or peak-peak sine-wave: Since the incoming signal is a.c. coupled to the voltmeter, indications are correct in the presence of a d.c. level. The frequency response of the a.c. voltmeter is 1Hz to 100kHz and therefore it more than adequately covers the full audio spectrum. When power measurements are required they can be carried out by reading the r.m.s. voltage developed across either an external load (usually a loudspeaker) or by making use of the loads fitted internally. These loads can be configured for 4 ohm 60W, 8 ohm 30W, or 16 ohm 60W. Twin 8 ohm 30W loads are provided where it may be necessary to terminate both channels of a stereo amplifier during testing. The frequency meter is a linear scale analogue device covering the range 10Hz to 100kHz in four decades. It requires a minimum input level of 30mV r.m.s. for reliable operation and, as with the a.c. voltmeter, may be used to display either an incoming or an outgoing signal (from the signal generator). The Audio Tester derives its power from either 240V a.c. mains or an external 12V d.c. supply.

SYSTEM DESCRIPTION

A simplified block schematic of the Audio Tester is shown in Fig. 1. The input of the instrument is essentially common to the frequency meter, a.c. voltmeter and monitor amplifier sections. A separate input is provided for the dummy load section. The two inputs ('general' and dummy load) may be linked together externally for certain applications (e.g., when making output power measurements). The signal generator

section has a separate output which may also be routed to the frequency meter, a.c. voltmeter and monitor amplifier sections. Note that, for the sake of simplicity, all function switching has been omitted from Fig. 1. A power supply with a.c. or d.c. inputs is common to all sections with the exception of the dummy load.

The signal generator section is shown in block schematic form in Fig. 2. A low distortion sine-wave oscillator is used as the basic signal source. Its output is taken first to a sine-square wave converter and then to a passive attenuator. A low power output stage follows the attenuator in order to provide a high degree of isolation of the output and to minimise the effects of loading on the attenuator. The frequency meter is shown in block schematic form in Fig. 3. The input is taken via a high gain amplifier to a limiter stage. The effect of these two stages combined is to severely clip the incoming signal. The output waveform is thus rectangular in shape and of constant amplitude. This action is essential in order to remove any amplitude variations from the input signal. The following stage is a conventional charge-pump which provides a current output directly proportional to the frequency of the input.

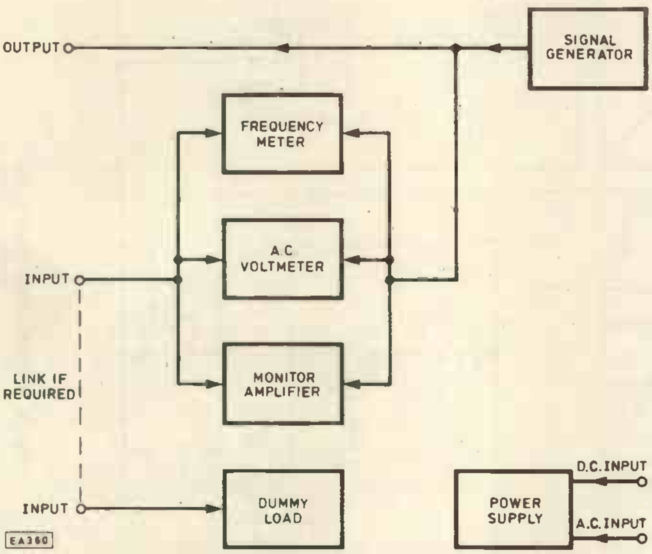


Fig. 1. Block schematic of the Audio Tester

The a.c. voltmeter is shown in block schematic form in Fig. 4. The input is taken directly to an attenuator so that input signals of widely differing amplitude are reduced to a common relatively low level output before subsequent amplification. The attenuator is followed by a high impedance buffer stage in order to minimise loading and to maintain a high degree of accuracy. The input stage is followed by a wide-band amplifier which incorporates a low-level low impedance output for driving the monitor amplifier and frequency meter sections. The high-level output of the wide-band amplifier is taken to a rectifier and meter. Heavy negative feedback is incorporated in order to ensure a wide bandwidth and a high degree of linearity. Note that since the meter display is common to both the frequency meter and a.c. voltmeter sections it is not possible to use both of these functions simultaneously. The signal generator, monitor amplifier, and load sections are, however, entirely independent functions. They may all be used simultaneously with either the a.c. voltmeter or the frequency meter sections.

CIRCUIT DESCRIPTION

The input attenuator is formed by R1 to R6 in conjunction with S2. C1 removes any d.c. level present on the input signal. A junction gate f.e.t., TR1, is used in a source follower

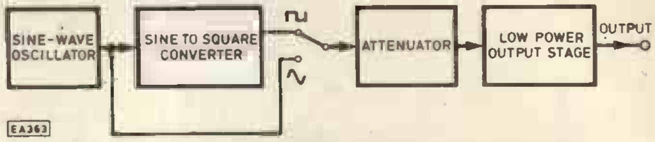


Fig. 2. Schematic of the signal generator section

configuration in order to ensure a very high input impedance and to minimise the effects of loading on the input attenuator. The arrangement of C2 and R7 helps to improve the high frequency response of the stage however, since the upper limit of the response is only required to extend as far as 100kHz, there is little need for additional capacitive compensation of the input attenuator which is normally considered essential in wide band test equipment such as oscilloscopes etc. Waveform calibration is determined by a potential divider in the source of TR1. The input stage is

Fig. 3. Schematic of the frequency meter section

followed by a two stage d.c. coupled wide band amplifier comprising TR2 and TR3 which are both connected in common emitter mode. A large amount of negative feedback is incorporated in order to improve linearity and ensure adequate frequency response. The overall voltage gain of the stage is adjustable by means of VR4. Signal rectification is provided by germanium diodes D1 and D2 whilst silicon diodes D6 and D7 protect the meter against inadvertent overload conditions.

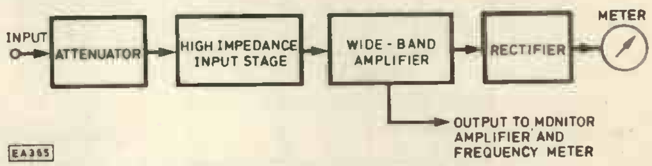


Fig. 4. Schematic of the a.c. voltmeter section

A common emitter amplifier stage, TR4, forms the input of the frequency meter section whilst TR5 acts as a limiter. The latter stage operates without base bias with D3 and the base-emitter junction of TR5 forming a simple aperture limiter. The square wave output at the collector of TR5 is capacitively coupled to the rectifier arrangement formed by D4 and D5. Frequency calibration is carried out by means of VR5. The signal generator section uses a Wien bridge configuration with a three-stage d.c. coupled amplifier formed by TR6, TR7, and TR8. VR6 and VR7 set both the loop gain and operating conditions for the amplifier whereas TH1, connected in the a.c. feedback path, provides amplitude stabilisation of the output. The sine to square wave converter is formed by a conventional Schmitt trigger comprising TR9 and TR10. The square wave output is taken from the collector of TR10 with VR10 providing amplitude calibration. Sine wave amplitude adjustment is provided by VR8, and VR9 is used to adjust the symmetry of the square wave output. S6 and VR2 provide attenuation whilst TR11, a Darlington emitter follower stage, operates as a low power output stage. The monitor amplifier employs a conventional arrangement using an LM380 i.c. and the mains supply is provided by T1 in conjunction with a bridge rectifier and an i.c. voltage regulator, IC2.

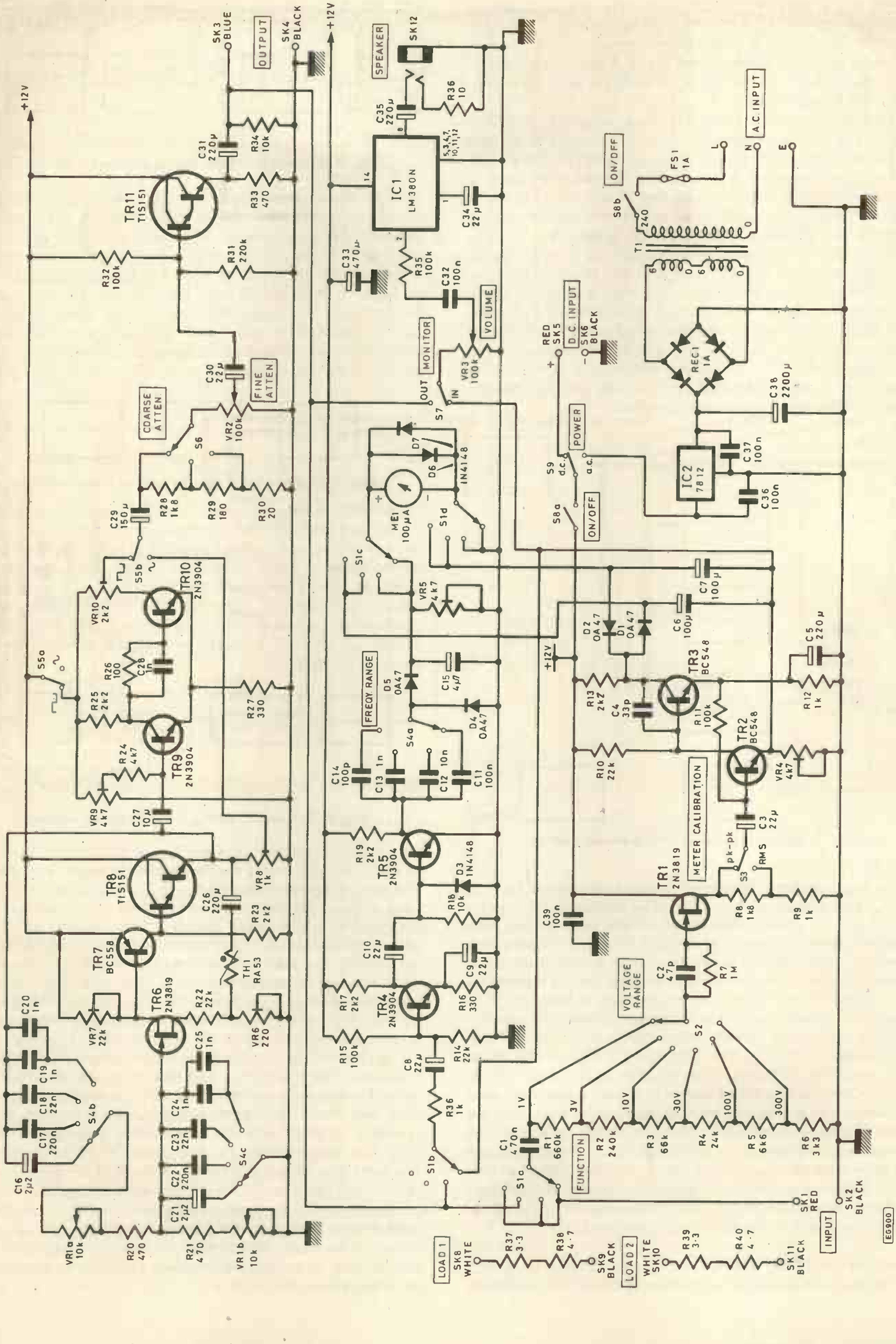


Fig. 5. Circuit of Audio Tester

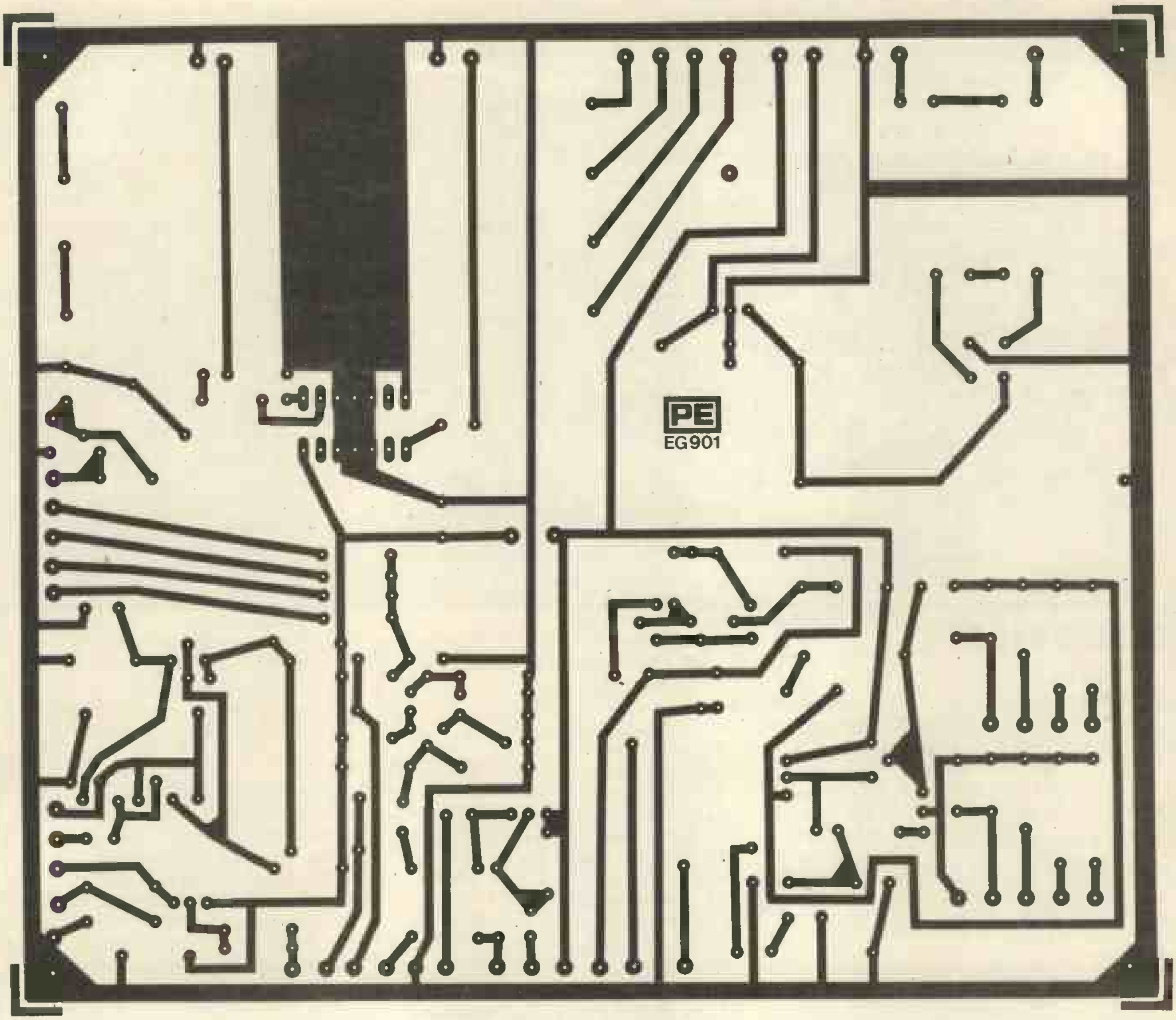


Fig. 6. Etching detail for board

CONSTRUCTION

The majority of the components are assembled on a single sided p.c.b. measuring approximately 145 x 170mm. The copper foil layout is shown in Fig. 6 whilst the corresponding component overlay is shown in Fig. 7. Care should be taken to ensure the correct location of the components—particularly the semiconductors. The use of a d.i.l. socket for IC1 is not recommended since direct soldering to the p.c.b. common foil can significantly increase the power dissipation of this device. The mains transformer is a p.c. mounting component and requires no fixing other than soldering to the p.c.b. High power load resistors, R37 to R40, must be spaced above the p.c.b. by means of ceramic insulators fitted to each connecting lead. This is instrumental in allowing air to circulate around the body of the resistors which can be expected to run quite warm when dissipating power levels in excess of 10W for long periods.

It is recommended that components be assembled in the following order: terminal pins, link, resistors, capacitors, diodes, transistors, i.c.s, bridge rectifier, mains transformer, thermistor. Care should be taken when handling and soldering the latter device as its resistive element and glass envelope are both fragile. The thermistor should be carefully mounted in a vertical position above the p.c.b. and may, if desired, be secured by means of a drop or two of epoxy adhesive applied at its base. When complete both sides should be carefully examined. The top should be checked for correct component placement and polarity (particularly important in the case of active devices and electrolytic capacitors) whilst foil side should be checked for dry joints and solder bridges between tracks. Double check the p.c.b. at this stage since its subsequent removal is not an easy task!

Once checked, the p.c.b. should be mounted in the base of the instrument case using four stand-off pillars. The controls, sockets and the remainder of the components are mounted on the front and rear panels of the instrument, the wiring diagrams for which are shown next month in Figs. 8 and 9. Note that the outer metal casing of S2 and S6 are employed as a common connection for R6 and R30 respectively. Note also that R1 to R5 inclusive and R30 each consist of two resistors connected in series. Once the front and rear panels have been assembled and wired they should similarly be carefully checked before fitting in place and wiring to the p.c.b. A final check is again recommended paying particular attention to the a.c. mains and +12V supply wiring to S8.

Table 1 Audio Tester Specifications

Signal Generator	Frequency range	10Hz to 100kHz in four decades
	Output impedance	20 ohm typical
	Output voltage	2V pk-pk max.
	Square wave rise time	Less than 40ns
	Sine wave distortion	less than 0·5% at 1kHz
Monitor Amplifier	Voltage gain	50 max.
	Output power	1W max. into 8 ohm at 1kHz
	Min. load	3 ohm
	Frequency response	60Hz to 30kHz
	Input impedance	1 Mohm
A.C. Voltmeter	Voltage ranges	1V, 3V, 10V, 30V, 100V, 300V
	Calibration	r.m.s. or peak-peak (sine wave)
	Accuracy	Better than 5% of full scale
	Frequency response	1Hz to 100kHz
	Input impedance	1 Mohm
	Max. d.c. input	400V
Dummy Load	Impedance	4 ohm, 8 ohm or 16 ohm
	Power rating	4 ohm 60W max., 8 ohm 2x30W max. 16 ohm 60W max.
	Accuracy	10%
Frequency Meter	Frequency ranges	10Hz to 100kHz in four decades
	Input impedance	1 Mohm
	Accuracy	Better than 5% of full scale
	Minimum input voltage	30mV r.m.s. (sine wave)
General	Power requirements	240V a.c. 50Hz mains 10W max. 12V d.c. (nominal) at 350mA max.
	Dimensions	Width 216mm, depth 235mm, height 94mm

COMPONENTS . . .

Resistors

R1	660k (2x330k) 1% 0·4W
R2	240k (2x120k) 1% 0·4W
R3	66k (2x33k) 1% 0·4W
R4	24k (2x12k) 1% 0·4W
R5	6·6k (2x3·3k) 1% 0·4W
R6	3·3k 1% 0·4W
R7	1M
R8	1·8k
R9	1k
R10	22k
R11	100k
R12	1k
R13	2·2k
R14	22k
R15	100k
R16	330
R17	2·2k
R18	10k
R19	2·2k
R20	470
R21	470
R22	22k
R23	2·2k
R24	4·7k
R25	2·2k
R26	100
R27	330
R28	1·8k 1% 0·4W
R29	180 1% 0·4W
R30	20 (2x10) 1% 0·4W
R31	220k
R32	100k
R33	470
R34	10k
R35	100k
R36	10 5% 0·5W
R37	3·3 10% 17W
R38	4·7 10% 17W
R39	3·3 10% 17W
R40	4·7 10% 17W

Unless otherwise stated all fixed resistors are ¼W carbon 5%.

Switches

S1	4P 4W rotary
S2	2P 6W rotary (1 pole only used)
S3	SPDT min. toggle
S4	3P 4W rotary
S5	DPDT min. toggle
S6	4P 3W rotary (1 pole only used)
S7	SPDT min. toggle
S8	DPST switch ganged with VR2
S9	SPDT (or DPDT) slide switch

Capacitors

C1	470n 400V polyester
C2	47p polystyrene
C3	22µ 16V tantalum
C4	33p polystyrene
C5	220µ 16V p.c. electrolytic
C6	100µ 25V axial electrolytic
C7	100µ 25V axial electrolytic
C8	22µ 16V tantalum
C9	22µ 16V tantalum
C10	22µ 16V tantalum
C11	100n polyester
C12	10n polyester
C13	1n polyester
C14	100p silver mica
C15	4·7µ 50V axial electrolytic
C16	2·2µ 63V axial electrolytic
C17	220n polyester
C18	22n polyester
C19	1n polystyrene
C20	1n polystyrene
C21	2·2µ 63V axial electrolytic
C22	220n polyester
C23	22n polyester
C24	1n polystyrene
C25	1n polystyrene
C26	220µ 16V p.c. electrolytic
C27	10µ 25V axial electrolytic
C28	1n ceramic
C29	150µ 16V axial electrolytic
C30	22µ 16V tantalum
C31	220µ 16V p.c. electrolytic
C32	100n polyester
C33	470µ16V p.c. electrolytic
C34	22µ 16V tantalum
C35	220µ 16V p.c. electrolytic
C36	100n polyester
C37	100n polyester
C38	2200µ 25V axial electrolytic

All polyester capacitors are 250V series unless otherwise stated

Potentiometers

VR1	10k log. dual potentiometer
VR2	100k lin. potentiometer with DPST switch
VR3	100k log. potentiometer
VR4	4·7k min. horizontal skeleton preset
VR5	4·7k min. horizontal skeleton preset
VR6	220Ω min. horizontal skeleton preset
VR7	22k min. horizontal skeleton preset
VR8	1k min. horizontal skeleton preset
VR9	4·7k min. horizontal skeleton preset
VR10	2·2k min. horizontal skeleton preset

Sockets

SK1	4mm socket—Red
SK2	4mm socket—Black
SK3	4mm socket—Blue
SK4	4mm socket—Black
SK5	4mm socket—Red
SK6	4mm socket—Black
SK7	3-pole miniature mains chassis socket
SK8	4mm terminal—White
SK9	4mm terminal—Black
SK10	4mm terminal—White
SK11	4mm terminal—Black
SK12	2-pole ¼in. jack socket with 'closed' contacts

Semiconductors

D1	OA47	TR1	2N3819	TR9	2N3904
D2	OA47	TR2	BC548	TR10	2N3904
D3	1N4148	TR3	BC548	TR11	TIS151
D4	OA47	TR4	2N3904		
D5	OA47	TR5	2N3904	IC1	LM380N
D6	1N4148	TR6	2N3819	IC2	7812
D7	1N4148	TR7	BC558		
REC1	1A bridge	TR8	TIS151		

Miscellaneous

TH1 RA53 thermistor, ME1 100µA meter scaled '0–3' and '0–10', T1 Mains transformer PC mounting with 2x6V secondaries, Ceramic stand-off pillars (8 off), Instrument case, Terminal pins.

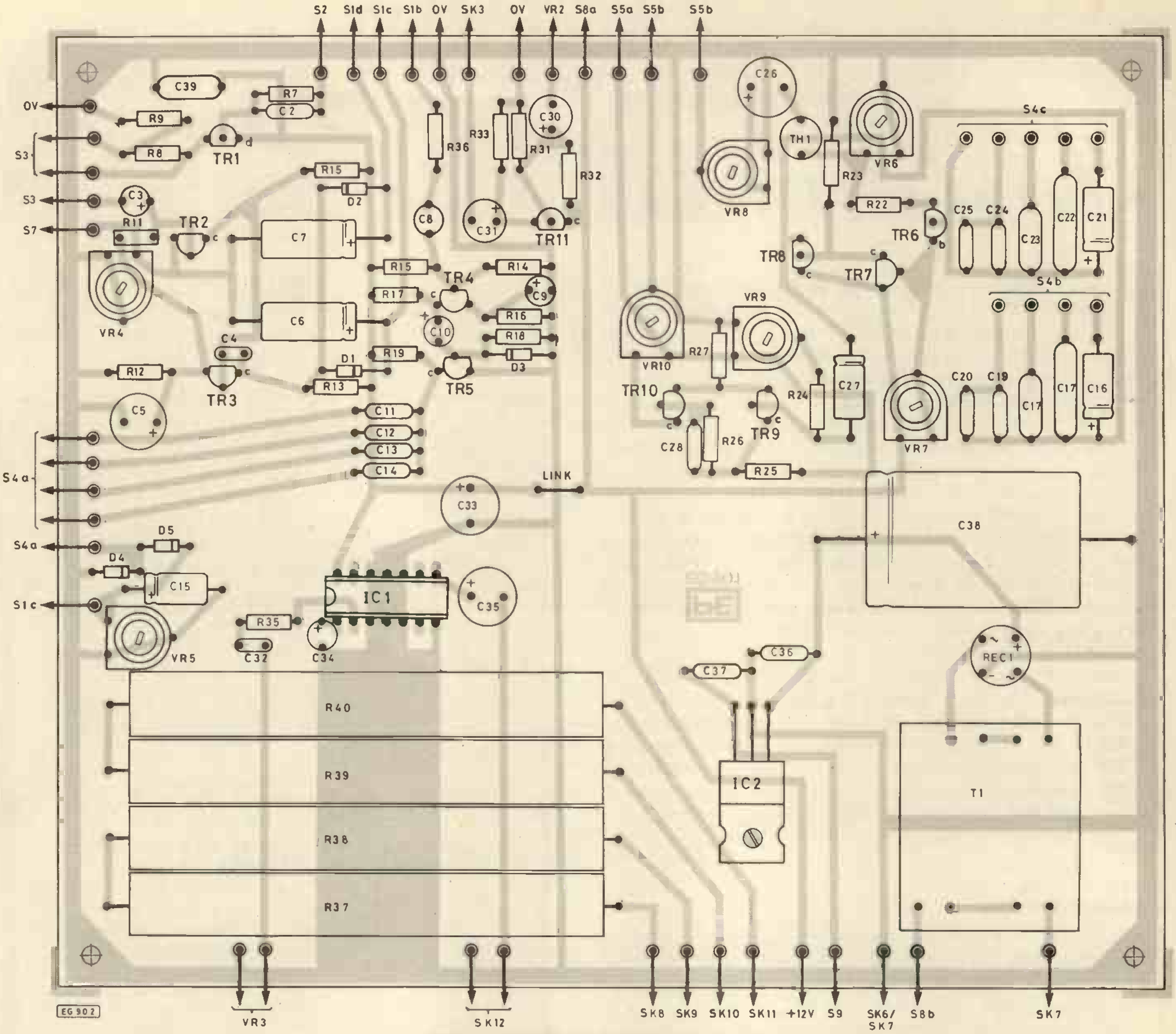


Fig. 7. Component overlay for p.c.b

Table 2 D.c. Test Voltages

TR1	s	1·6	TR7	e	12·2	
	g	0		b	11·4	
	d	12·2		c	7·6	
TR2	e	0·5	TR8	e	6·4	
	b	1·2		b	7·6	
	c	2·2		c	12·2	
TR3	e	1·6	TR9	e	2·5	(square) 0 (sine)
	b	2·2		b	2·6	(square) 0 (sine)
	c	8·6		c	3·1	(square) 0 (sine)
TR4	e	1·3	TR10	e	2·5	(square) 0 (sine)
	b	1·4		b	2·9	(square) 0 (sine)
	c	2·8		c	6·9	(square) 0 (sine)
TR5	e	0	TR11	e	7·0	
	b	0·3		b	8·1	
	c	2·9		c	12·2	
TR6	s	2·1	IC1	input	17·2	
	g	0		common	0	
	d	11·4		output	12·2	

IC2	1	6·3
	2 to 7	0
	8	5·9
	9 to 13	0
	14	12·2

Voltages measured with controls set as follows:—

S1 (function) 'Frequency–output'
S2 (voltage range) '1V'
S3 (voltage cal.) 'r.m.s.'
S4 (frequency range) '100Hz–1kHz'
S5 (waveform) 'sine' or 'square'
S6 (output level) '2V'
S7 (monitor) 'output'
S8 (on/off) 'on'
S9 (power source) 'a.c.'
VR1 (frequency) adjusted for reading of 1kHz on meter
VR2 (output level) adjusted to maximum–fully clockwise
VR3 (monitor volume) adjusted to minimum–fully anti-clockwise

Next Month: more assembly details

Instrument TUNER

BEING a music teacher by profession, the author is often asked to "tune up" guitars, clarinets, etc., and in an effort to make life as easy as possible, it was decided to try and design something that would save time and trouble. Several ideas were experimented with e.g. selecting different resistor values to affect the frequency of a normal CMOS astable circuit, but this was not very satisfactory for many reasons, including the difficulty in tuning up each preset, the limitations of switching, and the number of presets needed.

Eventually the idea of using a top octave generator IC evolved. It is an IC developed primarily for electronic organs, and requires a frequency of 2·0024MHz at its input. It will then provide 13 equally tempered notes i.e. corresponding to a piano semitone scale tuned "normally" (in inverted commas because until the time of J. S. Bach keyboards were not tuned equally, and sound out of tune to our modern ears).

Experiments were then carried out to see whether a crystal oscillator was needed for absolute accuracy, or whether a CMOS astable with a variable RC network would suffice. The latter proved satisfactory, and the project described quickly developed from this point. It uses only twelve components and two switches, apart from the power supply, and has proved to be an invaluable piece of equipment for the aspiring musician.

HOW IT WORKS

In Fig. 1 IC1c and d comprise an astable multivibrator whose frequency is dependent upon C2, R1, and VR1; VR1 thus provides tuning of the output to the desired frequency. This output clocks IC2, a 5024, which divides it internally into 13 equally tuned notes. Because 12 way switches are common, only twelve of these outputs are used. The selected output is connected via S2 to the input of IC3, a ripple binary counter 4024. Five outputs are selected (2^1, 2^2, 2^3, 2^4, 2^5) via S1a and fed into IC4, an LM386 audio amplifier, which has its input controlled by VR2, and its output connected to the loudspeaker. The power supply simply consists of a centre tapped transformer, two diodes, and a smoothing capacitor.

COMPONENTS . . .

Resistors

R1	2k2	¼W 5%
R2	6k8	¼W 5%
VR1	10k	Miniature horizontal presets
VR2	5k	Miniature horizontal presets

Capacitors

C1	1000µ 16V elect.
C2	47p polystyrene
C3	10µ 16V elect.
C4	470µ 16V elect.

Semiconductors

IC1	4011 or 4001
IC2	5024 (or Tandy S50240)
IC3	4024
IC4	LM386
D1–D4	1A 50V bridge rectifier

Miscellaneous

LS1	8Ω miniature loudspeaker
T1	12V or 6–0–6V 100mA miniature mains transformer
S1	Two pole 6 way switch
S2	Single pole 12 way switch
LP1	Mains neon indicator
FS1	p.c.b. fuse holder and fuse (250mA)

Vero case 150 x 85 x 60mm approx., knobs, grommet, p.c.b., wire, fixings, etc.

Stephen Ibbs

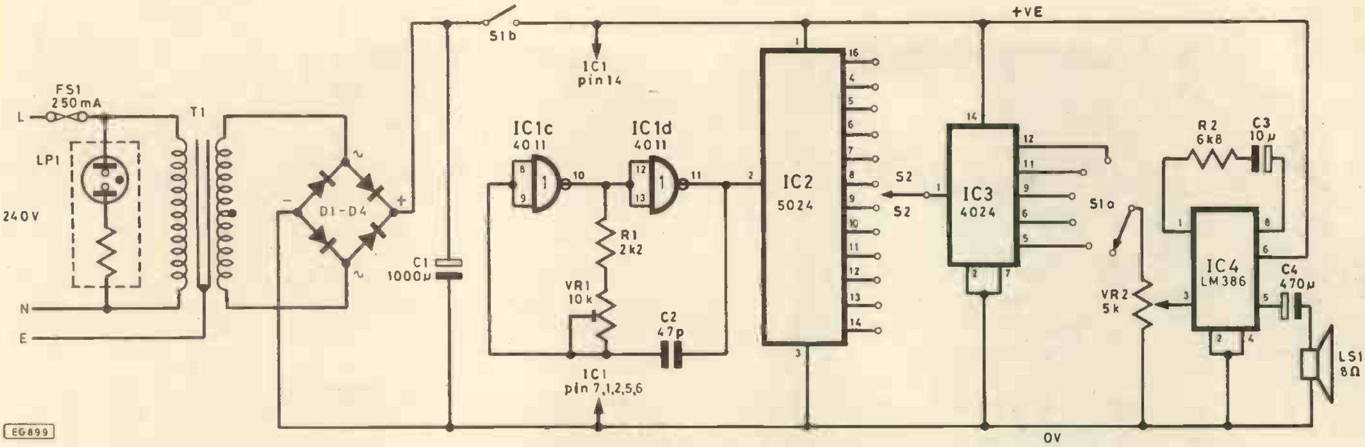
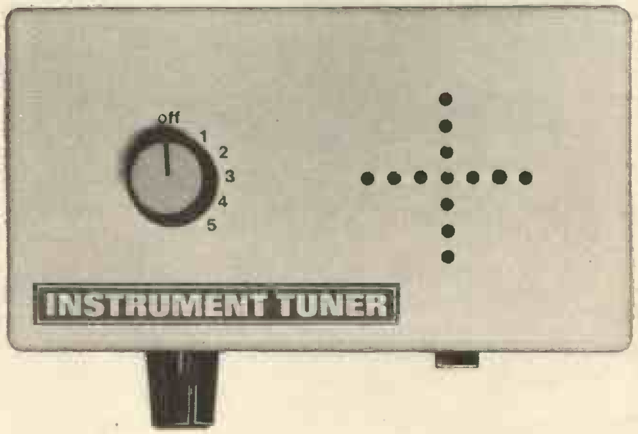


Fig. 1. Circuit diagram of the Instrument Tuner

CONSTRUCTION

There should be no problem with construction. P.c.b. designs are shown in Figs. 2 and 3. Ensure that the IC's and capacitor are inserted the right way round. A 13 way ribbon cable is used to connect the 12 outputs and the wiper to S2. As stated earlier, five divisions from IC3 are used, and 6 way ribbon cable connects these and the wiper to S1a, a two pole six way switch. The second pole of S1 incorporates the on/off switch (S1b), position "one" being off. Figs. 4 and 5 should make the interwiring easier to understand.

Mount the diodes and capacitor the correct way round for the power supply, and connect the wires from the transformer's secondary winding. Connect the mains, with the live going via a fuse, to the primary winding. After a check has been made of all the connections switch on and adjust VR2 to give a pleasing volume, and VR1 to tune the unit, either by comparing with a correctly tuned instrument,



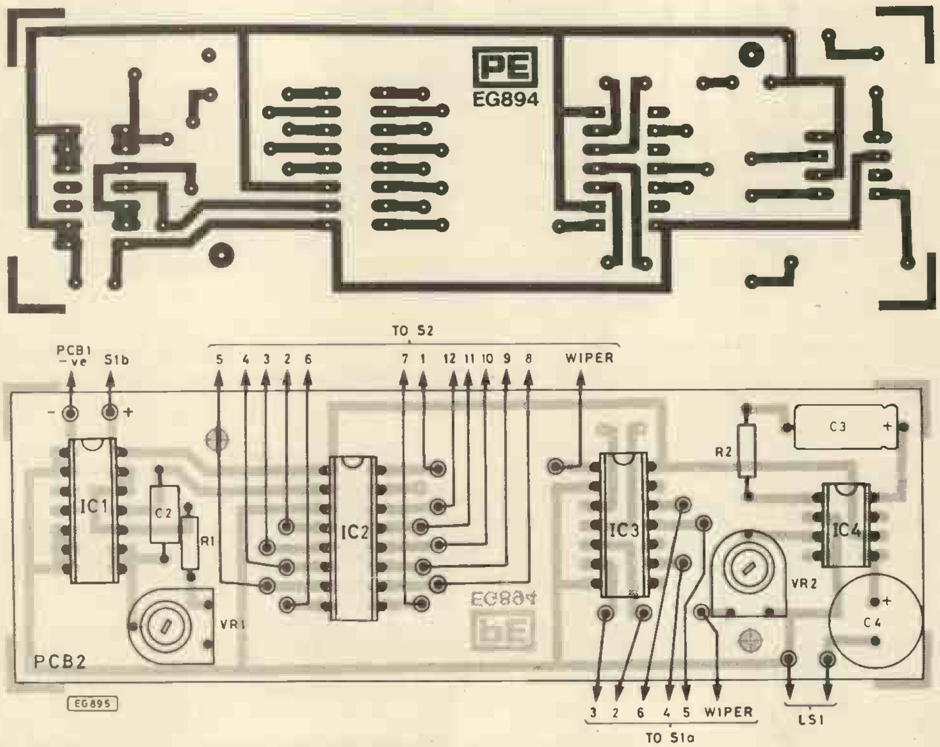
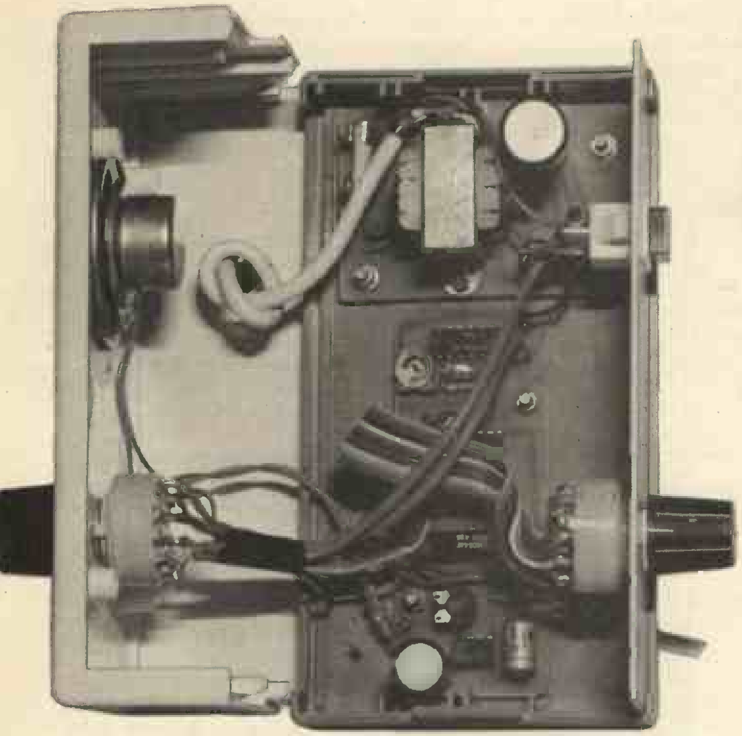


Fig. 2. Main p.c.b. (PCB2) design and layout



Construction of the prototype unit

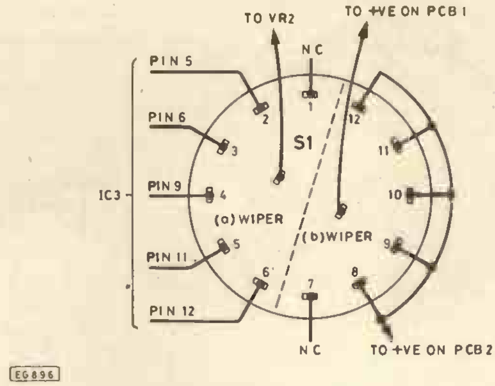


Fig. 4. Wiring of S1

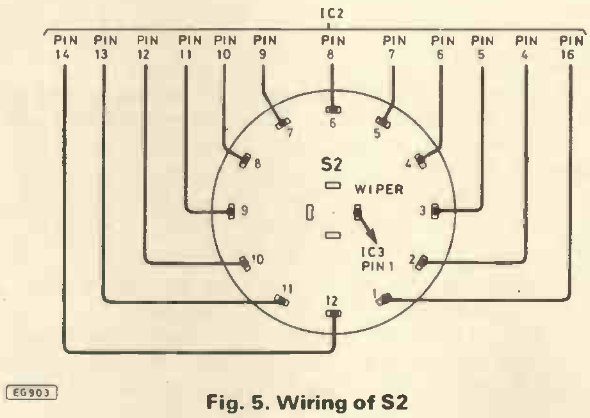


Fig. 5. Wiring of S2

or with a frequency meter. Altering the positions of S1 and S2 should change the octave and pitch of the note.

A Vero style case was used with the front panel being drilled to accept the neon and switch with the speaker glued to the top panel. Mount the p.c.b. and transformer into the case, and run the mains lead through the back panel, using a grommet to protect the sheathing.

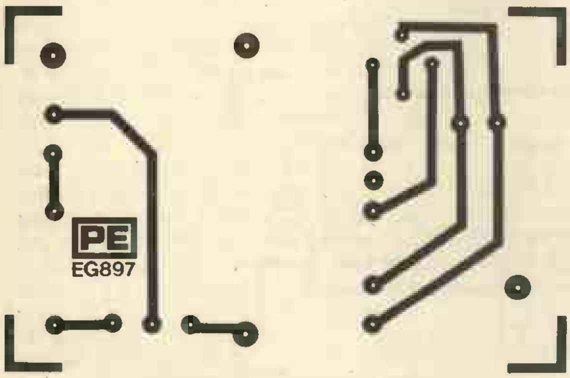
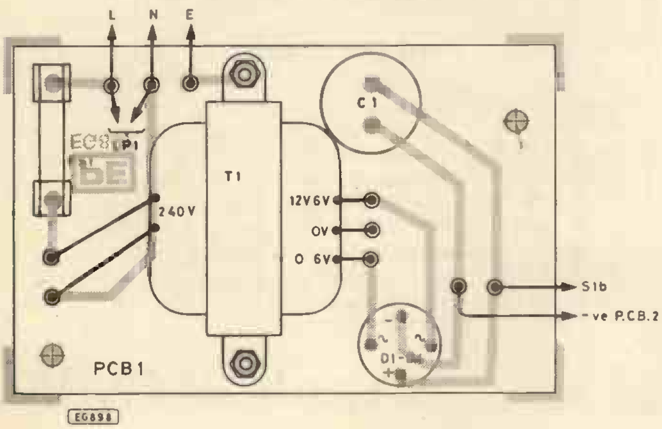
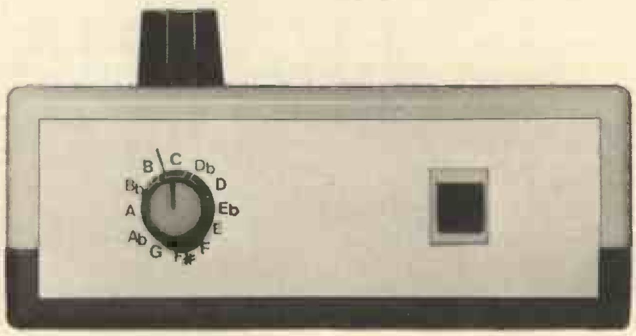


Fig. 3. Design and layout of PCB1



USE

This project has made life considerably easier for the author, because tuning can be done quickly, with very little fuss. Constructors may question the wisdom of using a mains power supply rather than batteries, which would obviously make the unit more portable. This is because the CMOS astable is voltage dependent and therefore no guarantee can be made for the instrument's stability and accuracy if a battery is used. Secondly the power supply requirement for the 5024 is between 11 and 16 volts and therefore a 12 volt battery would have been needed. The author has found no situation in the months this project has been in use, where there was no mains socket available, and the knowledge that the instrument would be reliable, with no batteries to run down, made the provision of a mains power supply a much more attractive proposition. ★



Space Watch...

COLUMBIA FLIES AGAIN

The third mission of the shuttle Columbia was somewhat different from the first two. During the first missions the astronauts used predicted performance characteristics rather than directly observed conditions. The two astronauts, Col. Jack R. Lousma and Col. C. Gordon Fullerton were specially instructed to observe the direction indicators and insure that the pitch error remained within 1·5 degrees of the centre reference datum. In the previous missions errors up to –5 degrees was observed. These were in reference to the predicted conditions. The new methods were based on the data gathered from the previous error conditions with known and assessed parameters which took the whole of past performance into account. Other new characteristics were also added for the third mission.

The lift-off of the third mission took place on the 22 March. Immediately the vehicle's solid rocket boosters started to maintain engine nozzle positions which were based on the assessments of the two previous missions. The 180 degree roll was completed at a height of 5,500ft. in scattered cloud. Thirty seconds later the Columbia began to make a flight path angle designed to reduce the acceleration loading. This steering was maintained for 1 minute and 18 seconds at which time the height was 60,000ft. at Mach 3. The vehicle reached a speed of 460kt. at 1 minute 25 seconds. This was less than the predicted speed of 466kt. at which the dynamic peaks had occurred on previous flights. Certain other changes were noted and these were partly due to the steeper trajectory during the ascent, main engine cut-off at lower altitude and the heavier flight mass of the vehicle.

The changes were observed in the vehicle's condition at 2 minutes 6 seconds into the flight. Here the separation of the boosters was made with the velocity of the vehicle a little faster than on the previous missions and at 3,000ft. lower. The weight was in excess of mission 2 by some 4,518lb. at 4,478,787lb. This incidentally was 17,000lb. greater than the first mission. During the ascent some tiles were damaged at the nose, this was probably due to ice from the external tank. Lousma radioed that he had seen "quite a blizzard" at a time of 3 minutes into the flight.

There was some uneasiness because of overheating engines, however at 7 minutes 30 seconds into the flight it was suggested that the Auxiliary Power Unit 3 should be shut down. This was done at 8 minutes 30 seconds when the velocity was 25,860ft./second and the altitude 57 naut. miles. So 10 minutes 33 seconds after launch the Columbia was in orbit and after a further burn of 1 minute 27 seconds, to give an additional 153ft./second velocity, the final position in initial orbit was 130 naut. miles apogee and 46 naut. miles perigee.

SPECIAL TASK

One of the special tasks during the mission was the deployment of the remote manipulator arm. The manipulator arm was the Canadian contribution to the mission. It was put to its task of lifting out the "plasma diagnostics package" from the payload bay while over the Indian Ocean. The tests were carried out in the sequence of manipulations required. The intention had been to lift out the much heavier "induced environment contamination monitor" for manipulation. This, unfortunately had to be abandoned because of the failure of the camera at the wrist of the arm.

The replacement of the plasma package was carried out successfully though there had been some misgivings about the operation. Despite the failure to secure some of the data relating to the dynamics of the manipulator, the observational data gave every confidence. The elbow camera was able to secure colour pictures of the Earth and the orbiter itself. Fullerton was quite happy about the situation and told astronaut Sally K. Ride (who will be one of the team on mission number 7 and the first woman astronaut from America) the communicator for this mission, "I am very impressed with this piece of mechanism". He also confirmed that the actual performance was very close to that at simulation.

ASTRONAUT COMFORT

It has been established that there are some difficulties with respect to the comfort of the astronauts. Fatigue due to the work load, in particular that involved with the testing of the manipulator, led to changes in the programme. The schedule was hampered by the nausea affecting Lousma soon after moving the vehicle into the zero-g conditions in an orbit of 130·7 × 131 naut. miles. This was accomplished within 0·3 naut. miles of the nominal path round the Earth.

The condition of Lousma resulted in his abandonment of solid food in favour of a liquid diet. Lousma has a medical history of difficulty in that he suffered in a similar way when he piloted the Skylab mission in 1973. In the present mission both Lousma and Fullerton had taken Scopolomine/dexedrine to deal with the nausea problem. It did not seem to help Lousma.

ELECTRON BEAM GENERATOR

The Electron Beam Generator was directed at four orbiting satellites during the Shuttle mission. The manipulator was deployed to detect the phenomenon caused by the passage of the orbiter through space. The investigators responsible for the vehicle charging and potential experiment had an additional objective for the system which was the creation of radiowaves with the electron beam. The beam was fired from the payload bay and was photographed by the crew. The four satellites chosen for the experiment were the NASA Dynamic Explorer 1, the International Sun Earth Explorer 1 and two Canadian Research Council craft Isis 1 and 2. The object was to determine whether these satellites could acquire the radio waves with their sensitive receivers.

It is thought that a new dimension of research and application is available here. In addition to the spacecraft, as receivers of the energy, stations over the Americas and New Zealand were participating in the experiments. Initial results have been satisfactory and much as predicted. The crew of the shuttle observed the beam using infra-red TV cameras.

Bright illumination was observed which outshone the beam itself and it is suggested that this may have been due to a diffuse plasma discharge. The Plasma Diagnostic package aboard the shuttle found that the beam produces strong low frequency waves between 100Hz and 10kHz. There were some very interesting findings during the Plasma package experiments. The package sensed electronics going up as well as down the beam. It was expected that the concentration of the electrons would be directly in the path of the beam. In fact they proved to be more of less uniform across the whole 20 feet spread of the beam. Interaction was observed between the beam and the space plasma. Also there were high plasma pressures observed before entering the beam but as soon as the package entered the beam the pressure dropped very sharply in the electron cloud.

It will be possible to use some of the results of these experiments in the investigation of fusion and the study of planetary and solar interactions. Such conditions were found in the case of Jupiter and its Moon Io causing bursts of radio waves. It is also possible to consider the idea of using tethered satellites to produce electrical power for use on board the Orbiters. This would be a useful way of supplying power to the Orbiter. By firing an electron gun at the end of a trailing wire some of the electrons could be sucked up by the tethered satellite and a considerable amount of power could be generated. One very interesting experience was that during the time that the beam was operating the whole bay was bathed in a glow. The next Orbiter mission is to be at the end of June this year.

SOLAR FLARES

Several observations were made of solar flares and one was specially made at the request of other departments who detected the possibility of flares from the weather spacecraft. The X-ray polarimeter had been shut down in preparation for the return of the shuttle but was reactivated to obtain data from the flare. The versatility of the crew and the coordination of the ground stations indicates that the system can be a powerful tool for investigations.

Frank W. Hyde

Microsynth...

Part Two A.R. Bradford M.Sc.

IN this part more of the circuitry will be described together with assembly details of the main board and power amplifier.

VOLTAGE CONTROLLED OSCILLATORS

The VCOs are built around a fairly standard triangle/square oscillator, configured for voltage control.

Consider VCO1: assume IC14b is open, then a positive control voltage applied to the input network (R70 to R73) will cause integrator IC11 to ramp negatively until it reaches the negative threshold of Schmitt trigger IC5d. The Schmitt then switches hard positive, turning on IC14b and removing control voltage from the inverting input of IC11. The input voltage is still connected to the non-inverting input however, so the integrator now ramps positively until the Schmitt flips negative again, and so on. IC5d need not be a high impedance type, yet it so happens that the chip used for the VCO Schmitt triggers and for the sample and hold circuits has a high slew rate of 13V/µsec. Using a 741 in this application results in the VCO going alarmingly flat at high frequencies!

Comparator IC12 compares the triangle waveform with a reference voltage set by VR14, in order to generate a square wave; varying VR14 changes the duty cycle, or mark/space ratio of this square wave, which in turn varies the harmonic content of the sound. In VCO1 this may be done automatically by applying a modulation voltage to R79 for phasing effects. R77 attenuates the squarewave to the same level as the other waveforms.

Generating a ramp or sawtooth from a triangle waveform can be very complicated, but here a novel system is employed. The input control voltage is also fed via R76 to a second integrator IC13, which ramps negatively until C17 is discharged by a pulse from IC5d momentarily closing IC14c. Thus a secondary or slave relaxation oscillator is formed, with its frequency permanently phase locked to that of the triangle/square master oscillator. In this way reset time problems are eliminated—only the amplitude of the ramp waveform changes with frequency, and in practice this change is so slight as to be unnoticeable (unlike slight changes in pitch!)

Nulling out the offset on integrator IC11 by means of VR13 enables the VCO to remain in tune with very low input voltages, thus expanding the usable range of the VCO down to less than 100Hz.

VCO2: IDENTICAL FUNCTION

VCO2 (IC15 etc) functions identically, except that in its LFO mode it will oscillate down to about 0·3Hz, and possibly as low as 0·1Hz. The lowest frequency may be obtained by carefully selecting R82. In VCO2, the ramp integrator IC16 is biased by R95 and R96 so that its output waveform is symmetrical about ground, and IC17 is added to provide a sawtooth of opposite sense. VR16 attenuates the input voltage to VCO2 and so determines its frequency. Rotary switch S21 selects the output waveform and VR20 controls the level. With S6 in the LFO or RM positions, the output is disconnected from the audio signal paths and the output may be routed through any of S14 to S17. With S6 in the VCO position, S21b sends the ramp or square wave outputs to the VCF, but the triangle is sent directly to the VCA. This is done because a triangle contains very few harmonics and thus sounds smooth—almost like a sinewave only more interesting, and so is not filtered. Doing this leaves the VCF free to filter the squarewaves from the sub octave generators. The triangle output from VCO1 is similarly fed directly into the VCA via waveform select switch S3.

SUB OCTAVES

There would be no excuse for not including a circuit which is so simple yet which has such a dramatic effect on the sound potential of the synthesiser. IC22 is a dual J-K flip-flop wired as two divide-by-two circuits and driven by the squarewave from one or both VCOs. Thus it can be used to generate either an octave below the frequency of VCO1 and/or an octave below that (selected by S4), or an octave below each of VCO1 and VCO2 (selected by S5). The resulting squarewaves are fed into the VCF.

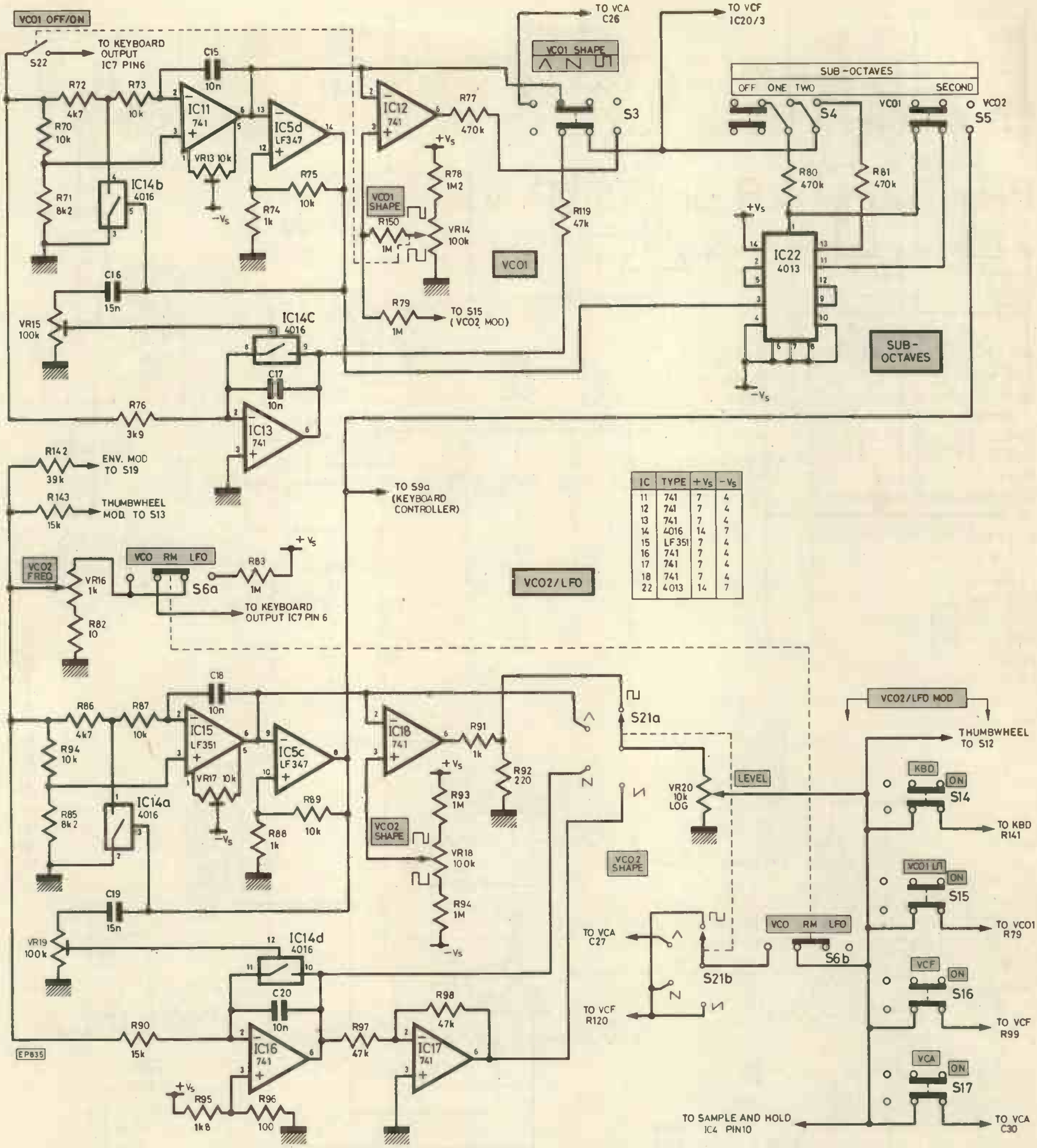
As stated above, the VCO triangle outputs, when selected, are fed directly into the VCA, leaving the filter free to smooth out the tone of the sub octaves. In this way four-note chords may be generated from a single key, giving rise to the remarkably full sound of the Microsynth. Indeed, the variety of waveforms which can be used and added, or multiplied together is probably the strongest point of this instrument, for example, it can create remarkably rich church organ type sounds, particularly when reproduced through a good quality amplifier and speaker.

VOLTAGE CONTROLLED FILTER

IC20 is a dual operational transconductance amplifier (OTA) and is configured here as a state variable filter providing low pass and band pass outputs. The operation can be understood by considering each half of IC20 as a non-inverting integrator, the time constant of which depends on the control current flowing into the bias inputs of the OTAs (pins 1 and 16).

The control current is sourced by another exponential converter, TR4, TR5 and IC19, in order that the filter should track the VCOs. The "law" of this converter is not accurate enough to drive VCOs, but is quite adequate for the VCF. This is because slight changes in harmonic content of a sound go undetected, whereas slight changes in pitch are very noticeable. Again, TR4 and TR5 are glued together for thermal stability.

The bandpass output from pin 8 of IC20 is fed back to the signal input via VR23, producing a resonant peak in the response of the filter. It is this resonant peak which produces the characteristic synthesiser "Waa-Waa" sound, as it is

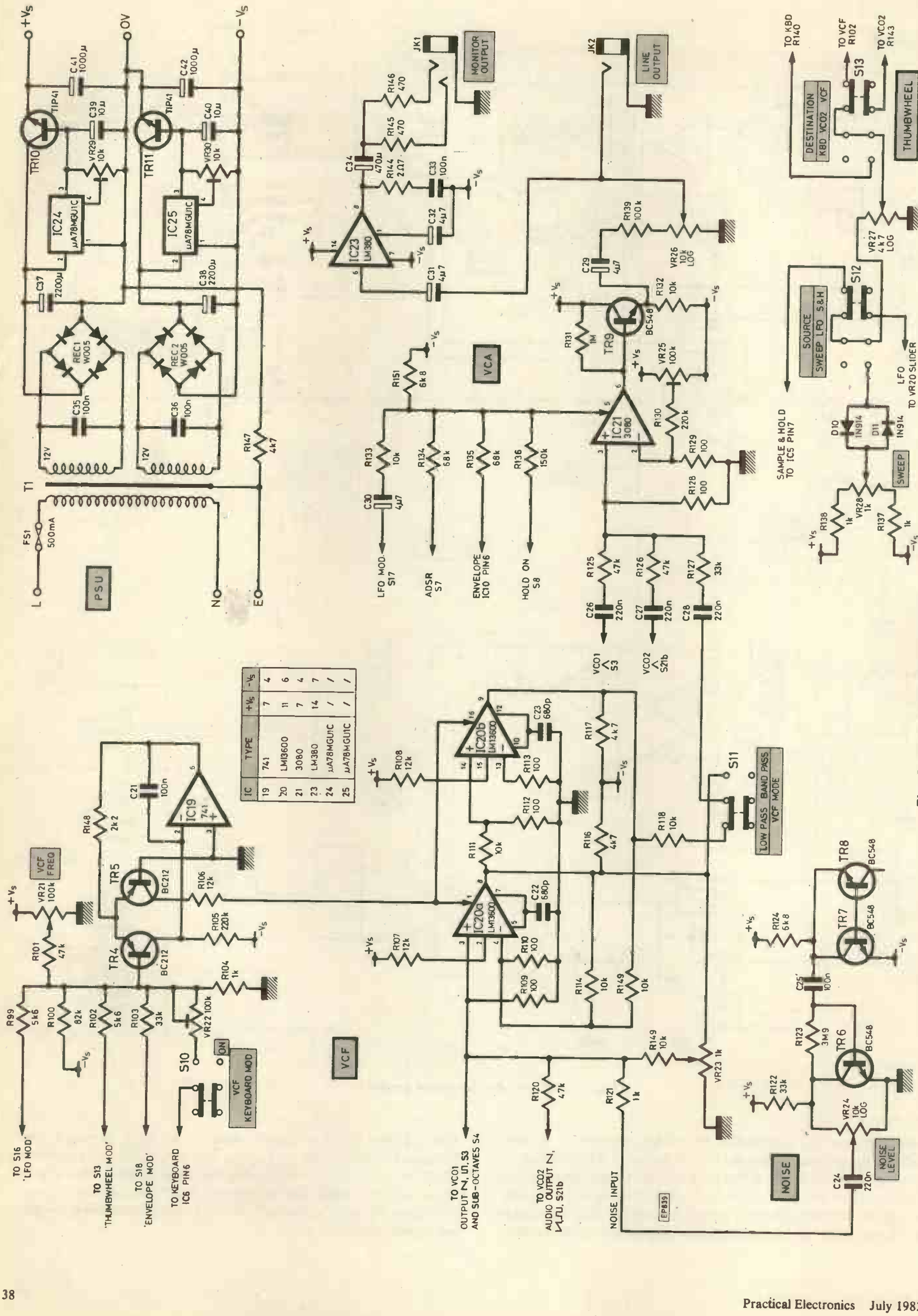


IC	TYPE	$+V_s$	$-V_s$
11	741	7	4
12	741	7	4
13	741	7	4
14	4016	14	7
15	LF351	7	4
16	741	7	4
17	741	7	4
18	741	7	4
22	4013	14	7

Fig. 5. VCOs and sub octave generator

swept through the harmonics of a VCO waveform. It also creates wind effects when the VCF is fed with white noise.

The frequency at which the VCF begins to cut off is set by VR21, but this frequency is modified by the various modulation inputs. In particular the envelope can be used to create the "Waa-Waa" effect as keys are depressed, and moving S10 to the "On" position enables the VCF to track the keyboard voltage, to a degree set by VR22. In practice, VR22 is adjusted so that using the band pass output and a noise input, a tune can be played from the keyboard consisting of filtered "whistles". The "Q" control VR23 must be set at maximum for this.



IC	TYPE	+Vs	-Vs
19	741	7	4
20	LM3600	11	6
21	3080	7	4
23	LM380	14	7
24	µA78MGU1C	/	/
25	µA78MGU1C	/	/

Fig. 6. VCA, VCF, PA and PSU

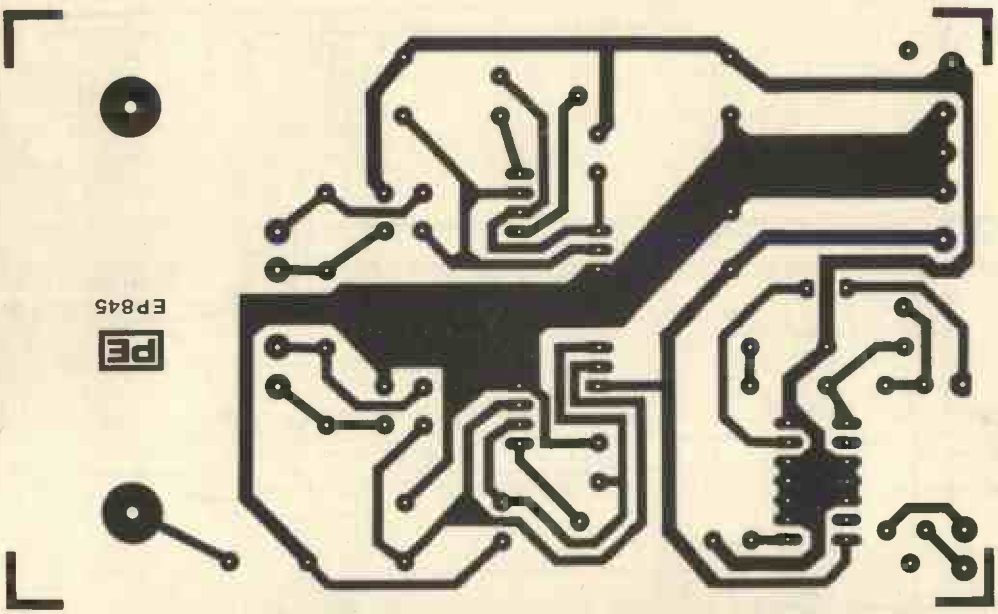
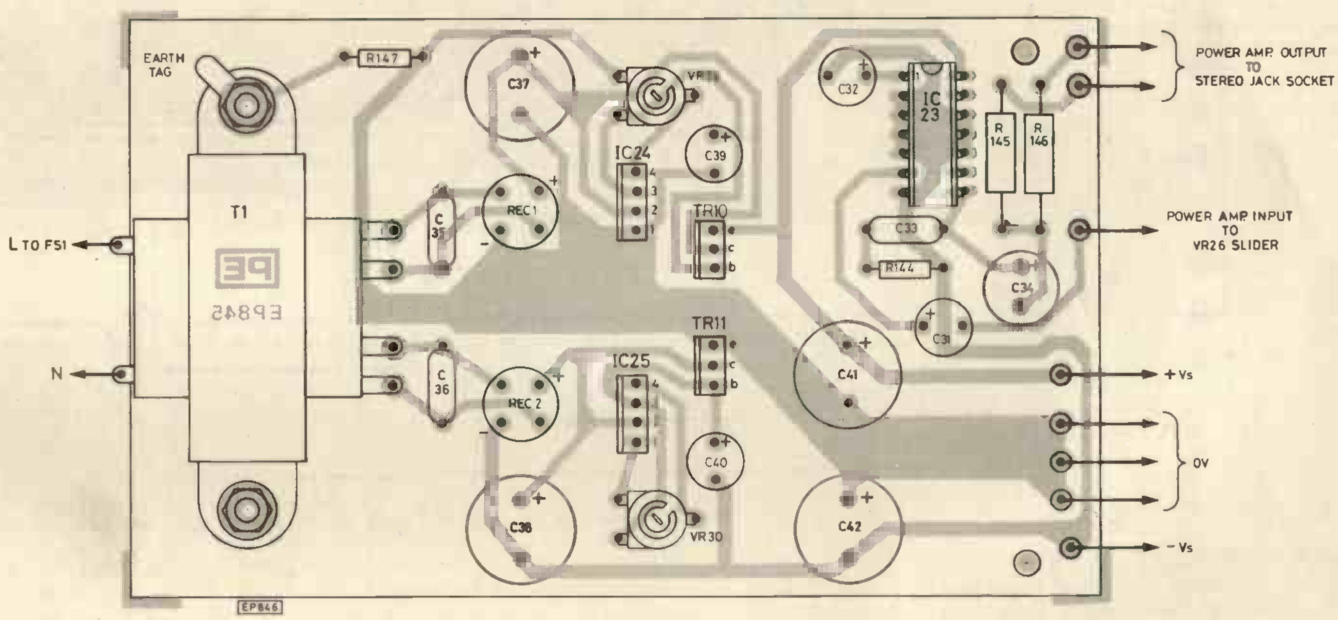


Fig. 7. (Left) printed circuit of power supply

Fig. 8. (Below) component layout of PSU board



NOISE

There seemed little point is following the trend for using shift registers with feedback to generate digital pseudo-random noise, when an ordinary type reverse-biased transistor (TR8) will generate real random noise at a fraction of the cost. TR6 and TR7 amplify this noise up to a usable level and VR24 controls the noise level fed to the VCF. Frequency analysis revealed the noise spectrum to be of reasonably constant amplitude at all audio frequencies.

VOLTAGE CONTROLLED AMPLIFIER

Another OTA IC21 is used in a circuit similar to the filter, except that here there is no time constant involved, so that the current flowing into the bias input simply modulates the amplitude of the input signals. Preset VR25 is adjusted to minimise breakthrough of the control signal. TR9 buffers the output, and VR26 is the master volume control for the synth.

THUMBWHEEL

This is simply an edge potentiometer located alongside the keyboard. It allows the musician to impart greater expression to his playing in several ways, for example by sweeping the VCOs' pitch to any degree up or down, preset by the voltage from the sweep pot VR28. D11 and D12 again provide a dead band at the centre of VR28 corresponding to zero modulation. Alternatively the pitch of VCO2 relative to VCO1 could be bent in this way, or the roll off frequency of the filter, for a manual "Waa-Waa" effect.

The thumbwheel may also be used to introduce LFO modulation (or ring modulation) to a level preset by the VCO2/LFO level control VR20, routed into either the keyboard or VCF via S13. The output of the Sample and Hold is also routed via S12 and the Thumbwheel.

This is a feature normally found only on the more expensive machines.

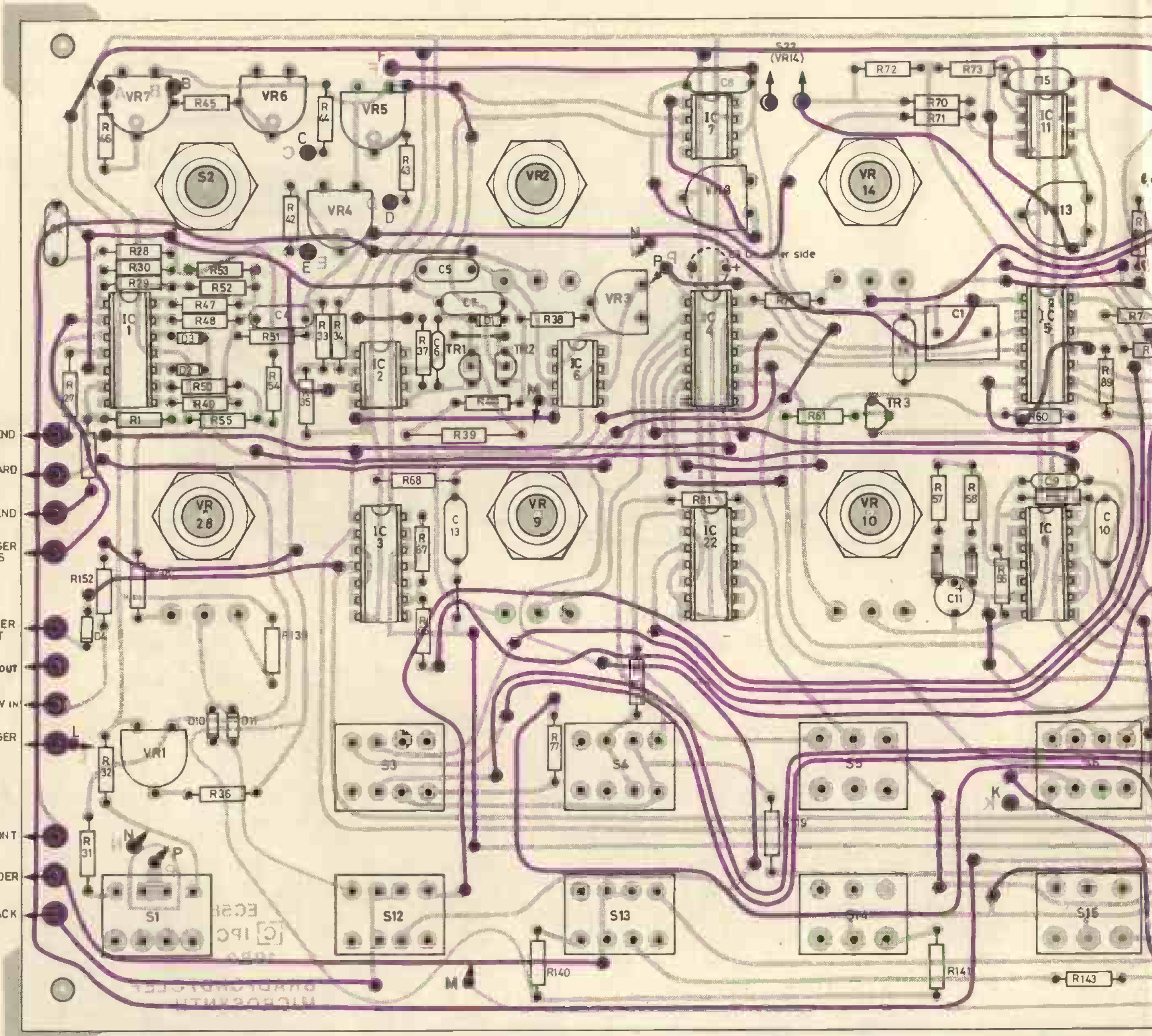


Fig. 9. Track layout and component overlay for the

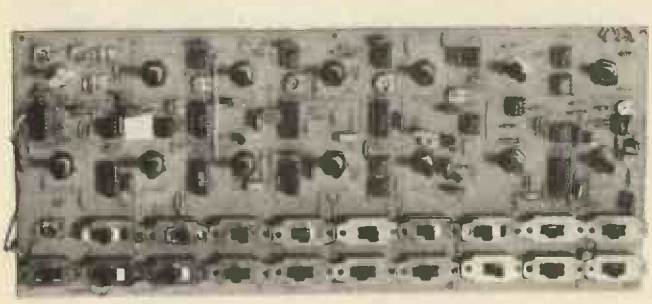
POWER AMPLIFIER

IC23 is a monolithic amplifier providing nominally 2 watt into 8 ohms, and will drive normal stereo headphones, although a loudspeaker could also be driven. The output load resistors (R145, R146) are duplicated so that if a loudspeaker is connected using an ordinary mono jack plug, the output will not be shorted.

POWER SUPPLY

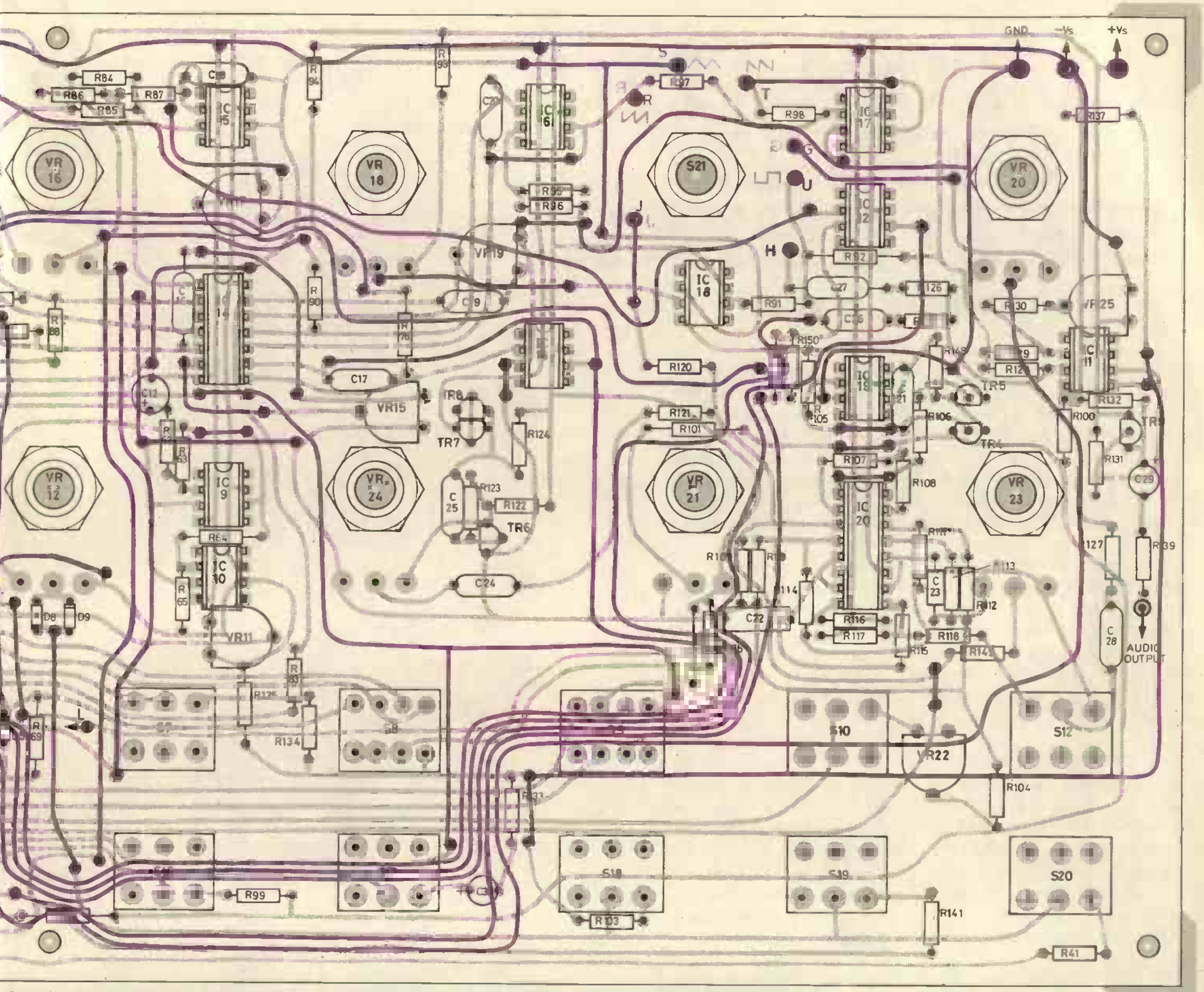
There is nothing quite like a synthesiser for amplifying defects in a power supply, since inability to supply the requisite current on demand results in alarming changes of VCO pitch, not to mention oscillator breakthrough, clicks as circuits change state, and so on.

To overcome these problems the circuit shown here employs two monolithic i.c. regulators (IC24 and IC25) driving the bases of two power transistors (TR10 and TR11). The output voltage of the positive and negative rails is set relative to 0V by presets VR29 and VR30 respectively. Ample smoothing is essential, in the form of C37 and C38. C35 and C36 reduce mains spikes which can cause spurious triggering of the envelope shaper, and C41 and C42 are there to reduce oscillator breakthrough on the power rails.



WARNING

Under no circumstances should the rails be set to greater than ±9V. A total of 18V is as much as the CMOS chips can take, which, for simplicity of design, are run directly across the positive and negative rails. This setting up should be done before any CMOS chips are inserted on the main board.



double sided main board. Here the board topside is coloured and the underside etching tinted

CIRCUIT BOARDS

Working from the top side of the main p.c.b., solder pins into all the holes in the tracks on this side, then turn over the board and solder the other ends of all these pins. Check to make sure none have been missed. This completes the links from one side of the board to the other.

Next assemble the board in the usual manner: wire links and resistors first, followed by capacitors, presets, semiconductors. Pins should be used for all the off-board connections. Low profile d.i.l. sockets should be used for the CMOS i.c.s, and for preference, all the i.c.s. Solder the slide switches in using the ⅛in. spacers. Finally mount the pots and rotary switches from below the board, having first cut the spindles to 1in length, and solder the pot pins directly to the pads on the p.c.b. The rotary switches are wired to the appropriate pins on the board with short flying leads. Long wire links are denoted by letters at each end, that is, connect "L" to "L", "M" to "M", etc.

Thoroughly inspect the board for shorts, etc, then scrub the underside and re-check. Double check all components against the schedule.

Similarly construct the power supply p.c.b.

SETTING UP

First check the power supply, setting the outputs to ± 8V5 using VR29 and VR30. Connecting the power supply to the main p.c.b., if there is any drastic departure from the nominal supply voltages switch off at once and recheck the board for shorts, incorrect (that is, too small) resistors, etc. If all is well, retrim the power supply to exactly ±8V5 and proceed.

Start with all switches to the left except "Drift" which should be "Off" (centre position). Set the range switch to 4', Sweep and Envelope Level to mid-way, and the thumbwheel fully towards the front. Attack, Noise Level, VCO2/LFO level and Q should all be at minimum. Set Release one quarter up and VCF frequency full up and connect the output to an amplifier, making sure the volume control on the back panel is full up. Pressing any key should enable the triangle waveform from VCO1 to be heard. Shape controls should be midway.

With the range control at 4', the octaves of the keyboard are first tuned relatively, against pitch pipes, ear, DFM, guitar, or whatever is available, using VR3.

Next Month: Setting up the synthesiser with test programs.

AUTOMATIC SIGNAL SWITCHING

Andrew Parr

EVERY good model railway has points and signals, and ideally these should be linked so that a train cannot pass a red signal onto a wrongly set point. With semaphore signals there is little problem since the coils operating the semaphore arm need a "passing" contact, in the same manner as the point solenoids, and can simply be paralleled with the point coils. Colour light signals are more difficult however, as a permanent contact is needed to illuminate the bulbs.

Point motors with integral switches are available, but these are large, expensive, and need to be mounted under the baseboard or hidden in a line-side hut. The technique outlined below was developed for the slimmer and cheaper point motors which clip directly onto several manufacturers' points. The cost of the circuit plus point motor is less than the larger motor with integral switch, and allows the inclusion of other facilities as described later.

CIRCUIT DESCRIPTION

A typical point motor consists of two solenoids, as shown in Fig. 1a. These are pulsed by either a.c. from a flash contact switch, or a d.c. pulse from a Capacitor Discharge unit similar to that described in *Practical Wireless* August 1978. A common arrangement (used by the author) is to wire all the solenoids back to studs on a mimic panel as shown on Fig. 1b, and do the switching with a wandering pencil. This is considerably cheaper than providing a bank of passing contact switches.

The signalling unit is built on the extremely simple circuit block of Fig. 2. It utilises one half of a 7400 to construct a simple memory IC1a, IC1b. The circuit has two inputs, A and B, which connect direct to the coils of the solenoid. (If a mimic diagram and studs are used, the circuit can sit behind the mimic diagram, and the inputs can be connected to the studs.) When a coil is fired, the corresponding transistor turns on, taking its connection to IC1 to 0V. This sets, or resets the memory, indicating which input was fired last. QA is thus at '1' if input A was fired last, and QB is at '1' if input B was fired last. Diodes D1 and D2 protect TR1 and TR2 against the incredibly nasty spikes occurring on the solenoids when they de-energise.

A simple application is shown in Fig. 3a, where we have one point, connecting a siding to a main line. With the feed as shown, and the two sections X and Y formed by track breaks, most points will feed track power to the selected route, and trains will stop as they reach the break on the non-selected route. The point is shown by two signals and these are controlled by the simple circuit of Fig. 3b.

The colour signals on the author's layout take 30mA per bulb at 12 volts, and this is within the capability of a 7406 (40mA max, 30V max). The colour bulbs can therefore be connected to the circuit of Fig. 2 via four sections of a 7406 acting as buffers. The bulbs will light when the corresponding 7406 input is taken to a '1', so the signals will follow the points giving green for "go" and "red" for stop.

One of the advantages of the circuit of Fig. 2 is the ease with which it can be incorporated into more complex schemes. Fig. 4a shows part of the track around a station on the author's layout. This has two main lines, a trailing crossover and a station bay. There are, in addition, two isolated sections X and Y to allow trains to be held in the station, controlled by S1 and S2, and the bay can be isolated by S3 to allow a train to arrive in the platform with its last coach pointside of the break, and have a tank engine tow the coaches away.

Fig. 4b shows the wiring of the three point motors. The crossover is wired as a pair for obvious reasons, so there are four wires to the mimic diagram. There are four two aspect signals. Signal 1 is controlled by the section switch S1 and the crossover. Signal 2 by the section switch S2 and the bay point. Signal 3 is controlled by the crossover point and has a diverting left route indicator (a row of yellow l.e.d.s) controlled by the bay point (this was an unsuccessful attempt to

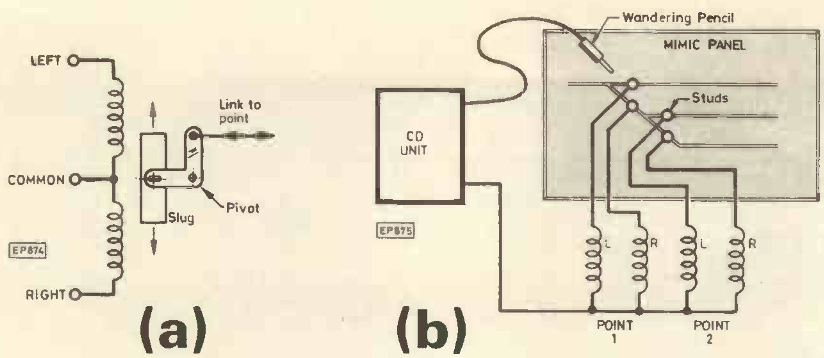


Fig. 1. Basics of electric points. (a) Point solenoid (b) CD unit and mimic panel

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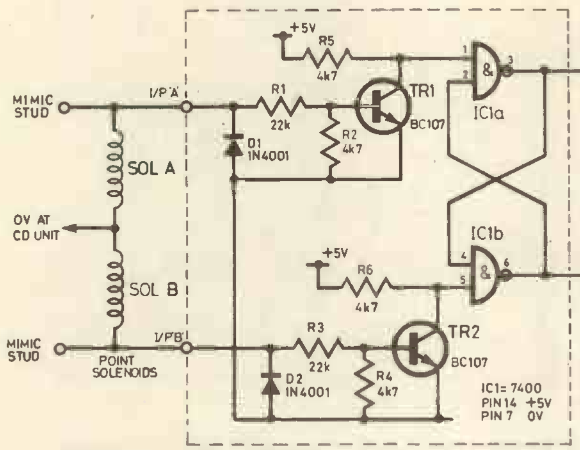
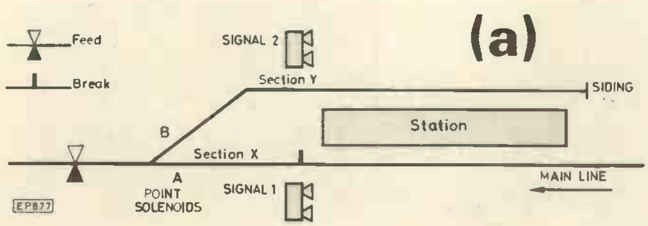


Fig. 2. Basic circuit. This circuit uses $\frac{1}{2}$ 7400 which leaves two gates spare for an identical circuit or another logic circuit



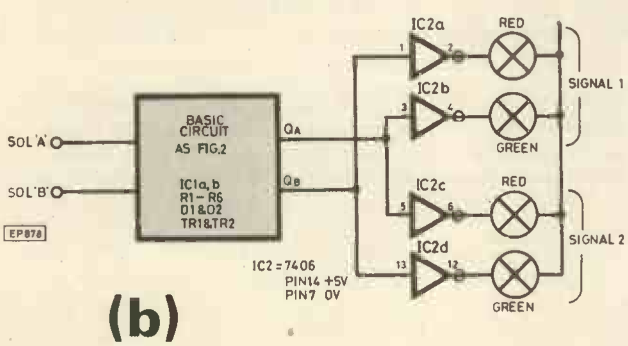


Fig. 3. Simple system. (a) Track layout. (b) Circuit diagram

stop number one son going full chat into the bay with an HST by mistake). Signal 4 is controlled simply by the section switch S3.

The circuit to control the colour signals around this station uses just four stripboards and four transistors and is shown on Fig. 4c. This should be fairly self-explanatory; IC1a and b memorise the state of the bay point and IC2a and b the state of the crossover. The section switches are all two pole single way. One pole switches the track and the other goes to the logic. On signal 1 and 2, the switch overrides the point memory at IC1c and IC2c. Switch S3 drives signal 4 via IC4d,e. Although a changeover switch could have been used, half a 7406 costs less than the difference in price between a two pole on/off switch and a two pole changeover switch.

A power supply for the unit is shown on Fig. 7. This is fairly straightforward, but the routing for the 0V returns should be followed to avoid noise problems. IC2 is an optional addition, the normal bulbs in model railway colour signals are, in the author's opinion, overbright and underrunning them reduces the current to something like 20mA, reduces the intensity to a more realistic level and lengthens their life considerably.

PRACTICAL NOTES

Obviously, only suggested control circuits are given, as each railway will have its own requirements. Stripboard was used for the prototype, and is probably the most versatile method.

Model railways are probably the most fiendish electrical noise generators known to man, and because this circuit uses memories it is particularly vulnerable. There are several precautions that should be taken. Firstly is the use of a separate transformer for the circuit; do not use the auxiliary output from a train controller which will have all sorts of spikes on it. Secondly, separate out the solenoid 0V, logic 0V and colour signal 0V as shown on Fig. 8. Thirdly, allocate the colour signals to 7406s in such a manner that the load on a 7406 is reasonably constant (i.e. have three red/green pairs per 7406, not six reds on one 7406 and the corresponding six greens on another). This will keep the 0V current from the chip reasonably steady. Finally put a 100n capacitor between pins 14 and 7 on each 7406. This will decouple the 5 volts supply and remove any spikes.

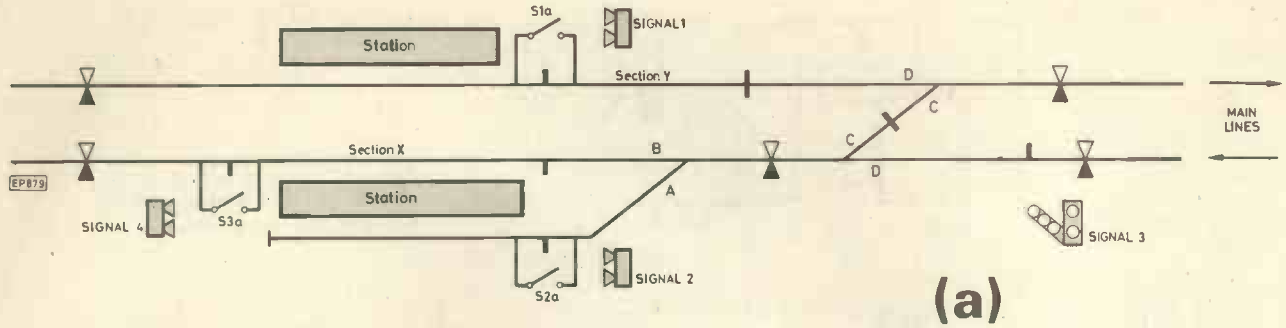
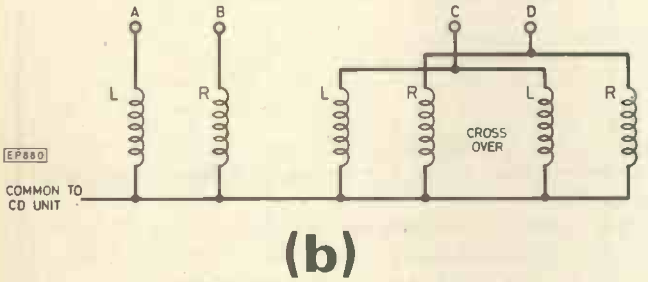
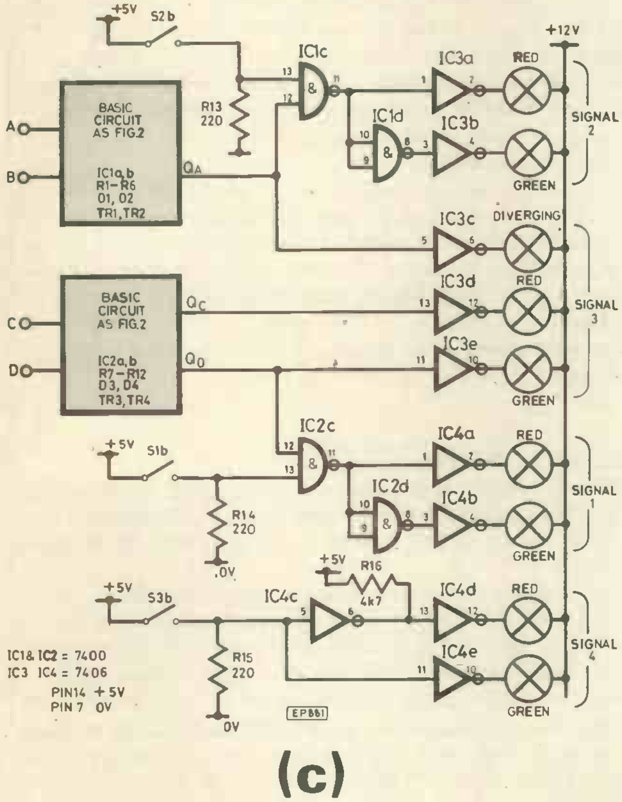


Fig. 4. A section of the author's layout. (a) Railway station layout. (b) Coil configuration. (c) Overall control system





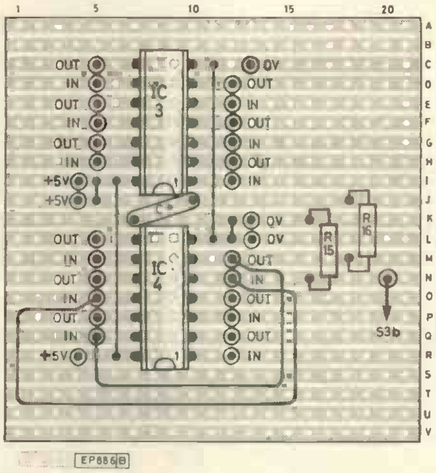


Fig. 5. Driver board. This stripboard, although wired here for the author's layout (R15, R16 & two links) may be used as an uncommitted driver module

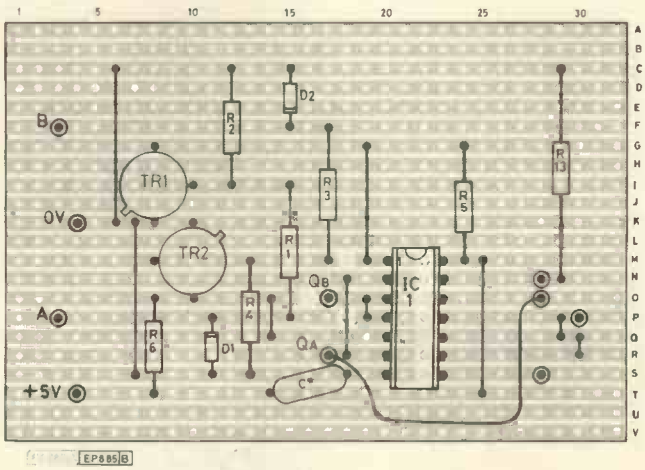


Fig. 6. "Basic circuit" stripboard. Again, this is shown wired for the author's particular application (R13 etc.) but is essentially an uncommitted module with spare board space to the right for wiring up unused gates.

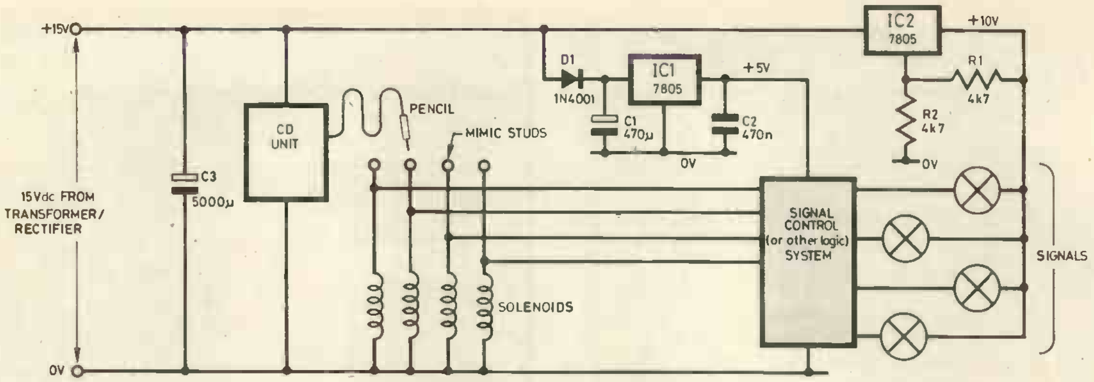


Fig. 7. Power supply circuit diagram

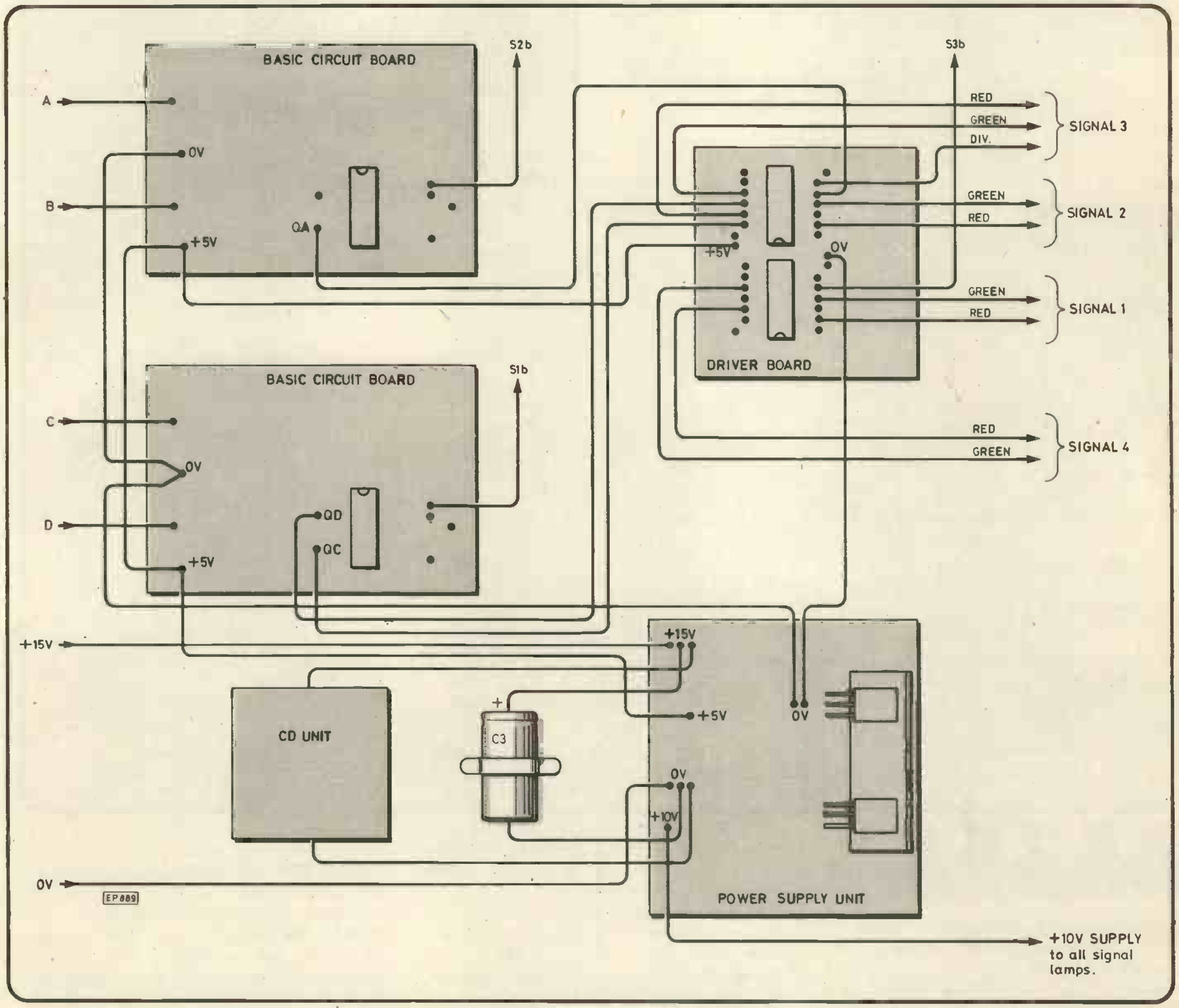


Fig. 8. Inter-module wiring for the railway control system described in Fig. 4. Ground and supply wire routing is critical. The earthing arrangement shown must be adhered to, i.e. logic signal currents and inductive drive currents must be returned separately to the PSU regulator

Noise on the circuit is something that will be peculiar to a particular railway, and it is strongly recommended that the user tries out a simple point circuit to see what precautions are necessary before embarking on a marshalling yard. The author's circuit gave no problems, but there have been some very odd effects with model railways and logic in the past.

It should be noted that at power up, the bulbs will come up in random states. This is no real problem, since the first act on power up should be a quick setting of all points to make sure they are hard over. This will also align the bulbs and points. ★

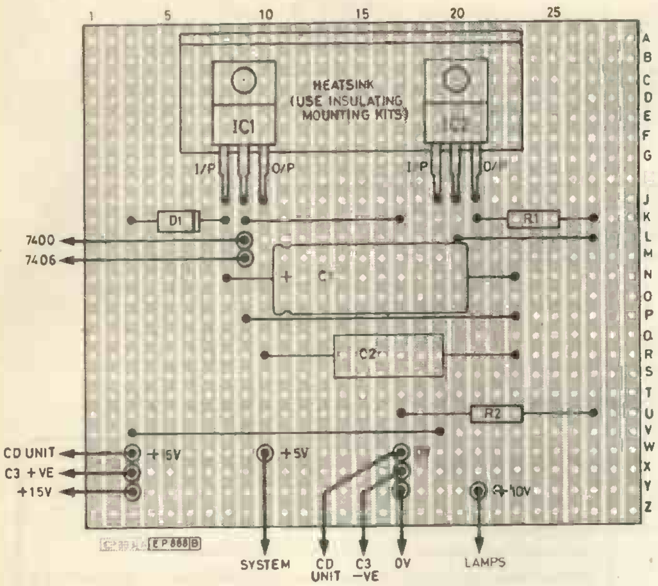


Fig. 9. PSU board stripboard layout

COMPONENTS . . .

PSU BOARD

Resistors

R1, R2	4k7 ¼W 5% (2 off)

Capacitors

C1	470µ/16V
C2	470n
C3	500µ (or 4700µ) 25V elect.

Semiconductors

D1	1N4001
IC1, IC2	7802 regulator (2 off)

Miscellaneous

Stripboard, Veropins etc.
Heatsink (alloy plate)
Insulating kits for regs

BASIC CIRCUIT (two required)

Resistors

R1,R3 (R7,R9)*	22k (2 off) (4 off)*
R2,R4-R6 (R8, R10–R12)*	4k7 (4 off) (8 off)*

All resistors ¼W 5%. *For control system described here

Capacitors

A 100n disc ceramic should be placed across the supply pins of *at least* every other TTL i.c. employed

Transistors & Diodes

TR1, TR2 (TR3,TR4)*	BC107 (2 off) (4 off)*
D1, D2 (D3,D4)*	1N4001 (2 off) (4 off)*

Integrated Circuits

IC1 (IC2)*	7400

Miscellaneous

Stripboard, Veropins etc.
Ins. and 22SWG tinned copper wire

DRIVER

Resistors

R15*	220 ¼W 5%
R16*	4k7 ¼W 5%

*For control system described here

Capacitors

A 100n disc ceramic should be placed across the supply pins of *at least* every other TTL i.c. employed

Integrated Circuits

IC3, IC4	7406 (2 off)

Miscellaneous

Veroboard, Veropins etc.
Insulated wire & 22SWG tinned copper wire etc.

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UK101 8K wooden case with cassette (300/600), fan no flicker video, 1/2MHz, assembler, data dynamics printer £300. Mr. A. Pettitt, 2 Caburn View, Firle, Nr Lewes, Sussex. Tel: Glynde 492.

UK101 cased 8K with MONO2 monitor £120 o.n.o. Also Garrard AP76 record deck £15 o.n.o. Mr. K. R. Hilton, 52 Balmfield, Liversedge, West Yorkshire NF15 7PN. Tel: 0924 402690.

WANTED oscilloscope, must be suitable for TV work and be in good condition. B. Ward, 51 Berry St, Burnley, Lancashire. Tel: 50574.

AUTOMATIC DIAMOND CROSSING CONTROL

Andrew Parr

THE circuit was developed to prevent accidents on a model railway where two tracks cross on a diamond crossing. The layout (greatly simplified) is shown in Fig. 1. The full circuit is actually layout 9 in the *Hornby track circuit book,* 4th edition.

The diamond crossing is also shown on Fig. 1. The crossing points are straddled by two isolated sections. These sections are fed via relay contacts, so with RL1 energised trains can pass on track A; with RL1 de-energised trains can pass on track B.

In the track bed, four light dependent resistors (ORP12) are mounted. These detect the passage of the trains over the crossing and control the relay RL1. The transition from room lighting to train shadow is a more than adequate change for the l.d.r.s to detect.

The circuit for the unit is shown on Fig. 2. If a train passes on track A, LD1 or LD2, or both will go to a high resistance state, and TR2 will turn off, taking point A to a binary 1. Capacitor C1 slugs the change from dark to light so the circuit does not see the gap between coaches, and to allow a single engine to traverse from LDR1 to LDR2. Resistor R7 provides hysteresis to give crisp triggering. A similar circuit detects the presence of a train on track B.

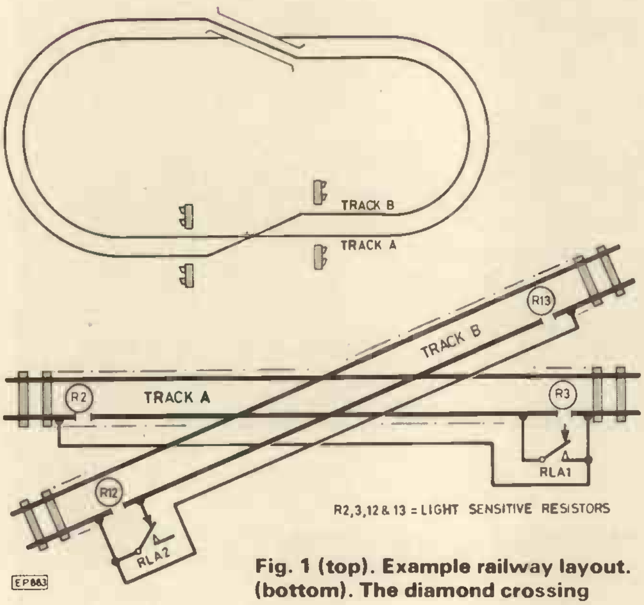

Fig. 1 (top). Example railway layout. (bottom). The diamond crossing

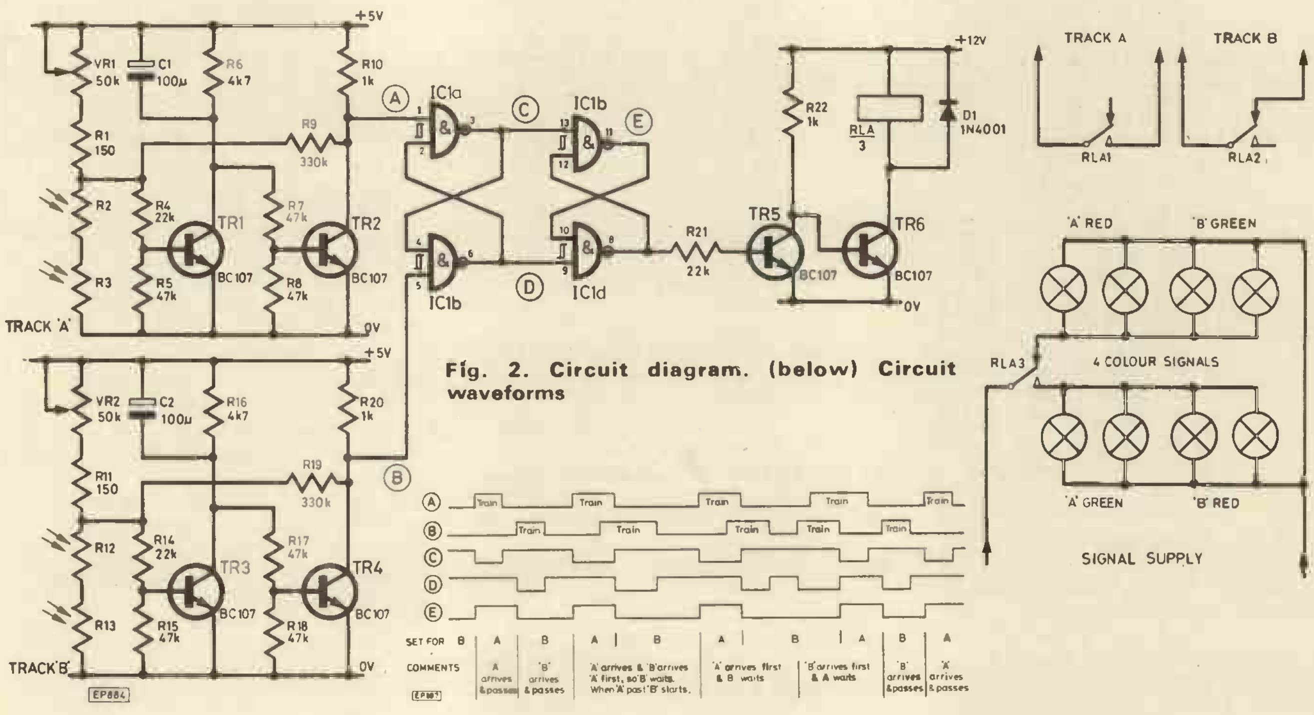

Fig. 2. Circuit diagram. (below) Circuit waveforms

Device IC1a and b forms a "first come first served" circuit when two trains arrive together. If train A arrives first, point C locks out train B's signal until train A has passed. Point D locks out A should B arrive first.

The signals C (A train present) and D (B train present) set and reset the memory ICc and d. This in turn energises and de-energises the relay RL1 to power the requisite section.

Contacts on RL1 also drive the four colour light signals at the crossing. These relay contacts should not be used for semaphore signals which require a pulse output. To drive semaphore signals the contacts should be used to control a CD circuit similar to designs recently published in many electronic and railway modelling magazines.

Also shown on Fig. 2 is a diagram of the behaviour of the circuit. This shows all possible combinations of train movements, and the resulting state of RL1.

The circuit runs on a 12V supply separate and floating from the train supplies. Model railway locos are excellent noise generators, and connecting any logic circuit to a model railway supply is a recipe for disaster. The 5V supply for IC1 is derived from the 12V supply by a 5V regulator i.c. In the author's layout the supplies are designed to be adequate for further automation of the system.

The circuit allows operation with trains moving in any direction. If the crossing is used mainly in one direction the outgoing l.d.r. can be omitted on that track.

The isolated sections should start sufficiently far back from the crossing to allow a train to stop before the crossing. The l.d.r.s should be mounted close to the isolating gap. Distances of the l.d.r. and the isolating gaps from the crossing on Fig. 1 are shown small for convenience. ★

COMPONENTS . . .

Resistors

R1,R11	150 (2 off)
R2,R3,R12,R13	ORP12 l.d.r. (4 off)
R4,R14,R21	22k (3 off)
R5,R7,R8,R15,R17,R18	47k (6 off)
R6,R16	4k7 (2 off)
R9,R19	330k (2 off)
R10,R20,R22	1k (3 off)
All resistors ¼W 5%	

Potentiometers

VR1,VR2	50k lin. (2 off)

Capacitors

C1,C2	100µ elect. (2 off)

Transistors & Diodes

TR1–TR6	BC107 (6 off)
D1	1N4001

Integrated Circuits

IC1	74123

Miscellaneous

Stripboard, Veropins etc.
12V relay. 3 pole c/o

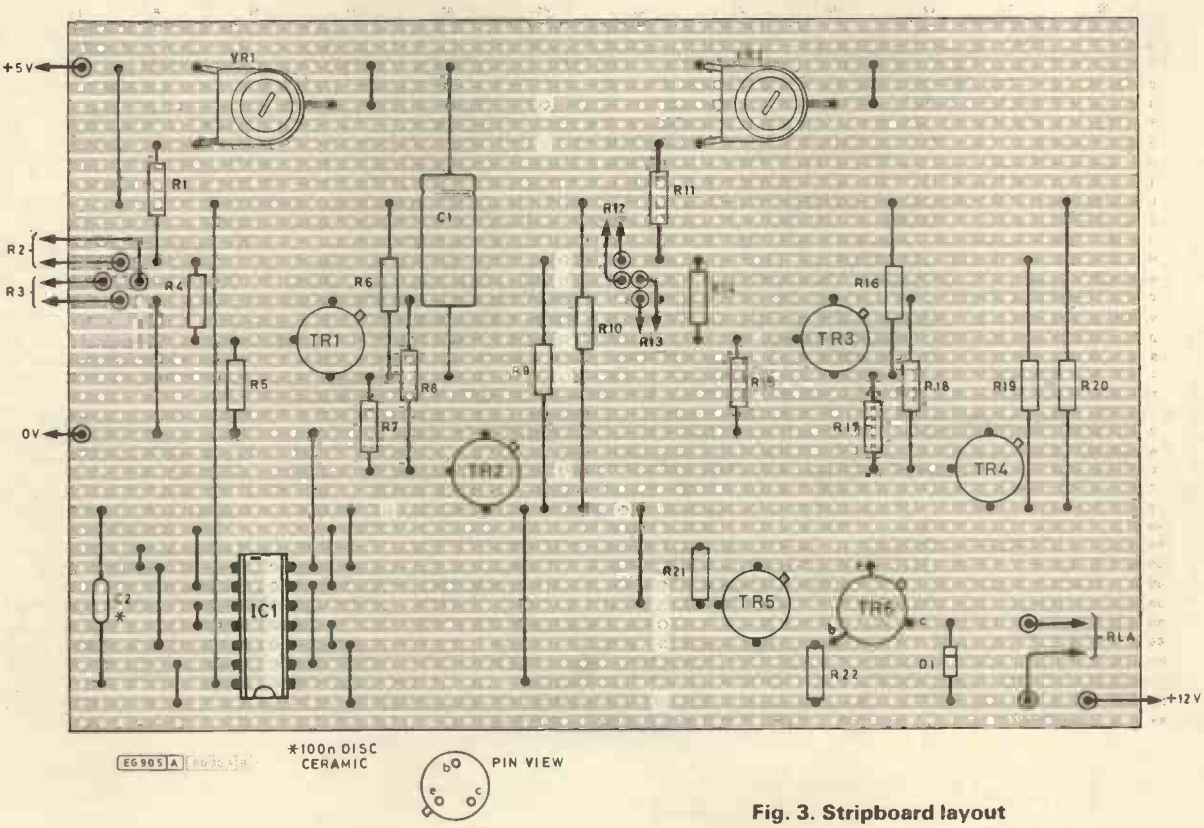

Fig. 3. Stripboard layout

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MICRO-BUS

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Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

THIS MONTH'S Micro-Bus looks at the game of Life, and two different ways of programming it on microcomputers. Also, a dice-throwing puzzle is posed for BBC Microcomputer owners.

LIFE

For those who have not already encountered "Life", it is best described as a "simulation of a society of living organisms". The game was invented in 1970 by *John Horton Conway*, a mathematician at Cambridge University. Starting with an initial configuration of organisms, represented as counters on a grid, rules are applied to determine what happens to the society in successive generations. The three rules are as follows:

Birth: An organism is born in a cell if, in the previous generation, exactly three of its neighbours (horizontally, vertically, or diagonally) were alive.

Death by overcrowding: An organism dies if it has four or more neighbours.

Death by exposure: An organism also dies if it has only one neighbour, or none at all.

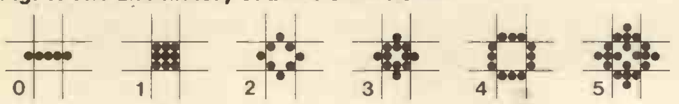
These two rules for death can be summarised more simply in one "survival" rule, as follows:

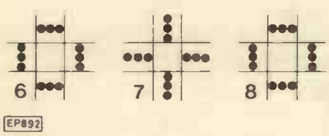
Survival: An organism will only survive to the next generation if it has two or three neighbours.

It is important that these rules are applied to the pattern simultaneously; thus, when programming Life on a computer, it is necessary to calculate the new generation separately from the previous generation, and only when the calculation is complete over the whole grid should the new generation replace the previous generation.

As an example of the types of patterns that can occur, Fig. 1 shows the fate of a society consisting initially of a line of five cells. The final pattern, called "Traffic Lights", alternates indefinitely between two states, and so is said to have a "Life cycle" of 2.

Fig. 1. The Life history of a line of five cells.





The fate of Life patterns is very hard to predict from the initial configuration. Some patterns become stable; for example, a line of seven cells turns into a stable configuration of hexagons called "Honey Farm". Some oscillate between a number of different patterns; for example, a line of ten cells turns into the "Pentadecathlon" with a Life cycle of 15. Some patterns, such as a line of 6 cells, fade away entirely after a few generations. Finally, some patterns continue to grow indefinitely; an example of this is the "Glider Gun", a pattern that "fires" out gliders which remain stable, but move steadily across the grid; see Fig. 2. Some apparently simple patterns have extremely complicated "Life histories", such as the r-pentomino, shown in Fig. 3 (a), which reaches a steady state only after 1102 generations, having emitted 6 gliders in the process! Fig. 3 shows several other interesting patterns whose Life-histories can be investigated with the programs to be described.

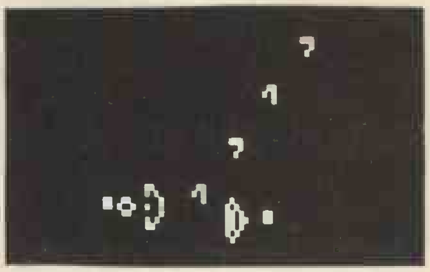


Fig. 2. The Glider Gun fires out gliders which carry on indefinitely.

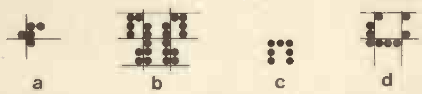


Fig. 3. Four Life patterns with interesting histories:
(a) R-pentomino, lasts for 1102 generations.
(b) Tumblers invert themselves every 7 generations.
(c) Pattern becomes stable after 173 generations.
(d) Spaceship, moves horizontally.

PROGRAMMING LIFE

The obvious way to represent a Life pattern on a computer is as an array of memory locations, whose contents are used to determine whether a cell is alive or dead. This array is scanned, cell by cell, and for each cell the number of neighbours is counted. The count then determines whether the cell will be alive in the next generation. Note that, because the rules are applied to the entire pattern simultaneously, the cell's new state must be stored separately from its previous state while the remainder of the array is scanned. On memory-mapped displays the actual display memory can be used as the array of cells, thus saving memory and avoiding having to copy the array to the screen.

ATOM LIFE

The first Life program is for the Acorn Atom, and was devised by *Nick Toop* of Cambridge. It will process a 64 × 64 array of cells in about a second, and uses a four-colour graphics mode, mode la, in which each memory byte is mapped to four adjacent cells on the screen. Thus two bits determine the colour of each cell on the screen, as shown in Fig. 4. The upper bit of the pair is used for the previous generation, and the lower bit is used to store the new generation as it is calculated. The method has the additional feature of appearing very colourful during the processing of a pattern.

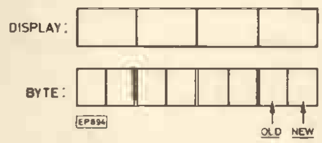


Fig. 4. The assignment of bits to Life patterns in the program of Fig. 5.

LIFE PROGRAM

The program, shown in Fig. 5, uses the Atom's built-in assembler to code the main routine, LL11, into machine code. This routine is called from a simple BASIC program in lines 510 to 700; this draws a 53 × 53 cross on the screen as the starting pattern, and then calls the machine-code routine to calculate successive generations (unless interrupted by typing the SHIFT key). One generation is shown in Fig. 6.

The program works as follows: routine LL11 (lines 430 to 470) sets up the coordinates of each cell in XX1 and XX2, and calls LL1 to process that cell. Routine LL0 takes the coordinates of the cell, and calculates the address of the byte containing that cell in C, with the position of the pair of

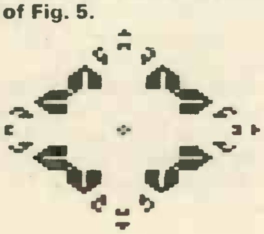
```
  1 REM LIFE
 40 DIM LL20,XX2,CC2
 50 C=#80;D=#81;M=#82;S=#86
 52 T=#87;!M=#2082080
 54 XX1=#88;XX2=#89
 56 CC1=#8A;CC2=#8B
100 P.$21;F.I=0TO1;DIMP-1;[
105\ GET ADDRESS AND MASK
110:LL0 LDA XX2;STA D
120 LDA XX1;ASLA;ASLA;LSR D
130 RORA;LSR D;RORA;LSR D
140 RORA;SEC;ROR D;RORA;STA C
150 LDA XX1;AND@3;TAX;LDY@0
160 RTS
165\ TEST LOCATION XX1,XX2
170:LL1 LDA@0;STA S;DEC XX1
180 DEC XX2;LDA@3;STA CC2
190:LL2 LDA@3;STA CC1
200:LL3 JSR LL0;LDA(C),Y
210 AND M,X;BEQ LL4;INC S
220:LL4 INC XX1;DEC CC1
230 BNE LL3;DEC XX1;DEC XX1
240 DEC XX1;INC XX2;DEC CC2
250 BNE LL2;DEC XX2;DEC XX2
260 INC XX1;JSR LL0;LDA(C),Y
270 AND M,X;BEQ LL5
275\ CELL PRESENT
280 SEC;LDA S;SBC@3;BMI LL6
290 SBC@2;BPL LL6
295\ WILL LIVE
300:LL7 LDA M,X;LSRA
304 ORA (C),Y;STA(C),Y;RTS
308\ WILL DIE
310:LL6 LDA M,X;LSRA;EOR@#FF
312 AND (C),Y;STA (C),Y;RTS
315\ CELL ABSENT
320:LL5 SEC;LDA S;SBC@3
330 BMI LL6;SBC@1;BPL LL6
340 JMP LL7
370:LL9 LDY@0;STY C;LDA@#80
380 STA D;LDX@4
390:LL10 LDA(C),Y;AND@#55
400 ASLA;STA(C),Y
410 INC C;BNE LL10;INC D
420 DEX;BNE LL10;RTS
430:LL11 LDA@#3E;STA XX2
440:LL12 LDA@#3E;STA XX1
450:LL13 JSR LL1;DEC XX1
460 BNE LL13;DEC XX2;BNE LL12
470 JSR LL9;RTS
500];N.;P.$6
510 CLEAR1;COLOUR3
520 MOVE32,6;DRAW32,58
530 MOVE6,32;DRAW58,32
600 DO LINK LL11;UNTIL ?#B001<>#FF
700 G.700
```

Fig. 5. Complete colour Life program for the Atom.

bits in that byte in the X register. The state of the cell can then be read (in lines 200 and 210) by the sequence: LDA (C), Y; AND M, X where M is a vector containing the appropriate masks to mask off each pair of bits.

The number of live neighbours is counted in S by testing the eight cells around the central cell (XX1, XX2) in lines 190 to 270. The survival rules are implemented in lines 275 to 340. Finally, when the new generation has been calculated for the whole grid, routine LL9 (lines 370 to 420) shifts the new generation over the old generation.

Fig. 6. Pattern in the Life history of a 53 × 53 cross, displayed by the program of Fig. 5.



LIFE ON THE BBC MICRO

The second Life program, shown in Fig. 7, plays Life on the BBC Microcomputer using the Teletext screen of 25 lines by 40 cells. Live cells are represented by an asterisk, and empty cells by a space. Since this program uses one byte per cell it is less efficient on memory than the previous Atom program, but it is much faster, processing approximately 12 generations per second. On the Teletext screen the value of the top bit is ignored; this is used to store the state of the previous generation, with a '1' indicating that the cell was alive.

```
 10 REM Life
 20 DIM MC%200
 30 screen=&7C00: bottom=&7F98
 40 pointer=&70: temp=&72: counter=&73
 50 FOR I%=0 TO 2 STEP 2
 60 P%=MC%
 70 [
 80 OPT I%
 90 .life LDA #screen AND 255
100       STA pointer
110       LDA #screen DIV 256
120       STA pointer+1
130 .line LDA #38
140       STA counter
150 .cell LDY #0 next cell
160       LDA (pointer),Y '1'
170       AND #&80 get top bit
180       LSR A
190       STA temp
200       INY
210       LDA (pointer),Y '2'
220       LSR A
230       AND #&C0
240       ADC temp
250       STA temp
260       INY
270       LDA (pointer),Y '3'
280       LSR A
290       AND #&C0
300       ADC temp
310       STA temp
320       LDY #40 next line
330       LDA (pointer),Y
340       LSR A
350       ADC temp '4'
360       ROR A
370       LSR A
380       LSR A
390       LDY #42
400       CLC
410       ADC (pointer),Y '5'
420       LDY #80 next line
430       ADC (pointer),Y '6'
440       AND #&38
450       INY
460       ADC (pointer),Y '7'
470       INY
480       ADC (pointer),Y '8'
490       STA temp
500       LDY #41
510       LDA (pointer),Y centre cell
520       AND #8
530       ORA temp
540       AND #&38 no. of neighbours
550       TAX   in bits 3, 4, and 5
560       LDA (pointer),Y
570       ASL A save old state
580       ASL A   in top bit
590       ASL A
600       ASL A
610       CPX #24 three empty?
620       BNE no
630       ORA #&0A a star is born
640 .no   ORA #&20
650       STA (pointer),Y
660       INC pointer
670       BNE high
680       INC pointer+1
690 .high DEC counter
700       BNE cell
710       INC pointer add 2 at boundary
720       BNE not
730       INC pointer+1
740 .not  INC pointer
750       BNE not2
760       INC pointer+1
770 .not2 LDY pointer+1 all done?
780       CPY #bottom DIV 256
790       BNE line
800       LDX pointer
810       CPX #bottom AND 255
820       BCC line
830       RTS
840 ]
850 NEXT
860 REM DEMONSTRATION
870 CLS
880 VDU23;10,32,0;0;0;
890 PRINT TAB(9,12);"***** ***** *****"
900 REPEAT CALL life: UNTIL GET=0
```

Fig. 7. Fast Life program for the BBC Microcomputer.

The program works as follows: for each cell the characters in the eight surrounding cells are added together. These cells are identified in the program as '1', '2', etc. A two-bye zero-page pointer, called 'pointer', contains the address of cell '1'; the contents of the other cells are obtained from this by indexed indirect addressing using the Y register. The variable 'temp' is used to count the number of neighbours, and the previous state of the cell is then saved in the top bit. As in the Atom version the program includes a short BASIC program to set up a starting pattern—in this case four dashes of five cells each—and this calls the machine-code repeatedly until ESC is pressed. A BASIC "Etch-a-Sketch" routine could be added to either of the above programs so that patterns could be drawn from the keyboard using four keys as cursor controls.

LIFE PROBLEMS

Although a large amount of research has been put into investigating the fate of different Life patterns, many problems remain unsolved that can profitably be investigated on micros. For example, can patterns be discovered with any arbitrary Life cycle? Can one predict how a line of a certain number of cells will behave? Can one create, to order, patterns that will fade away after any chosen number of generations? And, what is the largest increase in size that a pattern can achieve if its eventual fate is to fade away completely?

DICE PUZZLE

A problem is posed for owners of the BBC Microcomputer: write the shortest possible program that will print up a random dice face, in true 3 by 3 format, every time a key is pressed. The size of the program should be measured by typing:

PRINT TOP-PAGE

As an example of what can be achieved, Fig. 8 shows a solution, devised by *Tim Dobson* of Warrington, that takes 96 bytes. Some sample throws produced by this program are shown in Fig. 9. The function in the PRINT statement returns the ASCII code for an 'o' or a space depending on A%, the face number, and B%, the dot position number.

The next Micro-Bus will present a solution that takes several bytes less than this, and we invite readers to submit their attempts before then.

Fig. 8. Dice-throwing program for the BBC Microcomputer.

```
10WIDTH3:REPEATA%=RND(6):FORB%=0TO14:
PRINTCHR$(32+79*(((A%AND1)*16-(A%>1)*68-
(A%>3)*257-(A%=6)*40)DIV2^B%AND1));:NEXT
:UNTILGET=0
```

Fig. 9. Some random dice throws printed by the program of Fig. 8.

DRAWING STARS

The final topic in this month's Micro-Bus is a pattern-drawing program which can produce a great variety of attractive patterns. The program, shown in Fig. 10, was designed by *J. Huxtable* of Herts for the BASIC on an Apple II, but is very easily altered for any other machine with high-resolution graphics.

The pattern is determined by 6 parameters, and some sample plots for different values of these are shown in Fig. 11. The parameters are as follows:

WX and WY determine the size of the hole in the centre of the pattern. The smaller they are the larger the hole.

ANGLE determines the angle between the arms of the pattern and hence the number of points to the star. For example, if ANGLE is 60 then the pattern will have 360/60 or 6 points.

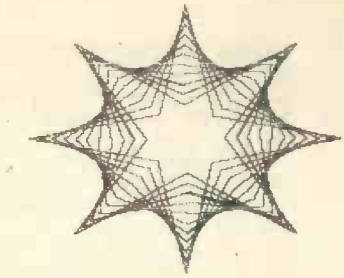
N is the number of lines drawn in each arm. A value of about 10 gives the best effect.

RX and RY determine the size of the pattern in the X and Y directions respectively.

The program should translate directly to other BASICs: the only statements peculiar to the Apple are HGR, which selects the high-resolution graphics mode and clears the screen, and HPLOT x1,y1 TO x2,y2 which plots a line from (x1,y1) to (x2,y2). Note also that MX and MY should be set to the coordinates of the centre of the screen.

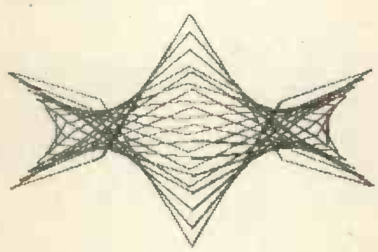
Fig. 10. Stars program for the Apple II.

```
10  REM     STARS
20 RX = 90:RY = 90
30 WX = 4:WY = 4
40 MX = 120:MY = 90
50 N = 10
60  INPUT "ANGLE: ";A:ANGLE = A / 57.28
70  HGR
80 X = MX:Y = MY + RY
90 X1 = MX:Y1 = MY + RY / WY
100 D1 = (X - X1) / N:E1 = (Y - Y1) / N
110  FOR I = 1 TO 10
120 T = T + ANGLE
130 X2 = MX + RX *  SIN (T):Y2 = MY + RY *  COS (T)
140 X = (X2 - MX) / WX + MX:Y = (Y2 - MY) / WY + MY
150 D2 = (X - X2) / N:E2 = (Y - Y2) / N
160  FOR A = 0 TO N
170  HPLOT X1 + D1 * A,Y1 + E1 * A TO X2 + D2 * A,Y2 + E2 * A
180  NEXT A
190 X1 = X:Y1 = Y:D1 =  - D2:E1 =  - E2
200  NEXT I
```

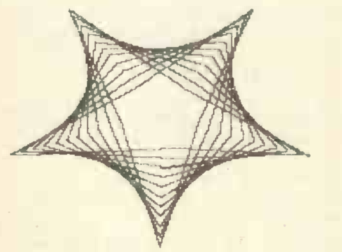


WX=4 WY=4 ANGLE=45 N=10 RX=90 RY=90

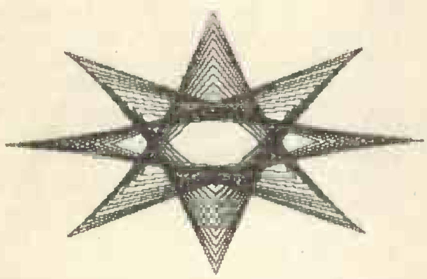
Fig. 11. Altering the parameters in the Stars program produces a variety of interesting patterns.



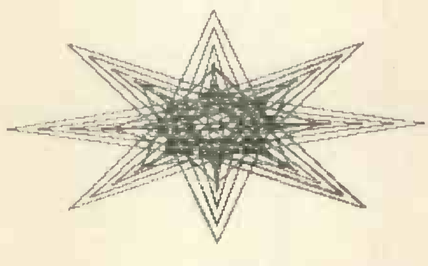
WX=2 WY=-2 ANGLE=60 N=10 RX=120 RY=80



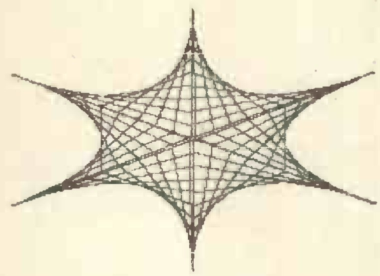
WX=4 WY=4 ANGLE=72 N=10 RX=90 RY=90



WX=2 WY=3 ANGLE=135 N=10 RX=120 RY=90



WX=-2 WY=-2 ANGLE=45 N=10 RX=120 RY=80



WX=100 WY=100 ANGLE=60 N=10 RX=120 RY=90

BAZAAR

OSCILLOSCOPE Heathkit model IO 4540 solid state 5MHz single beam. Superb condition with probe £90. B. A. Adkinson, 22 Heron Close, Eastbourne, Sussex. Tel: 0323 766477.

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WANTED circuit diagram Dynamco oscilloscope D7100 D7110 including Y amplifier, timebase, also parks to suit. D. R. Taylor, 3 Abbotsgrange Rd, Grangemouth FK3 9JD. Tel: 0324 48 3153.

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Ingenuity Unlimited

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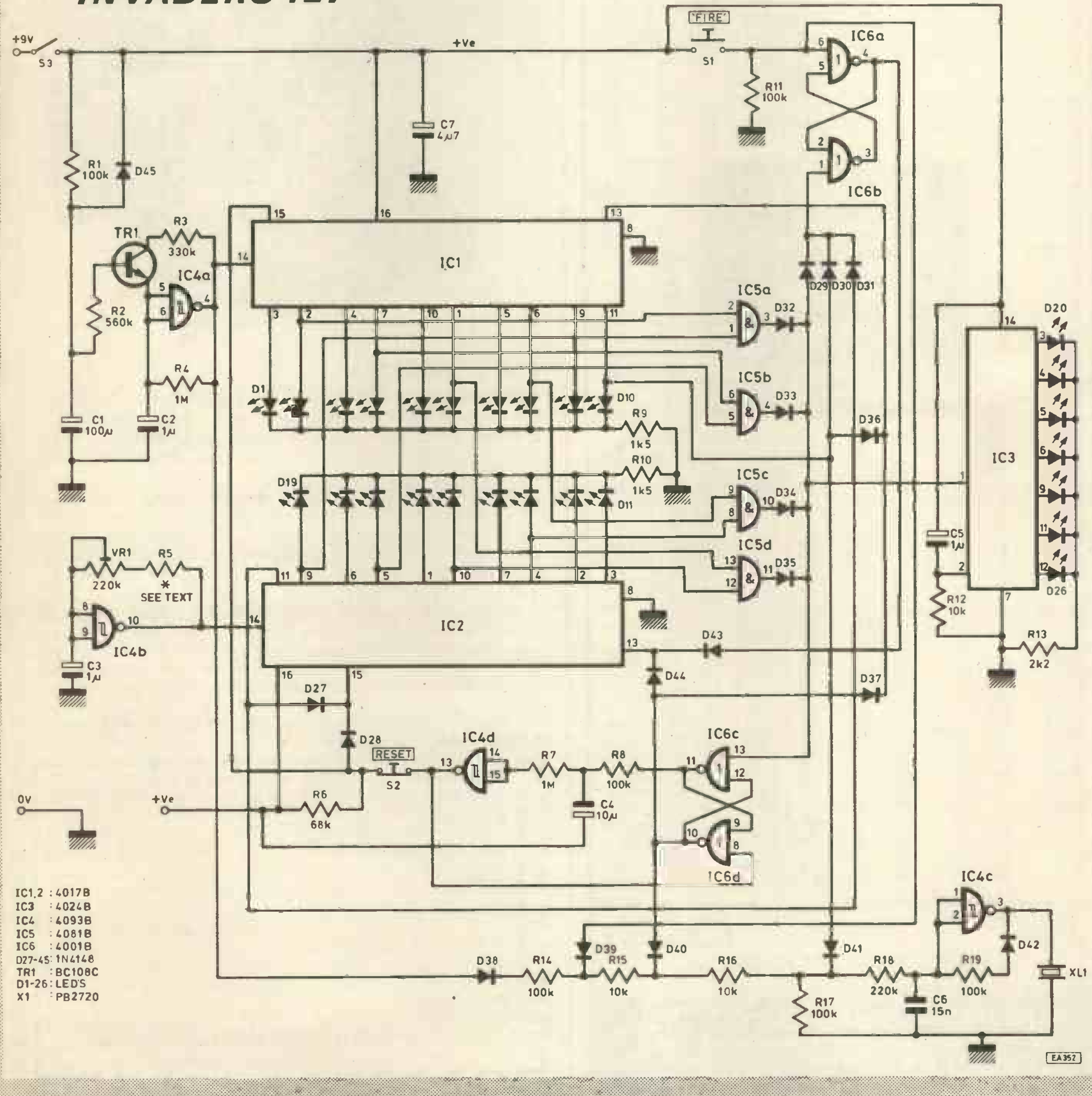
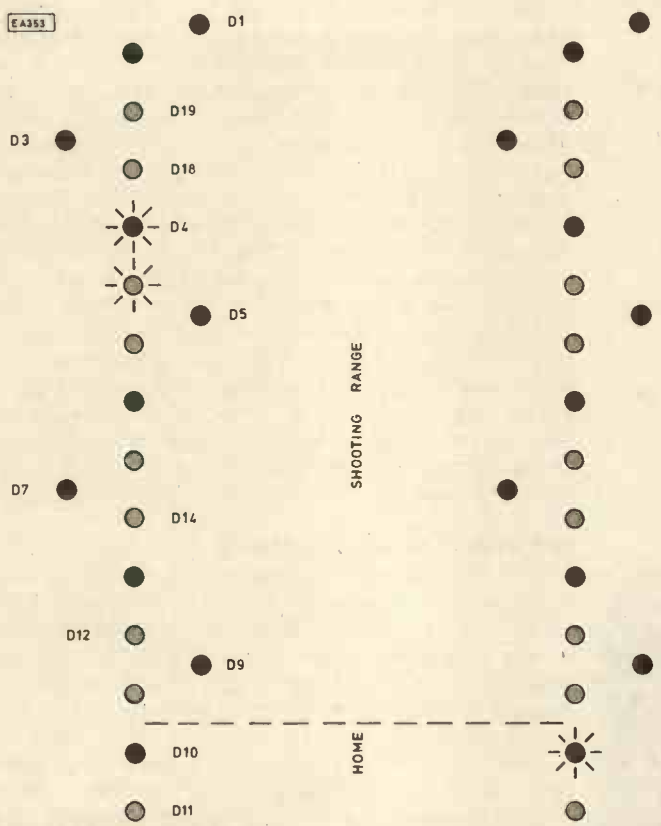
Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

INVADERS 127





IC1 and IC2 are both decade counters which respectively display the attacking invader and the launched missile. IC4a is wired up as a voltage controlled low frequency oscillator which gradually increases the rate at which the invaders are moving. IC4b on the other hand is a presettable low frequency oscillator which controls the speed of the launched missiles, being adjustable by VR1 (decreasing R5 to 68k is also possible).

When S1 is depressed, IC6a-b bistable enables IC2 decode counter which displays the launching of a missile. If a 'hit' occurs one of the sets of AND gates — IC5 — will go high thus resetting bistable IC6a-b and clocking IC3 ripple counter to add 1 to the score. Meanwhile the monostable formed around IC6b, c, d and IC4d has been triggered; and after approximately 1 second, IC4d goes high resetting both decode counters thus eliminating the high logic level on IC6c input. Once IC4d output goes low again, another invader begins to fall and S1 is ready again.

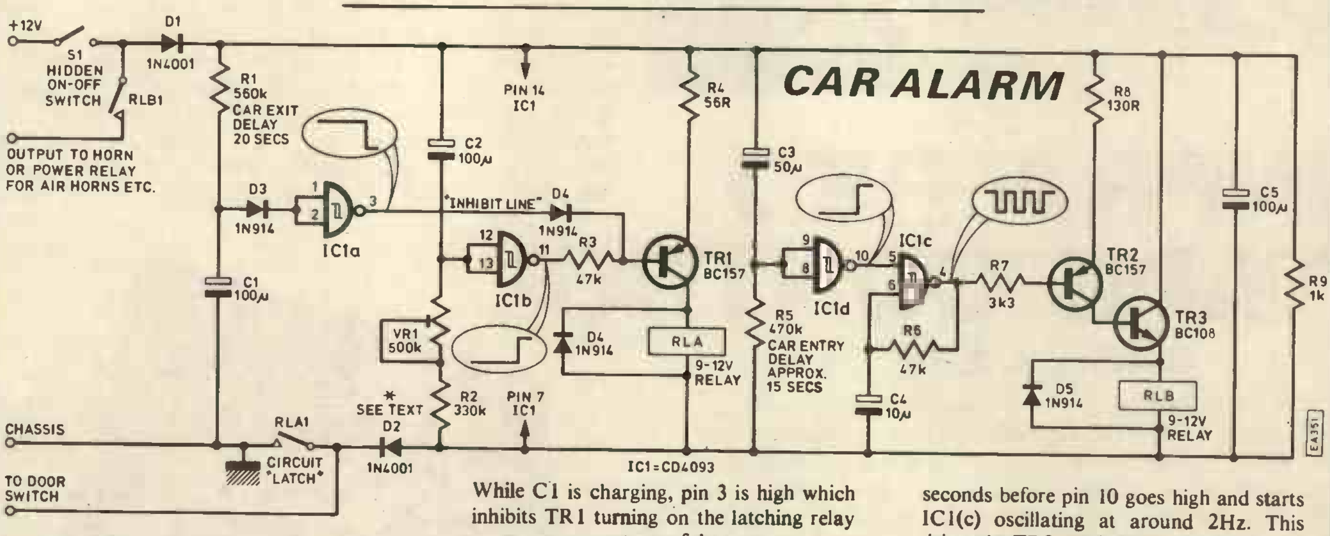
The circuit around IC4c is another VCO but in this case is used to drive a piezo ceramic transducer (PB2720), which is the basis of the simple sound effects.

If an invader knocks out your missile launcher the game is over unless you want to cheat by recommencing the game without affecting the score. This is achieved by the depression of S2. The maximum possible score is 127 before recycling back to zero, although it can be replaced by a CMOS 4040B with extra l.e.d.s to give a possible score of 4095.

Fig. 2 illustrates the arrangement of l.e.d.s and the situations encountered.

W. Leung,
Harlow,
Essex.

CAR ALARM



This burglar alarm is infallible — it cannot be triggered by anything other than a car door being opened. It provides an exit delay of about 20 seconds and an entry delay of around 15 seconds. If after this entry delay the alarm has not been switched off the horn will sound intermittently for up to one minute.

The circuit consists of an exit delay provided by IC1(a) which is a Schmitt trigger and the combination of C1 and R1. (Time delay can be calculated at T=CR).

While C1 is charging, pin 3 is high which inhibits TR1 turning on the latching relay — so you can get out of the car.

TR1 is turned on by a door being opened — by this time C1 will have charged up so pin 3 is now low and won't inhibit TR3 anymore. Similarly pin 11 is also low as the Schmitt trigger delay circuit provided by C2 and VR1/R2 is still charging. So TR3 turns hard on and the RLA1 latches the circuit to chassis. Even if the car door is now closed, it's too late.

IC1(d) is also a delay circuit — you don't want the alarm to sound the moment a door is opened, so you have about 15 seconds before pin 10 goes high and starts IC1(c) oscillating at around 2Hz. This drives the TR2, TR3, RL8 combination.

When C2 has charged up, IC1(b) pin 11 will go high — turning off TR1, making the RLA1 drop out and once again totally isolating the circuit, ready for the next intruder!

Don't try replacing the Schmitt triggers with normal NAND gates because IC1(d) won't oscillate — you'd need two NAND gates to make this oscillator.

R. S. Bacon,
Enfield,
Middlesex.

INFRA-RED TAPE CONTROL

CHRIS LARE

AN INCREASING number of pieces of domestic entertainment equipment are controlled from "light touch" switches. These switches are not true touch switches in the electronic sense but merely single pole mechanical switches in which the action is very light and generally non-latching. The trend towards this type of switch is particularly marked in tape recorders, and the implication is that a remote control system which generates the same electrical signals as the mechanical switch can be added without too much difficulty. Some tape recorders go so far as to provide a socket for this purpose, although those which don't can be easily modified.

A remote control facility can be as simple as a multicore cable stretched across the floor, although the disadvantages of this (apart from cheapness) are obvious. The design presented here is for an infra red remote control system primarily designed to interface to a tape recorder fitted with these light action switches.

TAPE RECORDER INTERFACE

Before embarking on the design it was necessary to establish how the light action switches function. In the tape recorder in question (Pioneer CT-200) each of the mechanical switches grounds an input to a control integrated circuit. The circuit develops from this any necessary latched signals to drive the motor, function solenoids, and signal routing in the amplifiers. Six such inputs are generally used, referred to as Stop, Play, Record, Pause, Forward and Rewind, although Record must always be used in conjunction with Play or Pause. A simple experiment showed that the inputs in question could be driven from an open collector transistor and so this interface was adopted. On no account should the inputs be driven from an active high source such as a CMOS gate because voltage level differences could well cause the destruction of the control integrated circuit. Fig. 1 shows the configuration intended. If other switching systems are required a simple redesign of the driver section can accommodate most functions, even if a CMOS switch is required to take care of strobed or multiplexed systems.

THE TRANSMITTER CIRCUIT

Infra-red transmission was chosen for reasons of economy and reliability. Fortunately the design is much simplified by a set of integrated circuits designed specifically for remote control applications such as this. The transmitter is built around an SL490, and as can be seen from the circuit diagram an absolute minimum of extra components are required around it.

This transmitter can be used with up to 32 channels due to the method of coding up the input switches, which uses 5 binary bits which are then transmitted sequentially using pulse position modulation. In this application only six of these codes are used, although a further ten are readily available at the receiver if required. Fig. 2 shows the method of connecting the 32 switches to the i.c. Each switch position corresponds to a 5 bit binary number indicated by EDCBA where A is naturally the least significant. The transmission itself takes the form of six d.c. pulses, and by varying the time between each pulse the binary information is coded onto this pulse train. Fig. 3 shows a typical 5 bit sequence, the ratio of 2:3 determines if a '1' or '0' is being sent. Each set of 5 bits is separated by a space

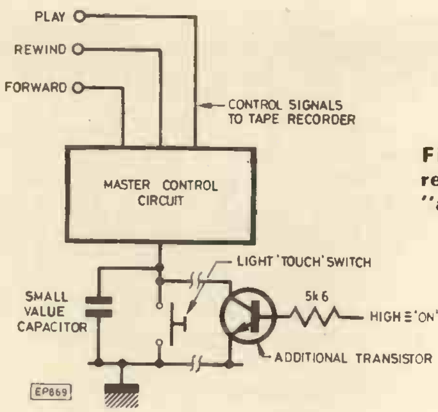


Fig. 1. Adding remote control to an "active low" system

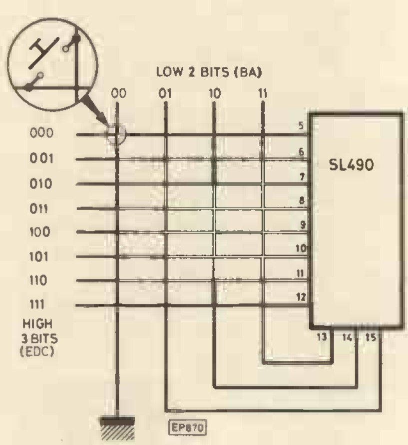


Fig. 2. Complete transmitter matrix

corresponding to a ratio time of :6. The transmitter generates this code whenever a switch is pressed, but the code generated if two switches are pressed simultaneously is not valid. The same transmitter can be used for ultrasonic transmission where the d.c. pulse is replaced by a burst of ultrasonic, the modulation frequency of which is generated by the i.c. itself.

The codes employed in this design correspond to binary counts of 1–6. Code Zero is not used because of the design of the receiver. The timing of the transmitter is based around an internal oscillator which uses C1 and R2 to generate the required frequency. The component values for this are a fairly arbitrary choice, although the receiver requires a related oscillator. Pin 18 is grounded via a 2k2 resistor; a time constant would be attached here to generate a carrier for an ultrasonic transmitter if required. The output from pin 2 is used to drive a transistor which switches on two infra-red l.e.d.s. A "transmission in progress" indication was fitted on the prototype using a green l.e.d. and associated series resistor across the infra-red l.e.d.s and their resistor. Decoupling in the form of a100n capacitor and a 100µ tantalum capacitor is necessary to help absorb the current pulses required to drive the l.e.d.s.

One major feature of this transmitter is that it consumes virtually no current unless a switch is pressed, and it is perfectly in order to power it from a small 9 volt battery such as a PP3. Note that C3 must be a tantalum type since an electrolytic would flatten the battery because of the leakage currents which would flow through it.

TRANSMITTER CONSTRUCTION

The transmitter was housed in a fairly small white plastic box. Undoubtedly a smaller box could have been used but it was considered that the time spent looking for such a box down the back of chairs would obviate any advantages of owning a remote controller. All the components fit on one single sided p.c.b., which is held into the box by means of the nuts on the switches. The leads on the l.e.d.s should be formed for the holes drilled and the switches should be attached on short lengths of tinned copper wire rather than terminal pins to allow for a small amount of movement during final assembly. The battery was held in place with the bottom of the box and a small piece of foam rubber which was glued in place.

THE RECEIVER CIRCUIT

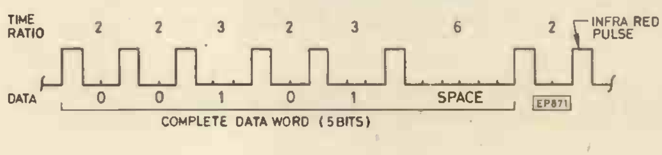
The receiver uses slightly more components than the transmitter although the number is still low considering the complexity of the functions available. The receiver consists of three sections, detector and amplifier, pulse decoder, and discrete line decoder.

In common with many designs a SFH205 photodiode detector is employed. This has the advantage that it is packaged in a material which helps filter out ambient light without affecting the passage of infra red signals. Even so the detector should be placed in a position where direct light does not fall on it, probably most easily accomplished by recessing it in a panel. A further point to note is that the sensitive face of this detector is the curved side and not, as might be expected, the flat side. The diode is used in photo voltaic mode, and the minute signals are amplifed by a SL480 infra red preamplifier. This amplifier is part of the set of circuits for this purpose and interfaces directly to the following decoder stage.

The amplifier has a high input impedance (20M) and high gain 100dB) and so some care must be taken with the layout of the design to avoid stability problems. To this end an earth plane was left under the components in the amplifier section by using a double sided p.c.b. linked through with a pin to the earth track on the layout side. The gain of this device is split into three stages, each of which is decoupled with a capacitor, and in the case of the second stage, with an additional resistor which determines the overall gain of the device. The output from this amplifier is connected directly to an ML926 receiver decoder circuit. This decodes the regenerated pulses into 4 lines of BCD (Binary Coded Decimal), and therefore operates at full capacity with the first 16 transmitter switches. A 15p capacitor on the pulse input was found to improve the ability of the preamp/decoder combination to obtain valid data. The floating outputs of the decoder are pulled down by three 100K resistors unless a valid code is received in which case the relevant information is placed on the outputs by driving the '1' bits high. In this application the D output is ignored.

The receiver decoder required a clock frequency of 40 times that of the zero time of the transmitted pulse train. This should be within 10% of the exact value and a preset is included to make adjustment possible. The clock generator is similar to that in the transmitter. The receiver works by detecting the first pulse of a sequence and then comparing an internal count with the time to the following pulse. Two

Fig. 3. Pulse position modulation



correct and consecutive 5 bit data sets are required to change the outputs.

Several other decoders besides the ML926 used here are made by Plessey. These decoders offer a variety of functions and the choice of decoder will depend on the end design. For obvious reasons those decoders with analogue outputs tend to be more expensive than the purely digital versions. Each of the analogue outputs corresponds to two of the transmitted codes, one code being increase, the other decrease. Table One shows the full set of decoders which may be used with the SL490 transmitter.

Table 1. Full set of decoders available

ML 920	20 digital outputs and three analogue channels*
ML 922	10 digital outputs and three analogue channels*
ML 923	16 digital outputs and one analogue channel*
ML 924	Raw 5 bit code output as transmitted
ML 925	Multi function controller intended for remote control toys
ML 926	Momentary outputs from codes 1–16
ML 927	Momentary outputs from codes 17–32
ML 928	Latched outputs from codes 1–16
ML 929	Latched outputs from codes 17–32

*Some of the digital outputs are special function such as standby switching.

The BCD information from the decoder is then fully decoded into 6 discrete lines by a 4208 eight-from-three selector. Output 0 is not used since this corresponds to all three inputs being low and hence corresponds to the inactive state of the system. It could, however, be used for a form of Transmission Received indicator since it will go high every time a valid transmission is received. Note that the channel chosen for Record sets the "record" transistor and the "pause" transistor on by means of a couple of diodes. This is necessary since pressing Pause and Record on the transmitter will result in an invalid code being transmitted, but the tape recorder logic expects Record to be used with either Play or Pause and thus ignore the Record signal on its own.

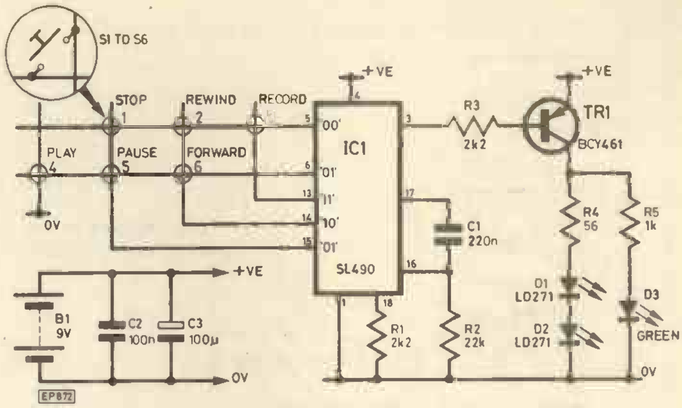


Fig. 4. Transmitter circuit

Obviously the diodes could be connected in the play line, or a separate signal used if required. Note also that the BCD outputs do not correspond to the relevant BCD inputs of the 4028. This was done to facilitate p.c.b. design, but obviously has no effect on the final system although some care must be taken when tracing signals through.

The actual output stages consist of open collector transistors as required in the initial specification.

The board was designed to run off a rough 20 volt supply, although a 15 volt supply can be used if available. The board develops its own 15 volt supply via a resistor/Zener dropper and the usual decoupling capacitors. An additional ceramic capacitor is mounted adjacent to the preamplifier.

RECEIVER CONSTRUCTION

The receiver was constructed on a printed circuit board with an earth plane around the area of the preamplifier. It was not boxed since it is likely to be installed in existing equipment. Do not forget to insert the pin to earth the top plane and note that the i.c.s are aligned differently.

Fig. 5. Infra-red receiver and decoder circuit

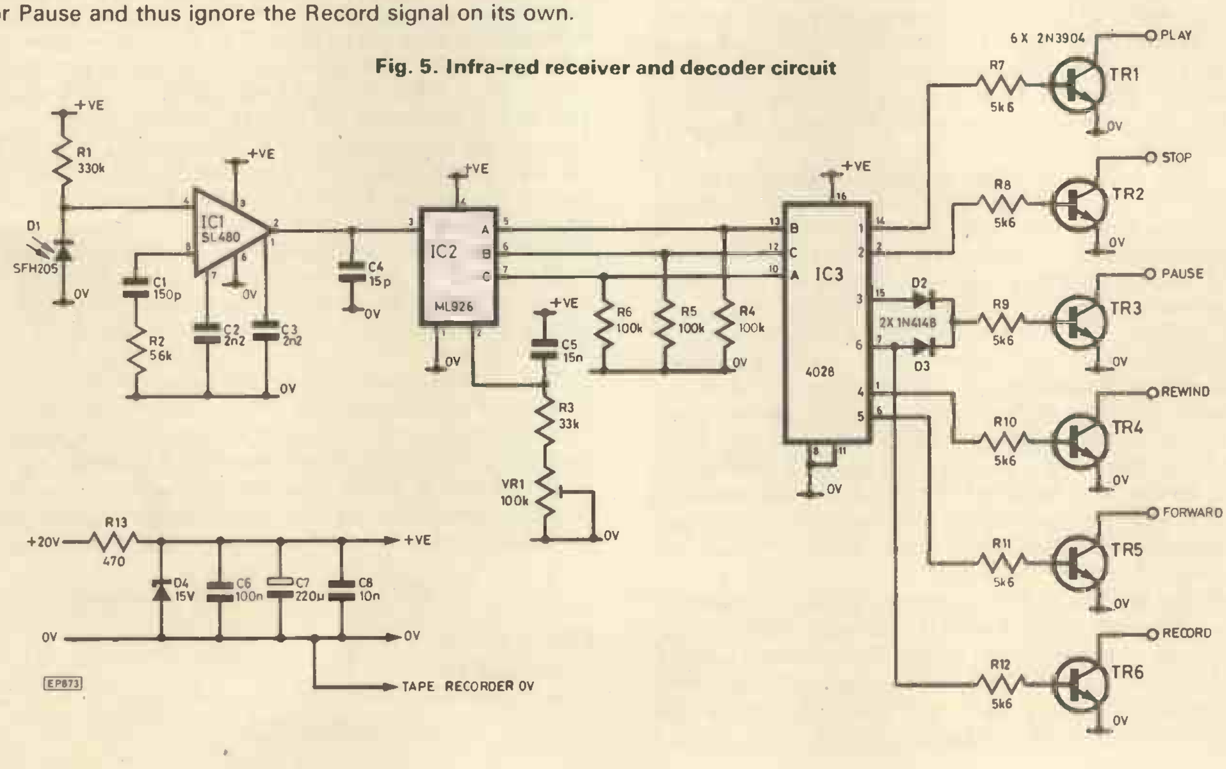


Fig. 6. Transmitter printed circuit (actual size)

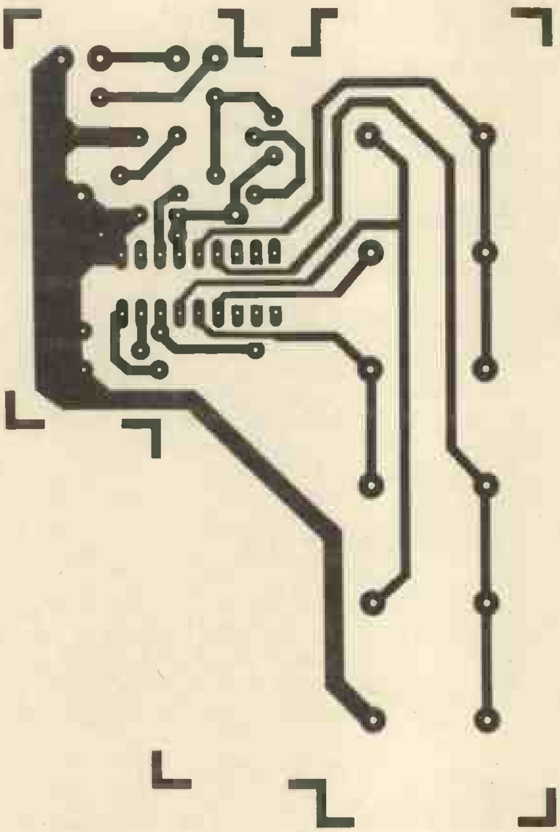
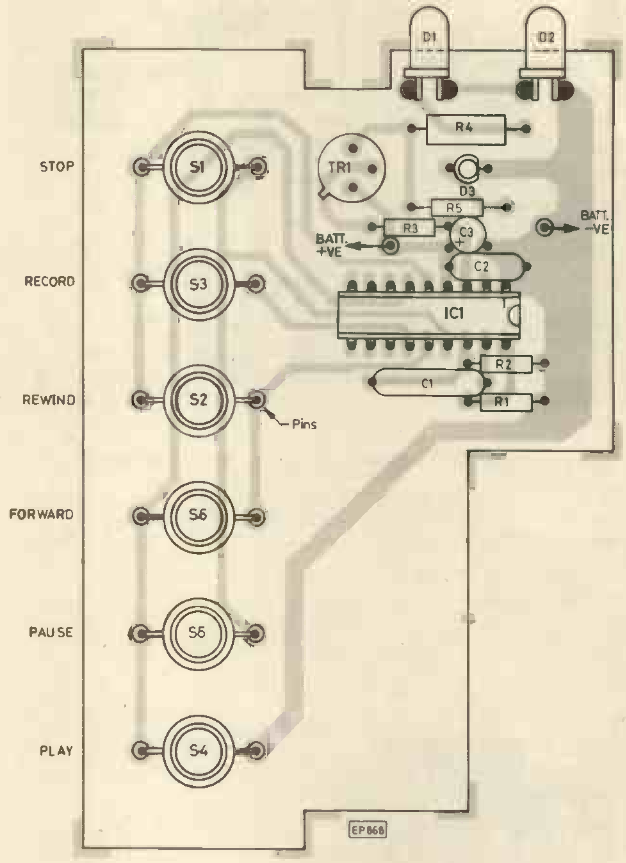


Fig. 7. Transmitter component layout



COMPONENTS . . .

TRANSMITTER

Resistors

R1, R3	2k2 (2 off)
R2	22k
R4	56
R5	1k

All resistors are $\frac{1}{4}$W 5%

Capacitors

C1	220n C280 polyester
C2	100n C280 polyester
C3	100µ 10V tantalum

Semiconductors

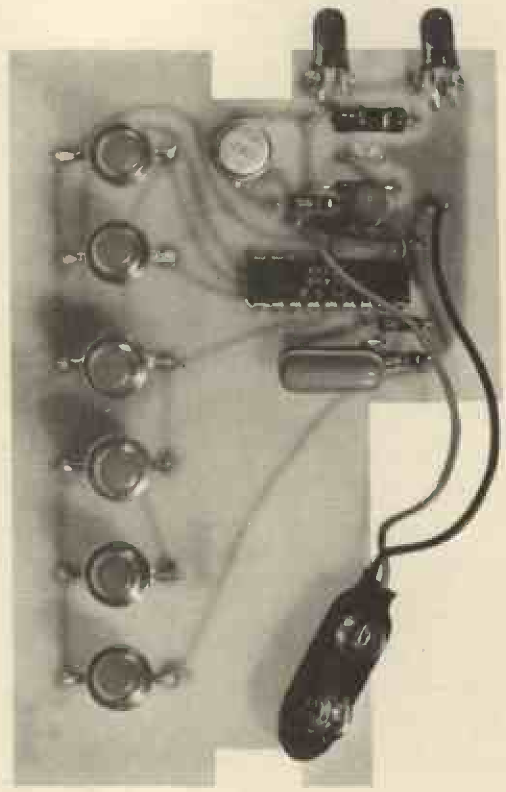
D1, D2	LD271 or equivalent infrared diode
D3	Green l.e.d.
TR1	BCY 461
IC1	SL490

Miscellaneous

S1–6 Push button switches (6 off)
PP3 battery
Battery clip
PB1 box
Printed circuit board
Terminal pins

Constructor's Note

The infra-red l.e.d.s, photodiode, and the three control i.c.s are available from **T.K. Electronics.**



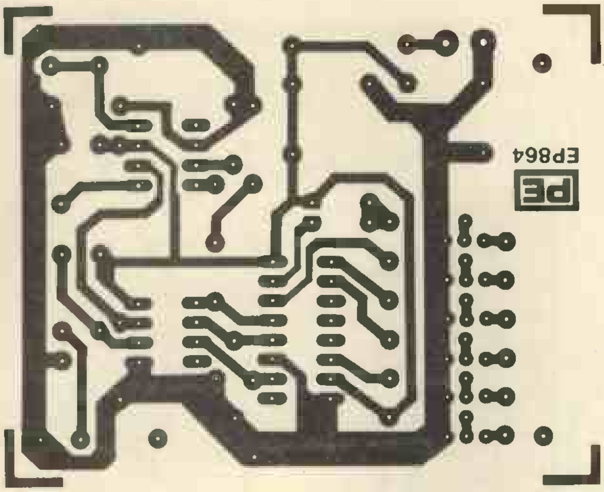
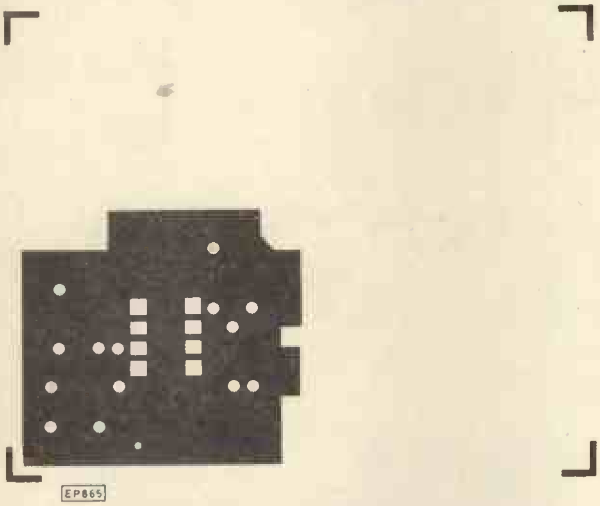


Fig. 8. Above and below—Receiver p.c.b. (actual size)



COMPONENTS . . .

RECEIVER

Resistors

R1	330k
R2	56k
R3	33k
VR1	100k hor. preset
R4–6	100k (3 off)
R7–12	5k6 (6 off)
R13	470

All resistors $\frac{1}{4}$ watt 5%

Capacitors

C1	150p polystyrene
C2, C3	2n2 polyester block (2 off)
C4	15p polystyrene
C5	15n C280 polyester
C6	100n C280 polyester
C7	220µ 16V elect.
C8	10n ceramic

Transistors and Diodes

D1	SFH205 infrared photodiode
D2, D3	1N4148
D4	15V 400mW Zener
TR1–6	2N3904 (6 off)

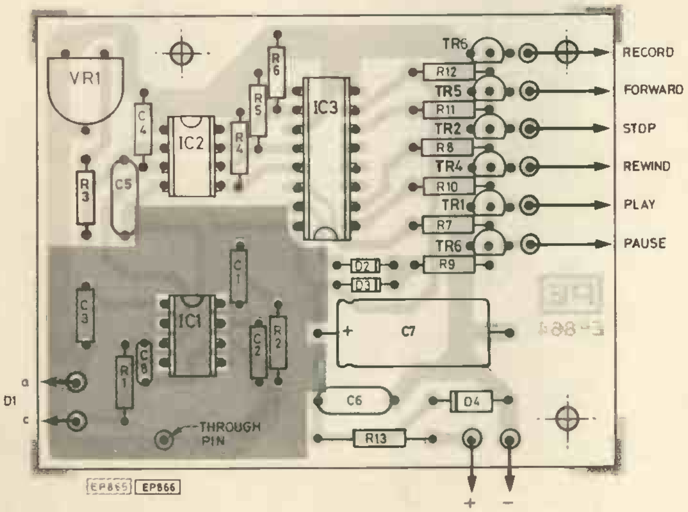
Integrated Circuits

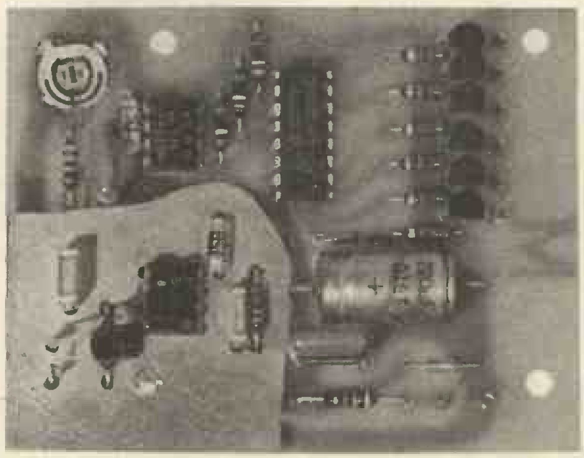
IC1	SL480
IC2	ML926
IC3	4028

Miscellaneous

Printed circuit board
Terminal pins

Fig. 9. Receiver component layout



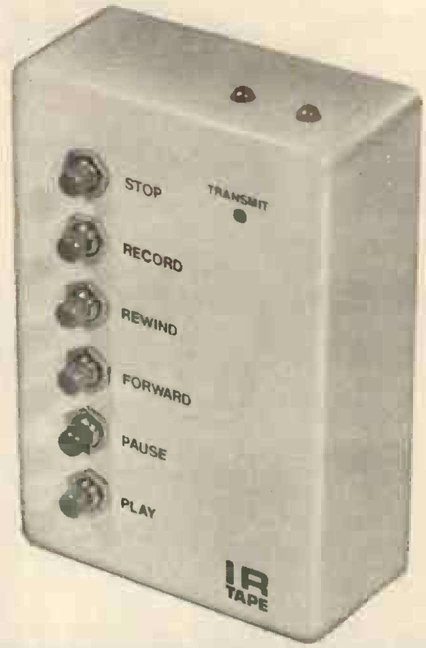


TESTING AND ADJUSTMENT

Apply power to the transmitter and check that the transmitter indicator l.e.d. comes on when any of the switches are pressed. Do not expect to see any activity from the infra red l.e.d. however. Apply power to the receiver, and measure the output of the preamplifier. Press a switch on the transmitter and check that this output varies. Do not do this under a bright light and expect it to work because the infra red will be swamped, particularly if the photodiode is exposed.

Once it is established that the preamplifier is working the decoder oscillator should be adjusted. The easiest way to do this is to transmit a known code, say STOP (0001) and monitor the A output of the decoder on pin 5. Slowly adjust the preset until this output goes high, indicating that the correct code is being received. Check that the 4028 then outputs the correct level to drive the stop transistor. Finally check that all the other codes work.

The receiver is now ready for installation. If it is to be fitted into the equipment a hole for the photodiode will be required as close to the board as possible. One suggestion is to use an unused jack socket, alternatively it may be mounted behind the meter panel. The receiver power supply is then connected to the equipment supply, the necessary corrections being made to R14 if the rail is much above 20 volts. ★



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Versatile Car Alarm...

Michael Tooley B.A.

IT WOULD appear that, in recent years, there has been a considerable increase in the number of thefts of vehicles and their contents. It is therefore not surprising that a number of proprietary car alarms have become available to the motorist wishing to protect his vehicle against theft and damage. There is, however, a considerable variation in both the cost, complexity, and effectiveness of such devices.

Various techniques are currently employed in car alarms. These include trembler switches (which detect a slight movement of the vehicle), voltage sensors (which detect any change of load on the battery), ultrasonic sensors (which operate on the Doppler principle), and last, but by no means least, the humble microswitch. Each technique has its own peculiarities, advantages and disadvantages. Some can be difficult and time consuming to install whilst others are prone to false triggering which can result in considerable nuisance and embarrassment for the owner.

The alarm described in this article is simple to build and install and requires no elaborate or expensive sensors. Trigger inputs can be derived from existing courtesy light and/or ignition circuits and various alarm outputs are available to permit intermittent (car horn and/or lights) and continuous (siren or piezo electric transducer) operation. Furthermore, an output is available for disabling the vehicle's ignition system. No external 'keyswitch' is required and the system is easily 'set' from inside the vehicle. Appropriate delay times are incorporated which permit exit and entry to and from the vehicle without sounding the alarm.

An l.e.d. display is provided to indicate the state of the alarm system at any time. This may, if desired, be placed in a conspicuous position to act as a deterrent. The alarm cannot, however, be disabled by removing the display or cutting the connecting cable from the main p.c.b. In common with most car alarms this device will not confound the most determined and practised thief. It should, however, prove to be an effective deterrent and could be instrumental in alerting those nearby to the perpetration of a crime.

PRINCIPLE OF OPERATION

The circuit is based on the well known 555 timer i.c. Four such devices are used, three connected in monostable and one in the astable mode. The three monostable timers are used to provide the required delay times which are as follows:—

(1) *Lock-up delay.* This allows the owner to lock-up and leave the vehicle before the alarm becomes active. The delay is approximately 60 seconds.

(2) *Trigger delay.* Once the vehicle door has been opened or ignition switched 'on' there is a delay of approximately 10 seconds before the alarm sounds. This allows the owner to disable the alarm by means of a hidden switch located in the interior of the vehicle.

(3) *Alarm period.* Once the alarm has been set-off it will operate for approximately 2 minutes and then automatically re-set. This prevents excessive drain on the battery by the horn, lights, or siren. Once re-set the alarm is again active and can be triggered as before.

The fourth (astable) timer is used to determine the frequency of the intermittent alarm which is primarily intended for sounding the car horn or flashing the lights with the addition of an intermediate relay. A block schematic diagram of the alarm timer is shown in Fig. 1.

THE 555 TIMER

The 555 is one of a range of i.c. timers suitable for either monostable or astable operation. The device requires a minimum of external components and provides accurate time delays which are virtually independent of supply voltage variations. A simplified block diagram of the 555 connected in monostable mode is shown in Fig. 2. The timing period is initiated by a negative going trigger pulse ap-

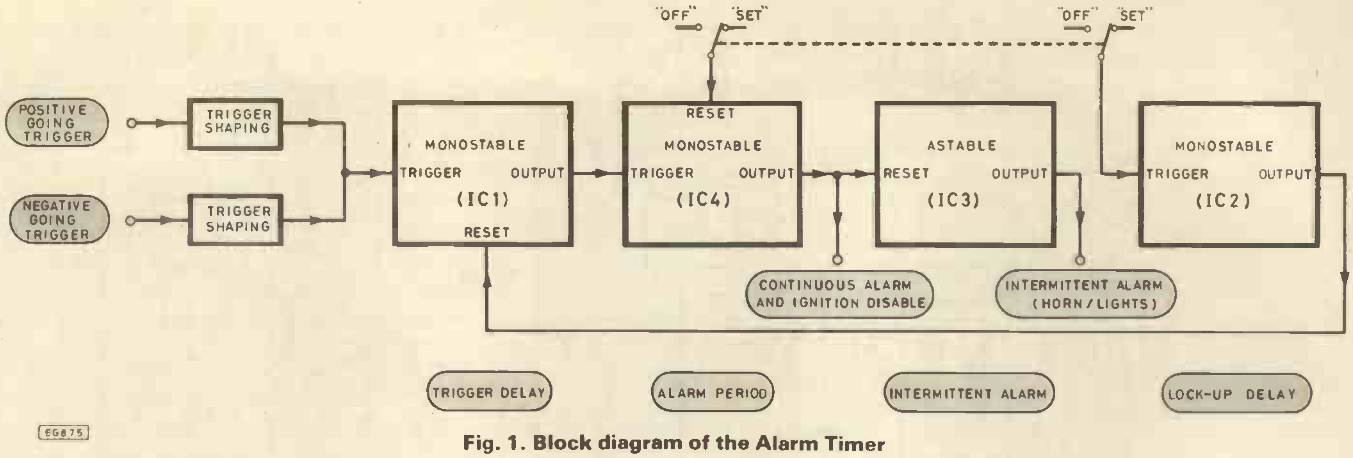


Fig. 1. Block diagram of the Alarm Timer

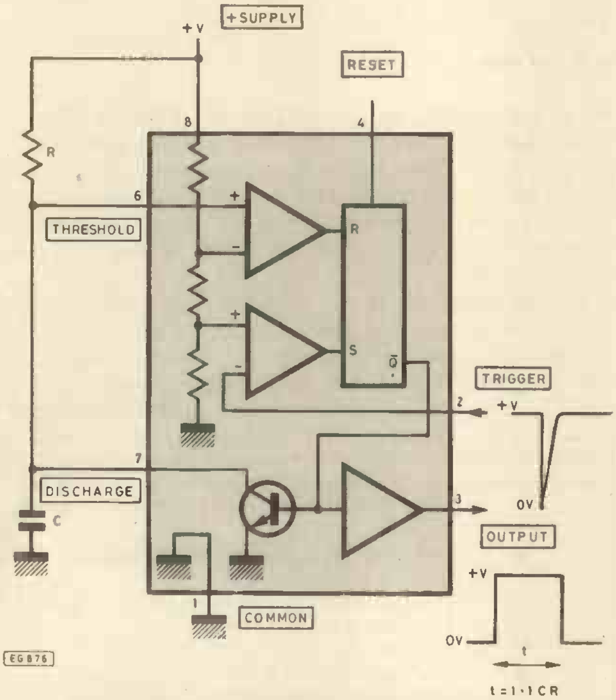


Fig. 2. The 555 timer as a monostable

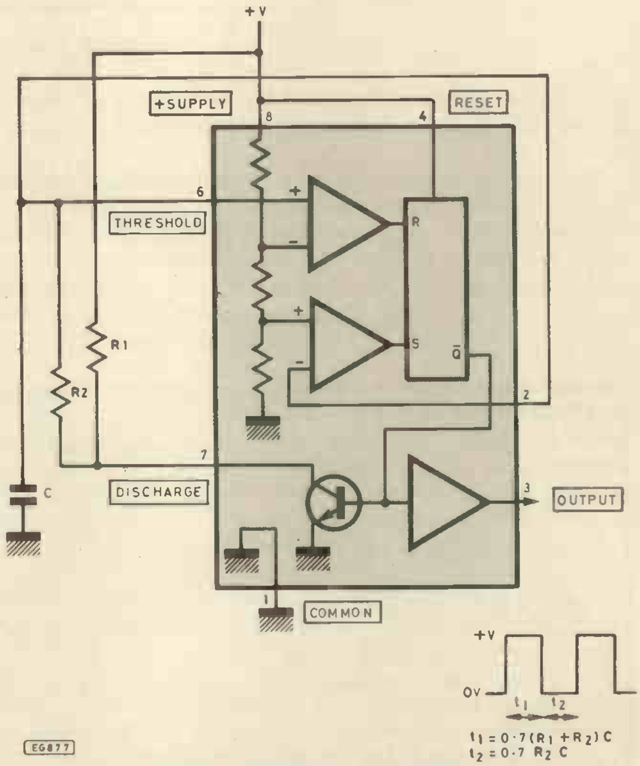


Fig. 3. Astable arrangement

plied at pin 2. Once triggered this input is disabled and any further trigger pulses which occur during the monostable period are ignored. The monostable period may be aborted by the application of 0V to pin 4. The output (pin 3) then reverts to 0V as is the case at the end of the timing period. An astable arrangement using a 555 timer is shown in Fig. 3. The trigger and threshold inputs are linked and an additional resistor is connected between the discharge and threshold pins. The reset input (pin 4) is taken to the positive rail in order to enable astable operation. If, however, pin 4 is taken to 0V the output remains at 0V indefinitely.

CIRCUIT DESCRIPTION

The circuit diagram of the alarm is shown in Fig. 4. The trigger pulse to IC1 is conditioned by TR1 and associated components. The inverting action of the transistor allows the timer to be triggered on positive as well as negative going inputs. Note that, in either case, the circuit is 'edge triggered' and the normal state of the negative and positive going trigger inputs is 'high' and 'low' respectively. IC1 provides the 'trigger delay' period and its falling edge output is used to initiate the 'alarm period' which is provided by IC4. The output of IC4 operates the continuous alarm facility and is also used to 'set', the astable, IC3, which provides the intermittent alarm. The 'lock-up delay' is provided by IC2. The output of this monostable is used to inhibit the operation of IC1 by means of the intermediate transistor inverter, TR2. S1 provides 'set' and 'off' switching of the alarm. When moved from the 'off' to the 'set' position the switch triggers IC2, thus initiating the lock-up period. The 'alarm period' timer, IC4, is inhibited when S1 is in the 'off' position.

CONSTRUCTION

The majority of the components are mounted on a single sided p.c.b., the design layout for which is shown in Fig. 5. An alternative to using a p.c.b. is that of building the circuit on Veroboard or matrix board and, provided that due care is exercised, this form of construction should be quite adequate. The component layout for the p.c.b. is shown in Fig. 6. The following sequence of assembly is recommended: i.c. sockets, terminal pins, resistors, capacitors, diodes and tran-

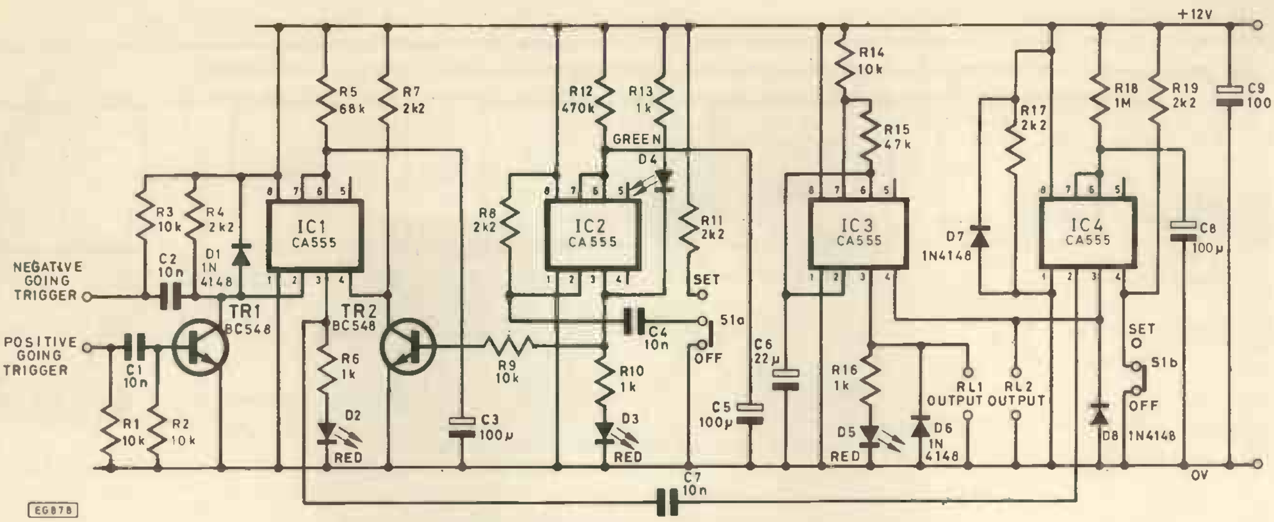


Fig. 4. Circuit diagram of the Alarm

sistors. Care should be taken to ensure the correct orientation of the polarised components such as diodes, transistors, and capacitors.

The l.e.d.'s are mounted on a separate p.c.b. which may be remotely mounted from the main p.c.b. and linked to it using an appropriate length of 6-way ribbon cable. The l.e.d. panel may either be fixed in a suitable location behind the car's dashboard with $\frac{1}{4}$" holes cut for each l.e.d. or mounted in a free-standing case or pod. Where the constructor does not wish to have the display immediately visible the l.e.d.'s may be wired directly to the main p.c.b. S1 is mounted in an accessible yet hidden location and connected to the main p.c.b. using an appropriate length of 5-way ribbon cable. The wiring for S1 is shown in Fig. 7 and the p.c.b. layout for the display panel is shown in Figs. 8 and 9. Fig. 10 shows the interconnecting arrangement and the wiring schedule is given in Table 1.

A final visual check of the completed p.c.b.'s and wiring should be carried out before inserting the i.c.'s in their respective sockets. Care should be taken to ensure correct pin orientation of the timers. Testing, as described in the next section, should be carried out *before* attempting to

COMPONENTS . . .

Resistors

R1, R2, R3, R9, R14	10k (5 off)
R4, R7, R8, R11, R17, R19	2k2 (6 off)
R5	68k
R6, R10, R13, R16	1k (4 off)
R12	470k
R15	47k
R18	1M

All resistors $\frac{1}{4}$ W 5% carbon

Capacitors

C1, C2, C4, C7	10n polyester (4 off)
C6	22µ
C3, C5, C8, C9	100µ 16V elect p.c.b. mounted type (4 off)

Semiconductors

D1, D6, D7, D8	1N4148 (4 off)
D2, D3, D5	Red l.e.d. (3 off)
D4	Green l.e.d.
TR1, TR2	BC548 (2 off)
IC1, IC2, IC3, IC4	CA555 (4 off)

Miscellaneous

S1	Min slide switch d.p.d.t.
Terminal pins	
*Push-fit connectors	
*Relays	*See text
12V d.c. siren (optional)	

Constructor's Note

A complete kit of parts is available from **Howard Associates, 59 Oatlands Avenue, Weybridge, Surrey KT13 9SU** (SAE for details).

REFERENCE	FUNCTION AND CONNECTION
A	–ve going trigger input from courtesy lights etc.
B	+ve going trigger input from ignition coil/switch
C	trigger delay period l.e.d. (D2 anode on display p.c.b.)
D	0V (see note)
E	'off' position of S1a
F	'centre' position of S1a
G	'on' position of S1a
H	lock-up period l.e.d. (D3 anode on display p.c.b.)
I	0V (see note)
J	alarm active l.e.d. (D4 anode on display p.c.b.)
K	alarm active l.e.d. (D4 cathode on display p.c.b.)
L	alarm operating l.e.d. (D5 anode on display p.c.b.)
M	0V (D2, D3 and D5 cathodes on display p.c.b.)
N	intermittent alarm output (RL1)
O	0V (RL1)
P	0V (RL2)
Q	continuous alarm output/vehicle disable (RL2)
R	'centre' position of S1b
S	'off' position of S1b
T	0V supply input (–ve lead)
U	+12V supply input (+ve lead)

Note: These connections may be used for l.e.d. cathodes (D2, D3 and D5) where l.e.d.'s are to be wired directly to the alarm timer p.c.b.

Table 1: Wiring schedule for the alarm timer p.c.b.

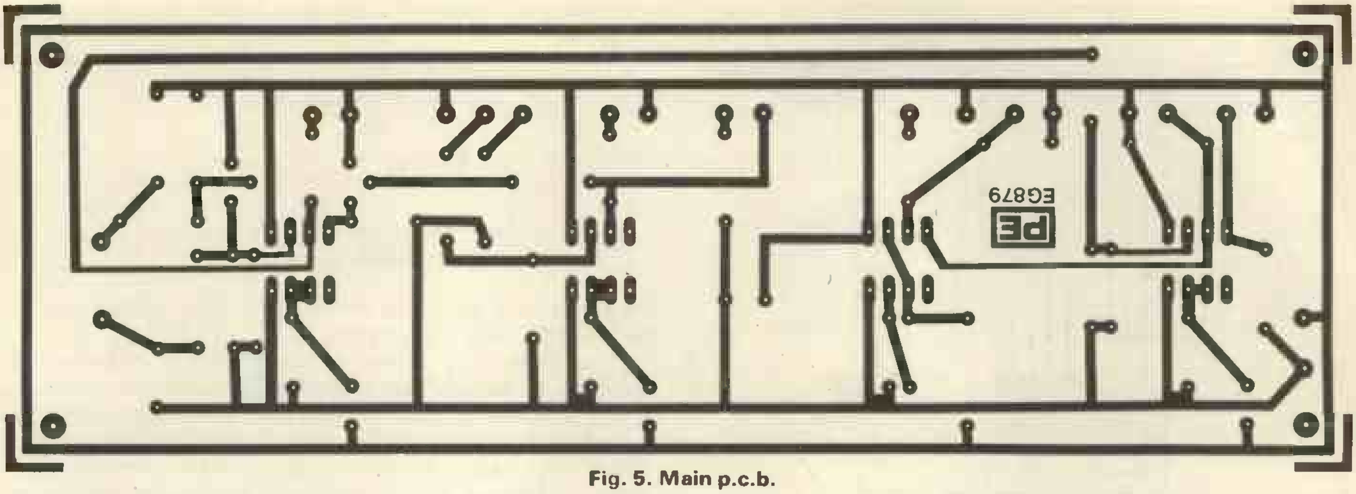


Fig. 5. Main p.c.b.

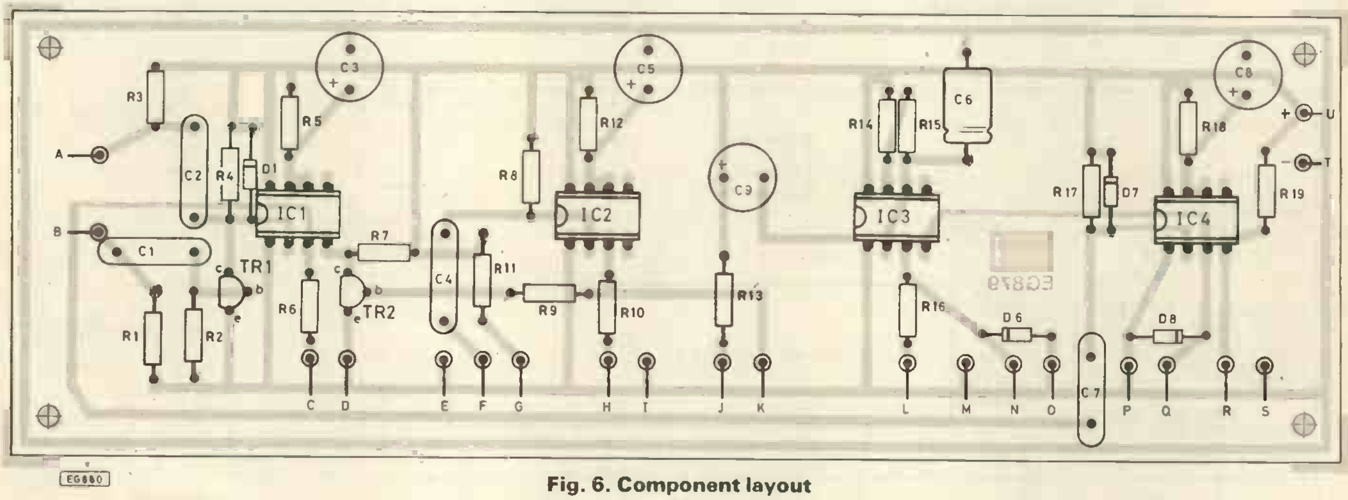


Fig. 6. Component layout

install the unit into a vehicle. This latter precaution can be instrumental in saving much agony and frustration at a later stage!

TESTING

The unit should be tested with the aid of a 12V d.c. supply capable of delivering at least 150mA. The power supply should be preferably fitted with electronic overcurrent protection and, where this is adjustable, it should be set to approximately 250mA. As an alternative, a 250mA fuse may be wired in the positive supply lead.

Connect the supply as shown in Fig. 10 and Table 1. Take care to observe the correct polarity (+ve lead to U and −ve lead to T). Place the l.e.d. display where it may be easily viewed and enlist the aid of a watch or clock which has an elapsed time facility reading in 1 second increments. The only remaining item required during the testing procedure is

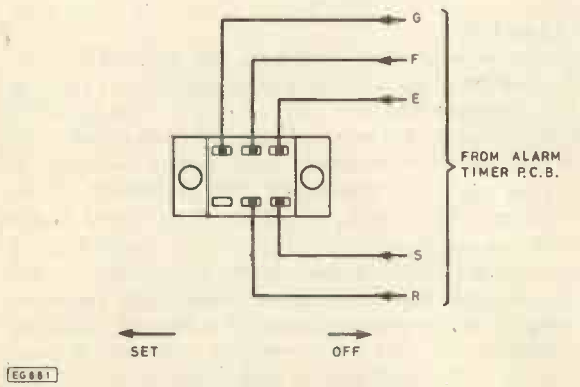


Fig. 7. Wiring for switch S1

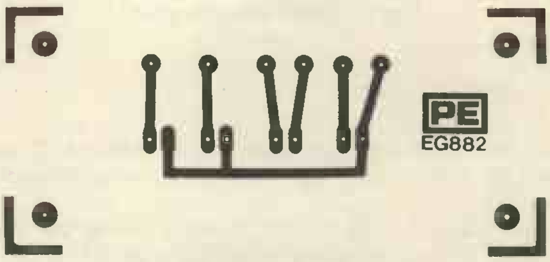


Fig. 8. Display panel p.c.b

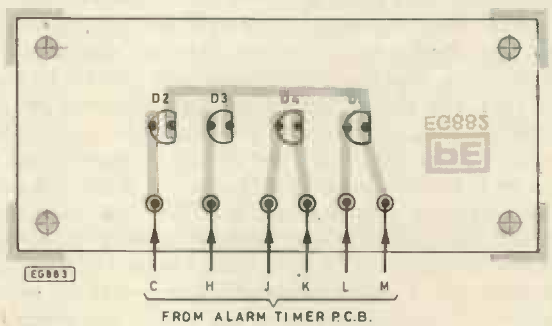


Fig. 9. Component layout

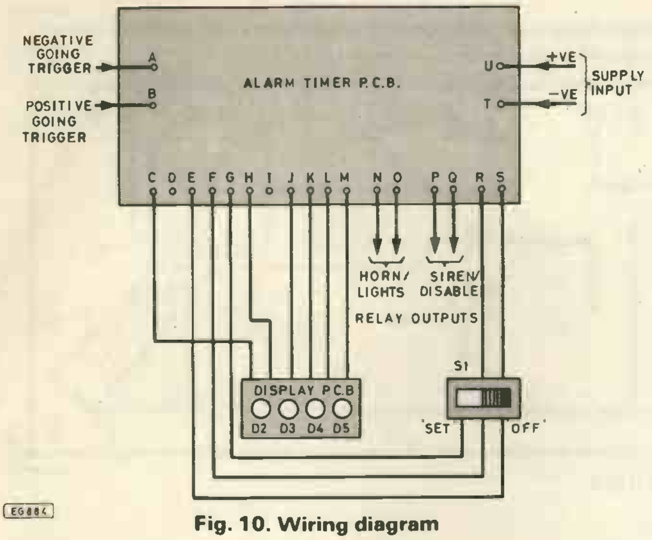


Fig. 10. Wiring diagram

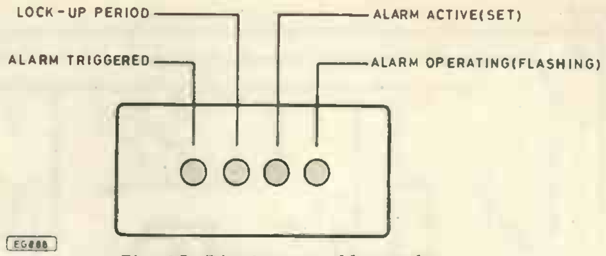


Fig. 12. Display panel legend

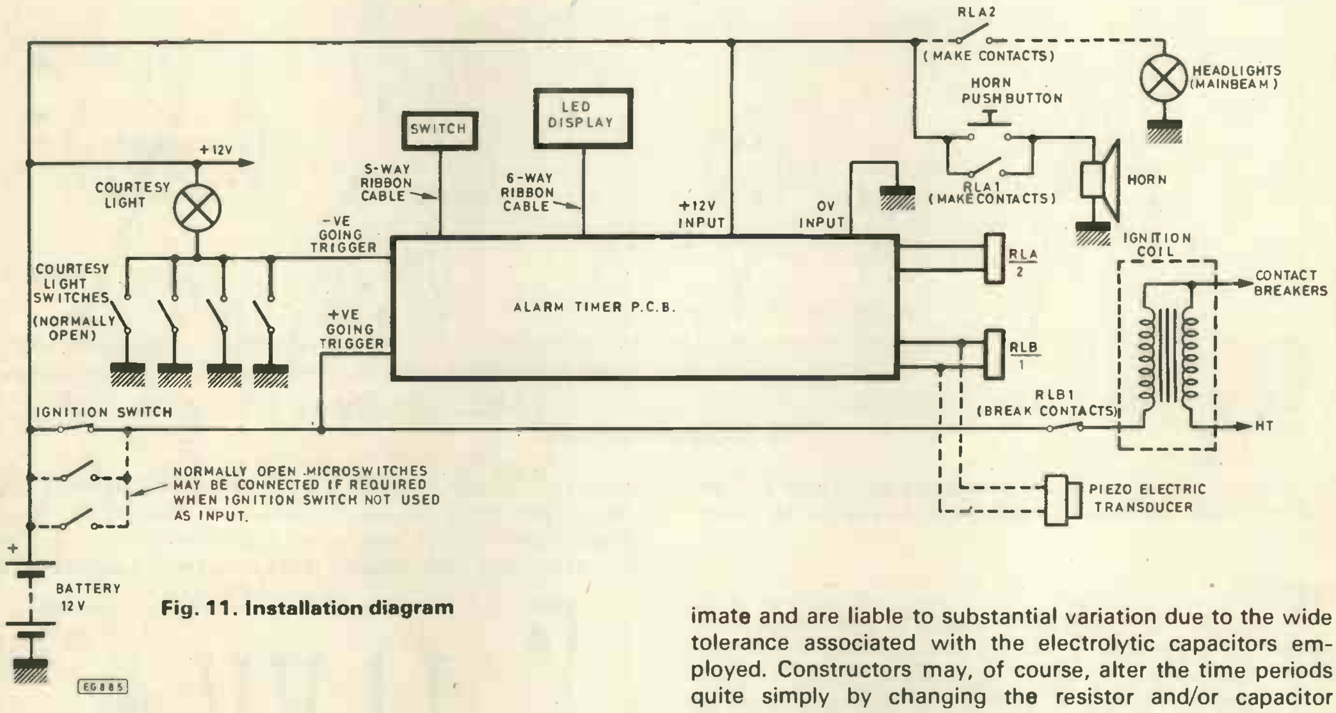


Fig. 11. Installation diagram

a short lead fitted with a crocodile clip at each end. This lead is used for linking the trigger inputs to one or other of the supply rails.

Check that S1 is in the 'off' position. Using the jumper lead, link the negative going trigger input (A) to the positive supply rail (U). Now switch to the 'set' position. D3 should become illuminated and the other l.e.d.'s should remain 'off'. The jumper lead may now be taken to the negative supply rail (T) and then returned to the positive supply rail (U), simulating the opening and closing of a door. The alarm trigger l.e.d., D2, should remain 'off' during this test provided that D3 remains illuminated. The time for which D3 is illuminated ('lock-up delay') should be measured and this should be in the range 25 to 100 seconds. After this period D3 will become extinguished and D4 will become illuminated signifying that the alarm is primed. Now repeat the earlier test, moving the jumper lead from U to T and back again. This time D2 should become illuminated for approximately 5 to 15 seconds and, at the end of this period, D5 should start to flash. The intermittent operation of D5 should be timed until the alarm resets itself. This should occur at between 65 and 200 seconds.

It is worthwhile repeating the complete sequence of events until the user is familiar with the alarm's operation. Check also that, at any time, the alarm can be cancelled by switching S1 to the 'off' position. Check that the positive going input trigger facility is operational by connecting the jumper lead from B to T, moving it to U and back again as before. Note that the time intervals stated are only approximate and are liable to substantial variation due to the wide tolerance associated with the electrolytic capacitors employed. Constructors may, of course, alter the time periods quite simply by changing the resistor and/or capacitor values. A doubling of the timing resistor value will double the existing delay and conversely halving the value will reduce the period by half. In applications where a continuous variation of delay period is required pre-set resistors may be employed.

INSTALLATION

The exact arrangement employed will depend entirely upon the individual constructor's requirements concerning triggering, alarm devices, and the requirement for disabling the vehicle. The diagram shown in Fig. 11 indicates the full range of possibilities from which constructors may wish to develop their own alarm systems. The placement of the p.c.b.'s and ancillary items will depend upon the space available in the vehicle and the need to have the main p.c.b. and relays (where fitted) housed in the more secure areas within the vehicle. Figs. 13 and 14 respectively show the p.c.b. design and component layout for a remote mounting relay suitable for use with the alarm. This relay may be used to operate the horn, headlights, or disable the ignition circuit. Each set of change-over contacts is rated at 5A and the con-

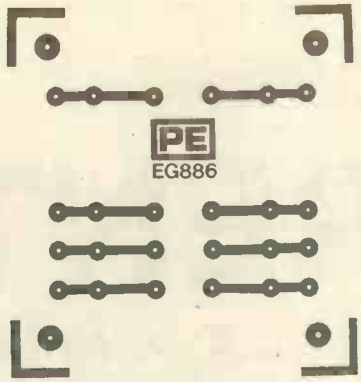
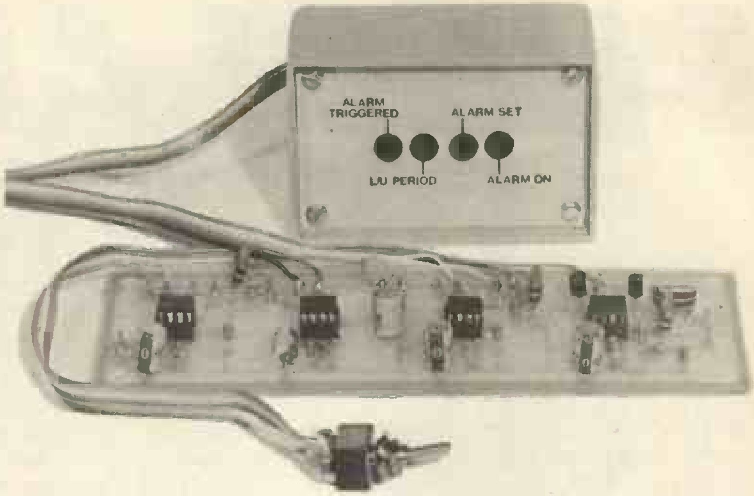


Fig. 13. Relay p.c.b.



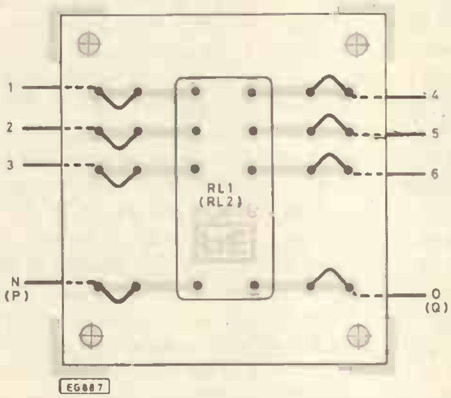


Fig. 14. Component layout

tacts may be wired in parallel to provide a 10A rating. Alternatively a single pole changeover relay is available which will fit the same pin-out configuration. Connectors are push-fit '250' ($\frac{1}{4}$") types and these provide a neat and adaptable method of wiring to the vehicle.

It should be remembered that the most determined car thief will undoubtedly find a way of disabling any car alarm system. He may even resort to removing the car battery before towing the vehicle away! The primary function of an alarm system should thus be considered to be more that of a deterrent rather than a means of complete protection. In any event, the installation of an alarm system is the first step in fighting back! ★

BURGLAR DETERRENT

R. A. PENFOLD

IF premises which contain valuable property are often left unattended it is obviously worthwhile fitting a comprehensive burglar alarm system, and it would probably be necessary to do so in order to insure against theft. Things are far less clear-cut in situations where premises are only occasionally left unattended, and there is little of value that can be easily removed. There is relatively small risk of burglary, especially in an area having a low crime rate, and the cost and inconvenience of installing a burglar alarm system is difficult to justify.

Many houses are in this second category, and relatively few are protected by a comprehensive alarm system. There are alternatives to an alarm system, and an increasingly popular one is to use a light-sensitive switch which turns on a light somewhere at dusk, and either switches it off again after some preset time, or at dawn.

When the premises are left unattended for some period of time, such as when the occupiers are on holiday, this gives the impression that the building is still occupied and deters would-be burglars.

There have been many burglar deterrent designs of this type for the home-constructor in the past, but these invariably seem to be of the simple type where the light is switched on at dusk and off again at dawn. In practice, the type having a timer to set the time at which the light switches off have a couple of useful advantages. One is simply that problems with feedback from the light bulb to the photocell (which can result in oscillation) are avoided. This largely removes restrictions on the relative placement of the bulb and the detector, and on the light level at which the bulb is switched on. In most households the lights are usually switched off some time before or after dawn, and this is something that can be achieved using a circuit with a built-in timer so that the illusion of normality is obtained.

The simple burglar deterrent unit described in this article has a timer which turns off the controlled lamp (which is a standard or table type) 2, 4, 6, 8, 10, or 12 hours after switch-on. However, these times can easily be modified to suit individual requirements. When the unit is switched off it is automatically by-passed so that the lamp can be used in the normal way.

BLOCK DIAGRAM

The block diagram of Fig. 1 illustrates the operation of the device, and the timer circuit is at the heart of the unit. A simple timer using a 555 monostable or some similar arrangement is not really suitable due to the long delay times involved, and the impractically large timing component values that would be required. Instead a Ferranti ZN1034E precision long timer is used, and by using an oscillator, divider chain, and control logic circuit this produces an output pulse of a few thousand CR seconds. This compares with a nominal figure of just 1·1 CR seconds for the 555 device.

A photocell circuit connects to the trigger input of the timer via a Schmitt trigger, and activates the timer when the light intensity falls below a certain level. The timer then switches on the lamp via a relay and a relay driver stage.

One slight complication is that if it is still dark when the output pulse ends and the lamp is switched off, as the light level falls the unit will be re-triggered. Some additional circuitry is therefore needed in order to prevent re-triggering.

The most simple way of achieving this is to hold the trigger input of the timer in the low state during the output pulse and for a short while afterwards, rather than allowing it to return to the high state after triggering when the photocell picks up the increased light level caused by the lamp switching on. The ZN1034E is a monostable of the type that only triggers on negative input transitions, and does not re-trigger if the trigger input is in the low state at the end of the output pulse.

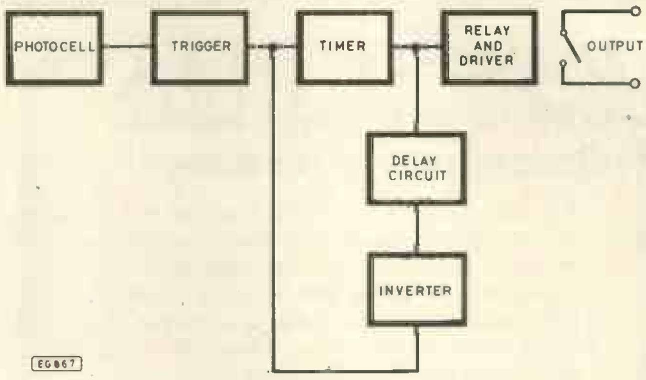
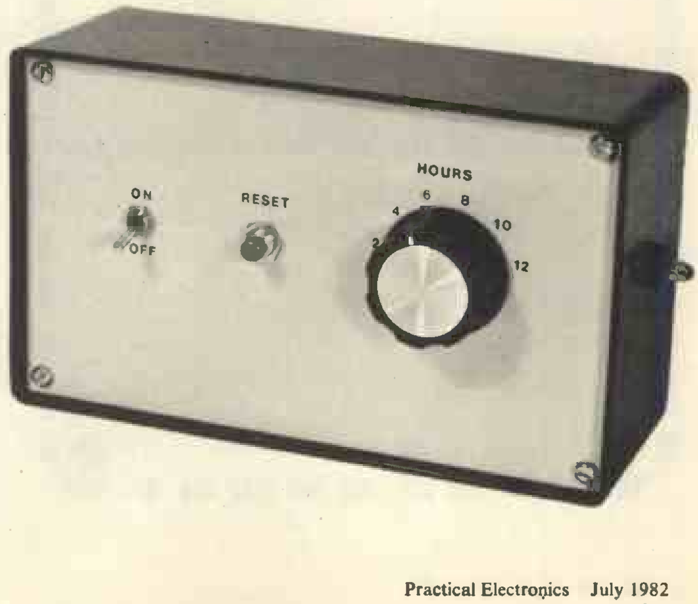


Fig. 1. Block diagram



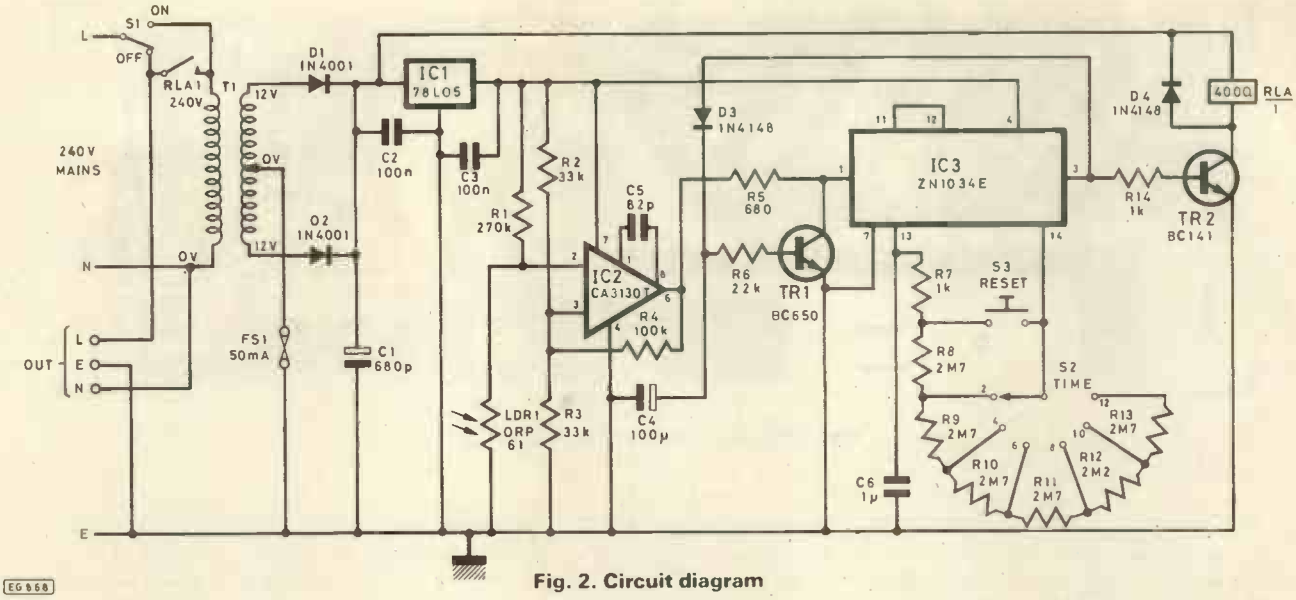


Fig. 2. Circuit diagram

The output of the timer is therefore connected to the trigger input by way of an inverter stage, and a simple delay circuit is used at the input of the inverter so that the trigger input is held in the low state for a short while after the timer's output pulse ends. This is necessary simply because it takes a short but significant time for the relay and light bulb to switch off.

THE CIRCUIT

The full circuit diagram of the Burglar Deterrent appears in Fig. 2.

Integrated circuit IC3 has both Q and $\overline{Q}$ outputs, and in this circuit only the Q output at pin 3 is used. Pins 11 and 12 are linked so that the internal 100k calibration resistor of IC3 is used, and the output pulse length is nominally 2736 CR seconds. C6 is the timing capacitor, and there are six timing resistors. These are R8 to R13, and from one to six resistors connected in series can be selected using S2. One resistor gives an output pulse of about 7387 seconds (which is sufficiently close to the required 7200 seconds), and each resistor increases the pulse length by a further 7387 seconds. This gives the nominal delay times of 2 to 12 hours in two hour increments. As the delay time provided by each resistor is slightly longer than the required 2 hours using a value of 2M7, a 2M2 component is used in the R12 position. This counteracts the gradual build-up in the timing error as more timing resistors are switched into circuit and gives improved accuracy with S2 in the "10" and "12" hour positions.

In this application it is obviously not necessary to have very precise delay times, and no means of trimming these times has been incorporated in the circuit. The timing components do not need to be close tolerance types, but as the timing resistance can be as much as 15M7 it is necessary for C6 to be a low leakage type, and a polycarbonate component has therefore been specified. On the longer time settings the timing resistance is actually a little more than the recommended maximum figure of 10M for the ZN1034E, but this does not prevent the circuit from operating, or even significantly affect the timing accuracy.

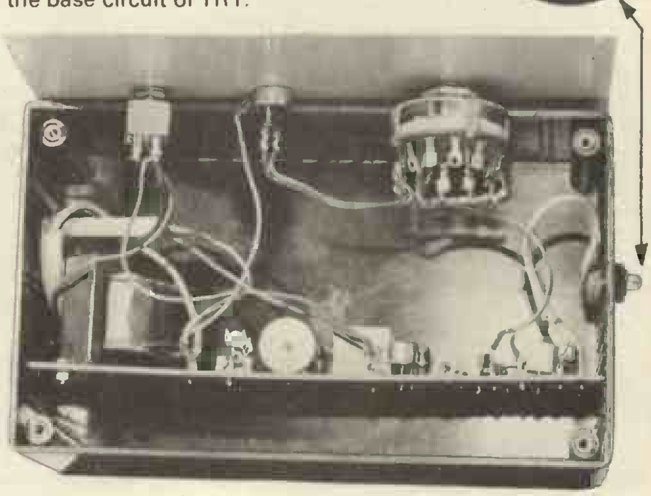
Of course, it is an easy matter to change the timing component values to produce delay times to suit individual requirements. For example, a twelve way switch and a series of twelve 1M3 resistors would give an approximate timing range of 1 to 12 hours in 1 hour increments.

R7 is connected in series with the timing resistance but is too low in value to have any significant affect on the delay time. However, when S3 is closed the main timing resistance is short-circuited and R7 then becomes the timing resistor. This gives a short output of only about five seconds in duration at most, and enables the circuit to be reset to the "off" state if desired.

Photocell LDR1 is a cadmium sulphide (Cds) light dependent resistor, and it forms a potential divider across the supply lines in conjunction with R1. IC2 is an operational amplifier which is used here as an inverting Schmitt trigger, and its output drives the trigger input of IC3 by way of R5.

Under reasonably bright conditions LDR1 will have a fairly low resistance and the resultant low input voltage to IC2 will give a high output. As the light level falls the input voltage to IC2 increases until the output of IC2 triggers to the low state and IC3 is triggered.

Pin 3 of IC3 then goes high, TR2 is biased into conduction, the relay coil which forms TR2's collector load is activated, and a pair of normally open relay contacts connect the 'live' mains supply to the output. TR1 will also be switched on and C4 will charge up, so that TR1 holds IC1's trigger input in the low state during the output pulse at pin 3, and for a second or so after the pulse has ended as C4 discharges into the base circuit of TR1.



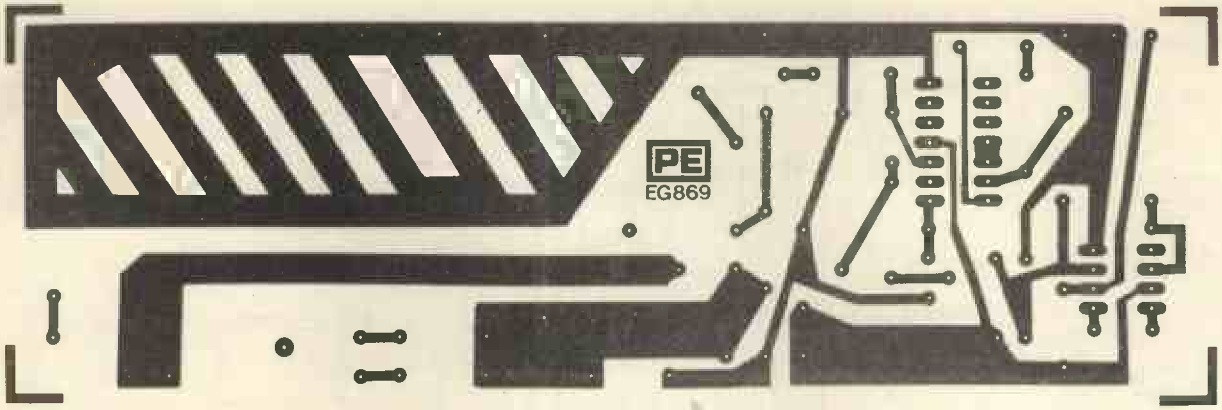


Fig. 3. Printed circuit layout (actual size)

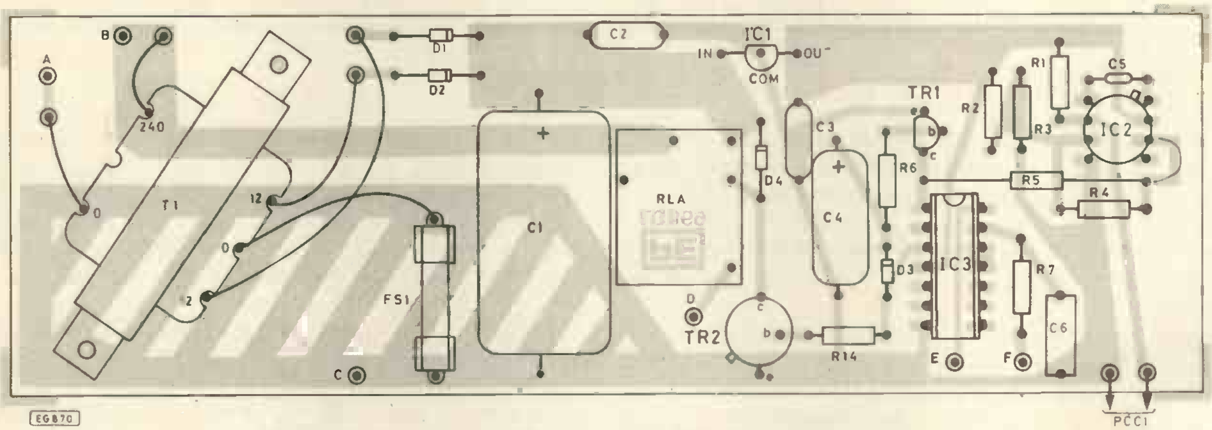


Fig. 4. Component layout

COMPONENTS . . .

Resistors

R1	270k
R2,3	33k (2 off)
R4	100k
R5	680
R6	22k
R7,14	1k (2 off)
R8–11,13	2M7 (5 off)
R12	2M2

All resistors ¼ watt 5% carbon film

Capacitors

C1	680u 25V electrolytic
C2,3	100n polyester (2 off)
C4	100u 10V electrolytic
C5	82p ceramic
C6	1u polycarbonate

Semiconductors

D1,2	1N4001 (2 off)
D3,4	1N4148 (2 off)
TR1	BC650
TR2	BC141
IC1	78L05
IC2	CA3130T
IC3	ZN1034E

Miscellaneous

T1 12–0–12 volt 50mA mains transformer
S1 S.P.D.T. miniature toggle switch (250 volt a.c. contacts)
S2 6-way 2-pole rotary switch
S3 Push to make, release to break type
12 volt 400 ohm relay having a single changeover contact rated at 10 amps at 240 volts a.c. (M.E.S. "10A Mains Relay")
ORP61 photocell
50mA. 20mm quick blow fuse and chassis mounting fuseholder to suit
Case measuring about 161 x 96 x 59mm (M.E.S. "Metal Panel Box M4005)
Control knob
Printed circuit board
Veropins
Mains lead, connecting wire, grommets, etc.

The circuit is powered from a conventional fullwave mains power supply which uses a small monolithic voltage regulator to give a well smoothed and stabilised 5 volt output. The ZN1034E has a built-in 5 volt shunt stabiliser, but this is inadequate for use in this circuit and a separate regulator has to be used. S1 is the on/off switch, and when in the "off" position it connects the 'live' mains supply lead to the output and thus by-passes the relay contacts.

CONSTRUCTION

Resistors R8 to R13 are mounted on S2, and LDR1 is mounted on one side of the case in a grommet having a suitable inside diameter (5mm), but apart from the controls the other components are all mounted on the printed circuit board. Details of the printed circuit and wiring of the unit are provided in Fig. 3.

T1 and the holder for FS1 are bolted to the board using 6mm M3 screws and fixing nuts, but the other components (including the relay) fit onto the board in the normal way. Of course, if you do not use the specified relay it will be necessary to alter the printed circuit layout to suit the particular component used, and it might not be possible to accommodate the relay on the board if the component used is not a subminiature type. IC2 is a CMOS device incidentally, and the usual CMOS handling precautions should be taken when dealing with this device. Note that the CA3130T device functions well in this circuit, but most alternative devices either will not work at all on a 5 volt supply, or will give an inadequate output voltage swing for satisfactory operation in this circuit. Use Veropins at points where the printed circuit board will connect to off-board components.

Provided the specified case is used the circuit board can be mounted horizontally in the lowest set of printed circuit guide rails moulded into the case. There are a few vacant areas on the board where mounting holes can be drilled if a different case is used. For reasons of safety the case must be a type which has a screw fixing lid or front panel, and not a clip-on type which would permit easy access to the dangerous mains wiring.

The wiring is mostly quite straightforward. The metal front panel must be connected to the mains earth lead, and a large solder tag fitted on the mounting bush of S3 provides a

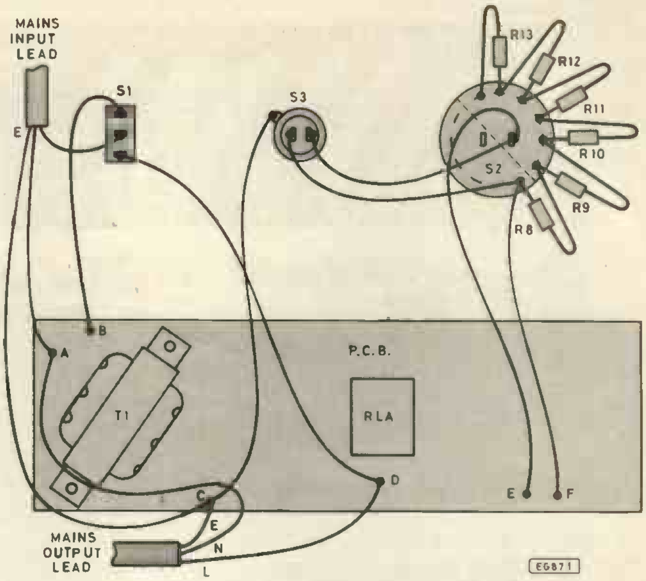


Fig. 5. Wiring diagram

suitable connection point to the panel. As it is likely that the unit will always be used with the same lamp it can be wired into the mains lead of this lamp, with holes for the input and output leads being drilled in one side of the case, rather than going to the trouble of fitting a mains outlet on the case.

The ORP61 photocell is a "side on" type which has a coloured spot on the body of the component just beneath the sensitive surface. Obviously the photocell must be mounted with this sensitive surface clear of the grommet in which the component is mounted, and facing forward.

It may be found that the finished unit triggers at switch-on, but depressing S3 for a few seconds will reset the circuit. After a second or two when C4 has discharged it will be possible to trigger the unit by reducing the light level received by LDR1. It is possible to alter the light level at which the unit is triggered by changing the value of R1, but satisfactory results should be obtained using the specified value. ★

PATENTS REVIEW...

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LOUDSPEAKER PROTECTION

Hitachi of Tokyo has patented (BP 1 593 295) what appears to be a genuinely novel approach to loudspeaker protection. It is all too easy to damage a loudspeaker by overloading it; the voice coils overheat, deform and go open-circuit. Protection devices have to strike a compromise between excessive sensitivity, which makes them trigger too early and too often, or inadequate sensitivity, which leaves the loudspeaker still at risk. Hitachi has already pioneered the use of Hall effect elements for magnetic recorder playback heads, and speed sensing turntables. So it is logical for Hitachi now to patent a Hall effect device for protecting a loudspeaker.

Figure 1 shows the basic circuit. Low frequency audio signals from source 1 are fed through resistor 2 and capacitors 3, 4 or LF power amplifier 5. The amplifier output feeds loudspeaker 9 through indicator 7, and resistor 8. The amplifier output is also fed through fixed resistor 17 and variable resistor 16 to Hall-effect element 13. This element is made of indium antimonide, indium arsenide or germanium. The element 13 is subjected to the magnetic flux created by the audio signal passing through inductor 7 and develops a proportional d.c. voltage at terminals 18, 19. The output voltage of the Hall element can be adjusted by changing the current through Hall inputs 14, 15 through control of the value of variable resistor 16.

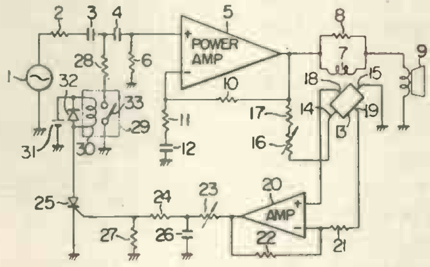

Fig. 1

The Hall voltage is fed to amplifier 20, of which the amplified output is sent to adjustable time constant circuit 23,26. The time constant of this R/C circuit is set approximately equal to that of the temperature rise in the voice·coil of the loudspeaker 9. The amplified voltage output is divided at 24,27 and applied to the gate of thryristor 25. When the voltage between the gate and cathode of the thyristor exceeds its firing voltage, the thyristor turns conductive and allows current to flow through the coil 30 of relay 29. This relay then operates to close switch 33 which earths one end of resistor 28. The LF signal from source 1 is divided by resistors 2,28 so that the signal supplied to amplifier 5 is attenuated. This decreases the output power of amplifier 5 and so protects the loudspeaker 9.

COMPATIBILITY

Sony has filed a British patent application (2 075 805) on a string of circuits intended to make portable radios and tape recorders more fully mono-stereo compatible. At the present time there is considerable confusion. A pair of Stereo headphones can have either a full size or a mini stereo jack; a single earpiece operates in mono mode and needs a mono jack, either full size or mini; a portable stereo radio or cassette player with a built-in loudspeaker, usually reproduces only one channel, rather than a mono mix of both channels, when there is no jack connected. Sony has already demonstrated a prototype for a combination jack plug which, by the use of a screw sleeve, converts between large and mini size. (This should soon be on the UK market.) The Sony patent application suggests a standard for jacks, and player circuitry, which would provide fully automatic switching between stereo headphone listening, mono headphone listening and mono loudspeaker listening.

Figure 2A shows the proposed format for a stereo jack and Figure 2B the proposed format for a compatible mono jack. Several suitable circuits are sketched. For instance in Figure 4 when a stereo jack is inserted in jack socket J, the stereophone functions in stereo. Voltage from source +B is divided by resistor R7, resistor R2 and the DC resistance of the headphone. Potential at P is supplied to the base of transistor Q1 through resistor R5 so that Q1 conducts. So the left and right channels are earthed through resistors R3, R4 without mixing, and amplifiers A1, A2 feed the left and right headsets separately to give stereo reproduction.

When a mono plug is inserted, jack socket contact SR is earthed through the plug and voltage +B is divided by resistors R7, R2. The potential at P is now decreased, so T1 becomes non-conductive and the output of the right channel signal from amplifier A2 is supplied to the input of amplifier A1. This provides a mixed mono output for the mono headset.

Figure 5 shows how the system can incorporate a mono loudspeaker SP. When no plug is in the jack J, the voltage +B is again divided by resistors R7, R2 and transistor Q1 again becomes non-conductive. So, as during mono headset reproduction, amplifier A1 produces a sum of the left and right signals. This sum signal is fed to loudspeaker SP, through movable contact SL and fixed contact SLF, which are closed when no jack is inserted in the socket. So the built-in loudspeaker produces a mono sum of the stereo signals.

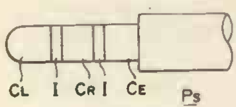

Fig. 2A

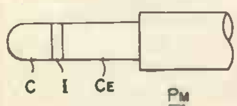

Fig. 2B

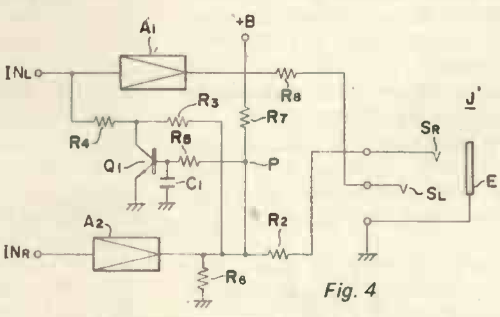

Fig. 4

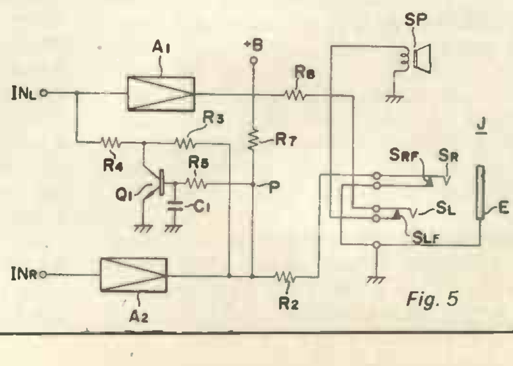

Fig. 5

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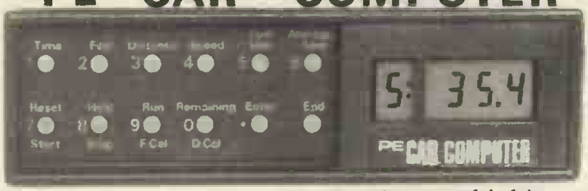

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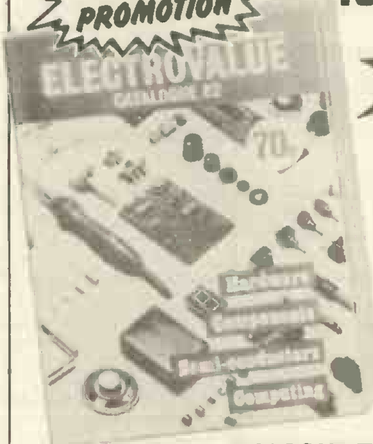

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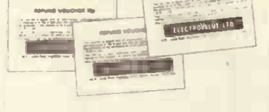

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BC548C 12p
BC549C 16p
BC557B 14p
BC559C 16p
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BFR79 25p
BFR80/1 25p
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BFX30 27p
BFX84/5 40p
BFX88 27p
BFX89 150p
BFY50 24p
BFY51/2 24p
BFY56 33p
BFY90 80p
BRY39 45p
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BU105 190p
BU108 250p
BU109 225p
BU126 150p
BU180A 120p
BU205 200p
BU208 200p
BU406 145p
BUX80 600p
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MJ2501 225p
MJ2955 90p
MJ3001 225p
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MJE2955 100p
MJE3055 70p
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MPF103/4 30p
MPF105 30p
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MPSA12 50p
MPSA13 50p
MPSA20 50p
MPSA42 50p
MPSA43 50p
MPSA56 32p
MPSA70 50p
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TIP42A/C 60p
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2N3704/5 12p
2N3706/7 14p
2N3708/9 12p
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2N3823 50p
2N3866 90p
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1N916 7p
1N4148 4p
1N4001/2 5p
1N4003/4 6p
1N4006/7 7p
1N5401/3 14p
1N5404/7 19p
IS920 9p

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1A 100V 20p
1A 400V 25p
1A 600V 30p
2A 50V 30p
2A 100V 35p
2A 400V 45p
3A 200V 60p
3A 600V 72p
4A 100V 95p
4A 400V 100p
6A 50V 80p
6A 100V 100p
6A 400V 120p
10A 400V 200p
25A 400V 400p

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2.7V-33V
400mW 9p
1W 15p

TRIACS PLASTIC
3A 400V 60p
6A 400V 70p
6A 500V 88p
8A 400V 75p
8A 500V 95p
12A 400V 85p
12A 500V 105p
16A 400V 110p
16A 500V 130p
T2800D 130p

THYRISTORS
1A 50V 70p
1A 400V 90p
3A 400V 100p
8A 600V 140p
12A 400V 160p
16A 100V 180p
16A 400V 180p
C106D 45p
MCR101 36p
TIC44 27p
2N3525 130p
2N4444 180p
2N5060 30p
2N5064 35p

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