Australia $1.25 New Zealand $1.30 Malaysia $4.95 IR £0p (inc. VAT)

PRACTICAL ELECTRONICS

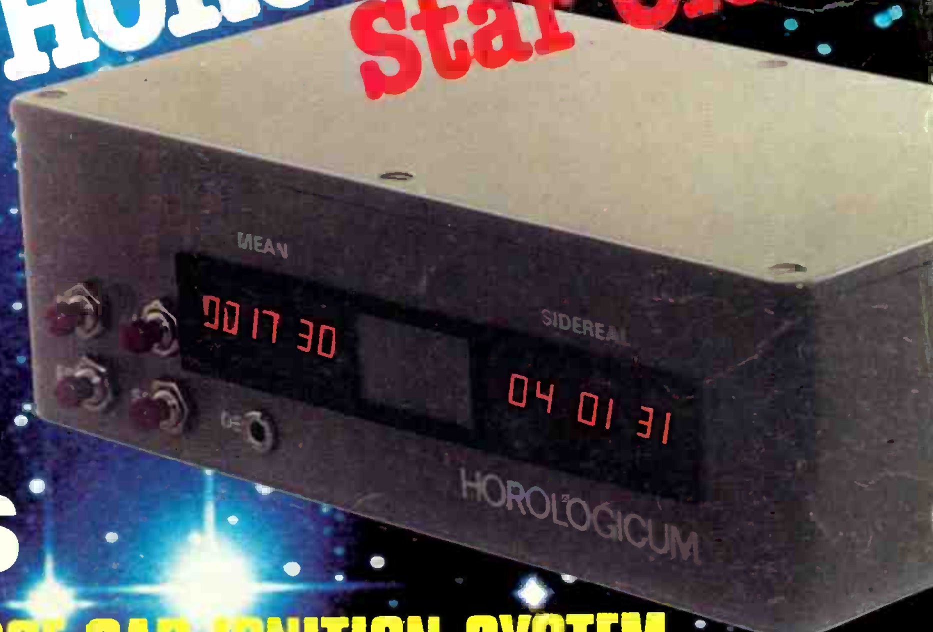
OCTOBER 1981

75p

FREE I.C. REMOVAL TOOL

(U.K. ISSUES ONLY)

HOROLOGICUM Star Clock



Also...

Introduction to ROBOTICS

INDUCTIVE DISCHARGE CAR IGNITION SYSTEM

PRACTICAL
ELECTRONICS
VOLUME 17 No. 10 OCTOBER 1981

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, 9 OCTOBER 1981
(for details of contents see page 57)

uter-

Available now-the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alpha-numerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

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 computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

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. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

☐ Please tick if you require a VAT receipt TOTAL £

*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.

Name: Mr/Mrs/Miss

Address:

FREEPOST – no stamp needed. Offer applies to UK only. PRE 10

sinclair ZX81

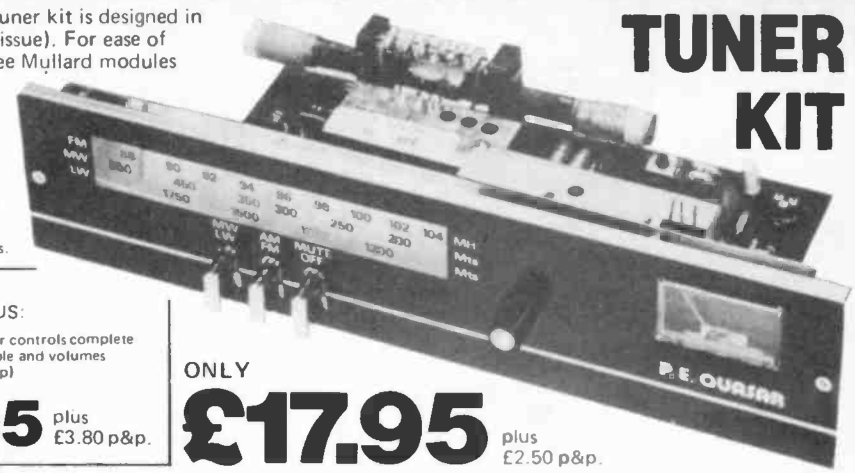
6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: (0276) 66104 & 21282.

NEW

PRACTICAL ELECTRONICS - STEREO TUNER KIT

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July issue). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF. System.

FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM - ferrite rod, FM - 75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10½"x 2½" approx. Complete with diagrams and instructions.

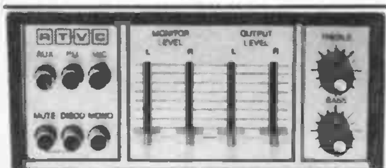


SPECIAL OFFER! TUNER KIT PLUS:

- Matching I.C. 10+10 Stereo Power amplifier kit (usually £3.95 + £1.15 p&p)
- Mullard LP1183 built preamp. suitable for magnetic/ceramic and auxiliary inputs (usually £1.95 + 70p p&p)
- Matching power supply kit with transformer (usually £3.00 + £1.95 p&p)
- Matching set of 4 slider controls complete with knobs for bass, treble and volumes (usually £1.70 + 80p p&p)

£21.95 plus £3.80 p&p.

ONLY **£17.95** plus £2.50 p&p.



STEREO AMPLIFIER KIT

- **Featuring latest SGS/ATES TDA 2006 10 watt output IC's with in-built thermal and short circuit protection.**
- **Mullard Stereo Preamplifier Module.**
- **Attractive black vinyl finish cabinet, 9"x8¼"x3¾" (approx)**
- **10+10 Stereo converts to a 20 watt Disco amplifier.**

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs - tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amp assembly kit and mains power supply. Also features 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia with matching knobs and contrasting cabinet. Instructions available, price 50p. Supplied FREE with the kit.

£14.95 Plus £2.90 p&p.

SPECIFICATIONS:

	Suitable for 4 to 8 ohm speakers.
Frequency response	40Hz - 20KHz.
Input sensitivity	P.U. 150mV. Aux. 200mV. Mic. 1.5mV.
Tone controls	Bass ±12db @ 60Hz Treble ±12db @ 10KHz
Distortion	0.1% typically @ 8 watts
Mains supply	220 - 250 volts 50Hz.

STEREO MAGNETIC PRE-AMP CONVERSION KIT
Includes FREE Magnetic cartridge with diamond styli.
All components including p.c.b. to convert your ceramic input on the 10+10 to magnetic.
Only available with 10+10 amp. **£2.00** includes p&p.

8" SPEAKER KIT Two 8" twin cone domestic speakers. £4.75 per stereo pair plus £1.70 p&p. when purchased with amplifier. Available separately £6.75 plus £1.70 p&p.

PRACTICAL ELECTRONICS CAR RADIO KIT

SERIES II

2 WAVE BAND MW - LW

- Easy to build
- 5 push button tuning
- Modern design
- 6 watt output
- Ready etched and punched PCB
- Incorporates suppression circuits.

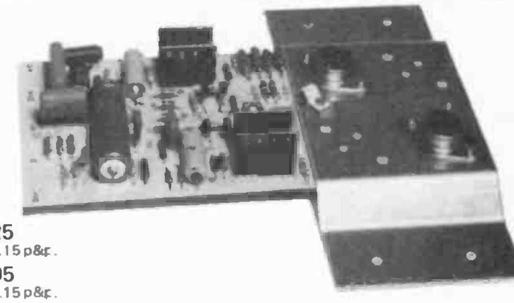
All the electronic components to build the radio, you supply only the wire and the solder, featured in Practical Electronics March issue. Features: pre-set tuning with 5 push button options, black illuminated tuning scale. The P.E. Traveller has a 6 watt output neg. ground and incorporates an integrated circuit output stage, a Mullard IF Module LP1181 ceramic filter type pre-aligned and assembled, and a Bird pre-aligned push button tuning unit.

£10.50 Plus £2.00 p&p.

Suitable stainless steel fully retractable aerial (locking) and speaker (6"x4" app.) available as a kit complete. **£1.95**/pack. Plus £1.15 p&p.

HIGH POWER AMPLIFIER MODULES

READY BUILT OR IN KIT FORM



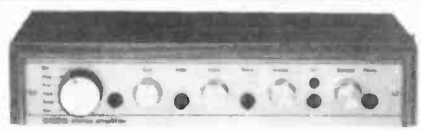
	KIT	BUILT
125 WATT MODEL	£10.50 Plus £1.15 p&p	£14.25 Plus £1.15 p&p.
200 WATT MODEL	£14.95 Plus £1.15 p&p	£18.95 Plus £1.15 p&p.

SPECIFICATIONS:	125 W Model	200 W Model
Max. output power (RMS)	125 watts	200 watts
Operating voltage (DC)	50 - 80 max.	70 - 95 max.
Loads	4 - 16 ohms	4 - 16 ohms
Frequency response measured @ 100 watts	25Hz - 20KHz	25Hz - 20KHz
Sensitivity for 100 watts	400mV @ 47K	40mV @ 47K
Typical T.H.D. @ 50 watts, 4 ohms	0.1%	0.1%
Dimensions (both models)	205 x 90 and 190 x 36mm.	

The P.E. power amp kit is a module for high power applications — disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC Board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

ACCESSORIES:

Suitable LS coupling electrolytic for 125W model	£1.00 plus 25p p&p.
Suitable LS coupling electrolytic for 200W model	£1.25 plus 25p p&p.
Suitable mains power supply unit for 125W model	£7.50 plus £3.15 p&p.
Suitable Twin transformer power supply for 200W model	£13.95 plus £4.00 p&p.



30+30 WATT STEREO AMPLIFIER

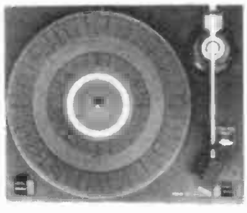
Viscount IV unit in teak simulate cabinet, silver finished rotary controls and pushbuttons with matching fascia, mains indicator and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape and auxiliary. Rear panel features fuse holder. DIN speaker and input socket 30+30 watts RMS, 60+60 watts peak. For use with 4 to 8 ohm speakers.
Size 14¾"x10" approx.
BUILT AND TESTED.

£32.90 Plus £3.80 p&p.

PHILIPS BELT DRIVE RECORD PLAYER DECK GC037

(Size: 15¼"x 12¼" approx.)

HiFi record player deck, 2 speed, damped cueing, auto shut-off, belt drive with floating sub chassis to minimise acoustic feedback. Complete with GP401 stereo magnetic cartridge



LIMITED STOCK.

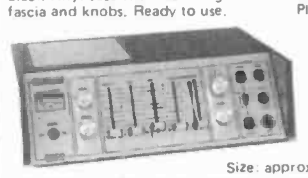
UNBEATABLE OFFER AT

£27.50 COMPLETE
Plus £3.16 p&p.

MONO MIXER AMPLIFIERS

50 WATT Six individually mixed inputs for two pick ups (Cer. or Mag.), two moving coil microphones and two auxiliary for tape, tuner, organs, etc. Eight slider controls - six for level and two for master bass and treble, four extra treble controls for mic and aux inputs. Size: 13¼"x6½"x3¾" app. Power output 50 watts R.M.S. (continuous) for use with 4 to 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.

£39.95 Plus £3.70 p&p.



100 WATT

Brushed Aluminium fascia and rotary controls.
Size: approx. 14"x4"x10¼".

Five vertical slider controls, master volume, tape level, mic level, deck level, PLUS INTERDECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre fade level controls (PFL) lets YOU hear the next disc before fading it in.
VU meter monitors output.
100w RMS output (200w peak).

£76.00 Plus £4.60 p&p.

RTVC

CALLERS ONLY
323 Edgware Rd, London W2. Tel: 01-723 8432.
Open 9.30am - 5.30pm. Closed all day Thursday.
Persons under 16 not served without parents authorisation.
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MAIL ORDER ONLY
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Note: Goods despatched to UK-postal addresses only.
For further information send for instructions 20p plus stamped addressed envelope.

All items subject to availability. Prices correct at 1/10/80 and subject to change without notice. RTVC Limited reserve the right to update their products without notice.

PE VOLUME 17 No. 10 OCTOBER 1981

REDUNDANT?

THE microprocessor and robots are about to rear their ugly heads in our pages. "Will this make hobbyists and journalists redundant?", we hear the laymen asking. As readers will be aware, much has been made of "the chip" as the popular press like to call the m.p.u., though why they should suddenly latch onto a term that has been used for i.c.s for a decade and frighten everyone into believing it will take over their jobs, is a mystery to most of us. Presumably, once the fuss is over they will take no more notice of further developments until an android is made by someone! Besides all that, what on earth are we talking about "make an appearance"? The m.p.u. has hardly ever been out of our pages in the last three or more years, so what do we mean?

DEDICATED

Dedicated, that's the word that changes it all. Up to now we have not used a dedicated m.p.u. in a project but we are about to commence publication of our first unit which has a built-in program specifically designed for a new item of equipment. It does not employ an "off the shelf" dedicated and programmed m.p.u. but uses an EPROM to store its controlling program.

This development is the next step in the ever-changing life of PE. Why has it taken about three years for us to publish something? Mainly because we do not agree with using an m.p.u. just for the sake of it; it should be cost effective above all else and up till now we have found it cheaper to design our projects in other ways.

However, now that the breakthrough has come to PE, we have a number of projects lining up with dedicated m.p.u.s to control them. The first will be the *PE Bandbox* which starts, along with our robots (more about them later), next month. This unit is an add-on development of the *PE Master Rhythm*—both designed by Alan Boothman—and can provide trio accompaniment (bass, drums and chord instruments) for a solo performer. It will store about 3,000 different chord changes between approximately 120 chords and thus replay around 80 user programmed tunes; capacity depends to some extent on the complexity of the scores. The Bandbox can be directed to play individual or groups of scores in any key at a controlled tempo. Facilities exist for composition of introduction, repeat chorus and coda sections including linked multiple score sequences, so the unit is extremely versatile.

ROBOTS

Now to get to the second item which will see off the few remaining jobs in the UK! The *PE Robots* are about to arrive in force. We will be publishing three robot designs all employing low pressure hydraulic systems driven by an electric motor and all available as complete professionally-engineered kits. They won't be cheap but then they are not Heath Robinson tin and string contraptions either, and they can be used for real work, not just as experimental toys. However, they are inexpensive when compared to similar ready-made commercial units costing £5,000 or more. Many industrial robots that perform similar tasks to those of which the *PE Robots* are capable cost tens of £1,000!

Our robotics article (page 30) written by the Director General of the Production Engineering Research Association, Professor Heginbotham, gives an introduction to the subject of robotics.

Mike Kenward

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We regret that lengthy technical enquiries cannot be answered over the telephone (see below).

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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 Practical Electronics.

All letters requiring a reply should be accompanied by a stamped, self addressed envelope 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 some of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders
Binders for PE are available from the same address as back numbers at £4·30 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 David Shortland & Jasper Scott

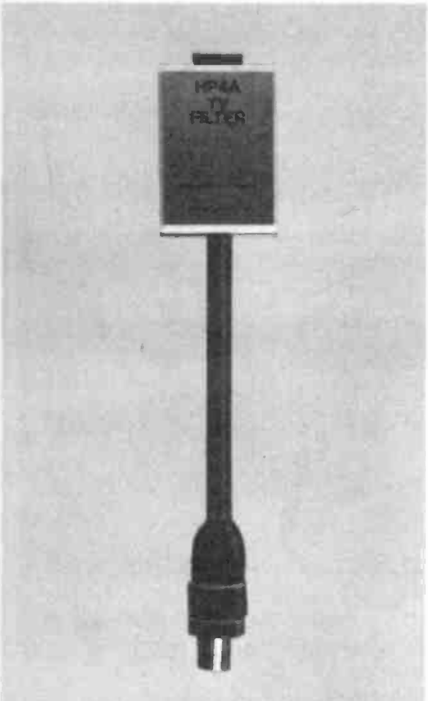
BBC's disappointment

The BBC is very disappointed with the response it has had so far from schools to the new Electronics and Microelectronics School Radio Course which it is due to start broadcasting on September 22nd.

The course which has been designed for 14 to 16 year old pupils is in ten parts and will cover developments in the field of electronics over the last decade. It will also give pupils the opportunity to carry out practical work with a specially developed kit of parts which enables the course projects to be constructed without soldering.

Five of the twenty minute broadcasts are radiovision programmes which link a tape recorded broadcast with a filmstrip which can be purchased separately. The teachers' notes which are available free of charge also contain the master copies of the pupils' worksheets which can be photocopied. The course starts off with an introductory programme to bridge the gap between basic school physics and microelectronics covering switches, relays, capacitors, diodes and transistors. Other programmes include logic, counters, frequency division, memory systems as well as factual programmes explaining how micro-circuits are made and the economic and social effects of microprocessors. The final programme is a look ahead to see how the microprocessor may affect our lives in the future with the aim being to make the pupils aware of the microprocessor revolution and its impact.

Full details of how to obtain the kits and the filmstrips are included in the teachers' notes which are available from Electronics and Microelectronics BBC School Radio, 1 Portland Place, London W1A 1AA on receipt of a s.a.e. with a 20p stamp.



STOP THAT NASTY TVI

The HP4A high pass filter has been designed to eliminate UHF TV interference caused by CB, police, taxis, amateur radios etc. although it is an unfortunate fact that in most cases of interference the fault lies with the TV receiver rather than the transmitter.

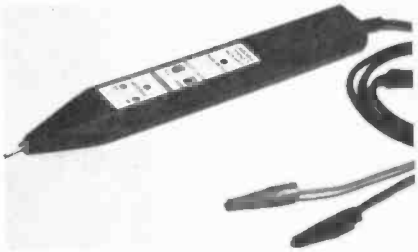
TV receivers have a very poor ability to reject stray local signals even if they are several hundred megahertz away from the TV band and as a consequence any radio transmitter that is close to a number of TVs is almost certain to cause interference to at least one set.

This filter is a double acting type which blocks signals on both the inner and outer conductors of the coax cable and the insertion loss is so low that no degradation of picture quality should be noticed even in poor reception areas.

The HP4A is priced at £5·95 including VAT and p&p from Waters & Stanton Electronics, 18–20 Main road, Hockley, Essex (0702 206835).

LOW COST LOGIC PROBE

Sinclair Electronics have introduced a small, low cost digital logic probe with a wide frequency response from d.c. to 50MHz suitable for use with high clocking rate circuits. Designated the LPD-076, the probe is designed for use with TTL/DTL as well as CMOS logic families and has three l.e.d.s indicating high, low, open circuit or poor level states respectively. A major feature is the powerful pulse/memory mode



and indicator which extends use of the device from continuous high speed pulse monitoring to very slow repetition, narrow width pulse detection. The LDP-076 comes complete with its own case as well as an i.c. clip cord and a ground shield cord for high frequency work.

LDP-076 operates using the power from the system under test and is protected against an input overload of ±120V d.c./a.c. Maximum power input protection is ±100V d.c./a.c. An additional audible alarm is activated when the input signal level exceeds that of the operating power, when the power voltage exceeds 30V d.c., or a reverse polarity is applied, and when a.c. power is connected to the input.

The LDP-076 is priced at £49·50 plus VAT. Sinclair Electronics Ltd., London Road, St. Ives, Huntingdon, Cambs. PE17 4HJ.

MICROBUS

We apologise to regular readers of Microbus for its non-appearance in this issue. It will be published next month.

ADCOLA

In last month's News & Market Place we gave the address of Adcola Products Ltd., as 113 Camden Road. This was incorrect. Adcola's correct address is 113 Gauden Road, London SW4 6LH. (01-622 0291).

MARKET PLACE

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

Briefly...

The growth in the sale of teletext receivers continues with Mullard announcing an order from Thorn Consumer Electronics for 120,000 teletext modules worth around £2 million. Thorn's are currently producing teletext set at an annual rate approaching a quarter of a million.

● ● ● ●

Watford Electronics have just announced that they have been appointed as distributors to the amateur market by Texas Instruments and will supply the complete range of TI semiconductors.

● ● ● ●

The first national CB exhibition will take place at the Royal Horticultural Society's Old Hall, Westminster, London on the 11, 12 and 13 September. With the legalisation of CB expected during September/October all the equipment at the show will become legally available a few weeks after the exhibition.

● ● ● ●

Anyone with an interest in amateur robotics will be pleased to hear of 'Transducer'—a club which specialises in the subject.

The annual membership fee and subscription to the newsletter is £5. Complete club membership can also be arranged. For a sample newsletter and further details readers should send a cheque or postal order for 50p to D. Stocqueler, 66 Waterloo Road, Penylan, Cardiff.

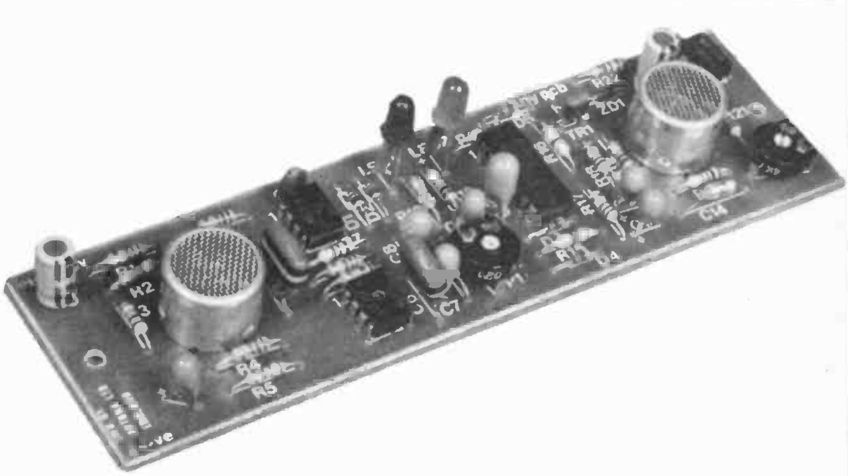
● ● ● ●

Newcastle upon Tyne Education Committee inform us that they are running a radio course at Gosforth, beginning in September. The course is designed to prepare students for the Radio Amateurs Examination in May/June 1982 and will run at the Gosforth Adult Association Classes at Gosforth Secondary School, Gosforth, Newcastle upon Tyne.

Although specifically for the R.A.E. the course is also ideal for anyone wanting to get an insight into radio theory, having just taken up radio or electronics generally as a hobby or professionally. The course will be held on Tuesdays of each week from 7pm to 9pm, and candidates may sit the R.A.E. at the school.

Enquiries should be addressed to: The Principal, Gosforth Adult Association, Gosforth Secondary School, who will forward a prospectus by return, or further information can be obtained by telephoning Newcastle upon Tyne 668439.

ULTRASONIC ALARM



The US 4012 is a new ultrasonic alarm unit from Riscomp operates at 40kHz with an effective range of up to 25ft. The unit incorporates the usual 40 sec 'switch on' delay together with a fixed alarm time and an inhibit period following an alarm to prevent the slow decay of the siren retriggering the unit. Two l.e.d. indicators are provided to enable the unit to be set up visually rather than audibly and with a standby current of only 15mA at 12V the US 4012 can be operated from batteries in the event of a power failure.

A power supply and relay unit together with a ready drilled enclosure is also available and the complete system is priced at £22·17 including VAT and p&p.

Riscomp Ltd., 21 Duke Street, Princes Risborough, Bucks HP17 0AT.

Tooled up

A new electronics service wallet from Toolmail Ltd., is designed for work with all electronic equipment including video, audio and computers.

The fitted zipper wallet contains a carefully selected range of 25 precision miniature tools including a soldering iron, desolder braid, solder, soldering tools, a range of pliers, cutters and screwdrivers, wire strippers and contact cleaners.

The kit is priced at £39·50 including VAT and p&p, and it is available from Toolmail Ltd., Parkwood Industrial Estate, Sutton Road, Maidstone, Kent ME15 9LZ.

...NEWS & MARKET PLACE

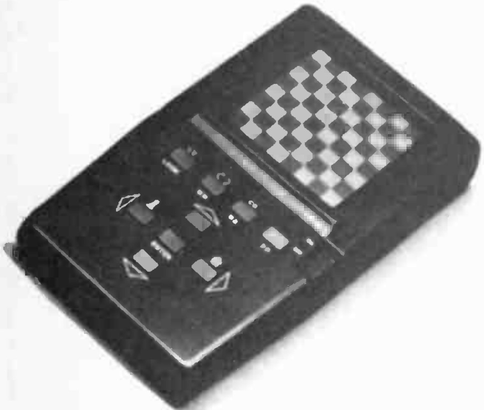
TRAVELLERS CHESS SET

Vulcan's executive chess set is a hand-held chess computer which is especially recommended by the World Chess Federation for travelling chess enthusiasts. It has a large l.c.d. chessboard and black futuristic styling.

For the first time, a player can move electronic chess pieces across the board as if they were real pieces on a conventional board, with the novel cursor control system.

Executive chess has 8 levels of play—from beginner to expert— and it can be operated from mains or battery. It offers most of the features of non-portable models, plays either black or white and is easily reversible. This model will even play against itself.

The price of the Executive is £89·95 including VAT.



UPGRADED BIMBOARD

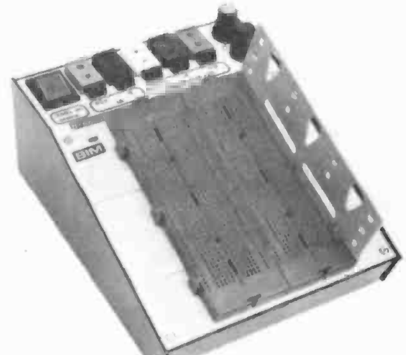
Boss Industrial Mouldings have upgraded their range of Bimboard prototyping systems. The new range incorporates either 1, 2, or 3 individual bimboards mounted on a 15 degree sloping front panel with a triple range power supply.

Each Bimboard has a central breadboarding area in which 47 horizontal rows of 5 interconnected sockets are set either side of a central channel on a 2·54mm matrix together with integral bus strips on each side for carrying power.

The system incorporates a fixed 5V d.c. ($\pm$0·2V) at 1A supply plus independently adjustable positive and negative rail $\pm$5V TO $\pm$15V at 0·5A supplies. Each supply is fully isolated and has short circuit protection.

The basic Bimboard is priced at £70 ex. VAT and p&p with extra boards available for £5·70 ex. VAT.

Boss Industrial Mouldings Ltd., 2 Herne Hill Road, London SE24.



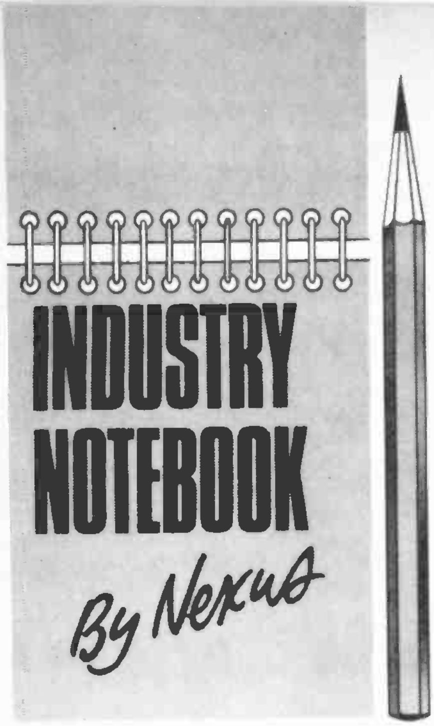
Countdown...

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

BEX Cardiff Sept. 3–4. Centre Hotel. K
Business & Light Aviation Sept 3–5. Cranfield Airport. Z1
Microprocessor Workshop Sept. 7–8. University of Liverpool. D
Laboratory Sept. 8–10. Grosvenor House, Park Lane, London. I
Personal Computer World Show Sept. 10–12. Cunard Hotel, London. M
West of England Electronics Show Sept. 15–17. Bristol Exhibition Centre. Q
Microtest Sept. 21–24. University, Kent. G1
Business Telecoms & Electronic Office Sept. 23–25. Royal Lancaster Hotel, London. O
Microtest Sept. 21–24. (Symposium), Kent University, Canterbury. S1
BEX Edinburgh Sept. 30–Oct. 1. Assembly Rooms K
Viewdata Oct. 6–8. Wembley Conference Centre, London. O
BEX Bristol Oct. 14–15. Exhibition Centre. K
Video Show Oct. 16–18. West Centre Hotel, London. Z1
There are **Continuous Events & Permanent Exhibition** at the National Micro & Electronics Centre. L1

D Liverpool Univ., Brownlow Hill, PO Box 147
G1 Sert, 8 Charing Cross Rd., London
I ITF, Solihull ✆ 021-705 6707
K Douglas Temple, Bournemouth ✆ 0202-20533
L1 World Trade Centre ✆ 01-488 2400
M Montbuild Exhibitions ✆ 01-486 1951
O Online, Northwood, Middx. ✆ 09274 28211
Q Exhibitions for Industry ✆ 0883 34371
S1 SERT ✆ 01-403 2351
T Trident, Tavistock ✆ 0822 4671
Z1 IPC Exhibitions, Sutton ✆ 01-643 8040

Simply place the tool over the ends of d.i.l. 8, 14 or 16 pin i.c.s and pull them out—it's that easy now!



Jobs

The urban disturbances during the summer inevitably focused attention on their causes with jobs, or more precisely lack of them, as a leading contributor. This may be true but we shouldn't be surprised at the rise in the unemployed.

When we look back to 1974 when the miners' strike toppled the Heath government, unemployment was 2.6 per cent with 585,000 people out of work according to the register. But was this the true figure? When the nation was forced to operate a three-day working week most firms achieved figures of upwards of 80 percent of normal output and some, in the excitement of the new challenge, were reported to have produced over 100 per cent of their normal weekly output.

It was jokingly observed that perhaps a three-day week could be made permanent. But Labour won the day on the slogan of 'getting the nation back to work', at the same time giving the miners all and more than they had demanded, thus triggering off big pay increases all round which led to over 25 percent inflation and ultimately to the 'winter of discontent'.

The three-day week revealed that industry was over-manned. As wages and inflation soared the crunch became inevitable. De-manning started seriously under Labour who doubled the dole queue, and has accelerated during the Conservative drive for greater efficiency. Unemployment, previously concealed by overmanning, is now on public view. We are no longer deceived.

The point is perfectly illustrated by Jaguar whose current output of cars is higher and of better quality than a year ago with 40 per cent fewer employees. And yet, say Jaguar, the company is not yet cost-competitive with comparable manufacturers on the European mainland.

No politician dare admit it but it has to be faced that what is described as the 'natural' level of unemployment in the UK will settle at a figure in excess of two million even following a substantial increase in world trade which, according to a recent forecast from the International Monetary Fund, is unlikely in the immediate future.

In fact the unthinkable, the unspeakable, the politically unacceptable, has actually happened. The meaning of the term full employment has in seven years changed from half-a-million to a new norm of two-million plus on the unemployed register. This would be perfectly supportable with nine people out of ten profitably employed but for the present uneven distribution among geographical regions, among ethnic groups and among age groups.

No political party in a free society is able to solve the problem. You cannot force people to move from one area to another, or force industry to employ unwanted people or invest in areas which are regarded as troublesome. The easy option of injection of yet more public cash into the areas of difficulty is only a short-term palliative.

In the end the individual is forced to look to his own resources. In this respect the Welfare State, so hopefully instituted more than 30 years ago, may have done more harm than good by diminishing personal initiative. 'They' will care for everyone, it's 'their' fault, etc.

Has the great educational experiment of recent years been successful? This shifted the emphasis from vocational training (i.e. producing factory and office fodder) to instruction in life and living with the objective of students emerging as well-rounded responsible citizens equipped to exploit all the exciting possibilities of increased leisure which was bound to come, and seen to be coming, in the age of automation. One result of liberal education is a growing hard core of youth, illiterate, inarticulate, often delinquent, virtually unemployable, yet equally unable to direct their energy to harmless enjoyment. The common excuse for vandalism or worse is boredom.

All, however, is not disaster. The popularity of *Practical Electronics* and a whole host of other hobby journals among the young is one yardstick of the current level of intelligent spare-time activity with a strong element of painless self-education and even career advancement. It is remarkable how many of the engineering and technician grades in the electronics and electrical industries are filled by people who started as hobbyists and then realised that a good amateur, literally a lover of the craft, could equally well be a good professional.

My advice to the unemployed young is to get into electronics as quickly as possible. The industry still needs recruits but can afford to be selective — in fact has to be selective if it is to continue to ride high in world markets.

Results

All the 'majors' in the industry have now reported full-year results with GEC, Plessey, Racal and Ferranti all having record years. Thorn-EMI had a profit drop from £125.5 million to £94·3 million but even this hiccup still pleased the City who feared a worse result.

GEC, the traditionally cautious plodder, upped profits from £415 million to £476 million which compares more than favourably with British Steel's loss of £668 million in the same period. Racal, despite fears that the Decca acquisition was too expensive and would be difficult to turn round, upped profits by £22 million to £73.2 million. The Racal-Decca companies which account for some 30 per cent of turnover were losing £12 million a year. The loss is now down to £2.5 million and all set for profit next year.

How is it that companies like Racal and GEC continue to prosper through good times and bad, seemingly unaffected by oil shortages or glut, high or low exchange rates, good or bad government? It can only be that they have goods or services that others want to buy. Without that they are nothing. Now add on leadership, management, sound economics, market strategy and a willing, if not always enthusiastic, workforce and you get somewhere near the complete success package. It is quite true that big and well established companies have a momentum of their own but you don't need to be big to be successful. The big companies also had to start small.

One of the year's best success stories is Memory and Electronic Components (MEMEC) started in the 1974 recession by Dick Skipworth and his aide Ed Sturmer. They had a single product range to sell, integrated circuits from Harris Semiconductor, and later expanded the range to include other components and microcomputer equipment. Turnover by 1976 had grown from nil to £454,000. Last year it was up to nearly £7.3 million.

When the company went public in July the 10p shares were offered at £1.40 each. The issue was oversubscribed 58 times and dealing started at £1.96. As chairman and managing director 43-year-old Dick Skipworth draws £55,000 a year salary. He also owns nearly 4 million shares. Ed Sturmer, who is 34, is on £40,000 and has over a million shares. Both are now wealthy men through providing a service that people wanted to buy and they did it during recession. The original 'one-man-and-a-boy' has expanded to 73 employees and more people are being recruited.

Fight Back

According to BREMA, UK manufacturers will capture half the small screen TV market this year compared with only one quarter last year. Fidelity Radio is one company fighting back with a low priced colour set with the first 40,000 production already sold. The company has taken on 100 more workers, over half school leavers.

Another fight-back factory is at Bridgnorth where the former Decca TV factory is now under the Taiwanese management of Tatung (UK). Employees there are happy with a new tougher disciplinary code eased by a courtesy from management previously unknown in the area. The unions like it, too. Of the 580 workforce only 40 are reported to have taken redundancy rather than work in newly imposed conditions. The remainder have welcomed the new regime.

HOROLOGICUM Star Clock

J. S. B. Dick

SOCRATES is believed to have said astronomy is good for the soul. Certainly, looking up at the heavens on one of those crisp frosty nights, with a myriad of stars twinkling gently, is a beautiful sight. As the space age progresses, many people have become interested in astronomy as a hobby; the mystery of infinite space, the spectacular objects to be seen, and the ever-changing planets all exert an attraction to the star-gazer.

The stars, as seen from Earth, appear to be fixed to a celestial sphere which revolves continuously. The apparent position of any particular object changes throughout the night, but all is not chaos, however. The stars on their celestial sphere have, over the centuries, been mapped—just as the earthly sphere has been—with an astronomical equivalent of latitude and longitude. Knowing the celestial co-ordinates of any object and a quantity called "Local Sidereal Time" enables the astronomer to find any object in the sky and train a telescope on it.

This article describes a simple, dual-system clock designed to indicate both *Greenwich Mean Time* and *Local Sidereal Time.* Small physical size, low power consumption and ease of use permit the clock to be used out of doors—even, perhaps, at a remote observing site chosen for dark skies.

THE HEAVENLY CLOCKWORK PROBLEM

Why does the astronomer require this quantity called sidereal time? Sidereal time (time of the stars) has years, days, hours, etc., like mean time. One mean-time day, or solar day, is the time taken by the Earth to revolve until the sun re-occupies a set position in the sky; the sun is thought of as being due south each day at noon, for example. A sidereal day is the time taken until a star re-occupies a set position in the sky; it is shorter than the solar day, the effect essentially being caused by the motion of the Earth in its orbit. In units of mean time, the sidereal day is *23 hours 56 minutes 4 seconds* long. Alternatively, there are *24 hours 3 minutes 56 seconds* of sidereal time in a solar day.

This sounds rather baffling, but simply means if you observe a star at the same time on two nights, on the second night it will have moved further towards setting. If you wanted to observe it at the same position, you would have to do so some 4 minutes earlier. The inequality causes sidereal time to move ahead of solar time; the determination of a star's position requires sidereal time to be calculated—a fairly lengthy procedure—or obtained from a special clock like the unit described here.

The non-standard rate may be obtained by using a crystal oscillator with a custom-cut crystal or by dividing the output from a frequency-standard crystal (1·0MHz say) by an appropriate value to obtain 1·002738Hz instead of 1·000000Hz. A custom-cut crystal might cost £10 with a seven week delivery time and would require a high resolution frequency counter to trim to the correct frequency. A long divider chain with output decoding would employ many integrated circuits. Using CMOS devices a maximum crystal frequency of 5·0MHz could be used to give a conversion accuracy (mean to sidereal rate) of one part in one million. These methods are shown schematically in Figs. 1 and 2.

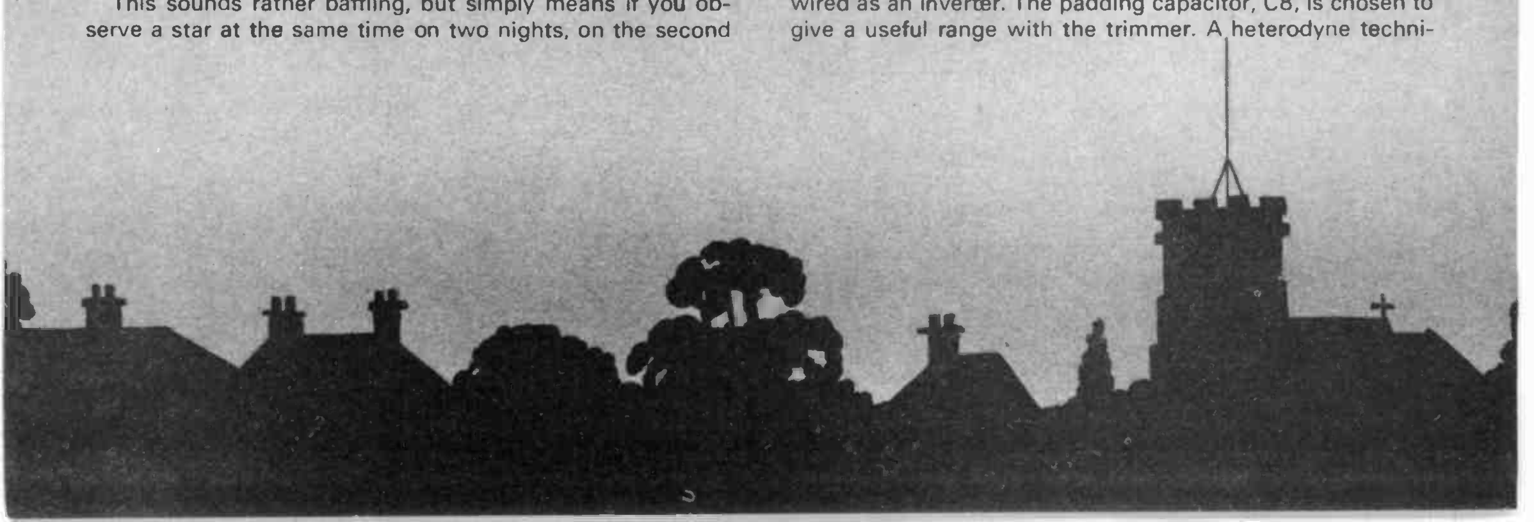
The HOROLOGICUM uses neither; a novel, incremental corrector is employed. With only six integrated circuits a time-averaged conversion accuracy of one part in ten million is obtained. Following a mathematical trend of thought, if any incoming frequency is divided by 1461 and, when a "carry" occurs, four extra pulses are injected into the original frequency, the output frequency, f_1, is (where f_0 is the original frequency):

$$f_1 = \left(1 + \frac{4}{1461}\right) \times f_0 = 1{\cdot}002738\, f_0$$

. . . which is the ratio required to obtain sidereal time from mean time. Hence, the problem has been elegantly solved. The block diagram of the design is shown in Fig. 3.

CIRCUIT DESCRIPTION

The circuit diagram of the star clock is shown in Fig. 6. The system oscillator is crystal controlled and operates at a frequency of 1[redacted]MHz—well within the capabilities of CMOS devices. The crystal is driven by a NAND gate (ICd) wired as an inverter. The padding capacitor, C8, is chosen to give a useful range with the trimmer. A heterodyne techni-



ner may be used to set the oscillator accurately (described later). Alternatively, a frequency counter may be gainfully employed. If greater accuracy is required, the crystal could be housed in an oven to maintain constant temperature. This was not implemented here because of the low power consumption requirement. Two 4518 dual BCD decade counters divide the 1·0MHz signal to 100Hz ($=2f_0$). A further 4518 may be added to give one-second markers for an external circuit; a socket position has been left available on the printed circuit board design.

The binary counter, shown in Fig. 3, receives the 100Hz signal; the device is the CMOS 4040 12-bit counter (IC8). Outputs Q2, Q6, Q7, Q9, Q10 and Q12 go to six inputs of the 4068 (IC7) eight input AND gate. Q8, Q11, Q3, Q5 and Q1 are tested for the ALL-ZERO condition by IC9a, c, d, IC6d, and IC7. At a count of 2914, IC6a sets the latch (IC4a, b) (Q—1, Q—0) and $2f_0$ is now routed through IC5a, IC4c, d. After eight counts (four extra plus four normal) IC8 reaches 2922 and IC6b resets IC8 and the latch (Q—0, Q—1). f_0 is now routed through IC5b, IC4c, d.

IC5c, d enable the outputs to be held, performing one of the setting functions of the clock.

The clock decoding is provided by an LSI chip, the MM5309. This is a general purpose MOS digital clock chip with (4 or 6 digit) drive capabilities compatible with the miniature displays used: Hewlett-Packard 5082–7405 and –7402 ("W" brightness class) devices. Display luminosity is equivalent to the average l.e.d. calculator and is certainly adequate in the astronomical environment! The MM5309 pin functions are shown in Table 1; selection pins left unconnected float to +ve voltage because of internal pull-up resistors. Six digit, 24-hour mode and 50Hz input are selected; the multiplex timing connections are shown in Fig. 4. The setting and display circuit is shown in Fig. 5 with function description in Table 2. At first reading, this method of setting may seem rather inefficient. However, it renders the exterior fitted push-buttons immune from accidental manipulation, an important criterion for portable equipment of this type.

To achieve the dual time option, two clocks are used (IC10 and 11) each with their own display. The mean-time clock is supplied with a 50Hz signal from the f_0 output shown in Fig. 3 while the sidereal clock is fed from the converted output ($f_0 \times 1{\cdot}002738$).

CONSTRUCTION

The unit is constructed on three 186mm x 50mm printed circuit boards; these fit the 2006 MB type plastic box, and the boards are held vertically by the guide slots provided. The track layout, component overlay and connections for each board are shown in Figs. 8a, b, 9a, b, 10a, b. Alternatively, since the layout is not critical, readers may care to design their own boards to suit individual applications.

Power supply connections are brought out from a common point—this helps to reduce the line noise from the oscillator and high-speed dividers. Ribbon cable may be used to link the clock i.c. outputs to the display board.

The cutouts on the front panel of the box which enable the displays to be seen are covered by oversize rectangles of magenta plastic available from art or photographic shops.

The Hewlett-Packard displays must be inserted the correct way, pin 1 of the package being asymmetric for identification.

TESTING

After completion of construction, the unit should be connected to a power supply of 12 to 16 volts while the current consumption is monitored. With the display off (d.i.l. 8 "on", no plug in SK2), 10mA (approx.) should be taken; 20mA with the display on (d.i.l. 8 "off").

If a frequency counter is to hand, connecting it to the buffered oscillator output will confirm the oscillator is functioning. For those who do not own a counter, the author recommends the purchase of a crystal earpiece. Surprisingly, this rather archaic acoustic apparatus makes an excellent logic probe. Placing the earpiece in the ear and touching the tip of the jackplug normally supplied on the circuit under test, will enable what is going on to be clearly heard. Note it is not necessary to connect the earth of the earpiece to circuit ground. Never use this test equipment with anything but

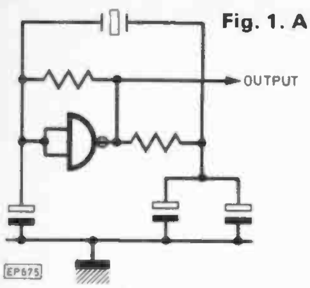


Fig. 1. A typical CMOS crystal-controlled oscillator

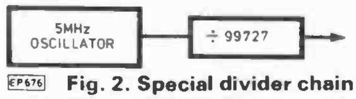


Fig. 2. Special divider chain producing 50 × 1·002738Hz

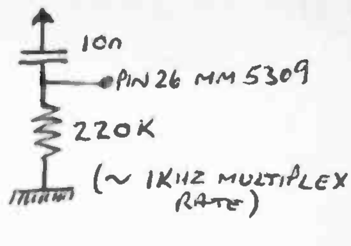


Fig. 4. Multiplex timing connections

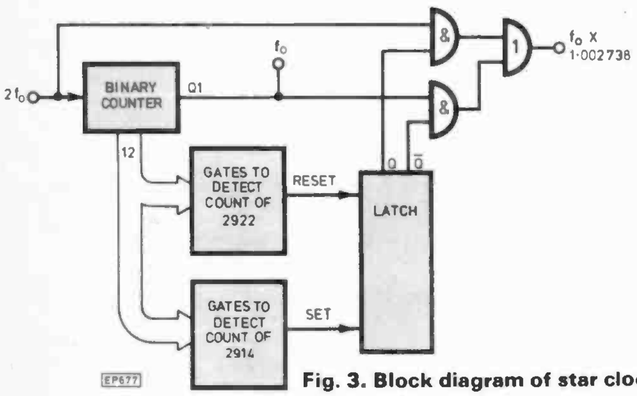


Fig. 3. Block diagram of star clock

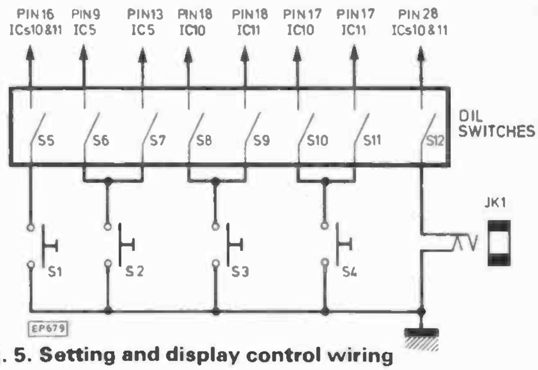


Fig. 5. Setting and display control wiring

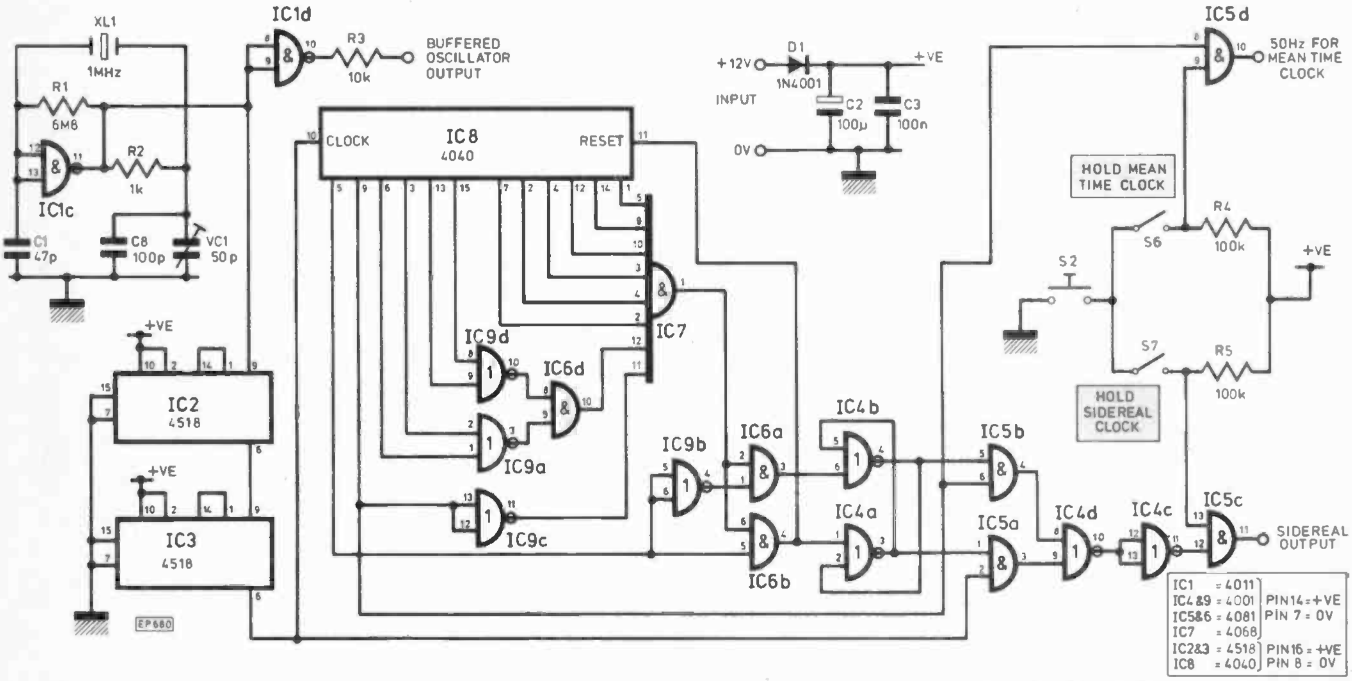
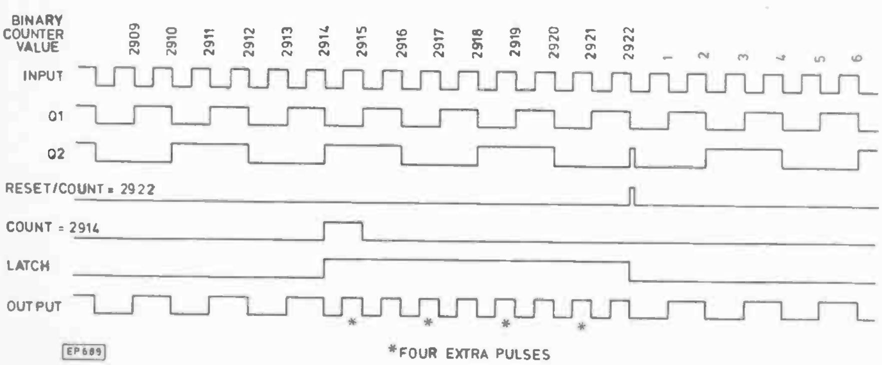


Fig. 6. Circuit diagram of star clock (oscillator, divider, converter)



Sidereal corrector pulse diagram

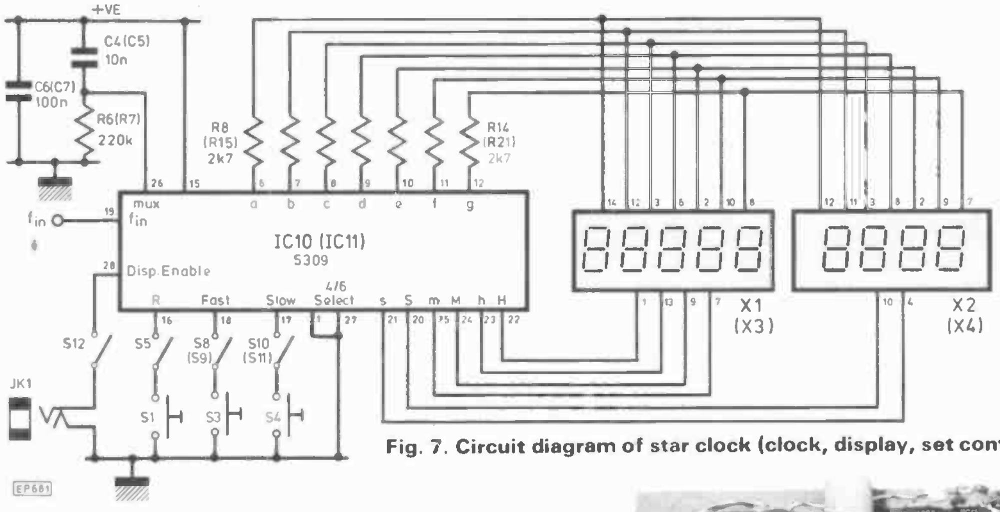


Fig. 7. Circuit diagram of star clock (clock, display, set controls)

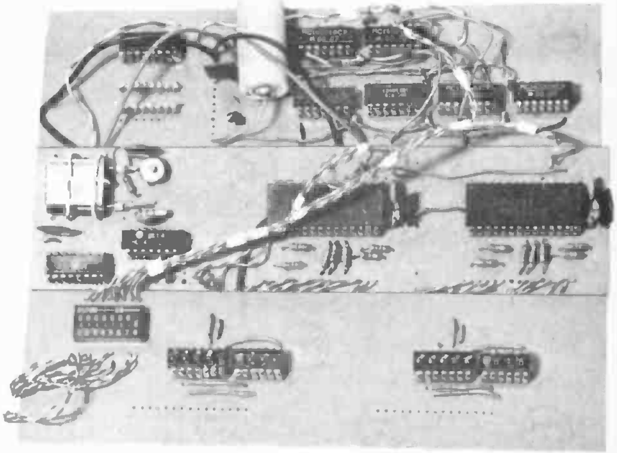
low voltage circuits! To confirm oscillator activity, place the tip of the jack on pin 14 of IC3—a loud buzz should confirm all is well.

A 50Hz signal will be present on pin 10 of IC5, the latch output (Q) should go high for 80ms every 29·2 seconds. An oscilloscope will show these signals, or the earpiece may be used to listen for a short squeak of 100Hz tone from pin 3 of IC5 every 29·2 seconds.

There is really no testing to be carried out with the LSI MOS clock devices. Checking the p.c.b. track and watching the display are the only pertinent activities. Note that the slow and fast setting functions should not be used simultaneously.

If all is functioning, the sidereal clock can be seen advancing in phase compared with the mean-time clock; the former gains ten seconds (approx.) per hour relative to the latter.

The crystal oscillator frequency may be checked using an accurate frequency counter and altered by adjusting the trimmer capacitor and C8. Alternatively, tuning may be achieved by timing the mean-time clock over, say, 24 hours, and iteratively correcting, or alternatively by heterodyning the signal against the 200kHz Radio 4 frequency. Bringing a radio close to the crystal oscillator produces a beat note with the Radio 4 signal which can be clearly heard. The trimmer may now be tweeked to minimise the beat frequency. It is advisable to leave the oscillator running slightly fast, clock correction may thenceforth be carried out with short presses on the HOLD button with both clocks connected (d.i.l. 2 and d.i.l. 3 "on").



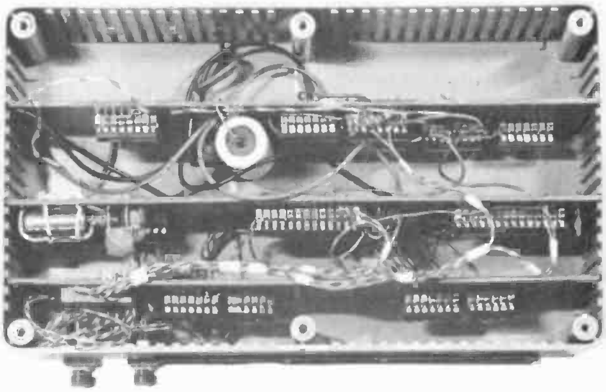


Table 1. MM5309 Pin Functions

1	Ground	28 ~~15~~	Display Enable	
2	BCD 8	27 ~~16~~	4/6 digit select	
3	BCD 4	26 ~~17~~	multiplex timing	
4	BCD 2	25 ~~18~~	unit	minutes
5	BCD 1	24 ~~19~~	tens	
6	a multiplex segment drives	23 ~~20~~	unit	hours digit drives
7	b	22 ~~21~~	tens	
8	c	21 ~~22~~	unit	seconds
9	d	20 ~~23~~	tens	
10	e	19 ~~24~~	clock signal input	
11	f	18 ~~25~~	fast	set
12	g	17 ~~26~~	slow	
13	12/24 hour format select	16 ~~27~~	reset	
14	50/60 Hz select	15 28	Positive Supply	

Table 2. Setting and Display Control Functions

DIL 1 "on"	Push S1 to RESET both counters
DIL 2 "on"	Push S2 to HOLD count on IC10 (clock 1)
DIL 3 "on"	IC11 (clock 2)
DIL 4 "on"	Push S3 to FAST SET IC10
DIL 5 "on"	IC11
DIL 6 "on"	Push S4 to SLOW SET IC10
DIL 7 "on"	IC11
DIL 8 "on"	Display off; insert J1 in SK1 to turn display on.

Note: If any d.i.l. switch is in the off position, pressing the push-button connected to it will have no effect on the corresponding clock.
With d.i.l. 8 off, the display is permanently on.

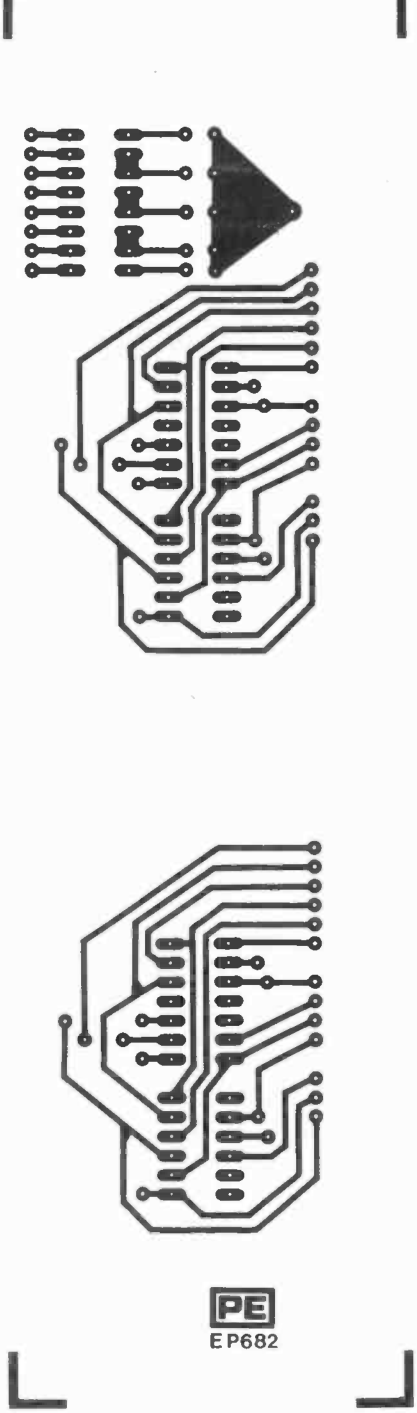


Fig. 8(a). Display p.c.b. (actual size)

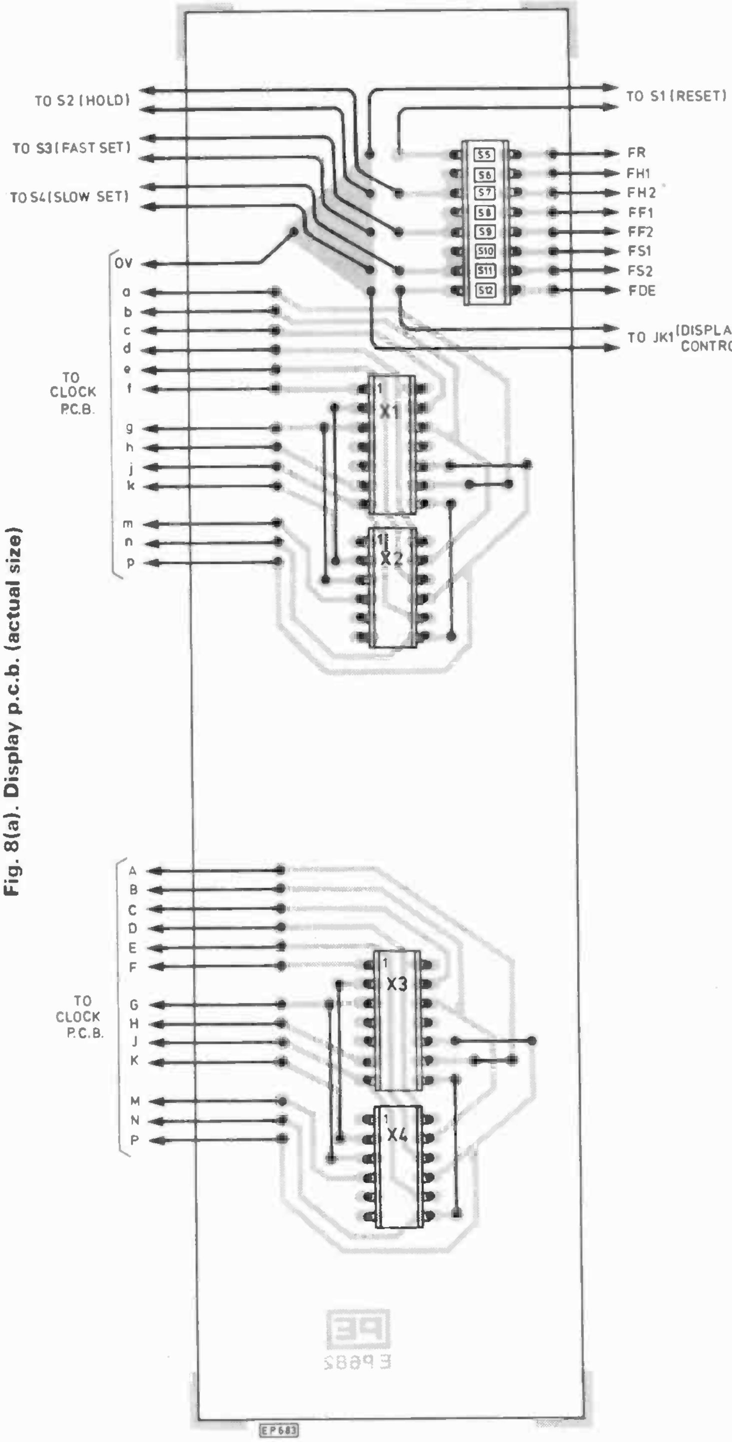
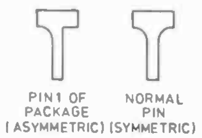


Fig. 8(b). Display board component layout



Pin identification of Hewlett-Packard displays

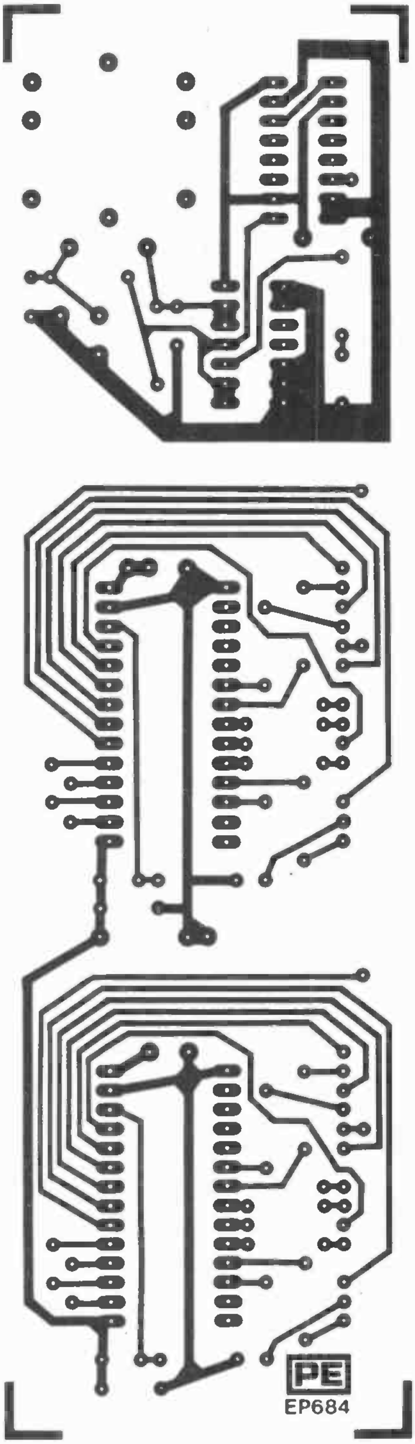


Fig. 9(a). Oscillator and clock p.c.b. (actual size)

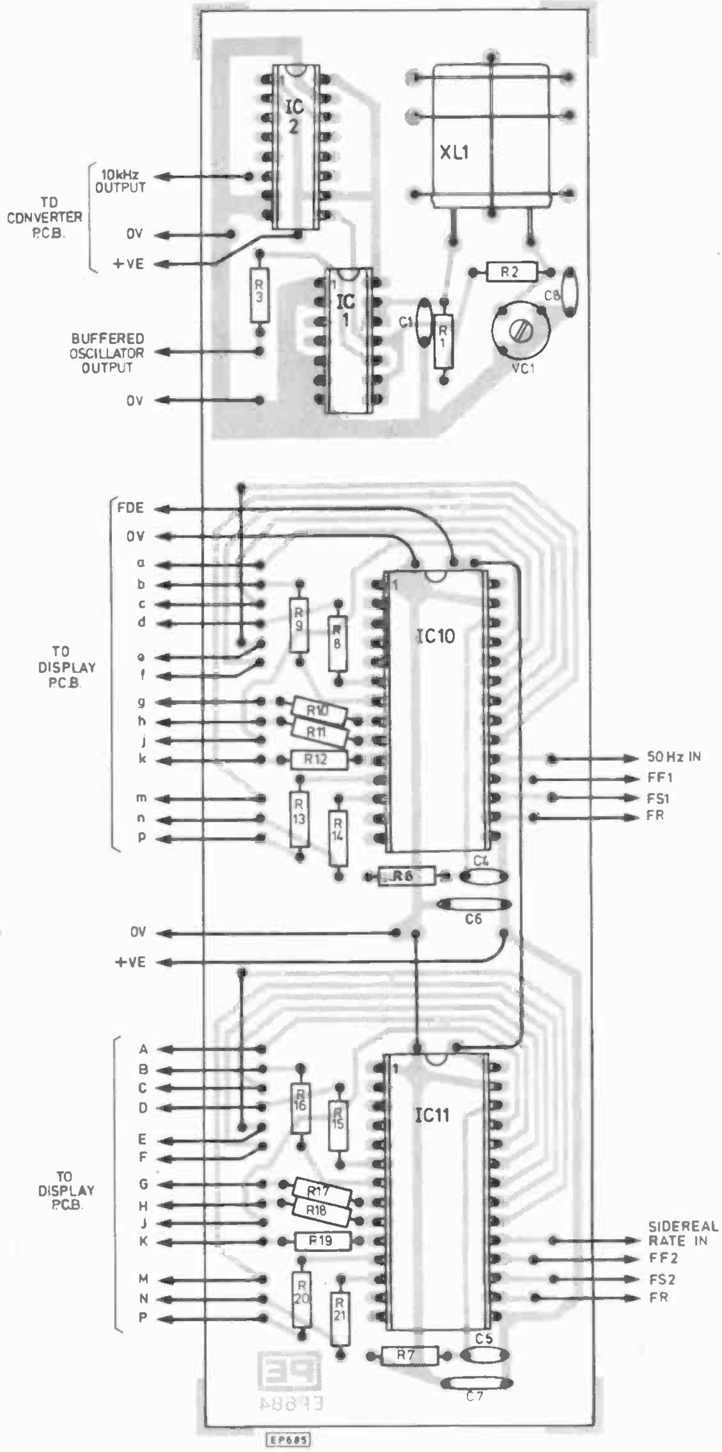


Fig. 9(b). Oscillator and clock board component layout

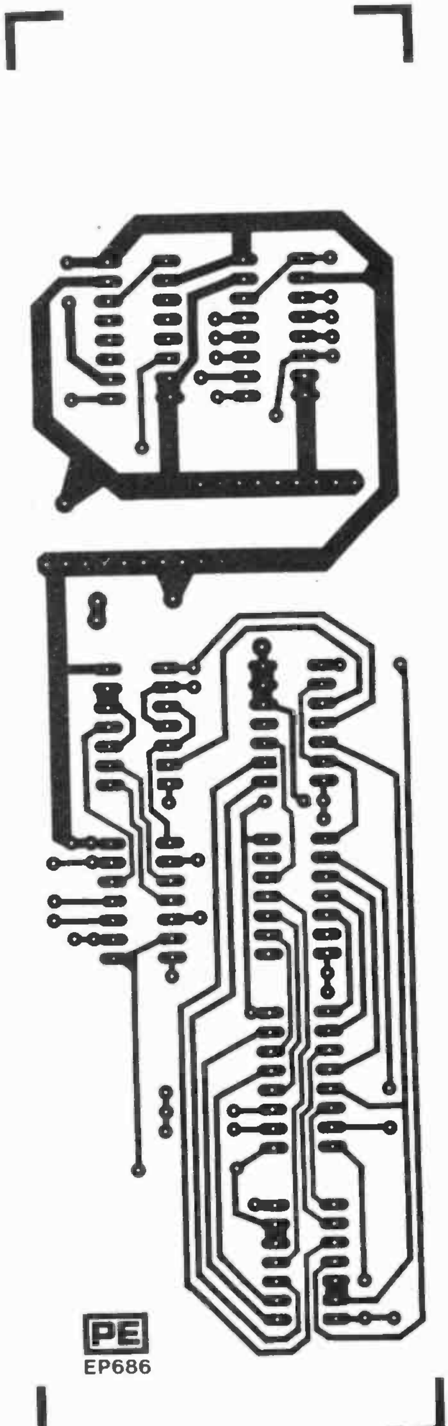


Fig. 10(a). Converter p.c.b. (actual size)

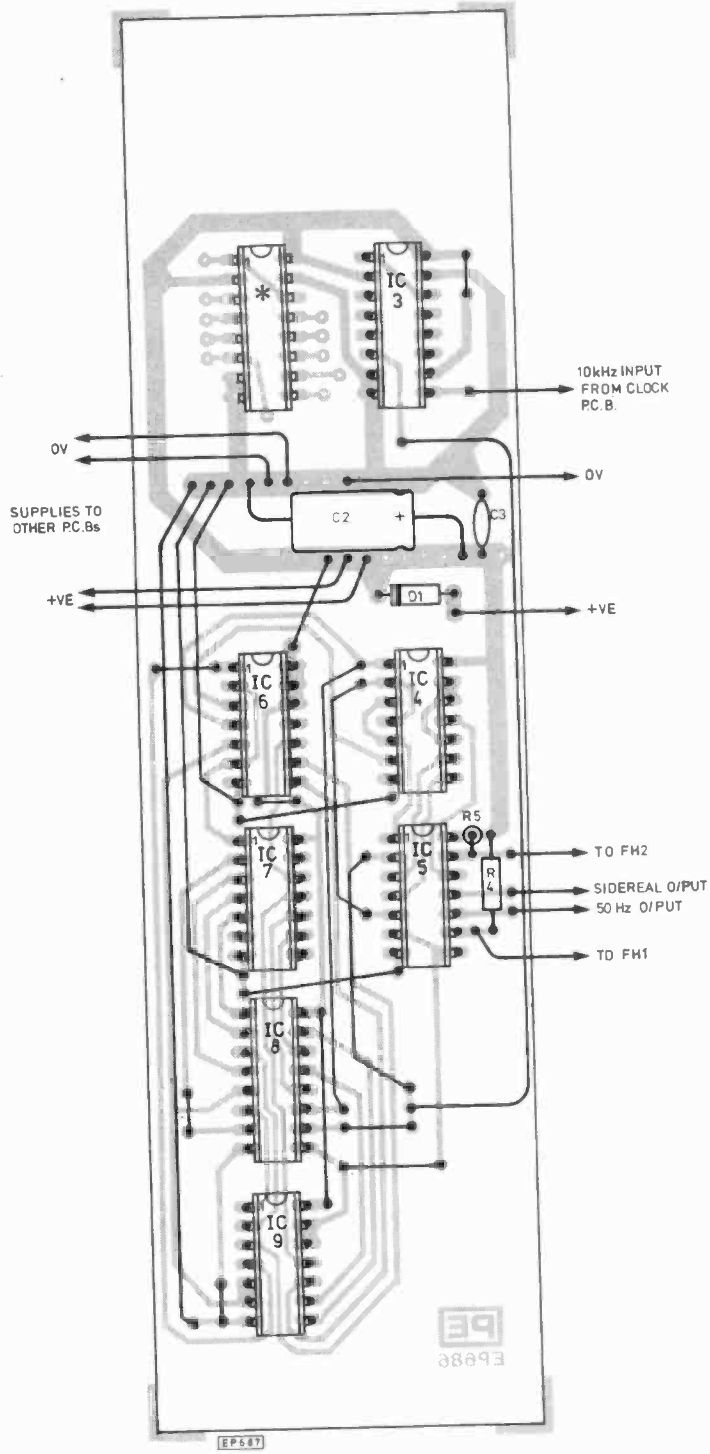


Fig. 10(b). Converter board component layout

COMPONENTS . . .

Resistors

R1	6M8	
R2	1k	
R3	10k	
R4,R5	100k (2 off)	
R6,R7	220k (2 off)	
R8–21	2k7 (14 off)	

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

Capacitors

C1	47p	Disc ceramic
C2	100µ 25V	Electrolytic
C3	100n	Disc ceramic
C4,5	10n (2 off)	Disc ceramic
C6,7	100n (2 off)	Disc ceramic
C8	100p	Disc ceramic
VC1	50p	Trimmer

Semiconductors

D1	1N4001	

Integrated Circuits

IC1	4011	Quad 2 I/P NAND
IC2,3	4518	Dual BCD decade counter (2 off)
IC4,9	4001	Quad 2 I/P NOR (2 off)
IC5,6	4081	Quad 2 I/P AND (2 off)
IC7	4068	8 I/P AND
IC8	4040	12-bit binary counter
IC10,11	MM5309	MOS digital clock (2 off)

Miscellaneous

J1	3·5mm plug	
JK1	3·5mm socket	
Xtal	1·0MHz	

D.i.l. Switch 8 SPST contacts (S5–S12)
S1–S4 Miniature Push-to-Make switches (4 off)
1,3 HP 5082-7405 } "W" brightness class
2,4 HP 5082-7402 } common cathode 0·1" displays

Constructor's Note

The MM5309 is available from DTV Group Ltd., 2-12 Ernest Avenue, West Norwood, London, SE27 0DJ.

APPLICATION

Following the instructions given in Table 2, the mean-time clock should be set to the correct time; astronomers may wish this to be GMT rather than any local time in operation. Suitable time signals to use are the six-pips of the BBC radio time signals (Home Services or World Service) or the numerous frequency and time standards transmitted on the short wave bands. The author has found the easiest method as follows: set the clock to an exact hour (or whenever the time signal is due) and then use the HOLD function to prevent counting until the time signal occurs, when the button should be released; a setting accuracy of $\pm\frac{1}{2}$ second can be obtained.

The sidereal clock is set in the same manner, although the correct local sidereal time needs to be established beforehand. Armed with a pocket calculator and a pad of paper, this is not too difficult. The sidereal time on the Greenwich Meridian (ie 0° longitude) was 6 hours 39 minutes 15 seconds at 0 hour GMT on 1st January 1980. To determine the Local Sidereal Time, calculate the number of complete days since 1st January 1980 (at 0 hour GMT) and add (to the 6 hours 39 minutes 15 seconds mentioned above) 3 minutes 56·555 seconds for each fully elapsed day. Decide the time of day (in GMT) at which the clock is to be set and convert this time from hours, minutes, seconds to hours and decimals of an hour. Multiply by 1·002738 and convert back again to hours, minutes, and seconds. Add this to the previous sum. A correction for longitude must now be applied. The reader's longitude may be obtained from a large scale map of his/her area; Ordnance Survey maps are excellent for this purpose in the UK. The value obtained should be converted to degrees and decimals of a degree West of Greenwich, then divided by 15 (to convert to hours and decimals of hours) and then converted back to hours, minutes, and seconds. This is subtracted from the previous sum.

If that little lot sounds terrible; two examples will show how easy it really is.

Let us suppose the Local Sidereal Time is required for 17 hours 30 minutes on the 5th March 1980 at Machrihanish (longitude 5° 44′ West, latitude 55° 25′ North).

1) Initial value for 1st Jan 1980	6h 39m 15s
2) 64 days (at 3m 56·555s) have elapsed	+ 4h 12m 20s
3) 17h 30m (ie 17·50h) times 1·002738	+ 17h 32m 52s
	= 28h 24m 27s
4) 5° 44′ West (ie 5·733°) divided by 15	− 0h 22m 56s
	= 28h 1m 31s
Subtracting multiples of 24h gives LST =	4h 01m 31s

. . . and for the 30th January 1981, 20h 15m local time, Coonabarabran (Australia) (longitude 149° 50′ East, latitude 31° 5′ South)

1) Initial value for 1st Jan 1980	6h 39m 15s
2) 395 days have elapsed (395 x 3m 56·555s)	+ 25h 57m 19s
3) This part of Australia is 10h ahead of Greenwich mean time normally, but operates one extra hour of Summer Time ahead for the date given. Hence, the GMT is 9h 15m so 9·25h x 1·002738	+ 9h 16m 31s
	= 41h 43m 05s
4) 149° 50′ East (ie 360° − 149·83° = 210·17° West) 210·17 divided by 15 = 14·0113h	− 14h 00m 40s
	27h 42m 25s
Subtracting multiples of 24h gives LST =	3h 42m 25s

Once set, the clock is ready for use. If, at some future date, the sidereal section is no longer required, the link between pin 24 of IC11 and pin 11 of IC5 may be disconnected and pins 24 of IC10 and IC11 connected—a dual time zone clock is then obtained to help with international telephone calls. Readers may care to note, for future reference, the basic conversion principle could be used to accommodate for local time on other planets! ★

Introduction to ROBOTICS

Professor Wilfrid Heginbotham O.B.E. D.Sc.

DIRECTOR GENERAL, PRODUCTION ENGINEERING RESEARCH ASSOCIATION (PERA)

INDUSTRIAL robots have little resemblance to the futuristic machines of science fiction. But there is one similarity. Most robots are designed to replace human workers and are built to the same scale, although they can generally lift much heavier weights and for longer periods. Apart from this superficial likeness, robots are very different from either humans or the robots of science fiction. They are really little more than machine tools, whose prime function is the handling of components. To carry out this task most robots have one manipulative arm which provides either point-to-point motion or a continuous path. The "architecture" of a robot may be cylindrical or polar, or it may consist of an arm and an elbow.

CAPABILITIES

Although at first sight an industrial robot can appear almost humanoid in its capabilities, the resemblance is a delusion. The facts fall better into place if one perceives the robot more as an "automated crane" controlled by an electronic cam system. Its most versatile feature is its ability to be re-programmed so that its arm obeys a different set of space/time co-ordinates. Once programmed, the machine reverts to being a mechanistic piece of automation that will perform a sequence of events.

Robots are good at mimicking the space/time co-ordination skills of a manual operator. For instance, one could record the movements of the conductor of an orchestra in such a way that, on future occasions, the robot would faithfully conduct the orchestra in precisely the same way as the conductor had done. It would, however, be completely unaware if the first violin were absent or, indeed, whether or not the entire orchestra were there at all. One could prepare for such hazards by equipping each seat with a sensor to detect the presence of players and so inhibit the robot motion until all were present; but even then the robot could be fooled by a "non-player" sitting in the chair. This simple example completely describes the present extent of robot intelligence and prevents one from expecting too much.

The full potential for robot versatility within a particular field of activity depends on how that activity fits the robot architecture and technology. Robots are ideal:

a. For the tracing of curves, where a low level of accuracy is sufficient.
b. Where no gripping is necessary, or where a loose grip is sufficient.
c. Where a standard no-variable gripping surface exists naturally on the component (ie, in die casting).
d. Where the skill of the manual operator is restricted to judgements within a clearly defined space/time pattern.
e. On relatively dedicated precision applications when sufficient peripheral "tooling" can "clean up" the final component position to the required accuracies.

These operations can be classed into four different categories, each with its own characteristics. They are listed below, with examples of typical operations.

QUICK AND EASILY CHANGED

The *first category* includes spray painting, shot peening, spot welding, stud welding, flame cutting, the application of gasket sealing compounds, coating, marking, heat sealing, glass cutting, water jet cleaning, drilling and any routine where no gripping is required. In these situations, so long as suitable means are available to initiate the process (ie, one single time/space co-ordinate to relate the start of the component/robot time relationship) then the job can be changed in a matter of minutes. Some robots can store a multiplicity of pre-recorded programmes.

The *second category* concerns operations where the gripping need not be very precise or where standard gripping surfaces are available (ie, gripping surfaces on the component or standard job holders). It includes the unloading of die casting and injection moulding machines, the dipping, quenching and handling of investment castings, unloading presses, unloading furnaces, flat sheet transfer, brick handling and stacking, heat treatment, rough transfer operations, stacking pallets and sacks and the general loading and unloading of machine tools over a range of cylindrical or other regular prismatic workpieces.

The *third category* demands more precise operations. Interstage tooling and special grippers and/or fixtures may be necessary for each different situation. Examples are the transfer between stations for hot and cold forging operations, the loading and unloading of machine tools in general work, inspection probing, filament winding, wire wrapping, sprue cutting, sorting and packing, deburring, fettling, drilling, routing and arc welding. The needs of any particular operation will need to be carefully scrutinised in order to select the appropriate activities.

The *fourth category* includes the control of assembly and parts in a factory where variability levels are high.

An analysis of 600 typical robot installations in the UK and West Germany showed that the proportion of activities in the various categories are:

	UK 1981 (BRA)	*West Germany 1980 (IPA)*
Category 1	36·0%	45·0%
Category 2	48·0%	42·0%
Category 3	15·0%	12·5%
Category 4	1·0%	0·5%

These interesting samples reflect very well the areas of activity where industrial robots of the present generation are easiest and most profitable to apply. The pattern does not seem to be significantly altered by differences in the two countries' economies.

From experience, it is possible to distil a few principles that determine the viability of robots in particular circumstances:

a. The skills required for the particular job:
   — sight
   — touch
   — hearing
b. The extent to which the pattern and need for these skills is repeated without ambiguity.
c. The "peripheral" controls required to ensure an adequate control of incoming material for:
   — position
   — quality
   — variability
d. The need for the human workforce to carry out inspection tasks as part of the operation.
e. Safety and "guarding" requirements.

The suitability of a robot for light handling depends upon the speed of the operation. It is generally difficult for a robot to keep up with a human operator because human responses are so much faster. In some machine operations, like forging, human operators can alter their scenario and cope with variable events on the periphery of the machine. But most current robots are generally incapable of reacting in this way. This kind of self programming will be the next stage of robot development.

These economic factors can be overruled by other factors. A bad working environment can be a powerful motivating factor in the decision to use robots instead of people. Indeed it is clear that many industrial robots are presently used in a relatively uncoordinated way, in a piecemeal fashion. It is apparent that for some time to come factories will have to adopt a hybrid approach to robots and introduce only partial automation.

THE MINI METRO

Safety is an important issue. It is important not to try to mix human work with any part of the possible working universe of industrial robots. There is a particular danger if a robot is handling dangerous materials. Some robots are used to pour hot metal into a die-casting machine or a mould. Any malfunction of the robot system might lead to a scattering of this dangerous material in areas occupied by humans. This danger should not be exaggerated. There are several successful installations of teams of robots performing relatively simple operations. In the new Mini Metro line two lines each of 14 unimates are used to spot weld car body shells.[1]

To get the best out of a robot in applications where the process cycle times are relatively long, it is desirable to allow the robot to service several machines placed within its reach, and to carry out auxiliary functions like inspection. For example, a Cincinnati T_3 industrial robot can serve two turning centres and an inspection station.[2] The inspection station uses a laser to measure the size of components and the robot can extract a part from any machine and pass it through the inspection system before accepting it as a correct component.

The fully versatile small batch automatic factory will only be achieved when robots have sufficient "intelligence" to deal with increasing levels of variability in their environmental conditions. Current trends are exemplified by the software control system of the Cincinnati T_3. It involves three distinct types of branching. The first is conditional branching in which several workplace "states" are monitored and the robot will not continue with its operations unless the signals received from the transducers are "green". The second type, offset branching, involves the construction of a repertoire of pre-taught sub-routines which form common parts of repetitive activities. The continuous need to programme these repetitive activities could be tedious and time wasting for the programmer. In the third kind, "interrupt" offset branching, pre-recorded routines are selected to deal with contingencies which may occur during the robot's automatic cycle of operations. For instance, a failure to insert a part at some point of the function would be noted by the robot which would divert that part to a scrap bin, initiate the re-selection of another part at the pick-up position, rejoin the sequence and try again to complete the function.

A ROBOT BLACKSMITH

A more advanced application of this technique is the development of a robot "blacksmith". For this particular application, it is essential to understand the process by which metal is deformed so that it can be represented by suitable algorithms in the computational software.[3, 4] The process is called "open die forging". The robot seeks to form a shape by manipulating the squeeze anvils of simple prismatic tools in a hydraulic press. A robot could be taught to complete the process of changing a shape by using the direct skill of a human operator, but usually

One of the two synchronised welding lines for the Metro

A Cincinnati T^3 serving two turning centres and an inspection station

this method takes a long time and very often takes longer than the time required to complete the whole batch. It is also a rather inefficient way of using a robot's computational facilities. It is better to develop blocks of programming incorporating the known characteristics of the process, so that changes in the number of steps and the size of steps can be initiated by inserting the appropriate numerical data. For instance, square-to-square and square-to-round reduction can be achieved by the routine insertion of data on the initial and final sizes required by the operator.

So far, we have assumed that a robot can complete its cycle without ambiguity. However, the variations in steel's characteristics and possibly temperature can necessitate a continuous feedback of information on the pressure and position of the anvil and the temperature of the billet. The robot could interpret the possibility of success within an envelope defined by certain critical values of these parameters so that it could take appropriate action. If the temperature falls below a prescribed minimum, for example, the robot would withdraw the billet from the forging press and insert it in a re-heating station and release it, all the time remembering at what step it had left off the process before re-heating. Next, it would continue to forge another billet. Then it would pick up the partly finished, reheated billet, rejoin the sequence and take the forging process to a successful conclusion. This routine is a valid alternative to the human's use of sight and touch. A machine's ability to see and feel is important, of course, but it is better in many cases to seek machine solutions to problems where the technology available can conveniently solve the technological problem.

ASSEMBLY BY ROBOT

The number of robots involved in small batch assembly is actually very small. Assembly is a highly skilled operation and implies levels of sensory interaction and mechanical dexterity which are not easy to achieve in an economic way. The Unimation PUMA Assembly Robot and the DEA Pragma Assembly Robot are the nearest we have to a general industrial application.[5] The PUMA incorporates another example of "branching off-set" technology and can be easily programmed to perform manipulative functions. One of the available sub-routines allows the device to execute a "pick and place" movement between two pre-selected points in its universe without each successive step having to be programmed. As with many other first generation devices, it is likely to be most adaptable in hybrid situations where the people conduct operations that demand a high level of cybernetic reaction and the robots perform the more mundane tasks.

The next step is the addition of facilities for artificial vision and an artificial sense of touch. These benefits over the next decade will be part of a cascade of development leading to more assembly processes being taken over in their entirety by robotic devices. These developments will be achieved by a process of evolution rather than single dramatic leaps in technology.

The wider implications for automated small batch factories of the future have yet to be really considered. The possibilities afforded by the micro-computer make it easier for machines to "communicate" easily with machines and eventually we shall have to proceed from the present piecemeal applications to an overall systems approach. At this stage we will have, or a computer will have, overall control of design and production functions. The situation was adequately expressed by Lord Kelvin who said, in 1880, "I often say that when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be".

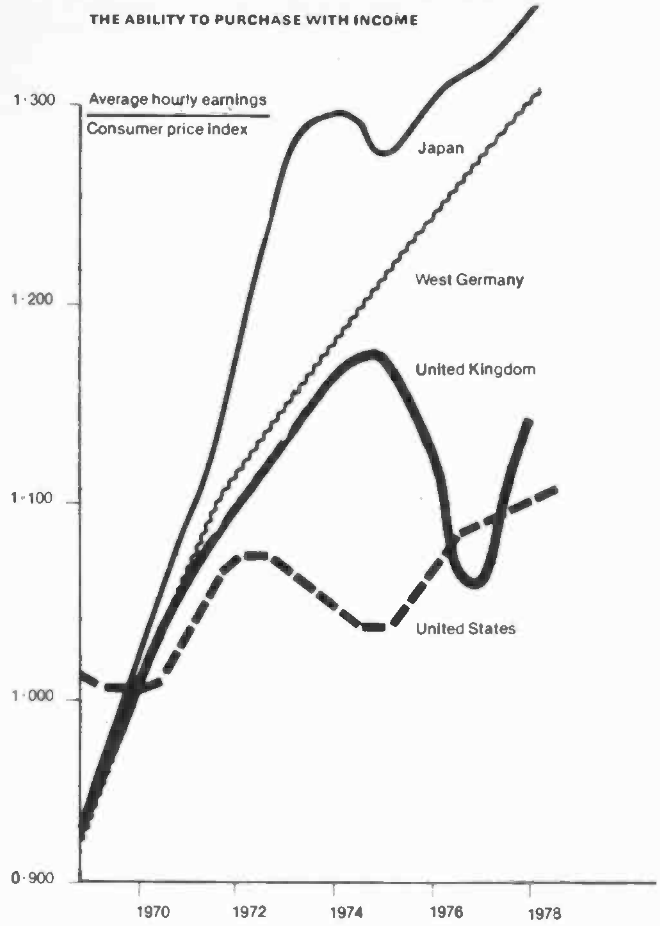
An example of an automated draughting machine controlled by a minicomputer is the PADDS system developed by PERA. Systems like the PADDS produce detailed drawings without drudgery. The operator uses a keyboard to enter the dimensions and shapes of the part, according to a simple code, and also specifies the reference co-ordinates of the dimensions. The computer needs no more information for the "dimensioning" of the component. As it works it will decide whether a drawing with only two "views" might lead to ambiguity in the specification of components, and produce extra drawings as required. It is a relatively small step from PADDS to the development of programmes for the numerical control of machine tools.

PERA PADDS automated draughting system

THE ECONOMIC EFFECTS

The use of robots will increasingly influence, if it does not already, national economic and sociological development. The economic issues range from the level of employment to the level of investment. An indication of these parameters in the UK, USA, Japan and West Germany since 1970 is illustrated in Fig. 1, which shows the ratio between the hourly earnings index and the consumer price index. It represents what can be bought with what is earned. The performances of Japan and West Germany, particularly after 1974, are remarkable. It is notable that both countries have made considerable progress in applying advanced methods of automation, and that Japan has as many as half the total world population of industrial robots. One could be tempted to draw a wrong conclusion from these statistics and it must be made quite clear that the application of industrial robots does not automatically ensure industrial success. Robots can only amplify success. They can only manufacture an already successful basic product. They make cheaper and more reliable that which is already successful and thereby render it even more successful.

It might seem that the application of industrial robot technology is counter-productive in terms of the number of jobs for people. However, it can be argued that industrial robots will cause no additional threat to employment. For instance, any country which manufacturers average products which sell in an average manner and achieve an average sales level cannot hope



from: *Yearbook of Labour Statistics, 1979* (tables 18 & 23)

Fig. 1. The ratios between earnings and prices in four countries

for anything but to subside into an average state of industrial mediocrity. Such average sales cannot create conditions that are capable of exploitation by the effective and correct application of industrial robot technology. In such a situation, advanced automation is powerless because the need to "amplify" production does not exist.

If the need for amplification does exist, however, the application of adaptable robotic systems will materially influence industry's capital investment programmes and will produce a less labour intensive situation in areas of industrial activity where lower batch quantity production situations apply. There will have to be a reappraisal of the relationship between advanced industrial automation systems and the whole manufacturing complex.

The amount one can afford to spend on an industrial robot installation will depend on:

a. The cost of labour.
b. The amount of human involvement required to complete the task.
c. The cost of a standard robot system.
d. The cost of adapting (c) to a particular job.
e. The frequency of job change.
f. The interest rate on capital.
g. Batch sizes.
h. Overall demand and the increase of output achieved by the robot.
i. Depreciation.
j. Maintenance and running costs.

The inherent versatility of a robot system is clearly dependent on the relationships between (c), (d), (e) and (f) in the table above.

Comparisons between automated and manual systems are generally made on the basis of direct cost savings. The comparison can lead to false conclusions. Indeed, if we compare the rate of production of a manual system with the rate of production of an automated system then the automated system can appear to have little or no advantage. A more relevant index is total daily production, since this total will reflect the robot's essential characteristics; the advantage of being able to work continuously, without a break and without variation, for much longer periods than can a human. A machine might be slower than a human, but its daily output could be significantly higher. It is benefits of this kind that signify the quality of robots in industry. ★

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Acknowledgement

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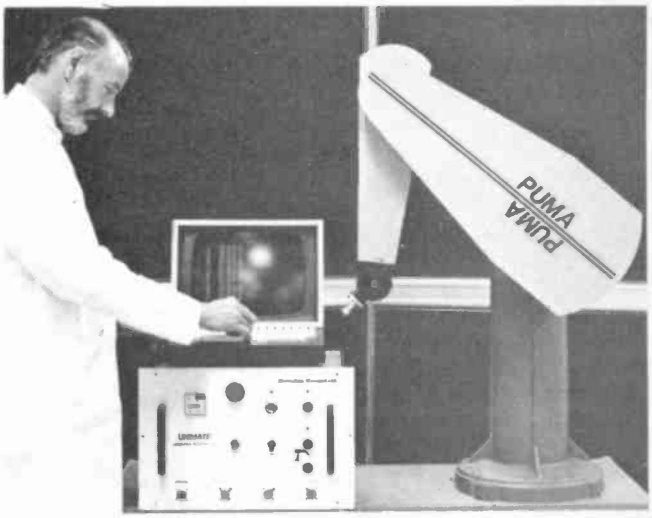
PE ROBOTS

Next month we start a series of articles describing the construction of three different hydraulically operated robots — see page 57 for more details.



Unimation PUMA 500 robot, control system and VDU

Semiconductor UPDATE...

FEATURING OPL100 WD55 LM396

R.W. Coles

SEE-THROUGH CHIP

L.e.d. numeric displays are now available in a wide range of styles and sizes and can be used in any application which does not require power consumption to be reduced to an absolute minimum. If power is a problem, then liquid crystal readouts should be considered, but remember that there is a big difference between the light EMITTING l.e.d. and the purely REFLECTIVE l.c.d. which has a lot in common with the printed page and its dependency on ambient lighting. The two technologies do compete in some areas, but there are also clearly defined applications where either the l.e.d. or the l.c.d. wins hands down. In digital watches, for example, there can be little doubt that the low consumption of the l.c.d. is the dominant factor despite the considerable inconvenience of having to provide an incandescent backlight for night viewing. On the other hand, in mains powered equipment such as digital alarm clocks where ample power is available, the brightness of the l.e.d. readout and its independence of ambient lighting, make it the logical choice. The use of l.e.d. readouts does bring some problems, however, and foremost among these is deciding just how bright the display needs to be to compete with any ambient lighting which may be present. The range of brightness required to compete with strong sunshine at one extreme and a darkened bedroom at the other is considerable, and rather than have illegible displays by day and "keep-you-awake" neon signs by night, many clock-radio manufacturers incorporate a dimming switch into their designs to reduce the problem to manageable proportions.

The provision of just two brightness levels is hardly a complete answer to the problem though, and what is really required is a CONTINUOUS adjustment of display brightness as the ambient light level alters throughout the day. You can probably see how to design one of these. All you need is a photo-detector such as a light dependent resistor or photo-diode, an amplifier, a voltage controlled pulse width modulator, and a high fanout driver to strobe all the digits on or off at a fairly high frequency which cannot be detected by the human eye. (You could vary the display voltage, and therefore current, instead of using the strobe approach but that would mean wasting a lot of power heating up an expensive power regulator, not to mention the problem of a distinctly non-linear voltage/brightness characteristic.) Although the concept of an automatic brightness control is simple enough, the realisation has usually been too expensive for all but the most up-market equipment, but that situation will soon change thanks to a new device from an American firm called TRW Optron.

What TRW Optron have done is to build a complete brightness control integrated circuit, including an ambient light sensor, into a diminutive eight pin d.i.l. package made of see-through plastic. The device is coded OPL100 and it contains a photodiode, a high gain amplifier, an op-amp and several comparators, a latch, some gating, an output stage and a voltage regulator. A brightness control range of zero to 100 per cent is possible using the pulse width modulation output to control the display duty cycle. The 7447 seven segment decoder which is widely used to drive l.e.d. displays can be directly controlled via its RBI input; other types of driver may require some gating. Thanks to its internal regulator, the OPL100 can operate from any available supply from 4·5 to 24 volts, and current drain is constant at around 10mA.

The OPL100 could be just the thing for that digital car instrument panel you have been promising yourself!

MICRO TIMER

Some time ago I wrote about the CY500 Stepper Motor Controller, which was actually a single chip microprocessor with a built-in program designed by a firm other than the micro' manufacturer to do a special job. Single chip microprocessors are being made by the million and they are all being manufactured with "built-in" software to do a special job of one kind or another, although usually they disappear without trace into a mass produced product such as an automatic washing machine or an electronic game, and are never offered for sale to anyone else. Some of these devices turn out to be of such general application however, that their designers DO offer them for sale to a wider market, recouping their own development costs and making a handsome profit into the bargain!

The CY500 was one example of such a general purpose development, and this month I would like to tell you about another, the WD 55 from Western Digital, distributed in the UK by Jee Distribution of Hayes, Middlesex. This interesting device is a mask programmed member of the WD 50 family of four bit single chip microprocessors, dedicated by the internal program ROM to perform the function of a capable timer system able to replace and out-perform timers currently using motors, gears, cams, and micro-switches. The WD 55 has two basic operating modes; the simplest of these requires very few external components and relies on an array of thumbwheel switches or even diodes to get the desired ON/OFF timing intervals with a range of up to 999 hours and a resolution of 0·1 second. The second mode is selected by a strapping option, and interfaces the WD 55 to a numeric keyboard matrix and a seven segment l.e.d. display to perform the function of a fully programmable timer/sequencer with up to seven sequential ON/OFF timing periods. In either mode the timing reference can be 50/60Hz mains frequency or an external crystal oscillator, and timing operations can be continuous or single shot. The timer outputs are capable of driving relays or triacs, and an alarm output is available to sound a buzzer at count termination if required. The use of simple membrane switch keypads is made easier by the provision of audible feedback via the alarm output to signify the proper actuation of keys which give little or no tactile response.

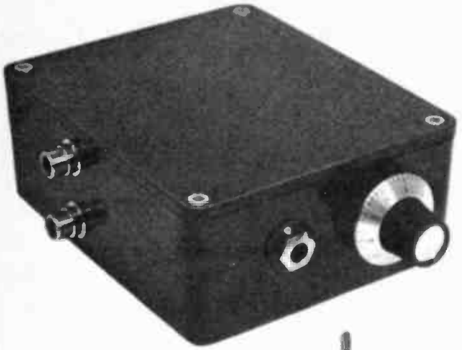
The WD 55 is made with PMOS technology, lives in a 40-pin plastic or ceramic DIP, and runs from nominally 13·2 volt supplies. I can think of all kinds of uses for it, how about you?

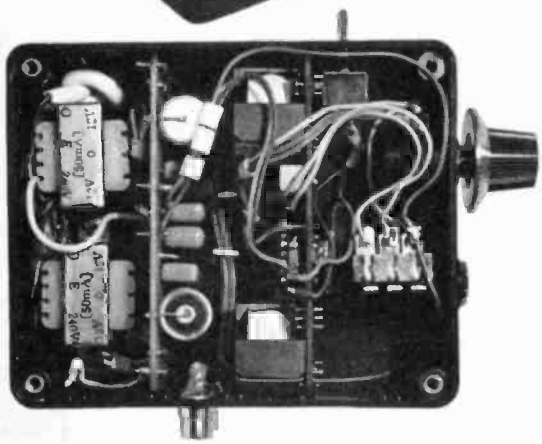
MOOSE

It seemed quite wonderful to me when someone first squashed a 1 amp 5 volt regulator circuit into a TO3 can. A whole amp I thought, that will keep my TTL happy! Since then we have seen 1·5 amp 2 amp and even 5 amp regulators in the same can and I for one thought that NOBODY would ever be able to do any better than that, until I saw the National LM 396. This device, known to its friends as MOOSE, can provide an astonishing TEN amps at power levels of up to 70 watts without even starting to melt its little TO3 package (provided it's on a heat sink of course!).

National have performed the trick by bringing together on one chip the best discrete power transistor and linear amplifier design principles. The MOOSE is voltage adjustable over a 1·25 to 15 volt range, and has excellent line and load regulation. If you are planning any arc welding, the LM 396 could be for you!

HEADPHONES





with a DIFFERENCE

A.B. BRADSHAW

THE writer spends much time listening to music on hi fi, stereo tape and disc, using headphones. This is often necessary in a family household where other members are playing the piano, practising the guitar or operating the washing machine! A friend of the writer's recently loaned him a "dummy head" tape, and listening to this material proved to be a revelation. It was realised that ordinary stereo sound played through headphones could be improved upon. A search of technical articles revealed that work on this subject goes back a long way in time.

THE PROBLEM

Most people are familiar with normal stereo sound, where microphones are spaced out across the sound stage and suitably mixed. The sound is then recorded or relayed to be eventually launched from suitably positioned loudspeakers, giving the illusion of the original sound space (See Fig. 1).

From the L.H.S. loudspeaker we have the direct path (1A) which enters the left ear; in addition, the path (1B) from the same loudspeaker diffracts around the listener's face to enter the right ear. This latter path will give a sound pressure which is both lower in amplitude and delayed in time compared to that perceived in the left ear.

A similar cross-diffracted signal is generated in addition to the direct path by the R.H.S. loudspeaker.

When we use headphones on normal stereo sound, the cross feed signals are absent.

This is the reason why headphone stereo is unnatural in its spatial rendition. We get the "outside-the-head" effect.

The diffraction of sound waves around the human head has been studied by "WEINER" (See ref. 1).

Graphs produced from data show the average differences in sound intensities, when the sound source is at 45° to the left of the listener (See Fig. 2).

Assuming an ear to ear spacing of 8 inches, the additional $5\frac{1}{2}$ inch of path length which must be traversed by the sound on its way to the more remote ear produces a calculated delay of 0·4 milliseconds.

These results were used by "Bauer" of C.B.S. (Ref. 2), to develop a dual cross feed network to restore electronically the original sound perspective. See Fig. 3 and Fig. 4. These show the original network, and a later simplification.

Both networks were designed to be driven from high power AF amplifiers since the voltage loss of the networks is in the region of 30 dB.

To evaluate the system the writer decided to feed the network from a point in the hi fi chain prior to the main L.S. amps, and provide voltage gain with enough power to drive a pair of good quality 8Ω headphones.

A dual stereo loudspeaker amp was used with its gain set by R9/R8, R10/R7 to give 40 dB. This is not the optimum arrangements from the noise point of view, but it is easily implemented and allows the system to be heard. See Fig. 5.

INDUCTORS

Many of the "RF choke" type of 10 millihenry coils that are advertised are for radio frequency use, where a large ratio of reactance to resistance is needed. This means that they are unsuitable for AF use. For this reason pot core assemblies are specified.

Using the specified pot assemblies: *Wind 158 turns of 28 s.w.g. enamelled copper wire, "random fashion" on the bobbin and tape the turns in place. The core adjusters are not required.*

CONSTRUCTION

Construction of the unit is straightforward. The main p.c.b. design for the unit is shown in Fig. 6 with the component layout shown in Fig. 7. A suitable p.s.u. design is also given in Fig. 8 together with the p.c.b. design and component layout in Figs. 9 and 10.

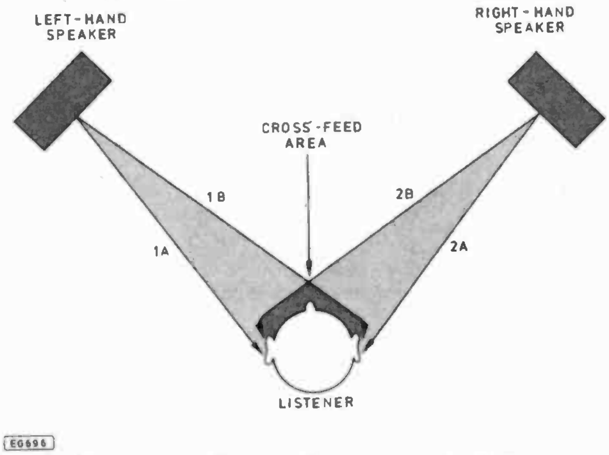


Fig. 1. Stereo recording produces cross-feed signals when reproduced in open air by loudspeakers

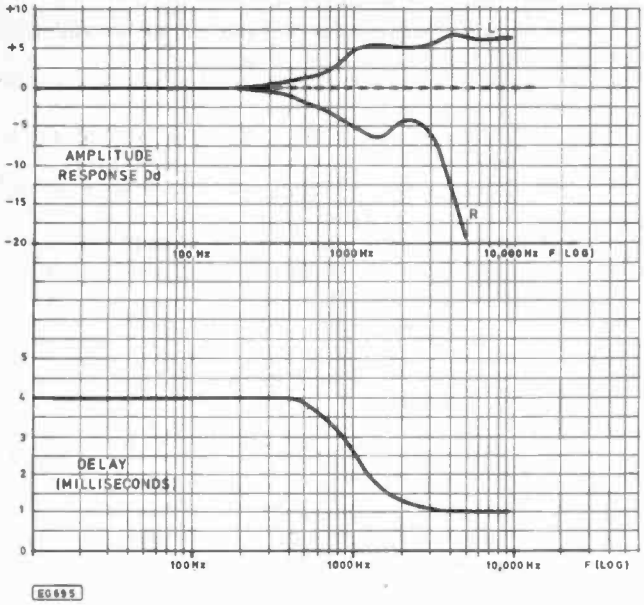


Fig. 2. Response of the "Bauer" network with a sound source 45 deg. on the left

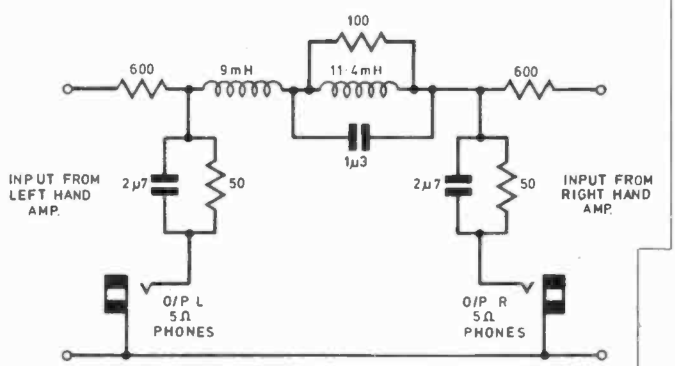


Fig. 3. Original network due to "Bauer"

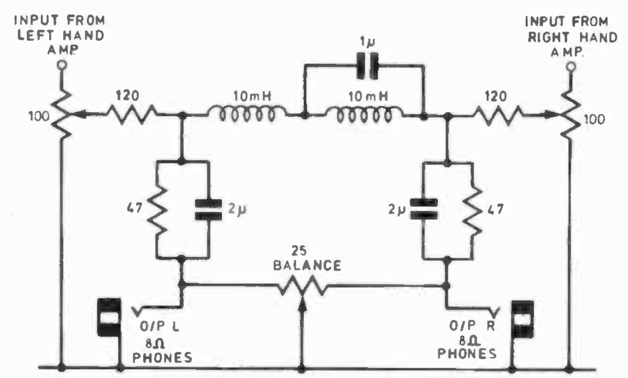


Fig. 4. Simplified version due to "Toneburst"

COMPONENTS . . .

Resistors

R1,R6	120
R2,R5	47
R3,R4	27
R7,R8	1k
R9,R10	100k

All resistors $\frac{1}{4}$W 2% m.o.

Capacitors

C1,C2	2µ 5% poly or paper
C5	1µ
C3,C4	470n

Integrated Circuit

IC1	National LM377 (Free air dissipation at 15°C = 2W)

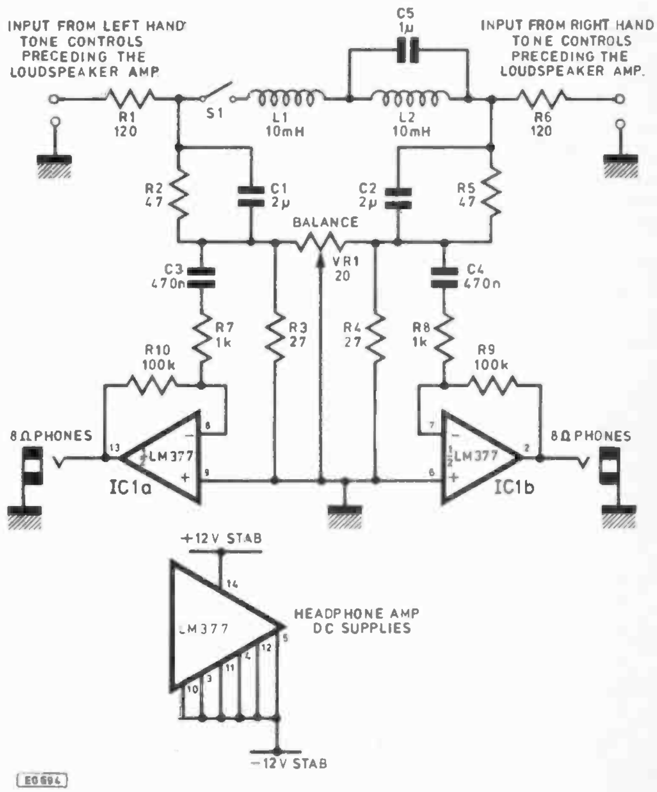
Switches

S1	Single pole (Low Capacity)

Inductors

L1,L2	RS Components Pot Core Assembly RM10 A_L = 400 (see text for winding details)

Fig. 5. Circuit diagram



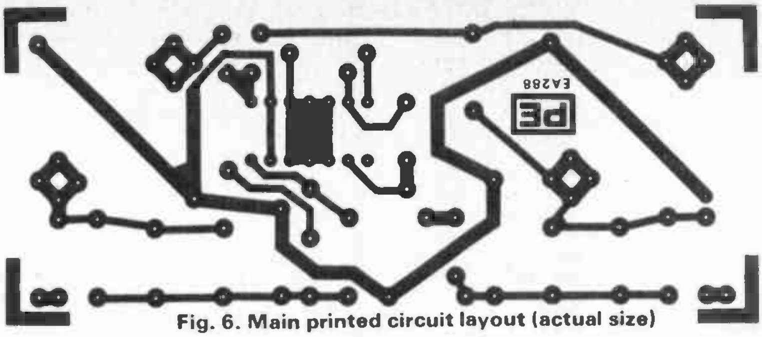


Fig. 6. Main printed circuit layout (actual size)

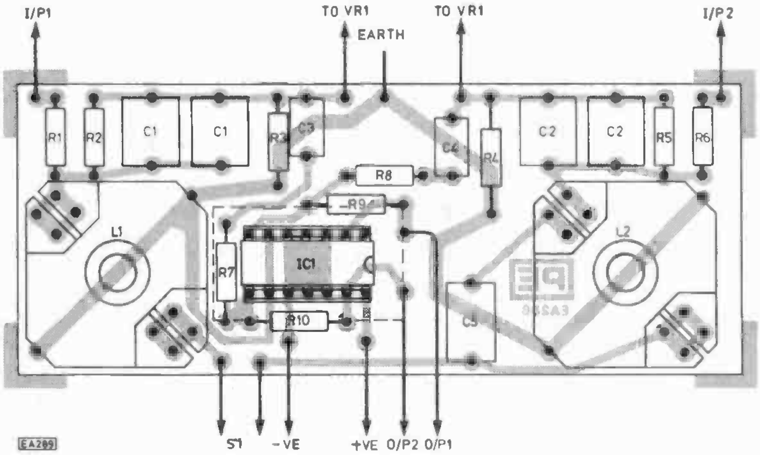


Fig. 7. Main component layout

OPTIONAL PSU

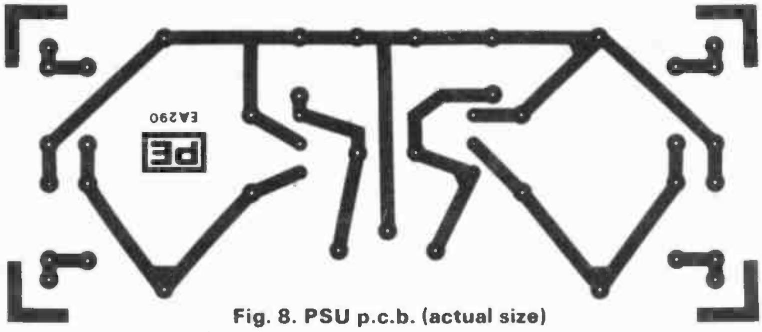


Fig. 8. PSU p.c.b. (actual size)

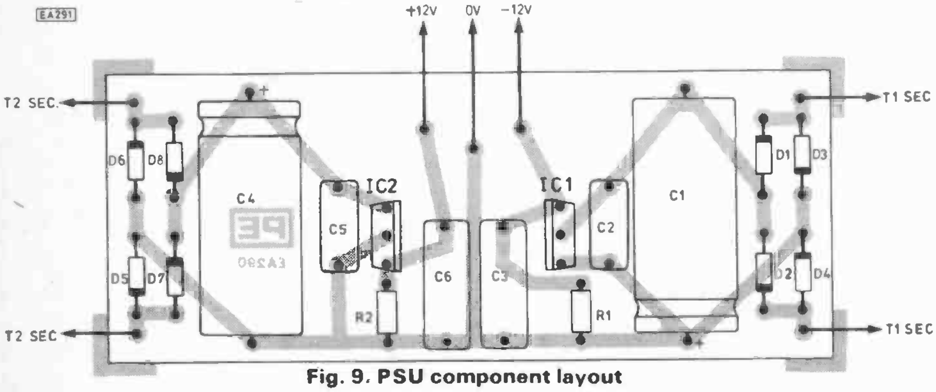


Fig. 9. PSU component layout

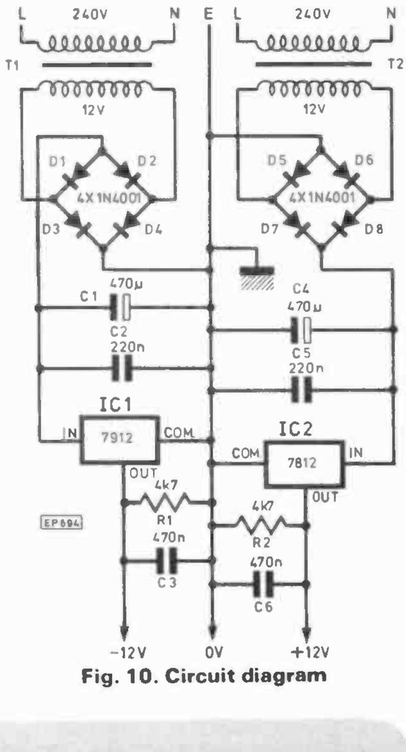


Fig. 10. Circuit diagram

RESULTS

The effect of switching the network into circuit will not be immediately obvious as the effects are rather subtle.

Choose sound sources with a good stereo separation, close your eyes and visualise the direction of the source, and whilst operating the IN/OUT switch the effects are readily heard. Once you have used the network over a prolonged period, accidentally removing it produces a very odd sound! ★

REF. 1 *Francis M. Weiner, "On The Diffraction Of A Progressive Sound Wave By The Human Head". J. Acoustic Soc. Am: Vol 19 pp 143-146 (1947).*

REF. 2 *B. B. Bauer, "Stereophonic Earphones And Binaural Loudspeakers". J. Audio Eng. Soc. Vol 9 number 2 April (1961)*

REF. 3 *Towards True Stereophony. By "Toneburst". Wireless World, Sept 1969.*

INDUCTIVE DISCHARGE CAR IGNITION SYSTEM

K. WEVILL B.Sc.

ELECTRONIC ignition systems fall into two basic categories, inductive discharge (ID) or capacitive discharge (CD) depending on whether the energy for the spark is stored in the coil or in a capacitor, which is then discharged into the coil. The capacitive discharge system is more efficient but requires an invertor, a capacitor able to withstand high discharge currents and a thyristor to discharge the capacitor into the coil. These items are relatively expensive and increase the circuit complexity, but in spite of this, capacitive discharge systems are popular with constructors and many designs have been published over the past few years.

Inductive discharge systems are usually simpler than capacitive discharge systems as they do not require the invertor, capacitor or the thyristor. Instead they use a comparatively less expensive high voltage transistor and relatively simple drive circuits. They also have the advantage of being compatible with both voltage pulse and current pulse tachometers without any modifications to the vehicle wiring, which is not always the case with capacitive discharge systems.

Many of the electronic ignition systems available from accessory shops are of the ID type, as are the systems fitted as original equipment by the car manufacturers. When fitted as original equipment they are usually of the contactless type, whereas the add on systems can be either contactless or triggered by the existing contact breakers.

The system to be described is an inductive discharge system incorporating an extended dwell circuit and can be triggered by either the contact breakers or by a contactless sensor. It is only suitable for negative earth vehicles.

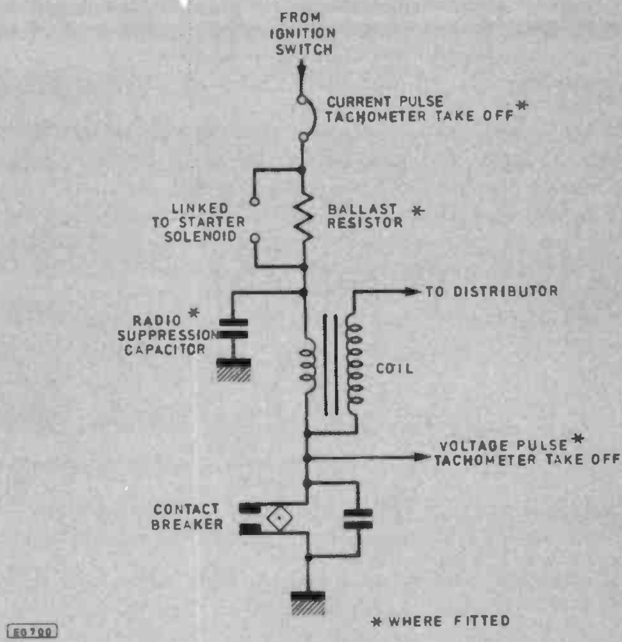


Fig. 1. Conventional ignition system

CONVENTIONAL IGNITION

Fig. 1 shows a conventional (Kettering) ignition system comprising a coil, contact breaker and capacitor (sometimes called the condenser). This is an inductive discharge system, because energy is stored in the coil as a result of the current flowing when the contact breaker is closed. When it is open, this stored energy is released in the form of a back e.m.f. pulse of approximately 300V across the coil primary, which then transforms it up to the 30kV required for the spark plugs.

The capacitor across the contact breaker prevents the points being rapidly eroded by the back e.m.f. pulse. Some cars are fitted with a ballast resistor to aid cold starting. In these cars the coil is designed to operate off 6V and during normal running this is obtained by means of a dropper or ballast resistor. During starting when the battery voltage drops because of the heavy loading of the starter motor this resistor is shorted out, which supplies the coil with the full, but reduced, battery voltage, providing approximately the same H.T. voltage as would be obtained during normal running.

Also shown in Fig. 1 are the positions of the radio suppression capacitor and the alternative take off points for the current pulse tachometers fitted to older cars and the voltage pulse tachometers fitted to more recent cars.

In spite of its simplicity, the conventional ignition system has several limitations, most of which are due to the contact breakers which, because of wear, have to be replaced at regular intervals during servicing. This wear also causes the timing to change gradually during the life of the contact breaker. In addition, at higher r.p.m., the contacts bounce, which further reduces the amount of energy available for the spark. The effect of all these limitations is to gradually reduce the overall performance of the engine between services.

TRANSISTOR OUTPUT IGNITION

In an inductive discharge electronic ignition system the current through the coil is switched by a transistor instead of the contact breakers. This makes it possible, with suitable drive circuitry, to overcome all the limitations previously mentioned with a consequent improvement in performance.

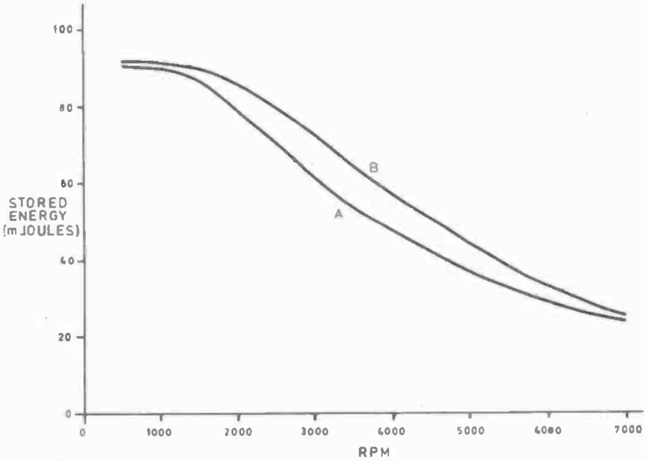
In the contact triggered version the wear on the contact breakers is considerably reduced, which greatly extends their service life. A life in excess of 20,000 miles can be expected, although they will eventually have to be replaced because of wear of the cam follower. The contactless version, by removing the contact breakers, reduces timing variations to a minimum, thus maintaining engine performance over a much longer period.

The switching transistor has to be a high voltage type able to withstand the 300V pulse produced when the current is switched off. It also has to be able to switch a current of up to 10A, which may be experienced in a ballasted system when starting. The transistor chosen for this ignition system is the BUY69C manufactured by Texas Instruments.

EXTENDED DWELL

The amount of energy stored in the coil falls off at higher engine speeds as shown by A in Fig. 2. This graph assumes that the current is switched off cleanly, which does not happen in practice with conventional ignition due to contact bounce, especially at the higher engine speeds. The net result of this is a weaker spark than would otherwise be expected.

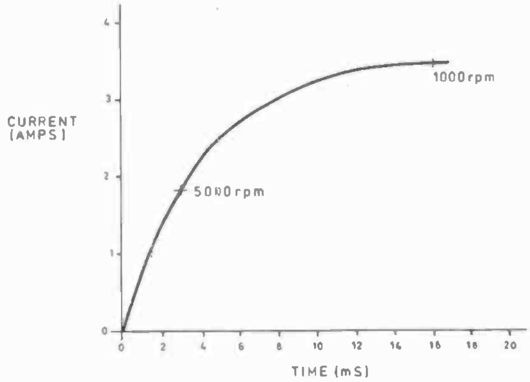
The actual fall off in stored energy is due to the exponential rise in the current through the coil (Fig. 3). At low speeds the current "on" time is greater than the time constant of the coil, hence the current builds up to a maximum of approximately 3·5A. However, at high speeds, when the "on" time is less than or equal to the time constant, only a fraction of the maximum value is reached. As the stored energy is equal to $\frac{1}{2}LI^2$ the reduction in stored energy is proportionally greater.



EG698

Fig. 2. Stored energy vs r.p.m.

If the current through the coil can be switched off just long enough for the spark to occur, then the current will have a much longer time to build up, resulting in an increase in the amount of energy stored. At low speeds there will not be much difference between the normal dwell and the extended dwell (the dwell period being the time current is flowing into the coil) but over the range 2,000 to 5,000 r.p.m. up to 25 per cent more energy can be stored in the coil, depending on its inductance and resistance, resulting in a better spark over that range. Graph B in Fig. 2 shows the energy stored in an extended dwell system. It also shows that there is a speed above which less energy is stored in the extended dwell system than in the normal dwell system. This occurs when the extended dwell "off" time is equal to the normal dwell "off" time. The speed at which it occurs, however, is normally above the maximum engine speed. For example, a 4-cylinder engine with a dwell angle of 50° and an off time of 1·4ms. The speed here is 9,500 r.p.m. and 7,100 r.pm. for a dwell angle of 60°.



EG699

Fig. 3. Exponential rise of current in coil

CB TRIGGERED SYSTEM

The simplest form of triggering the system is to use the contact breaker. This has two advantages:

1) No modifications to the distributor are required.

2) Should the electronic ignition fail it is very easy to revert back to conventional ignition.

The circuit is shown in Fig. 4. When the contact breaker opens, C1 charges up via R1 and D2. This turns TR1 on, giving a negative going pulse at its collector. D2 isolates C1 from the effect of any bounce on the contact breaker, and R1 causes a current of approximately 60mA to flow through this, which helps to keep the faces clean.

The negative edge from TR1 collector triggers a 555 monostable whose output (pin 3) goes high for approximately 1·4ms. This turns TR2 on which turns off the driver and output transistors TR3 and TR4 respectively. Thus when the contact breaker opens the output transistor is turned off for approximately 1·4ms, performing the extended dwell function.

The off time of 1·4ms was chosen to allow sufficient time for the spark to occur and to allow a sufficiently wide pulse to trigger a voltage pulse tachometer. Tests done on the tachometer fitted to the author's car showed that the pulse required to trigger it had to be greater than 7V with a width of greater than 1ms. If a tachometer is not fitted or the engine is capable of high r.p.m., then the timing components R8 and C4 may be altered to reduce the off time, which is given by the formula $t=1 \cdot 1C4\ R8$.

The output transistor is protected from excessive voltages by two 160V Zener diodes, D5 and D6, and the rest of the circuit is protected from transient pulses on the vehicle electrical system by means of C6, R9, C2 and D3.

Also included is an ignition inhibit facility, provided by R6 and D4, which prevents the 555 being triggered if the inhibit connection is earthed. This can be used as an anti-theft facility, if required, or for preventing the ignition from firing while setting the static timing. The l.e.d. across the contact breaker input provides an indicator for setting the static timing. This is a useful feature which can be easily incorporated in any electronic ignition system which uses the contact breaker.

CONSTRUCTION

The printed circuit board is shown in Fig. 5 and the component layout is shown in Fig. 6. The driver and output transistors are mounted on a heatsink, details of which are shown in Fig. 7. A solder tag is used under each of the output transistor fixing bolts for the output connection and for the protection Zener diodes. The heatsink is also used to fix the circuit board to the lid of the diecast box. When mounting the transistors on to the heatsink use the appropriate mica washers and some heatsink compound. C2 is a vertically mounting capacitor, but in this design it is mounted horizontally. To prevent it being damaged by vibration it should be glued to the board with cyanoacrylate adhesive (super-glue).

The l.e.d. should be soldered in place after the p.c.b. assembly has been fitted to the box lid. In this way the correct spacing of the l.e.d. from the board can be found. All the leads are brought out through a suitable grommet in the box lid.

TESTING

Once the board has been built, connect it to a 12V power supply with a 12V 2·2W bulb connected from the output to the +12V connection. When the 12V supply is switched on, the bulb and the timing l.e.d. should both light up. If the inhibit lines are now shorted together the bulb should go out. If not check for short circuits between the output transistor and the heatsink or a faulty driver or output transistor or a faulty 555.

Checking the extended dwell triggering is a little more difficult. If an oscilloscope is available the task is a lot easier. With the 12V bulb still connected, connect the oscilloscope to the output. If the contact breaker input is now shorted to 0V, the l.e.d. should go out and a 12V pulse of approximately 1·4ms duration should be seen on the oscilloscope. There should be very little change in the brightness of the bulb. If an oscilloscope is not available it is possible to check the operation of the circuit by means of a loudspeaker connected, via a capacitor of about 1μF, across the bulb. When the contact breaker input is shorted to 0V a click should be heard in the loudspeaker. This only checks that the output is switching but will prove that the unit is functioning. Once the board is working clean it to remove the flux and spray it on both sides with printed circuit lacquer. This will protect the board from the effects of the adverse environment in the engine compartment.

R14 should be mounted so there is a clearance of approximately $\frac{1}{8}$in. above the board as it runs hot in use.

CONTACTLESS INPUT

An alternative method of triggering the system is to dispense with the contact breakers altogether and use a contactless sensor instead. The advantages of this are that there is no contact bounce to worry about, the timing is more accurately defined and once set up no adjustment should be necessary during the life of the car.

There are many forms of contactless sensor, falling into two basic types, optical and magnetic. The optical sensors usually consist of an infra-red l.e.d. and a photo-transistor opposite each other. A slotted vane passes between them switching the photo-transistor on and off. This is then used to switch the driver and output transistors on and off.

Magnetic sensors usually use a proximity detector, where the presence of a small ferrite rod in a rotor is detected and used to switch the output stage on and off. Alternatively a Hall effect sensor can be used to detect either the presence of a magnet in a rotor or the presence of a ferrous vane between the sensor and a magnet.

SENSOR USED

The sensor used for this contactless ignition system is a Hall effect vane switch consisting of a magnet and Hall effect switch with a gap between them. With nothing in the gap, the transistors in each of the open collector outputs are on and can sink up to 4mA. When a ferrous metal vane is placed in the gap, the output transistors are switched off. For further details consult the data sheet supplied with the sensor which is available from stockists of RS components.

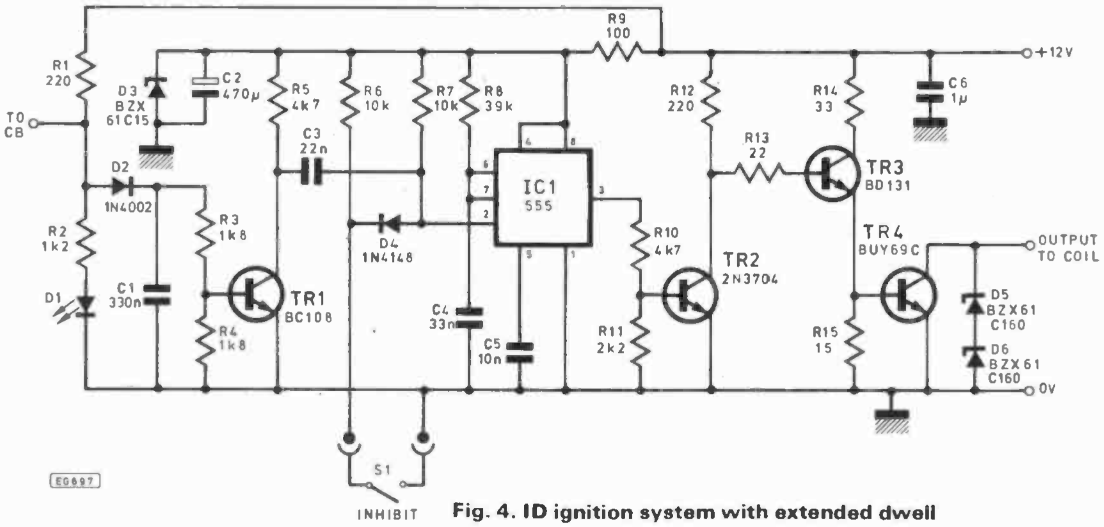


Fig. 4. ID ignition system with extended dwell

CIRCUIT

The circuit of the contactless inductive discharge ignition system is shown in Fig. 8. The Hall effect sensor, IC1, requires a 5V supply which is provided by a constant current source, comprising TR1, TR2, R1 and R2 and a 5·1V Zener diode D1. The use of a current source instead of the more usual resistor means that the 5V supply remains stable down to an input supply voltage of approximately 6·5V, enabling the sensor to work during starting with worn out battery. TR3 and TR4 convert the 5V signal from the sensor output to a signal suitable for triggering the 555. A l.e.d. is included in the collector of TR4 to act as a static timing light. Its use is equivalent to the l.e.d. across the points in the contact version. The remainder of the circuit is the same as in the contact version and operates in the same manner.

CONSTRUCTION

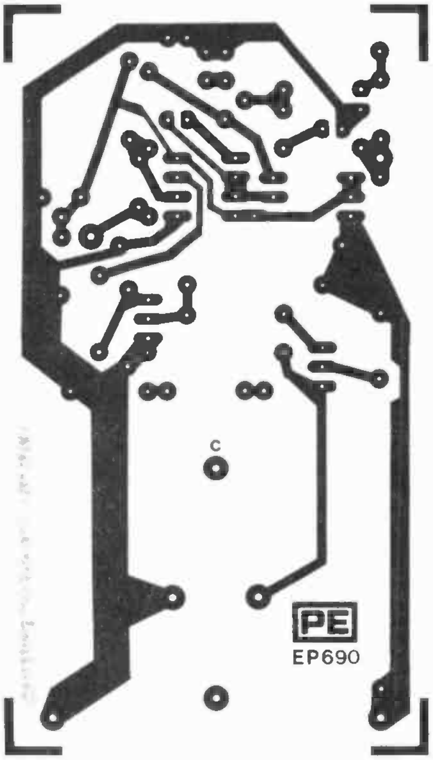
The printed circuit board is shown in Fig. 9 and the component layout is shown in Fig. 10. The heatsink for the driver and output transistors is the same as for the contact version (Fig. 7), and the same type of diecast box is used. As in the contact version do not forget the mica washers or the heatsink compound. Two grommets are used, one for the power, inhibit and output leads and one for the sensor cable.

TESTING

Connect the unit to a 12V power supply with a 12V 2·2W bulb from the output to the +12V connection. When the supply is turned on the bulb should come on but the timing l.e.d. should not. Check that there is +5V on point 1 with respect to point 3. Then short the inhibit lines together, and the bulb should go out, as in the contact version.

To check the triggering, short point 2 to 0V, the l.e.d. should come on and a 1·4ms pulse should appear at the output. This can be monitored by an oscilloscope or a loudspeaker as in the contact version test procedure.

The sensor should now be temporarily connected up, and with nothing in the gap the l.e.d. should be on. If a piece of ferrous metal (e.g. steel) is then placed in the gap the l.e.d. should go out, remove it and the l.e.d. should come on again. Each time the metal is removed a 1·4ms pulse should appear at the output. Once the board is working, clean it to remove all the flux, and spray it with printed circuit lacquer to protect it.



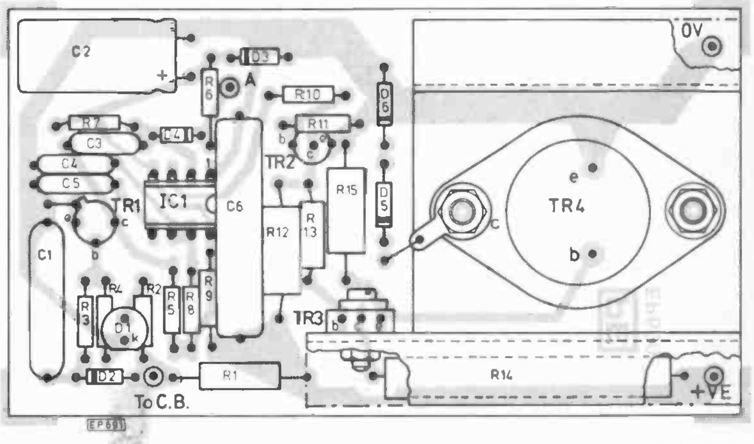


Fig. 5. Printed circuit and Fig. 6 (right) component layout for CB triggered system

CONTACT VERSION INSTALLATION

Wiring details for the contact version are shown in Fig. 14. Power for the ignition unit can be taken from the positive or SW contact of the coil in a non-ballasted system. If your car is fitted with a ballast resistor, then power must be taken from a point after the ignition switch but before the ballast resistor. Consult the wiring diagram for your car to see if a ballast resistor is fitted and for a suitable power feed point. The 0V connection can be made through any convenient bolt onto the body of the car, although the easiest way is to use one of the fixing bolts for the ignition unit. The contact breaker lead must be taken off the negative or CB connection of the coil and connected to the contact breaker input of the ignition unit via the appropriate connector, using spade terminals. Similarly the ignition output lead should be fitted with a suitable connector to mate with the coil negative connection. If the original connector on the contact breaker is retained then it is easy to revert back to conventional ignition should it ever be necessary; alternatively a switch can be fitted to effect the changeover. The diecast box should be mounted in such a position that it does not receive too much heat from the engine. It will probably be necessary to make up a bracket to do this, no details are given as each installation application is different.

CONTACTLESS VERSION MODS

The main requirements for the distributor are to replace the contact breakers with the Hall effect sensor and to replace the standard rotor arm with a rotor arm with a slotted ferrous vane attached to it. The vane and rotor arm and an adaptor plate to which the Hall effect sensor can be attached are available as part of a contactless ignition system made by Lucas. These parts are available from Lucas agents and are made to fit a number of distributor types for British and foreign cars. It is advisable to check the availability of the appropriate distributor kit before starting work on the contactless version. If a distributor kit is not available, then it may be possible to make up a suitable vane and contact breaker adaptor plate. Of course one reason for the non-availability of a kit is that the particular car is already fitted with electronic ignition.

The Hall effect sensor is mounted on a small printed circuit board (Fig. 11). It is recommended that epoxy resin is used to fill the gaps between the sensor and the printed circuit board, which should then be sprayed or painted with an insulating lacquer for protection against corrosion. The sensor is then mounted on an adaptor block shown in Fig. 12. This whole assembly can then be fitted to the contact breaker adaptor as shown in Fig. 13. The two locating pegs, which prevent the sensor assembly moving, are made from two 6BA bolts which are filed down at their ends to fit in the locating holes in the adaptor plate. A thread locking adhesive should be used on all the bolts on the sensor, to prevent them loosening as a result of engine vibration.

There are two identical outputs from the Hall effect sensor, either one may be used. The three wires which connect to the sensor should be tied together using Spirawrap sleeving before fitting into the distributor, details of which are given later.

It is advisable to use a connector to connect the distributor to the ignition unit as this enables each part to be installed and removed separately. This is advantageous if, for example, the engine has to be taken out.

Any 3-way non-reversible lockable connector can be used for this purpose. The author used a 3-way Molex type of connector but other types of connector, such as d.i.n. plugs and sockets, could be used provided they are of the lockable

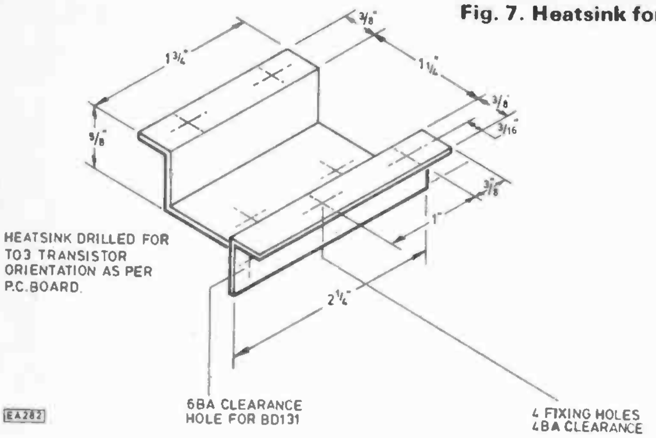
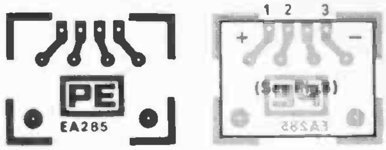


Fig. 7. Heatsink for BUY69C

Fig. 11. printed circuit for Hall effect sensor and connections overlay



type to prevent the sensor from becoming accidentally disconnected. Before fitting the connectors make sure that the wiring is long enough to reach from the distributor to the ignition unit when fitted in the car.

The major part of the installation work on the contactless system is fitting the sensor into the distributor. Although this could be done with the distributor in the car it is certainly much more convenient to remove it from the car because of the need for correct alignment of the sensor.

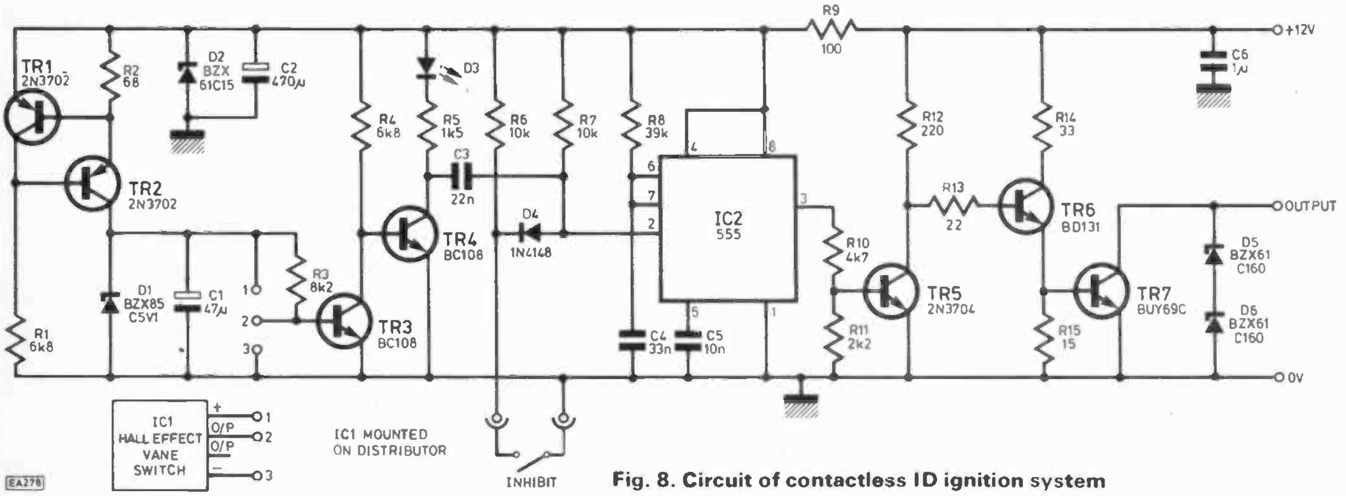


Fig. 8. Circuit of contactless ID ignition system

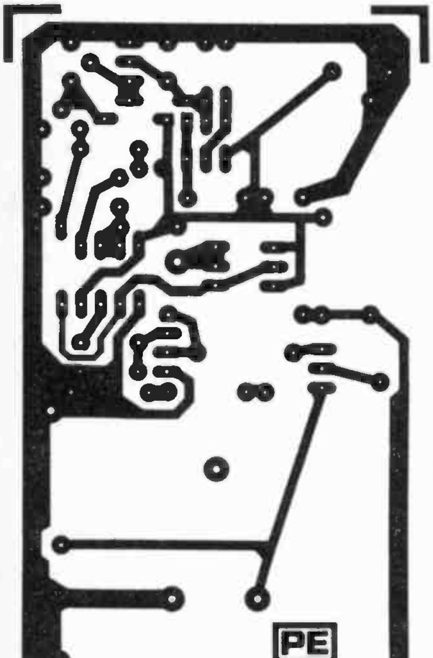
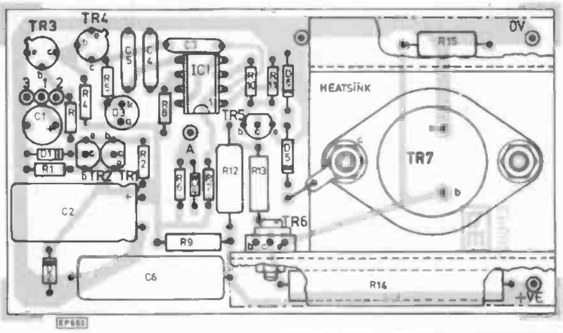


Fig. 9. Printed circuit and Fig. 10 (right) component layout for contactless system

INDUCTIVE IGNITION SYSTEM (Oct 1981)

The figure shown below should be substituted for Fig. 10 on page 44.



FITTING THE SENSOR

Before removing the distributor it is advisable to turn the engine to a known position, e.g. top dead centre with No. 1 cylinder in a firing position. The distributor cap should be removed and the position of the rotor arm marked on the distributor casing. The clamp fixing bolt or bolts should then be removed and the distributor removed slowly. If the distributor drive is via a gear, the rotor arm will turn as the distributor is removed. Try not to twist the body of the distributor as it is removed and if necessary mark the position of the rotor arm when the distributor is clear of the engine. Full details on distributor removal can usually be found in the workshop manual for the car. Once the distributor has been removed do not move the engine otherwise it will be necessary to retime it completely.

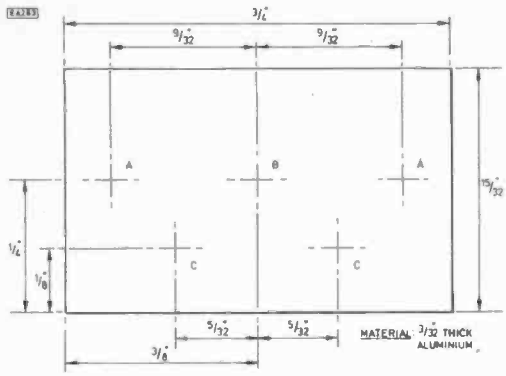


Fig. 12. Sensor adaptor block. Hole A is tapped 6BA for sensor mounting. B is tapped to suit mounting to CB adaptor plate. C is tapped for locating pegs

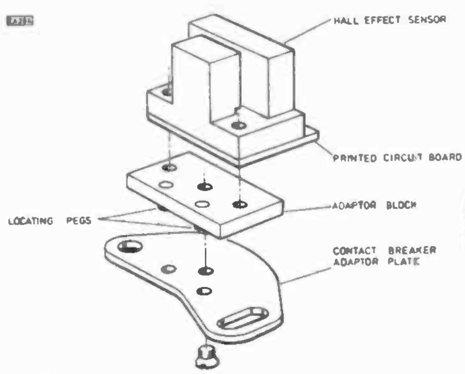
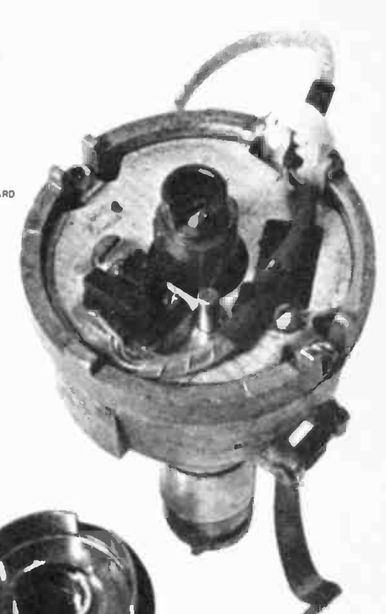


Fig. 13. Sensor mounting details



Showing the sensor mounted in the distributor with the vane and rotor arm beside which fits on the rotor drive shaft

Once out of the car, the rotor arm, contact breakers and the capacitor, if fitted internally, should be removed. Check that the Hall effect sensor on its adaptor plate will fit in place of the contact breakers. If it does not it will be necessary to modify the sensor assembly so that it does. No specific modifications can be given because of the variety of distributors in use, but in general no or only minor modifications will be needed with larger diameter distributors, whereas smaller diameter distributors may require the sensor board cut flush with the sensor to enable it to fit. Next check that the rotor arm and vane, when fitted, does not foul the sensor.

When the position of the sensor has been established, make sure that the vacuum advance mechanism is free to move (those of you with a Mini Cooper S need not worry about this point) and does not cause the sensor to foul the vane. Be careful not to let any metallic fragments get onto the sensor magnet face. The sensor should then be removed and the wiring soldered to the sensor p.c. board. Allow enough wire so that it is not subject to too much flexing by the vacuum advance mechanism, otherwise the continuous movement may break the wire. Do not forget to feed the wiring through the distributor body using suitably sized grommets before connecting it to the sensor. Replace the sensor in the distributor and check the alignment making sure that the vane is not fouled by the wiring or the sensor. Then connect the distributor to the ignition unit, apply power and rotate the distributor drive shaft. The l.e.d. should flash on and off, on when the sensor gap is clear and off when the vane is in the gap. The distributor can now be refitted in the car making sure that the rotor arm is aligned with the marks made when the distributor was removed. Once again the workshop manual should give more detailed information on refitting.

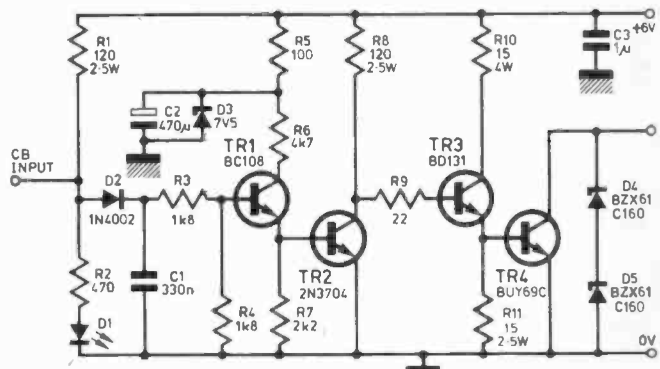


Fig. 15 (above) 6V contact input version with non-extended dwell

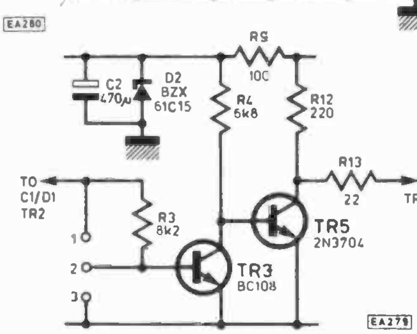


Fig. 16 (left) mods for non extended dwell contactless system

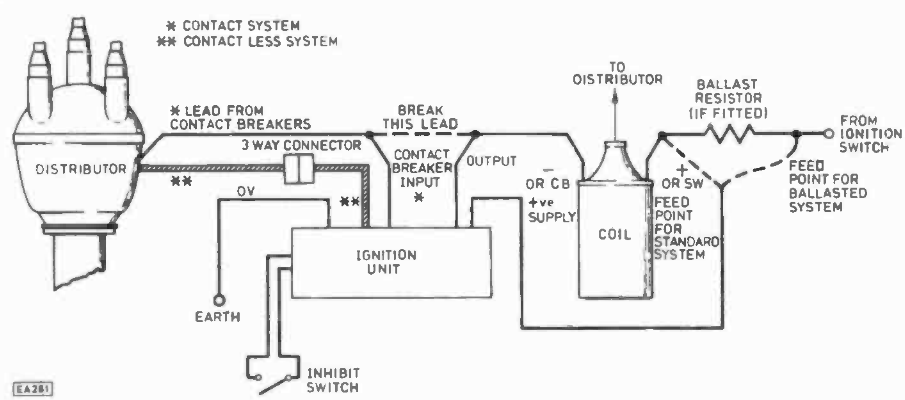


Fig. 14. Installation wiring

COMPONENTS . . .

Contact Version

Resistors

R1, R12	220 2·5W (2 off)
R2	1k2
R3, R4	1k8 (2 off)
R5, R10	4k7 (2 off)
R6, R7	10k (2 off)
R8	39k
R9	100 0·5W
R11	2k2
R13	22 0·5W
R14	33 7W
R15	15 2·5W

All $\frac{1}{4}$W 5% except where stated otherwise

Capacitors

C1	330n
C2	470μ 16V electrolytic
C3	22n
C4	33n
C5	10n
C6	1μ

All 250V polyester except where otherwise stated

Semiconductors

D1	0·2in. l.e.d.
D2	1N4002
D3	BZX61C15
D4	1N4148
D5, D6	BZX61C160 (2 off)
TR1	BC108
TR2	2N3704
TR3	BD131
TR4	BUY69C
IC1	555

Miscellaneous

Diecast box RS 509-939, printed circuit board, nuts, bolts, grommets, etc. (D5-D6 and TR4 can be obtained from Ace Mailtronix 3A Commercial St. Batley, West Yorks for a cost of £3)

Contactless Version

Resistors

R1, R4	6k8 (2 off)
R2	68
R3	8k2
R5	1k5
R6, R7	10k (2 off)
R8	39k
R9	100 0·5W
R10	4k7
R11	2k2
R12	220 2·5W
R13	22 0·5W
R14	33 7W
R15	15 2·5W

$\frac{1}{4}$W 5% unless stated otherwise

Capacitors

C1	47μ 6·3V elect. or tant.	
C2	470μ 16V elect.	
C3	22n	Polyester 250V
C4	33n	Polyester 250V
C5	10n	Polyester 250V
C6	1μ	Polyester 250V

Semiconductors

D1	BZX85C5V1
D2	BZX61C15
D3	0·2in. l.e.d.
D4	1N4148
D5, D6	BZX61C160 (2 off)
TR1, TR2	2N3702 (2 off)
TR3, TR4	BC108 (2 off)
TR5	2N3704
TR6	BD131
TR7	BUY69C
IC1	RS 309–492
IC2	555

Miscellaneous

Diecast box RS 509–939, printed circuit boards, 3-way lockable connector, Lucas distributor adaptor kit, nuts, bolts, grommets, etc.

The diecast box for the ignition unit should then be fitted in the same manner as the contact version, except that the contact breaker lead is replaced by the 3-way lead to the distributor sensor.

As a rough guide it took the author approximately half an hour to fit the sensor to a Mini with the Lucas 25D4 distributor, which required no modifications, and about an hour to fit it to a Ford Fiesta with a Bosch distributor which, being smaller, needed the sensor board modifying.

When installation has been completed start the engine and check the timing, especially if the contactless system has been fitted, preferably with a strobe timing light, and adjust if necessary to the manufacturer's recommended setting. If the car does not start, check all the connections and the position of the distributor. Also check the static timing, shorting the inhibit lines to prevent the ignition firing. More detailed information on setting the timing is to be found in the workshop manual.

This type of ignition system is fully compatible with any existing suppression equipment, therefore no changes should be needed. Some cars are fitted with a suppressor between the contact breakers and the coil. This suppressor should be connected between the coil and the ignition unit to maintain the radio suppression.

If any radio interference is experienced try connecting the ignition 0V lead to the engine instead of the car body.

Both voltage pulse and current pulse tachometers can be used with this ignition system and no modifications should be necessary to the car wiring or to the tachometer.

ADAPTATIONS

Several adaptations of the circuit are possible. These include versions without the extended dwell and a 6V version. A 6V contact input without the extended dwell is shown in Fig. 15; this version is suitable for 6V motor-cycles. Fig. 16 shows the necessary modifications for the contactless version without the extended dwell. The printed circuit boards shown in Figs. 5 and 10 can be used for these versions without modification.

It is also possible to use the contactless sensor input to trigger a capacitor discharge system but it is left to the individual constructor to devise a suitable interface.

Once fitted do not expect the dramatic improvements claimed by some of the electronic ignition adverts. Certainly it is possible to obtain higher m.p.g. and better performance with electronic ignition due to the better and more precisely timed spark but as has been pointed out many times the best improvement in m.p.g. can be obtained by careful use of your right foot. The most probable results of fitting electronic ignition will be better starting and smoother idling and perhaps an improvement in top end performance due to the elimination of contact bounce. These effects are most likely to be noticed on an older car rather than a relatively new one. ★

FRANK W. HYDE

SUNSPOTS AND THE EARTH'S CLIMATE

There is reason to suppose that there is a link between the cycle of solar activity and the weather. The evidence has been found in the mud of Australia. The idea of the Sun's influence on the weather is not new of course and much effort has been directed toward establishing a working hypothesis. The Sun's activity has scarcely changed over the last 500,000,000 years, that is to say, that solar activity has followed along its present condition of continuous radiation. The change of intensity of that radiation follows the advent of sunspots and flares. The sunspot activity has been logged for hundreds of years in great detail. Many claims have been made for the effect of sunspots on motor car sales, stock market movements, wars and revolutions, epidemics; in fact in every sphere of world activity. However, some years ago there was a cooperative investigation between the Electricity Authority and the Meteorological Office which revealed a special cycle of events which correlated with magnetic storms and sunspots. The reason for the investigation arose from the effect of high surges and lightning strikes on the grid network. A period of 174 years with certain significant sub-cycles was observed.

The recent work by G. E. Williams, who is a geologist with the Exploration Department of the Broken Hill Company, Camberwell, Victoria, was undertaken at the Flinders Ranges in South Australia. Here the sandstone deposits and siltstone deposits of sedimentary rocks show a layering which relate to climatic conditions and leave a 'signal' which is visible to the eye. Previously the periodic effects have been deduced from statistical data but in these deposits the layers are visible and show seasonal bands. Layers of this nature appear only under special climatic conditions. These layers are called 'varves'. The thickness of these varves indicate the temperature at the time they were laid down. The results shown agree with the 22 year double sunspot cycles and a 90 year cycle. Records are available now for 1760 years of the Precambrian varves.

Also the magnetic reversals are apparent and thus it seems very likely it will be possible to examine now some of the problems such as the 'lack' of nutrino counts which should exist according to present models. Again, if the varves are correct the period covered is a considerable part of the age of the Solar system and one in which the Solar clock has been very accurate.

A SECOND VISIT TO SATURN

The second Voyager spacecraft pictures of Saturn and its 17 moons became visible to mankind during August and September. Five of the satellites have not till now been more than blobs of light. The details were seen on the close approach in the early hours of August 26. Saturn's moon Phoebe will be seen for the first time. A number of the puzzling features observed on the first spacecraft flypast will be resolved after the data is scrutinised. The Cassini division which looks black from the Earth is in fact filled with many rings which seem to have polarised crystals or particles. When the first Voyager passed from above, the rings were bright but after passing below they became dark. This was discussed at a conference of a small group earlier this year. The writer made a suggestion that the answer might be that there were water ice crystals or particles and also carbon dioxide ice. It could be expected that there is polarisation or refraction of sunlight to produce this. As it happened the new controller of operations for this pass was there. Arrangements were to be made for this suggestion to be examined.

The ring system as a whole was quite unlike anything that had been imagined. It is understood that there are two satellites which change places and it is possible that they were once a single satellite; this will now be determined. The programme for the detailed examination of the rings is being carried out by looking at the rings against the light from the star Delta Scorpio. This will reveal the structured effect by the way the light is obscured, absorbed or scattered.

The spacecraft will pass closer on this occasion to the moons Iapetus, Hyperion, Enceladus, Tethys and Phoebe but will be further away from Titan, Dione, Mimas and Rhea. There are other mysteries to be cleared by the repeat pictures of Iapetus. Why should this satellite appear with one hemisphere completely dark as though sprayed with soot? Enceladus is covered in ice and smooth like a billiard ball. The others—Mimas, Tethys, Dione and Rhea—are covered in craters with deep valleys and what may be frozen geysers. The composition of each seems to be different. Some are a mixture of rock and ice though Tethys has the density of pure ice and Dione appears to be 40% rock.

More than 18,000 pictures were taken during this pass and now the spacecraft passes to its new target Uranus. It is hoped that all systems will remain operational till the five year journey to Uranus is accomplished. Then will come the opportunity to see the mystery planet Uranus and its environs. This will be in 1986. If at that time the spacecraft is still operational it will have as its next target the planet Neptune, which would be reached by 1989.

DYNAMICS EXPLORER MISSION

The Dynamics Explorer Mission is a twin spacecraft mission for the explorers to research the interaction between the magnetosphere, ionosphere and the atmosphere in both high and low altitudes. The purpose is to cover areas which have not been previously studied in regard to special phenomena. The mission is to gather new data on auroral processes. One of the spacecraft will detect, when over the equator, powerful signals from a transmitter based in the antarctic. The signal will be directed into the magnetosphere making changes in the space environment which will be detected by the spacecraft over the equator. This twin mission is essentially a follow-on mission to the Atmospheric Explorer and the International Explorer programme. Robert Hoffman, one of the Project Scientists, said 'The sunlight interacts with the upper atmosphere as well as the lower atmosphere. The interaction of sunlight with the upper ionospheric region was studied in the previous mission together with the solar wind. The data that was missing was the coupling between the magnetosphere, the ionosphere and the atmosphere. This gap will be filled by the new mission.'

The two spacecraft will be used together acquiring simultaneous data. For example one spacecraft would be sensing the magnetosphere while the other monitors the state of the ionosphere and the atmosphere Dynamics Explorer A (DE A) will go into an orbit of about 24,875km by 675km and inclined at 90° so passing over the Earth's poles. This will ensure that the spacecraft will spend the maximum time in the magnetosphere. The imaging system will monitor auroral activity. The photographs will enable assessment of the amount of energy transferred from the magnetosphere to the Earth's upper atmosphere to be made.

The second spacecraft DE B will be put into an orbit 1,300 by 305km. This also will be inclined by 90°. The two Explorers will be in the same plane. The DE A will carry 6 instrument packages and the DE B will carry 9 packages.

The antenna systems aboard DE A include two long wire units each 328ft. long. This will give an effective diameter of 656ft. In addition there will be:

– Two 19.3ft. triangular truss booms carrying a loop, search-coil and electric antenna for the plasma wave experiment and a magnetometer to form a 38ft. long span.

– A single 4.9ft long S-Band antenna.

– Two 13ft. long tubular antennas will be deployed as part of the plasma experiment.

The antenna systems carried by DE B will be:

– Six 36ft. long tubular antennas forming a span of 72ft. around the spacecraft axis as part of the vector electric field instrument.

– A 19.3ft. long triangular truss boom will carry a magnetometer.

– Two 2ft. probes which will sense electron temperatures and concentrations.

– A single 4.9ft. tall S-Band antenna supported by two guy wires of nearly equal length as it sits on top of the spacecraft at launch.

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PE RANGER 27FM CB
PART TWO

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

THE purpose of the speech processor is to convert the input signal from the microphone into a form suitable for modulating the bias on the varicap diode in the transmitter oscillator circuit. As has already been seen, the deviation obtained is dependent on the amplitude of the modulating signal, e.g. Fig. 1.3. (last month) shows that a peak-to-peak signal of approximately 5·8 volts will produce ±2·5kHz deviation at 27MHz. It is important, therefore, that the amplitude range of the modulating signal is restricted in order to prevent any undesirable over-deviation. Simple amplitude limiting, however, will result either in significant distortion, or in a low average level of the recovered audio signal. What is required, therefore, is a circuit which will compress the dynamic range of the speech signal, and limit the maximum amplitude. This will have the effect of reducing the 'peak factor' (ratio of the peak to the r.m.s. value) of the speech waveform, thereby allowing the average level to be maintained at a higher value without the risk of over-deviation. Typically, the peak factor expected in speech over a period of time is around 20dB.

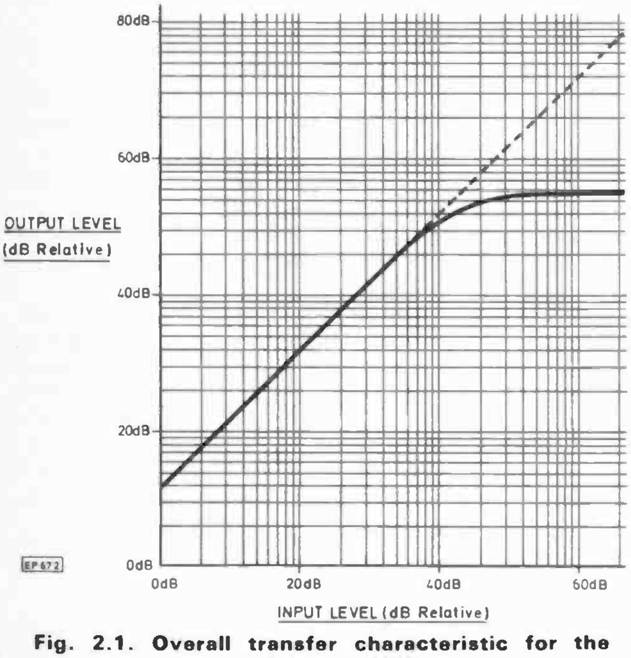


Fig. 2.1. Overall transfer characteristic for the modulator at 1kHz

The speech processor in the Ranger uses an active limiting arrangement, whose overall transfer characteristic is shown in Fig. 2.1. Some distortion of the audio signal is inevitable (indeed, it is intended!) in any speech processor circuit, and is primarily due to the generation of harmonics which result from the non-linear transfer chacteristic. Harmonics of the lower frequency components (say below 1kHz) in the waveform are more significant because they fall within the frequency range of normal speech. At middle and high frequencies, however, the speech waveform is filtered to limit the frequency range of the modulating signal.

The 'soft-limiting' characteristic used in the processor causes the slope of the transfer characteristic to fall progressively as the input level increases above the threshold level. This reduces the generation of unwanted harmonics of the input signal, and renders the resultant processed speech less harsh and more pleasant to listen to than it would be using a 'hard-limiting' characteristic (where there is no perceptible increase in output above the threshold input level). At maximum limiting, there is approximately 3dB change in output for 20dB change in input level. The frequency response characteristic, which together with the transfer characteristic defines the behaviour of the speech processor, is shown in Fig. 2.2.

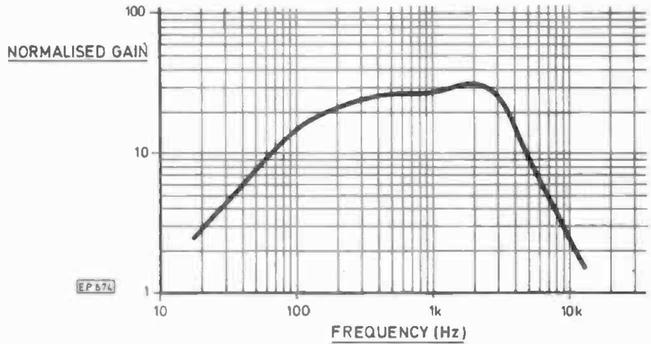
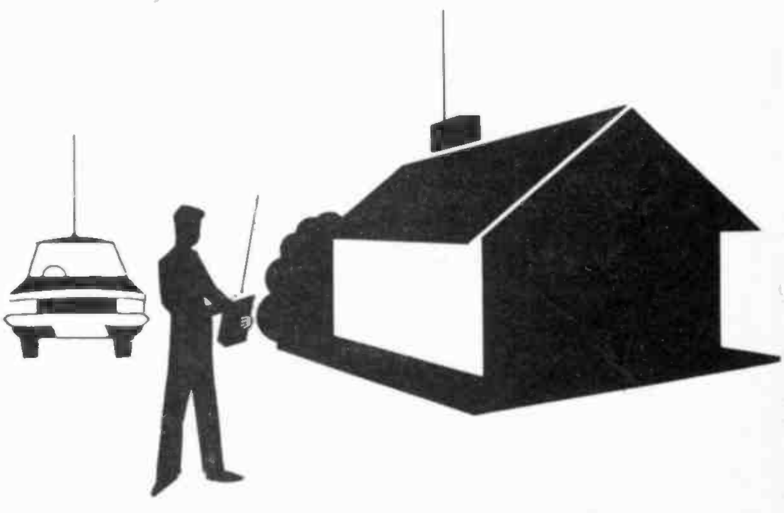


Fig. 2.2. Frequency response characteristic for the speech processor

A block diagram for the speech processor is shown in Fig. 2.3. Each of the four stages uses one of the operational amplifiers in IC1. The LM324 will operate from either differential or single-ended power supplies; the supply in the Ranger is single-ended and decoupled by R15, C17 and C18. The amplifier and limiter stages have their non-inverting inputs connected to the half-supply point formed by R16 and R20, and these inputs are decoupled to signal frequencies by C19.



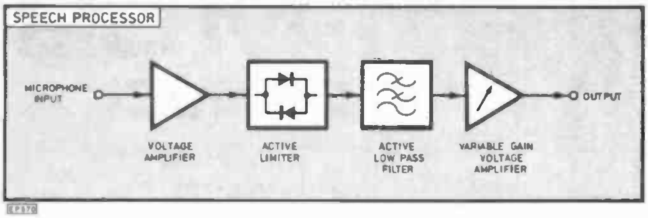


Fig. 2.3. Block diagram of the speech processor

The first stage is a conventional inverting voltage amplifier whose gain (defined by R18/R17) is set to match the microphone being used. The gain should be set, by variation of R18, such that the output of IC1a is 600mV peak-peak when the microphone input corresponds to the level at which the onset of limiting is required.

The active limiter is formed by IC1d, D4, D5 and associated components. The limiter has a fixed gain of 2, defined by R19 and R21. Since D4 and D5 are silicon diodes, a peak-peak voltage swing of approximately 1·2 volts will cause the diodes to conduct in turn on alternate half-cycles, and this in turn will provide a low impedance shunt path across the feedback component, R21, effectively reducing the stage gain.

The third stage amplifier, IC1c, is used as a low-pass Sallen and Key active filter. This is a second order filter whose cut-off frequency is determined by R22, R23, C22 and C24, and which exhibits a roll-off at higher frequencies of 40dB/decade (12dB/octave). The response of the speech processor at low frequencies is governed by the inter-stage coupling, e.g. C20, and the mid-band gain of this stage is unity.

The final stage is a variable gain stage whose voltage gain may be varied over the range 0·1 to 10·1. The gain is determined by (R27 + VR3)/R26, thus VR3 allows the output of the speech processor to be adjusted to provide the required maximum frequency deviation. R29 provides the necessary high source impedance for applying the modulating signal to the varicap diode in the oscillator and modulator stage.

RECEIVER

The receiver front-end employs two junction f.e.t.s, TR100 and TR101, arranged in a cascode configuration to provide a high input impedance, high gain and low noise amplifier. The cascode configuration is preferred to a comparable dual-gate MOSFET circuit due to its inherently robust performance but similar electrical characteristics. The number of passive components in both designs is identical, but the overall cost of the MOSFET design is higher and more careful handling during construction is necessary.

The aerial signal is coupled into the gate of TR100 via L100/L101. This coil, and L102/L103, has a Q of approximately 45, and the bandpass coupling between aerial and mixer input greatly enhances the rejection of unwanted signals. The amplified signal is coupled to the integrated mixer in IC100 via L102/L103.

The second input to the mixer is derived from the local oscillator. TR102 is configured as an overtone oscillator using third overtone crystals, X100-X105, to generate a local oscillator signal at 455kHz below the channel frequency, e.g. for channel 14 (27·73125), a crystal is selected to set the local oscillator frequency to 27·27625MHz. L104/L105 forms the tuned drain load for TR102 from which the mixer drive is taken. The tuning core of this coil allows a small range of frequency adjustment should this be necessary, although the circuit will oscillate satisfactorily over a wide tuning range. The oscillator is stabilised against supply voltage fluctuations by D100.

The i.f. amplifier and demodulator is built around the MP5071, which is a pin-compatible and lower power version of the Motorola MC3357 low power integrated narrow band FM i.f. strip. This device was designed for use in FM dual-conversion communications equipment, and it includes a number of highly sophisticated features. The i.c. contains an oscillator, mixer, limiting amplifier, quadrature discriminator, active filter, squelch, scan control, and mute switch. A functional block diagram for the i.c. in its design configuration is shown in Fig. 2.4.

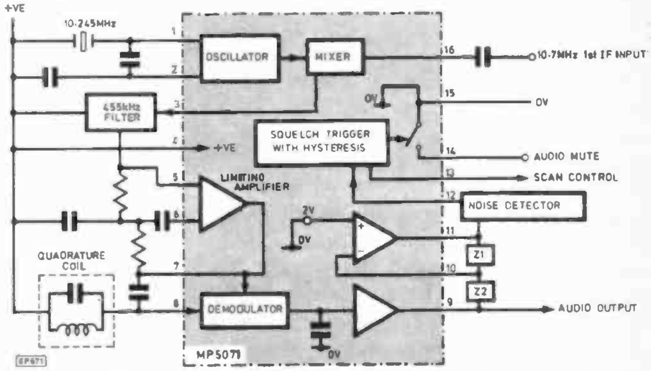


Fig. 2.4. Design configuration for dual conversion receiver applications

In the Ranger, the receiver is a single-conversion superhet design which uses a high frequency local oscillator, with overtone crystals, to avoid the need for any frequency multiplier stages, with the associated alignment problems. The MP5071's internal oscillator is, however, unsuitable for this application, and a discrete oscillator is therefore used in its place. The local oscillator signal, generated as described earlier, is a.c. coupled to pin 1 of IC100 via C106 because this input is tied up to the positive supply rail. The r.f. amplifier output is similarly coupled to the mixer input at pin 16. The input limiting voltage (—3dB limiting) at this point is typically 5µV, which gives the receiver an excellent overall sensitivity. The mixer conversion gain (a measure of the conversion of r.f. energy at 27MHz to i.f. energy at 455kHz) is similarly good at around 20dB. The mixer is double-balanced to reduce spurious responses.

The mixer output from pin 3 is filtered to remove unwanted mixing products, leaving the 455kHz i.f. signal. The filter also acts to define the bandwidth of the i.f. strip, which would otherwise have a broadband response. The arrangement used in the Ranger is to combine a 455kHz mechanical filter, FL100, with an input matching transformer, L106/L107. A mechanical filter (here a Toko type CFM2455D) is preferred to a ceramic i.f. type because of its

Fig. 2.5. Attenuation characteristic for a typical CFM 2455D filter

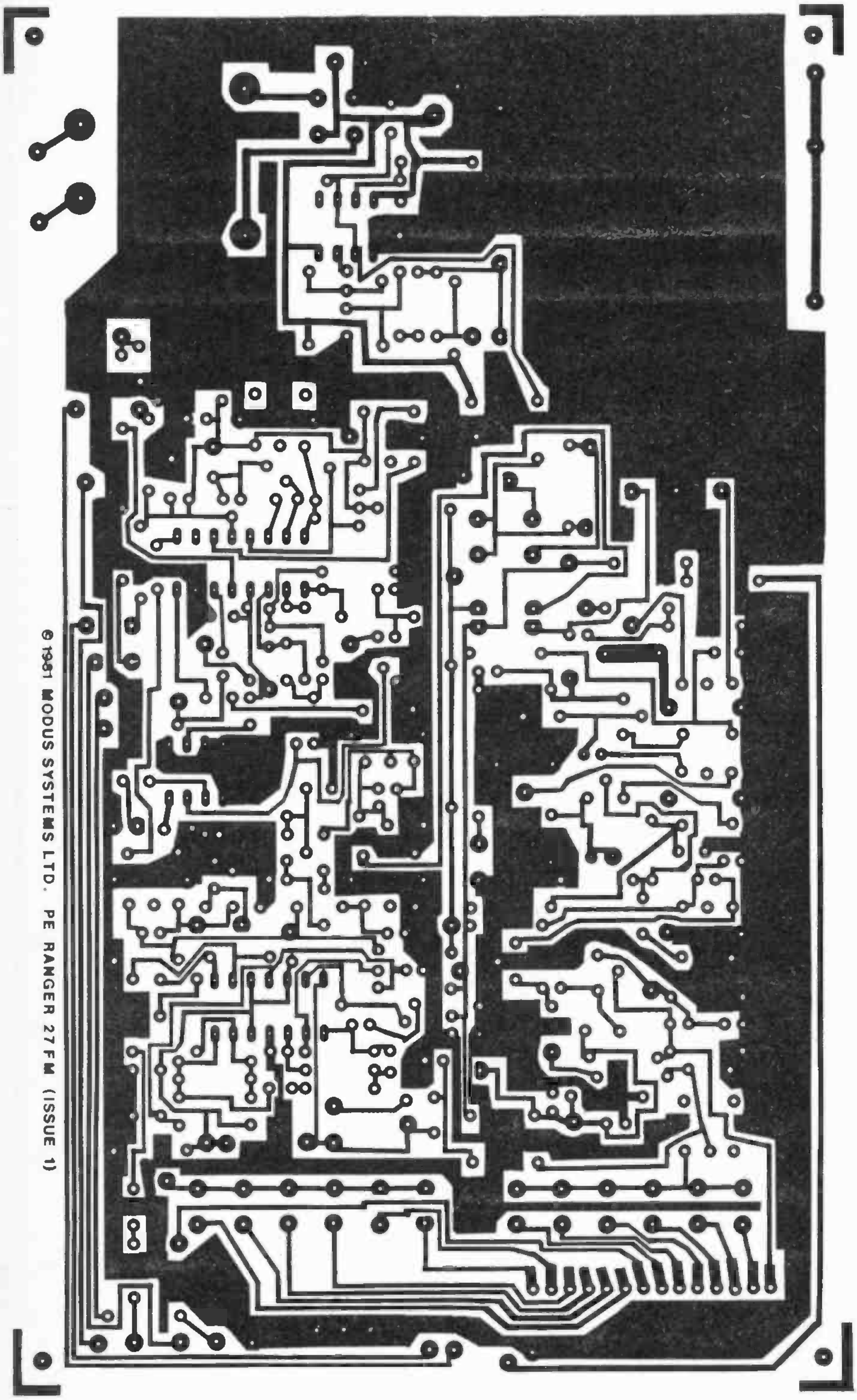


Fig. 2.6. P.c.b. design for the PE Ranger (*Copyright Modus Systems*)

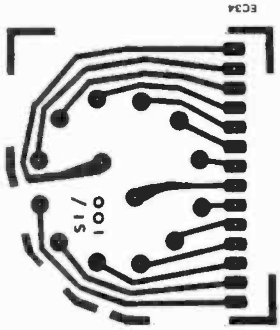


Fig. 2.8. Daughter board p.c.b. design for the channel selector switch

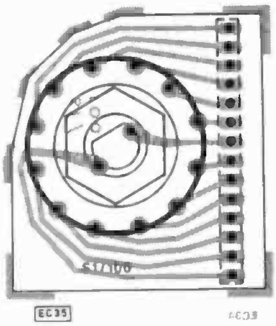


Fig. 2.9. Overlay showing the orientation of the channel selector switch

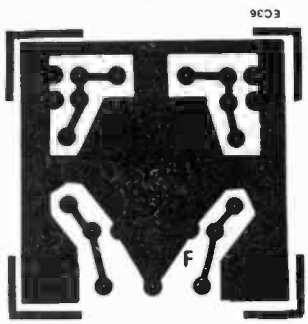


Fig. 2.10. Filter board p.c.b. design

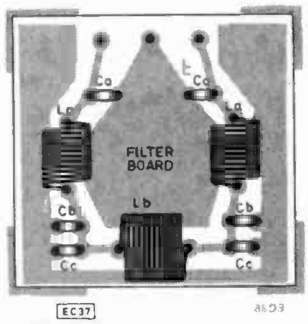


Fig. 2.11. Component layout for filter board

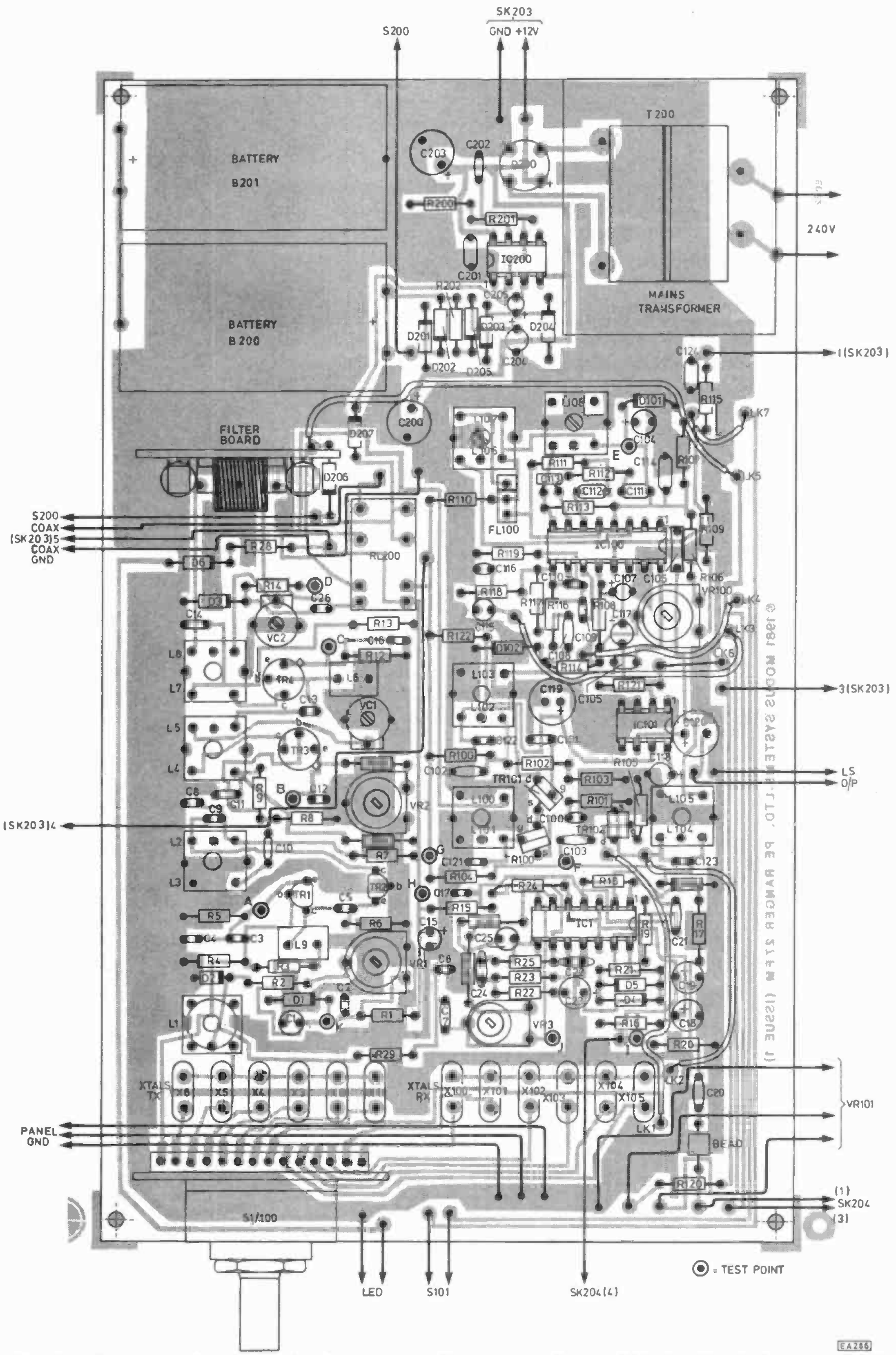


Fig. 2.7. Component layout for the Ranger p.c.b. Please note: Socket 203 should only have the GND and 12V connections made. The other connections are for the base station and a suitable 6 pin d.i.n. socket will be provided with the base station kit.

superior performance in rejecting spurii at higher frequencies, and its long term stability. The combination of a mechanical filter and an input matching transformer provides an overall response with excellent stopband characteristics, and up to approximately 80dB rejection of unwanted signals. The bandwidth of the i.f. is defined by the response of the filter used between the mixer and the limiting amplifier; the CFM2455D has a bandwidth of 10kHz (min) at a centre frequency of 455 ± 2kHz. The insertion loss is a maximum of 6dB, and a typical attenuation curve characterising the filter is shown in Fig. 2.5.

The filter output at 455kHz is applied to the input of the i.f. limiting amplifier at pin 5 of IC100, where most of the amplification is performed. The signal is amplified in a five-stage limiter whose output appears at pin 7. This signal then drives a multiplier demodulator, both by a direct internal path, and externally via the quadrature coil (L108) to pin 8, to recover the FM. The output of the demodulator at pin 7 is also used to supply d.c. feedback to pin 5, and the other side of the first limiter stage is decoupled at pin 6.

The recovered audio at the demodulator output is partially filtered within the i.c. and then buffered, giving an output impedance of around 400Ω at pin 9. The recovered audio signal at pin 9 is typically around 350 mV r.m.s., but this signal still requires de-emphasis, volume control and further amplification before it is suitable for driving a loudspeaker.

The audio signal at pin 9 is applied to an active high pass filter, formed by the combination of an internal operational amplifier and C110, C109 and R116. The filtered output from this stage is coupled via C108 to the AM detector formed by D102, R114 and C107, which looks for the presence of noise at frequencies above the normal audio band, and the detected noise level is then applied to pin 12.

The external positive bias on pin 12 provided by R106, VR100 and R109, sets up the squelch trigger such that the audio mute on pin 14 is open circuit (typically 10MΩ). If pin 12 is pulled down to 0·7V by the noise detector, pin 14 is internally shorted to ground, and the audio signal to the amplifier is muted. There is hysteresis of approximately 100mV on the input to the squelch trigger to prevent jitter on the mute operation. The squelch may be over-ridden by holding pin 12 high, via R107 and S101, to keep the mute switch open. The output from pin 13 may be used in scanning receiver applications; the output is low (less than 0·5V) when the mute is off, and high (min +5V) when it is on.

The MP5071 is designed to operate from low voltage d.c. supplies in the range +4V to +8V, and consumes only 2-3mA under these conditions. To provide a suitable supply, the 12V receiver power rail is regulated to around +6 volts by R110, D101 and C104. This also has the effect of making the performance of the receiver substantially unaffected by variations in battery voltage, with the exception of the audio output power level.

In the audio section, R118 and C116 provide the de-emphasis for the recovered audio signal, and IC101 supplies amplification for driving the loudspeaker.

POWER SUPPLY

The power supply for the Ranger allows the rig to be operated in one of five active modes:

(i) Internal NiCad battery pack
(ii) External +12V d.c. supply
(iii) Mains supply
(iv) Mains re-charging of the NiCad battery pack
(v) Re-charging of the NiCad battery pack from external +12 volt d.c. supply

The changeover between modes is automatic. The only manual switch in the circuit, S200, is used to turn the power on to the transmitter/receiver sections. Modes (iv) and (v) are inhibited when the transmitter or receiver is active in order to prevent noise generated by the charging circuit from de-sensing the receiver front-end or corrupting the modulation of the transmitter.

In normal portable use the Ranger operates from its own internal 12·5V 250mAh nickel-cadmium battery pack, i.e. in mode (i) above. This pack is sufficient to allow approximately 4-5 hours use when operated with a 10:1 receive:transmit duty cycle. The steering diodes, D201/2/5, are reverse-biased to prevent unwanted current drain to the unused sections of the power supply. The battery pack, B200/1, comprises 10 individual mass plate button cells in series, sleeved for insulation purposes. It features a high storage capacity for its size, has a low internal resistance, is resistant to extremely hostile environments, and can be stored without the need for periodic re-charging. A NiCad pack is thus an ideal choice for use in a portable rig.

Operation from an external battery supply requires that d.c. power is applied via SK203. A car battery or similar d.c. source will generally have a terminal voltage which exceeds

TABLE 1

Channel Number	Channel Frequency (MHz)	TX Oscillator Frequency (MHz)	RX Oscillator Frequency (MHz)
01	27·60125	9·20042	27·14625
02	27·61125	9·20375	27·15625
03	27·62125	9·20708	27·16625
04	27·63125	9·21042	27·17625
05	27·64125	9·21375	27·18625
06	27·65125	9·21708	27·19625
07	27·66125	9·22042	27·20625
08	27·67125	9·22375	27·21625
09	27·68125	9·22708	27·22625
10	27·69125	9·23042	27·23625
11	27·70125	9·23375	27·24625
12	27·71125	9·23708	27·25625
13	27·72125	9·24042	27·26625
14	27·73125	9·24375	27·27625
15	27·74125	9·24708	27·28625
16	27·75125	9·25042	27·29625
17	27·76125	9·25375	27·30625
18	27·77125	9·25708	27·31625
19	27·78125	9·26042	27·32625
20	27·79125	9·26375	27·33625
21	27·80125	9·26708	27·34625
22	27·81125	9·27042	27·35625
23	27·82125	9·27375	27·36625
24	27·83125	9·27708	27·37625
25	27·84125	9·28042	27·38625
26	27·85125	9·28375	27·39625
27	27·86125	9·28708	27·40625
28	27·87125	9·29042	27·41625
29	27·88125	9·29375	27·42625
30	27·89125	9·29708	27·43625
31	27·90125	9·30042	27·44625
32	27·91125	9·30375	27·45625
33	27·92125	9·30708	27·46625
34	27·93125	9·31042	27·47625
35	27·94125	9·31375	27·48625
36	27·95125	9·31708	27·49625
37	27·96125	9·32042	27·50625
38	27·97125	9·32375	27·51625
39	27·98125	9·32708	27·52625
40	27·99125	9·33042	27·53625

N = Channel Number
Channel Frequency = (27·59125 + (N x 0·01)) MHz
TX Oscillator Frequency = (27·59125 + (N x 0·01))/3 MHz
RX Oscillator Frequency = (27·13625 + (N x 0·01)) MHz

the 12·5 volts of the internal nickel-cadmium stacks. D201 will therefore be forward-biased and D202 will be reverse-biased, causing automatic changeover from the internal batteries. With S200 in the 'off' position, the battery charging circuit formed by IC200 and its associated components will be active. The 555 timer i.c. in this circuit is configured as an astable multivibrator running at approximately 20kHz. The astable output is added, via the steering diodes D203 and D204, to the supply voltage to develop a suitable charging potential across C204. The NiCad cells in B200/B201 are charged at almost constant current from this source via D205 and R202. The maximum charging rate for the 250mAh cells specified is 25mA, and 14 hours of charging are required to restore the charge in a set of fully discharged cells, i.e. the charge:discharge ratio is 1·4:1. The charging time may be extended beyond the fully-charged point by up to 200 per cent without risk of damage to the cells, allowing the unit to be left on charge overnight to replenish partially depleted batteries. The charging circuit is disabled when either the receiver or transmitter is active in order to avoid interference caused by harmonics of the astable output.

CRYSTALS

The frequencies of crystals required for the transmitter and receiver are listed in Table 1 for the 40 allocated 27MHz CB channels. The transmitter crystals are 9MHz fundamental types designed for use with the circuit loading. The receiver crystals are 27MHz third overtone series resonant types. By convention, channel 14 is used as the 'calling channel', and channel 9 is used as the 'emergency channel'; they are not working channels and should be reserved for their designated uses. A number of alternative channels are useful for continuing a conversation once contact has been established, usually via channel 14.

CONSTRUCTION

Arrange the work surface so that it is well lit and that all the necessary small tools are available. These should include a soldering iron rated at no more than 25W having a miniature bit, pairs of small long-nosed pliers and cutters, a small screwdriver, and a sharp knife or scalpel. A magnifying glass may also be useful for inspecting joints and checking that there are no solder bridges between tracks.

The p.c.b. copper foil layout is shown in Fig. 2.6 with corresponding component layout in Fig. 2.7. The earth plane, supply rails, and general component layout are quite critical and constructors should not attempt to use any other layout, p.c.b. design, or construction method since instability will almost certainly result. Carefully fit the channel selector switch, S1/S100, to its daughter p.c.b. (Figs. 2.8 and 2.9), check that it mates correctly and solder the tags. Then fit the in-line right-angle connector which is used to attach the daughter board to the main transceiver board. Take care not to strain the connector and check that the daughter board is aligned correctly at 90° to the main p.c.b., as shown in Fig. 2.7, before soldering it in place. Mount the mains transformer, T200, and solder its connecting tags to the main p.c.b. Having fitted these two components (channel selector switch/p.c.b. and mains transformer) it should now be possible to invert the p.c.b. and work on the copper foil side without damaging components fitted to the other side. The switch p.c.b. and transformer support the inverted transceiver p.c.b. clear of the work surface and this considerably aids assembly.

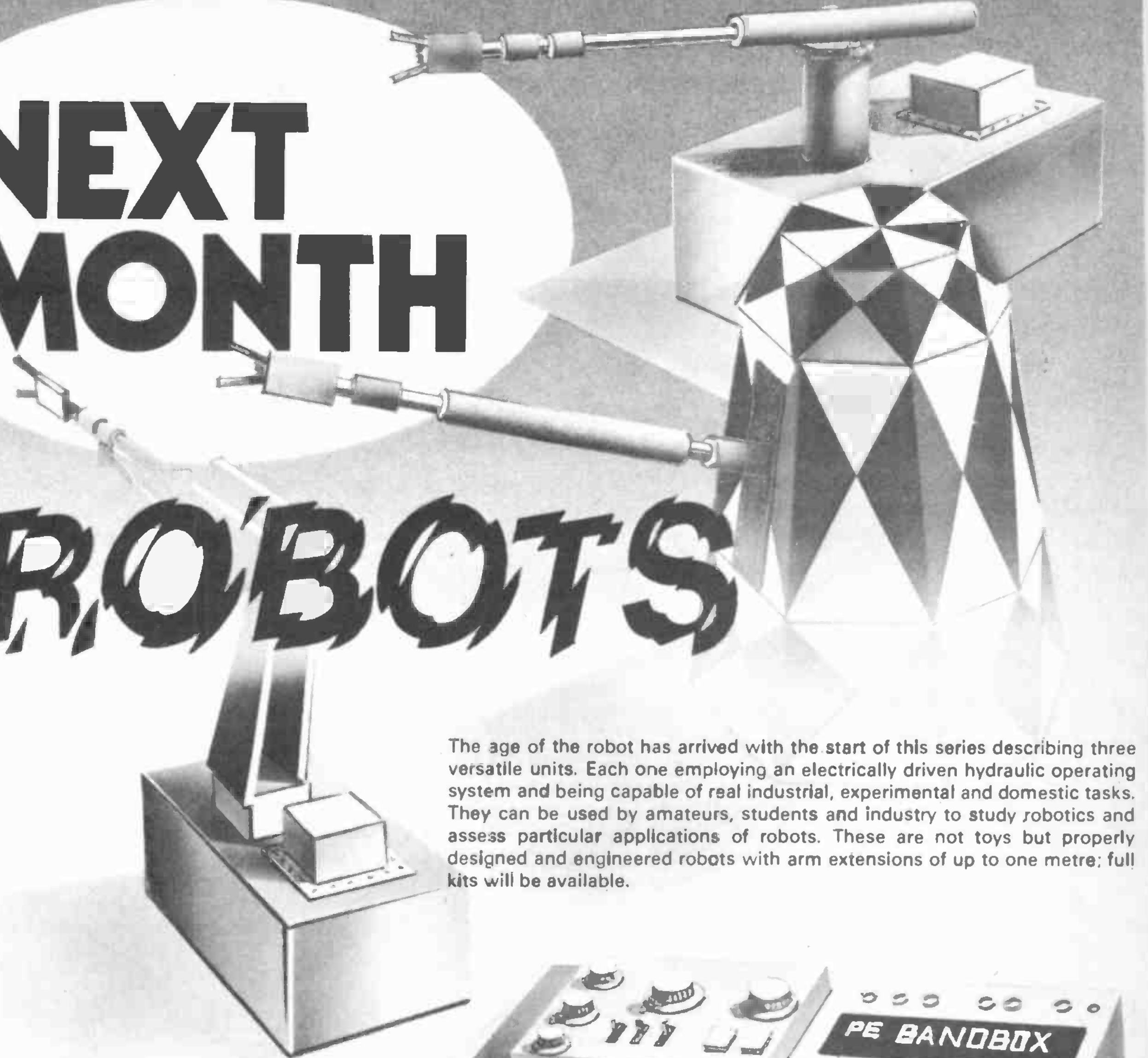
It is recommended that the remainder of the components be fitted to the p.c.b. in the following order:

1. r.f. and i.f. inductors and transformers
2. i.f. filter and r.f. chokes
3. variable resistors
4. variable capacitors
5. fixed resistors
6. fixed capacitors
7. transistors, diodes, bridge rectifier, and i.c.'s
8. test points
9. links
10. relay

Note that the crystals and output filter should not be fitted at this stage. Instructions for fitting these items are given later under the sections dealing respectively with "Initial Tests and Adjustment" and "Alignment". The filter input and output pads should, however, be linked together with a short length of connecting wire. When fitting the r.f. and i.f. transformers and inductors care should be taken to ensure that the correct component is fitted in the correct location on the p.c.b. (part numbers are printed on the metal screening cans). The transformers should be carefully eased into the p.c.b. observing the pin orientation which is non-reversible. When the bottom of the screening can is flush with the top surface of the p.c.b. the pins and earth tags may be soldered to the copper foil. Note that L1 has to be modified slightly before fitting to the p.c.b. This involves first removing the metal screening can by gently prizing the can away from the base using the blade of a small screwdriver and pushing the can upwards. The can may then be discarded and the ferrite cup (which is inverted over the coil former assembly) is then removed. The remaining coil former, tuning slug, and base is then mounted on the p.c.b. in a similar manner to that adopted for the r.f. and i.f. transformers however, in this case, there are no earth tags to solder. Carefully check the polarity of the electrolytic capacitors and the orientation of the diodes, bridge rectifier, transistors and i.c.'s before fitting, see Fig. 2.7. The use of i.c. sockets is not recommended for this project since, particularly in the case of IC100, instability may result due to the exceptionally high values of gain involved. Transistor leads should similarly be kept as short as possible and, in particular, TR3 and TR4 should be soldered so that they are flush with the surface of the p.c.b. Terminal pins of 1mm diameter are used for the test points. These should be carefully push into the p.c.b. using a pair of long nosed pliers and then soldered into place. The links, which consist of short lengths of insulated connecting wire, should be kept as direct as possible.

NEXT MONTH: Testing and Alignment

NEXT MONTH



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Digital Design Techniques...

Tom Gaskell B.A.(HONS) ELEC. ENG.

Part 3 Touch Switches, Timers & Oscillators

THIS month we are going to look at a more sophisticated circuit for a contact de-bouncer using a single pole changeover switch and two NAND or NOR gates. To introduce this circuit we must first look at the principles of cross coupled gates.

CROSS-COUPLED GATES

Fig. 3.1 shows an arrangement of cross-coupled gates. Let's assume that point X starts off at logic 1, and A and B start off at logic 0. If you work through the truth tables for the two gates; and I suggest you do, because it takes a bit of thinking about; you'll see that Q = 0, an (as we've already decided) X = 1. Now let input B go to logic 1. Again, follow through the truth tables and you'll see that when B goes to 1, X goes to 0 so Q goes to 1. If B is now taken back to logic 0, NOTHING CHANGES; Q is still 1, X is still 0. This condition will remain until A goes to 1 (and B is at 0). When this occurs, Q goes to 0 and X goes to 1. This again is "stable", i.e. unchanging, even when A drops back to 0, until B changes again.

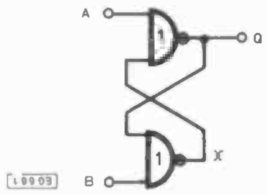


Fig. 3.1 Cross coupled gates (the 'latch')

This circuit is known as a "latch", "flip-flop" or "bistable" (stable in two states; Q = 0 and Q = 1); it is the most basic "memory" element, i.e. it remembers that B has been to logic 1, until re-set by input A, or vice versa. It has got a reverse version; if you replace the NOR gate with NANDS, and have A and B normally at logic 1 (then dropping to logic 0 temporarily), and Q and X reversed, then the whole thing behaves in the same way! Because NAND gates are used more widely than NOR gates, this latter version of the latch is more usually seen, although it can be a little more difficult to visualise working in practice.

CONTACT DE-BOUNCING USING THE LATCH

This is a fairly simple procedure; the switch is connected to the two latch inputs, with its wiper to Vss. See Fig. 3.2. When the switch is "ON", Q = 1 and $\overline{Q}$ = 0; when the switch is "OFF", Q = 0 and $\overline{Q}$ = 1. Contact bounce cannot affect the circuit, because the wiper of the switch has to travel from one contact all the way across to the other contact before the logic changeover occurs, and then all the way back to the first contact to make it change back again. Contact bounce cannot do this; it merely makes and breaks the contact at one position of the switch (the wiper movement is minimal) so the circuit effectively eliminates any contact bouncing that there might be. The logic gates used can be ordinary gates, although Schmitt trigger input types will tend to work better in difficult cases.

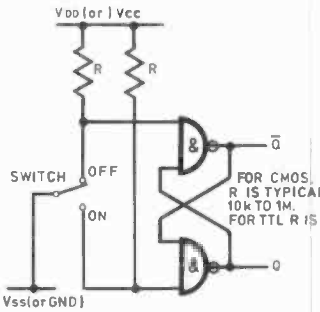


Fig. 3.2 Circuit using the latch as a contact de-bouncer

There are switches available which have no mechanical switching action at all, and hence do not suffer from mechanical contact bounce. One type of switch is the "touch switch" which still has a bounce-like effect due to the finger contacting then momentarily losing contact from the sensor plate; see below. The other type of switch is the "Hall-effect" switch. These work by using the Hall-effect principle of magnetic fields controlling the conduction in certain semiconductors. These types of switches are readily available, but fairly expensive, and they need a power supply to be fed to them for their internal circuitry.

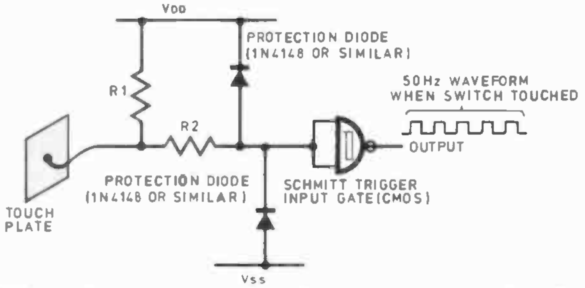
In large assemblies of switches, e.g. calculator or computer keyboards, it is often more economical to have common circuitry to contact de-bounce all the switches. The logic circuit "scans" the switch array, i.e. looks at each switch in sequence, for a short period of time. When it reaches the last switch it starts again at the beginning; over and over again, with each cycle of the process taking a tiny fraction of a second. When the control circuit sees that a particular switch has changed its logic state since the last time that is was scanned, it "remembers" that fact, and on each subsequent scan of the switch looks for further changes. When there has been no more changes for a set number of scans, say 10 for example, the control circuit assumes that all contact bounce has stopped. When this occurs, the logic state for that switch is now valid, and this logic state is finally fed out of the control circuitry into the rest of the system. Obviously, this circuit arrangement is fairly complex, and it is only suitable for fairly large switch assemblies.

TOUCH SWITCHES

There are three main types of touch switch; hum-inducing, resistive and capacitive. All of these are used with CMOS logic as TTL is unsuitable due to its low input impedance.

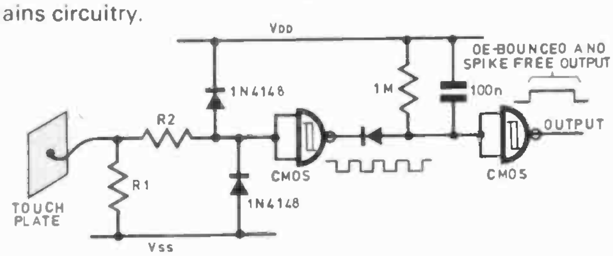
HUM INDUCING

These circuits work on the principle that the human body has a 50Hz signal of surprisingly high voltage induced into it by ordinary domestic and industrial mains wiring. This can be fed into a circuit when a contact is touched by a finger. (Fig. 3.3). The resistor R2 and the two diodes protect the CMOS gate against any transient voltages. The value of R2 should be between 10k and 100k. Resistor R1 sets the sensitivity of the switch and is dependent on the size of the touch plates and the proximity of the mains wiring; values between 1M and 10M are usual. (Try not to go above 10M if possible). Take care the touch plate is not too large as it may induce hum into the circuit and if the plate is large enough and the value of R1 high enough then the switch will become a 'proximity' switch i.e. you won't have to touch the metal plate merely approach it.



EG662 **Fig. 3.3 Conventional hum-inducing touch switch**

The switch gives a 50Hz waveform when touched which may be difficult to use in some applications. It also has 'bounce' associated with it, caused by the finger momentarily losing contact with the touch plate. This can be eliminated by adding a simple pulse stretching circuit as shown in Fig. 3.4. The RC constant is 0·1 sec which is long enough to remove any effects of mains hum or 'bounce'. These circuits are fairly standard designs and work well but not if they are used in the middle of a field well away from mains circuitry.

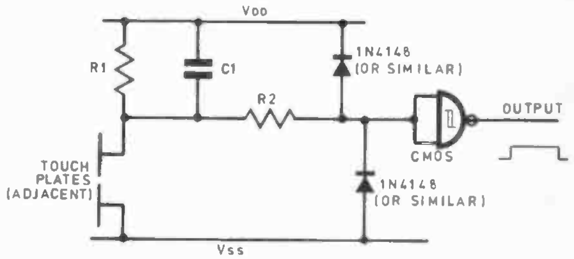


EG663 **Fig. 3.4 Improved version of Fig. 3.3**

For safety reasons, touch switch circuits should be treated with great caution if powered from mains supplies; it is generally better to use them in battery powered equipment where possible. Note also that hum inducing (and some capacitive touch switches) will not work unless Vss is connected to earth usually via the earth of a mains plug or via other equipment that is earthed. In all cases take great care to make connections correctly, any errors could prove to be fatal.

RESISTIVE TOUCH SWITCHES

The human body has a typical resistance of several hundred thousand ohms. This combined with very high input impedance of CMOS enables very simple touch switches to be made as shown in Fig. 3.5. The two diodes and R2 once



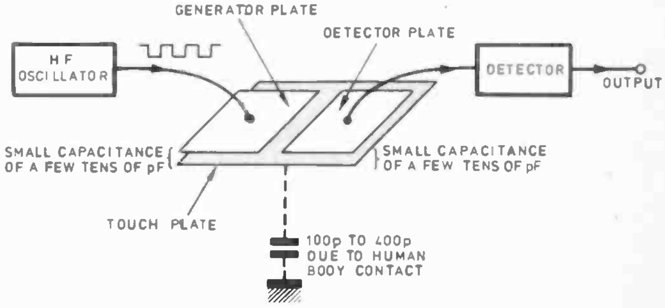
EG664 **Fig. 3.5 Resistive touch switch design**

again protect the input of the Schmitt trigger gate from high voltage transients. The touch plates are adjacent pieces of metal which must be bridged to operate the switch. The values of R1 and C1 should be experimented with: R1 sets the sensitivity of the switch and R1,C1 together set the time constant of the 'de-bouncing' circuit. Typically R1 should be 1M to 10M and C1 should be 0·1µF to 10nF respectively.

This circuit is unfortunately dependent on individual people's skin resistance which tends to vary depending on the amount of sweat on the fingers. Also any residual moisture between the touch plates can cause the false operation of the switch. Otherwise these are fairly simple and effective circuits.

CAPACITIVE TOUCH SWITCHES

These are the most sophisticated and complex type of touch switch. A simplified circuit is shown in Fig. 3.6. The two small plates are placed very close to but insulated from the larger touch plate. Normally the h.f. oscillator feeds its signal to the touch plate via the small capacitance between the touch plate and the generator plate and then the touch plate feeds the signal to the detector input via the small capacitance between the detector plate and the touch plate. The detector input has a very high impedance. When the touch plate is touched by a finger the 'human capacitance' to earth of 100 to 400pF attenuates the signal passing into the detector considerably, which then fails to operate the detector causing a change in logic state of the detector output.



EG665 **Fig. 3.6 Simplified diagram of a capacitive touch switch**

There are many variations on this theme of capacitive touch switches. They are very safe because the touch switch is insulated from the rest of the circuitry but are all fairly complex and we won't be looking at any practical circuits for this very reason.

POWER-ON RESET

There is frequently a requirement to 'reset' or 'clear down' a circuit shortly after power has been applied to it to prevent unwanted operation and initialise circuit states. This is easily implemented using one of the circuits shown in Fig. 3.7. The circuits provide either an initialised logic 0 changing to logic 1 after a period defined by RC or the other way round. The

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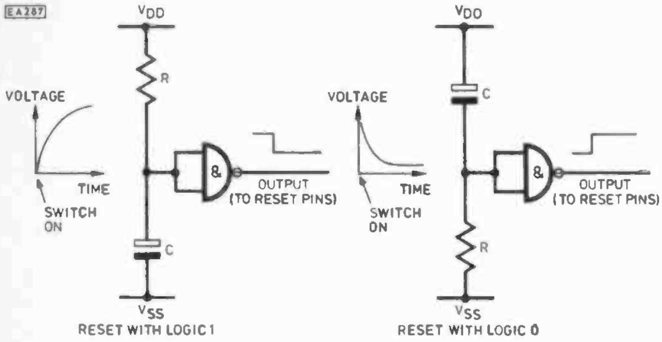


Fig. 3.7 Power on reset circuits

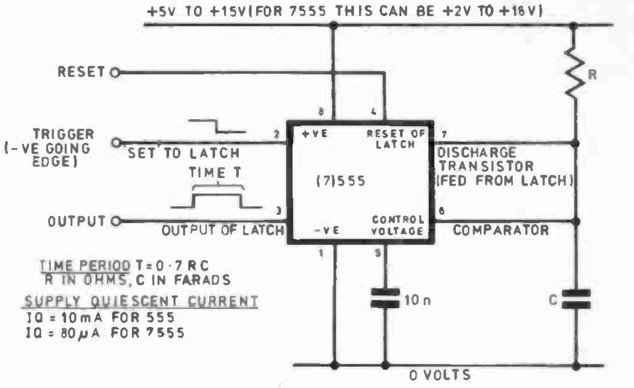
time period should be made long enough for all transients to die down; typically 1 or 2 seconds to be safe. For CMOS this is implemented by R=1M and C=1µF. For TTL only the reset with logic 1 circuit should be used; R should be 1k and C fairly large (the time delay will be shorter than with CMOS due to the low input impedance) typically around 100µF or even more. Schmitt trigger input gates should be used if it is important that the logic level change is free from spurious pulses and a pulse deriving network (as shown last month) can be added after the gate if a short reset pulse is needed a short time after power is applied rather than a continuous initial reset pulse as given by the circuit.

TIMER I.C.'s

In Part 1 we saw how we could generate short time delays using RC networks and logic gates. For longer delays, more accurately controlled delays or the removal of spurious pulses it is often preferable to use timer or monostable i.c.'s (i.e. stable in only one state) which are specially designed for timing applications. Both TTL and CMOS have such i.c.'s, the CMOS type being the 4047, 4528, 4538 and the 4531. These i.c.'s all use resistors and capacitors to form the timing interval but with accurate control over the charging and discharging of the capacitors and the thresholds at which the logic changes occur. We won't look at these i.c.'s in detail as the data sheets give the information required to build circuits using the chips. These chips are not cheap and many designers prefer the simplicity and flexibility of the 555 timer.

THE '555'

This is said to be the most regularly used i.c. in the whole of electronics! In its basic form it is very cheap indeed, but can cause difficulties in many circuits due to the large 'spikes' it puts on the power supply rails due to its poor output switching action. Fortunately, there is now a CMOS based version of the 555, known as a 7555, which is a much more satisfactory device, and is pin-for-pin compatible with the old 555. It is more expensive than the older devices, although still under £1, and is ideal for use in CMOS logic circuits. Pins 8 and 1 of the 555 are the supplies, pin 6 a comparator input, and pin 7 a discharge transistor. An RC network is provided externally, which has a capacitor charging up via a resistor towards the +ve supply rail. This feeds into the comparator, and when the voltage exceeds a certain threshold, an internal latch is reset and the capacitor discharges via pin 7. The 'trigger' input, pin 2, sets the latch in the first place, which then stops pin 7 discharging the capacitor and allows the capacitor to charge up slowly. The latch output forms the output of the device (pin 3) and the threshold at which the latch is reset can be controlled via pin 5. The timing interval can be shortened or prevented from occurring by permanently re-setting the latch; this is done by taking pin 4 to 0 volts.

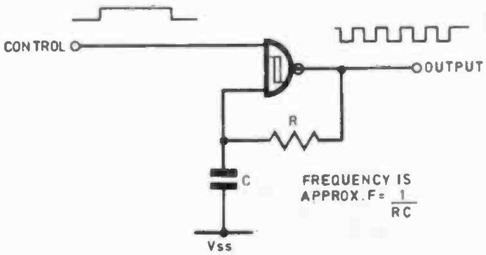


EO666 **Fig. 3.8 The 555 connected as a monostable timer**

The 555 in its monostable timing configuration is shown in Fig. 3.8. The timing period is activated by a negative going edge on pin 2; if the input to pin 2 stays at logic 0 for longer than the timing period, the output will remain at logic 1 until after pin 2 has been taken to logic 1 again; hence for most applications, the trigger input pulse should be kept shorter than the required timing interval. When the reset function is not being used, it should be taken to logic 1. (This is not critical in the 7555, and the 10n decoupling capacitor can be left out, but this will leave the device more prone to being affected by spurious pulses and noise.) The output can source and sink high currents in both the standard and CMOS versions, and both can drive CMOS or TTL inputs very easily. A final point to note is that the CMOS type can be very easily damaged by shorting pins 6 and 7 to the supply rails, so avoid doing this even for a short duration.

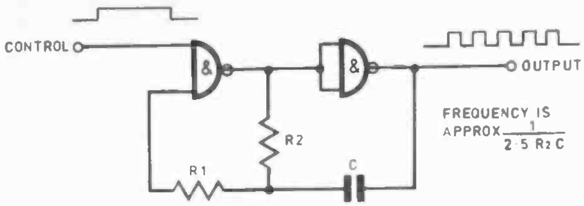
OSCILLATORS

An oscillator is sometimes known as an 'astable' multivibrator; i.e. not stable in either of its states. Functionally, it can be created by putting a suitable time delay in the feedback loop of an amplifier. If we substitute a logic gate for the amplifier, we can easily create a 'logic gate oscillator'. The simplest type uses a Schmitt trigger input inverting gate; see Fig. 3.9. If the control is at logic 0, the output of the gate will be at a fixed logic 1 level; if the control is at logic 1 then the gate will oscillate. It's as simple as that!



EG667 **Fig. 3.9 Basic Schmitt trigger oscillator**

If Schmitt trigger input gates are not available, then two gates can be coupled together to make an oscillator; see Fig. 3.10. If the control is at logic 0, the output is also at logic 0. If the control is at logic 1 the output will oscillate. The control function can be reversed in operation by using NOR



EG668

Fig. 3.10 Two gate oscillator

gates instead of NAND gates. R1 helps to stabilise the oscillator frequency against changes due to the different Vdd voltages; typically, R1 should be twice the value of R2.

Both these types of oscillator benefit considerably from having an extra gate added to their outputs, prior to them being fed to any other logic circuitry; this can be a buffer, or inverter, as required, or any gate connected to act as a buffer or inverter. The output waveform is 'sharpened' and cleaned up by doing this.

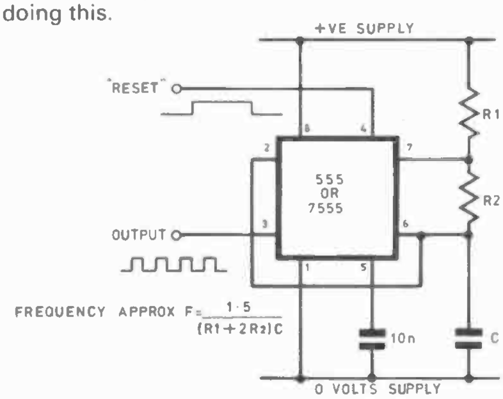


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Fig. 3.11 The 555 oscillator

The final type of oscillator circuit to look at briefly is that using a 555, or preferably a 7555 timer. The circuit is shown in Fig. 3.11, and similar comments apply in this case as applied in the case of the 555 monostable timer of Fig. 3.8. Once again, taking the reset pin to logic 0 will prevent the oscillator from running, and taking it to logic 1 will allow it to run.

TESTING LOGIC CIRCUITS

As with most electronic circuitry, the engineer's 'standard' tools of a multimeter and an oscilloscope are always useful. However, the nature of logic itself necessitates the use of rather more specialised instruments, to measure and test in ways that conventional instruments cannot.

LOGIC PROBES

These are small, hand held devices, with a sharp metal 'tip' at one end which is touched to the point in the circuit under test, and a pair of wires which clip to the power supply rails of the circuit being tested. Three l.e.d.s show the state of the circuit being tested. If the 'LOGIC 1 LED' (sometimes marked 'HI') lights, then that is the basic logic level present, likewise for the 'LOGIC 0 LED' (or 'LO'). If neither l.e.d. lights it means that the logic state is indeterminate; not connected to anything, or in the deadband between logic levels. If the 'PULSE' l.e.d. flashes on briefly, it indicates a logic level change or pulse, and if it flashes on and off repetitively (or in some probes, stays on), it indicates that a stream of pulses or changes is occurring. The 'pulse' l.e.d. is driven from a pulse stretching circuit, in order to make tiny logic pulses or changes long enough to light the l.e.d. visibly.

Often, probes are available with CMOS/TTL switches to change the logic thresholds being detected; if no switch is provided, then the probe takes a compromise between the two. Some more expensive probes have a 'memory' feature, which latches a l.e.d. on if a single pulse is detected, in case the operator is looking elsewhere at the instant the pulse occurs. The input of most probes is very high impedance in order to avoid loading the circuit under test, which could affect logic operation. Probes are able to detect very high speed pulses; the cheaper probes can detect pulses of 500ns, and frequencies of 1·5MHz, and the most expensive can detect pulses shorter than 10ns, and frequencies of 60MHz.

LOGIC MONITORS

These are small, self-contained instruments which clip over the pins of the i.c. under test, rather like a large clothes peg. The monitor senses the power supply pins of the i.c. and draws its power directly from these pins. At the top of the monitor there are two rows of l.e.d.s, each l.e.d. corresponding to a pin of the i.c. If the l.e.d. is lit, that pin is at logic 1, if not, it is at logic 0 or an indeterminate state. There are no pulse stretchers normally built into logic monitors, so pulses of less than 10ms are not easily visible. The main advantage of these devices is that they show all 14 or 16 pins simultaneously, enabling the user to relate what is happening on one pin to the operation of the rest of the i.c.

LOGIC PULSERS

These are very similar in appearance to logic probes, with two leads to connect to the power supply, and a tip to touch against the relevant point in the circuit. When a button on top of the pulser is pressed, it over-rides the logic level present at the tip for a very short time, forcing it to go to the opposite logic state. This changing of state only lasts for about 1 or 2 microseconds, so there is no damage done to any outputs of CMOS or TTL i.c.s which are connected to that point in the circuit. A pulser can be used to permanently change the setting of parts of a circuit such as a latch, or temporarily to change the state of combinational circuits (such as arrays of gates) so that the effect of these changes can be traced through the rest of the circuitry, using a logic probe, every time the pulser button is pressed. Some pulsers will give out a stream of pulses, at a rate of 100 or 1000 pulses a second, if the button is held down for a prolonged period.

MORE COMPLEX LOGIC TESTERS

There are many more comprehensive logic testing instruments than the basic types already described. Logic analysers can display the logic states of many separate points simultaneously, triggered by specific combinations of logic states on the points being monitored. Some store the data in memories, to be replayed step by step on a series of l.e.d.s or alpha-numeric displays, or others display the logic states as waveforms on a cathode ray tube, looking like a multiple trace oscilloscope. There are logic monitors for up to 40 circuit points at once, and hand held 'current tracers', which follow current flow in logic circuits, rather than voltage level.

Another technique used is 'Signature Analysis'. These instruments look at a particular point in the circuit for a period determined by specific start and stop pulses derived from elsewhere in the circuit. The stream of logic 1's and logic 0's fed into the analyser is treated as a stream of binary numbers (i.e. numbers with a mathematical base of 2, not 10 as our 'normal' number system is based on), and is mathematically divided by a special binary number generated by the instrument. The 'remainder' of this division is called the 'signature' of that point in the circuit, and can be displayed on alpha-numeric type displays, as found in some calculators. Other points in the circuit can have their signatures compared, to ensure that streams of logic changes are passing through the circuit correctly not just individual 1's and 0's.

All these instruments, and more like them, are very expensive, and have extremely comprehensive triggering and display functions. They are, as you can imagine, beyond the financial reach of many professionals, and most hobbyists! The simple logic testers, however, are very much cheaper, and worth investing in if you are able to. Let's have a look at how to use them.

USING SIMPLE LOGIC TESTERS

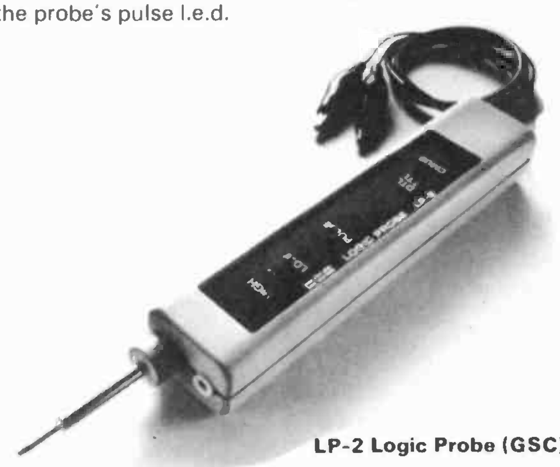
The logic probe is an easy-to-use device, but there are a few pitfalls to look out for. Although the input impedance is high, the probe circuit can be fooled by pull-up resistors on inputs. These are frequently between 100k and 1MΩ in the case of CMOS, and many probes give an incorrect reading when applied to an input with such a high resistance loading. Occasionally, it is found that a non-working circuit suddenly begins to work when a logic probe (or oscilloscope probe) is touched to a certain point in the circuit! This is almost always due to the slight extra resistance and/or capacitance to 0 volts caused by touching that point with

LM-1 Logic Monitor (GSC)

the probe; this often points to 'floating' inputs of CMOS devices not tied to Vss or Vdd, or sometimes to faulty inputs or outputs. This effect can also be seen if very short pulses (often spurious) are present at that point in the circuit — the probe can sometimes attenuate these and prevent them from having an effect on the circuit. Finally, be aware that some logic probes flash the 'pulse' l.e.d. on and off at a fixed rate if the input logic level changes faster than a certain rate; so, just because the 'pulse' l.e.d. is flashing on and off three times per second, it doesn't mean that there are necessarily three pulses per second coming into the probes!

The logic monitor is a very easy-to-use device. If the i.c. being examined has logic changes occurring too rapidly to see, it may be possible to slow the 'clock' or oscillator in the system (if it has one) to enable easier viewing of the logic monitor l.e.d. changes. The input impedance to a monitor is typically 100k, so it can seriously affect any RC network connected to the i.c.'s inputs; otherwise it does not usually affect an i.c.'s operation at all.

The logic pulser is often used in combination with a logic probe, to trace logic changes through a system by generating pulses with the pulser, and looking for those pulses with a probe. A pulser can normally over-ride all logic inputs and outputs to produce a pulse of the opposite logic state, but it cannot over-ride a power supply level. So if a probe and pulser are touched to the same point in a circuit, and the probe does not show a pulse when the pulser button is pressed, then that point is either a power supply rail, or a damaged input or output which has gone short circuit (internally to the i.c.) to a power supply rail, or it could be an RC network. Many RC networks cannot have their logic states over-riden by the pulser, because its pulse width of 1 or 2μs is not long enough to charge up the capacitors used. This extremely short duration pulse can also cause problems with some logic probes, if pulses are sent out very rapidly (but not as quickly as the 100 or 1000 p.p.s. rate). The probe can think that this is a pulse stream, rather than individual pulses, and it can start flashing its pulse l.e.d. on and off at a fixed slow rate. This can give the appearance of the probe 'missing' some pulses sent out by the pulser. If this seems to occur, allow several seconds gap between pulses. Pulse streams generated deliberately by the pulser, at 100 or 1000 pulses per second, inevitably give much faster flashing of the probe's pulse l.e.d.



LP-2 Logic Probe (GSC)

WHAT TO BUY

A logic probe of some sort is absolutely essential if you're going to do a lot of logic work! There have been many designs published in the past few years for probes, if you want to do it yourself, or you could save up and buy a high performance one ready built, which will cost you between £20 and £60.

A logic monitor is not as widely used as a probe or pulser, but is a very useful supplement to them if you can find between £30 and £40 to buy one. Finally, a logic pulser is almost as invaluable as a probe! Unfortunately, very few designs exist for the home constructor. For the optimum performance you'll need to pay out £50 for a ready built full professional one, and this, of course, is beyond many people. So, here's where we come to the rescue with the 'PE PULSER', a high quality, low cost instrument which will enable you to test all the circuits you're likely to come across when doing digital designs and construction work!

THE PE PULSER

This is a multi-family, all-purpose pulser, for use with CMOS and TTL. Its pulse width is 1·5 to 3μs, dependent on the logic family being used. It is designed to draw very little current out of the power supply, especially when left 'idling', i.e. not pulsing. (See the specification.) Pressing the 'pulse' button momentarily will inject one pulse into the circuit point touched by the pulser tip, flashing its l.e.d. once. Holding the button down will cause the pulser to wait for a second, then inject a stream of pulses at 100 pulses per second; the l.e.d. glows dimly when this is happening.

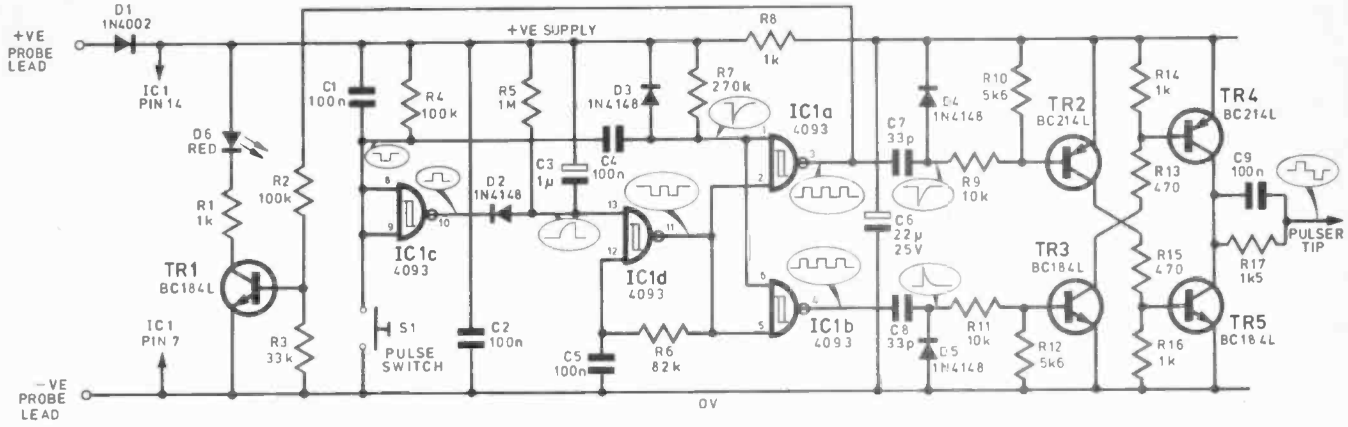


Fig 3.12 Circuit diagram of the PE Pulser

CIRCUIT DESCRIPTION

The circuit diagram of the PE Pulser is shown in Fig. 3.12. The 'pulse' switch is a simple push-to-make single pole switch, with contact de-bouncing by R4 and C1. When the switch is pressed, the C4, R7, D3 pulse deriving circuit generates a short negative pulse (logic 0). The output pin of IC1d (pin 11) is normally at logic 1, which means that the short logic 0 pulse applied to pins 1 and 6 of IC1 is inverted in each case to become a short positive pulse at pins 3 and 4 of IC1. This pulse length is approximately 30ms. The pulse at pin 4 of IC1b feeds into a pulse deriving network formed by C8, D5 and R11 (with R12 and TR3). This generates a positive pulse of a little over 1µs in duration when the output of IC1b changes from 0 to 1, which is fed to the base of TR3, turning it on for this period of time. When TR3 turns on, this then turns on TR4 via R13, causing the collector of TR4 to rise up to nearly the supply voltage for a little over 1µs. This large positive pulse is fed through C9 to the pulser tip, and hence to the point in the circuit required.

Connected to IC1a pin 3 is a pulse deriving network formed by C7, D4 and R9 (with R10 and TR2), which generates a negative pulse, a little over 1µs in duration, when the output of IC 1a changes from 1 to 0. The rest of the output stage (TR2 and TR5) is the exact complement of that for the other polarity of pulse. In fact, the two pairs of transistors form a very conventional complementary output drive circuit. From this, it can be seen that for every press of the pulse switch, a positive (logic 1) output pulse is given, followed 30 milliseconds later by a negative (logic 0) output pulse. The output current, being derived directly from the supply rails via TR4, TR5 and C9, is very high indeed, and can over-ride any logic level present at the pulser tip, with the exception of a power supply rail. Because this could cause large transient voltages on the positive supply rail, R8 and C6 are included to decouple the 'drive' section of the pulser from the rest of the supply. R17 ensures that the output drive capacitor C9 is fully discharged between pulses. If the point in the circuit to which the pulser tip is applied is at logic 1, then the positive pulse from the pulser will have no effect on this level, of course, only the negative pulse will affect it. Vice versa for logic 0.

When the pulse switch is not being pressed, pin 10 of IC 1c, is at logic 0, so the input pin of IC1d (which is connected as an oscillator with R6 and C5) is held at logic 0, and the oscillator cannot run. As soon as the pulse switch is pressed, D2 is reverse biased, and C3 starts to discharge towards the positive supply rail. After one second, the input pin 13 of IC 1d is at a high enough voltage to cause the Schmitt trigger input to pull up to logic 1, causing the oscillations to start at 100Hz. These oscillations feed via IC1a and IC1b, exactly as did the single pulses we looked at earlier, and once again this creates streams of positive and negative pulses at the probe tip, until the pulse switch is released again.

Final points to note are that C2 is included to provide further power supply decoupling, D1 prevents damage if the power supply leads are reversed, and that TR1 (with associated components) is used to drive the indicator l.e.d. from IC1a pin 3; the l.e.d. is then either lit by a 30ms pulse if the switch is pressed momentarily, or by a 100Hz square wave if the pulse switch is kept held down. If variations of this basic probe are wanted, then changing C5 will vary the pulse rate (e.g. if C5 = 10n, then the pulse rate is 1kHz), and changing C8, R11 or R12, and C7, R9 or R10 will vary the pulse width.

CONSTRUCTION

The pulser is built on a Matchboard, cut down to fit the Global 'Probe Case' CTP-1. Because the two power supply rails have to be cut off the Matchboard, there is a fair amount of inter-wiring to do, so it is wise in this case to fit all

SPECIFICATION

Supply voltage range	5 to 18V
Pulse width:	
For TTL outputs	Approx. 1·5µs
For 5V CMOS outputs	Approx. 1·5µs
For 15V CMOS outputs	Approx. 3µs
Pulse repetition rate	100Hz
Supply current (no load)	Less than 20µA
Supply current (driving into a short circuit)	Less than 10mA

The Pulser can handle reverse connections to its power leads and a short circuit of its probe tip without damage.

The PE Pulser

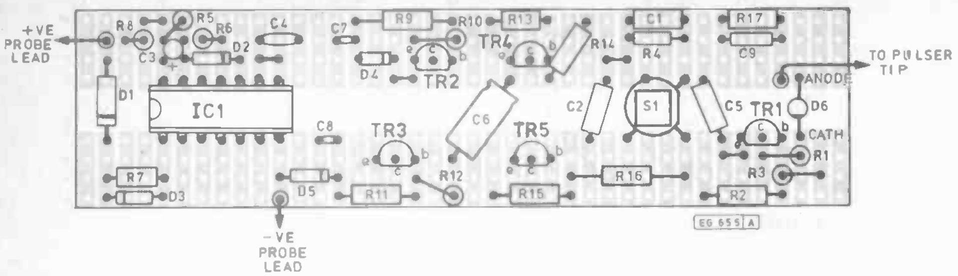


Fig. 3.13 Component layout for the Pulser

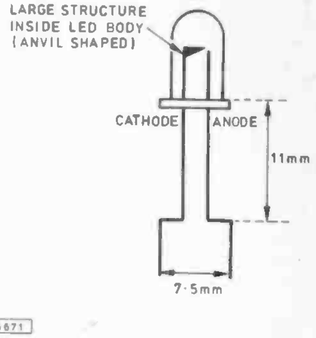


Fig. 3.15 Mounting detail for the l.e.d.

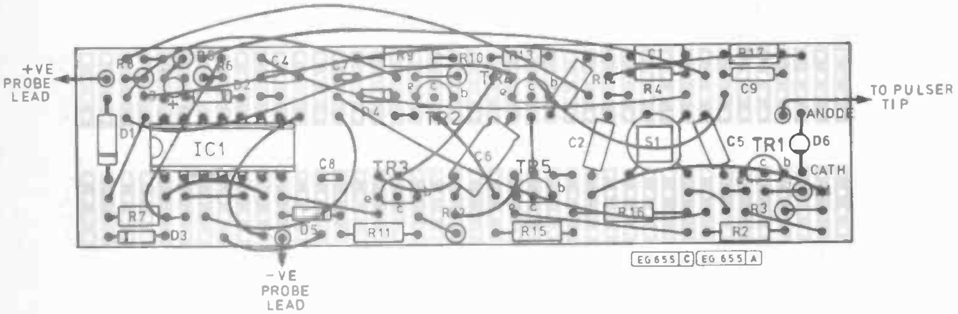


Fig. 3.14 Wiring diagram for the Pulser

the components first (Fig. 3.13), then add the wire links carefully afterwards (Fig. 3.14). Leave the fitting of the l.e.d. until later.

The top of the case should be marked in pencil where the pushbutton switch and the l.e.d. will protrude. Drill a hole the correct clearance size for the l.e.d. and a larger hole for the switch; this hole can then be enlarged with a needle file or sharp knife until the switch is a good, freely moving fit in the hole when the two halves of the case are assembled with the Matchboard in between. The l.e.d. should now have its leads bent carefully as shown in Fig. 3.15 so that the l.e.d. just protrudes through the hole when the case is assembled; don't let the leads force the l.e.d. too far off the board, as the case might bend the legs and damage the l.e.d. when it is screwed up tightly.

The supply leads provided with the case can now be soldered to the board (the black lead with the white stripe is the 0 volts wire). The hexagonal shaped tip holder should have a short length of flexible wire soldered to the 'pulser tip' point on the board. The square strain relief on the power supply lead can be pushed into place (make sure it's the right way up; it won't fit properly the other way!), the tip holder can be dropped into place, as can the Matchboard, and the case can be screwed together. Finally, the pulser tip can be screwed into the tip holder.

Test the pulser by first applying power, and then pressing the 'pulse' switch; once to give a single flash of the l.e.d., then hold it down continuously and after a second the l.e.d. should glow dimly. Then try over-riding TTL and/or CMOS outputs, checking the effects with a logic probe.

The PE Pulser is as simple as that! And, of course, with the exception of the fairly standard output driving part of it, the circuit design techniques have all been covered in the first three parts of this series.

NEXT MONTH: we'll start looking into the world of sequential circuits; circuits which count, latch, remember and sequence. Again, of course, there will be another mini-project to build.

COMPONENTS ...

Resistors

R1, R8, R14, R16	1k (4 off)
R2, R4	100k (2 off)
R3	33k
R5	1M
R6	82k
R7	270k
R9, R11	10k (2 off)
R10, R12	5k6 (2 off)
R13, R15	470 (2 off)
R17	1k5

All resistors $\frac{1}{4}$ or $\frac{1}{3}$ W carbon

Capacitors

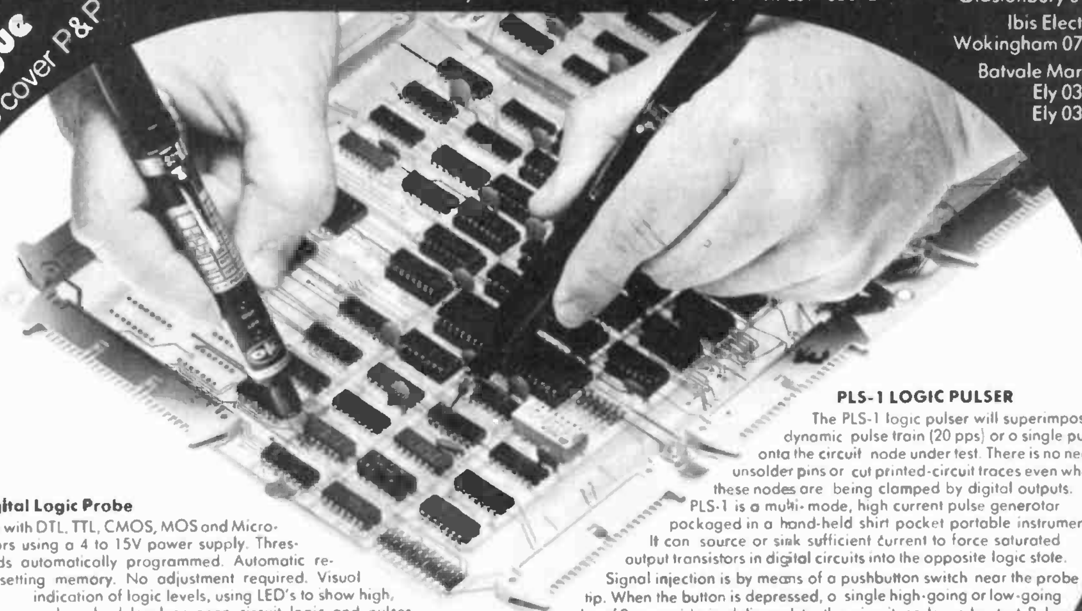
C1, C2, C4, C5, C9	100n polyester (5 off)
C3	1µ 35V tant.
C6	22µ 25V elect.
C7, C8	33p ceramic plate (2 off)

Semiconductors

D1	1N4002
D2, D3, D4, D5	1N4148 (4 off)
D6	Red sub-min l.e.d.
TR1, TR3, TR5	BC184L (3 off)
TR2, TR4	BC214L (2 off)
IC1	4093

Miscellaneous

Matchboard Global Specilities EXP-300 PC
Probe case Global Specialities CTP-1
Switch p.c.b. mounting Maplin type FF87U



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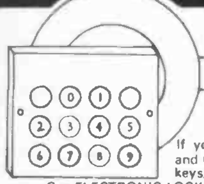
THE KEY TO YOUR SECURITY IS IN OUR LOCK



If you have problems with people tampering with your, car, electrical and electronic equipment, or if you are just in a habit of forgetting your door keys, we have just the kit for you.

Our ELECTRONIC LOCK KIT includes a 10-way keyboard and a special IC which provides a 750mA output to drive a solenoid or relay (not supplied) when four keys are depressed in the correct sequence. This gives over 5,000 possible combinations! The sequence is pre-wired and may be easily changed by means of a small plug and socket. A "SAVE" function is also available enabling the open code to be stored (especially useful in a car when it is left in a garage for servicing as the open code need not be disclosed). Size: 7x6x3 cms. Power Consumption is 40uA at 5V to 15V d.c.

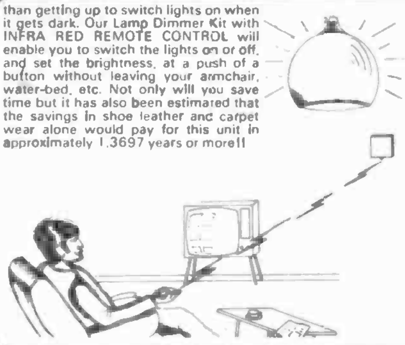
At only £10.50 + VAT, it will make a smaller hole in your pocket than a bunch of keys!

LOCK I.C.s

LS7220	with SAVE memory	£2.75
LS7225	with latched and momentary outputs and a tamper output	£2.60
Data only		.10

YOU MUST HAVE BETTER THINGS TO DO

than getting up to switch lights on when it gets dark. Our Lamp Dimmer Kit with INFRA RED REMOTE CONTROL will enable you to switch the lights on or off, and set the brightness, at a push of a button without leaving your armchair, water-bed, etc. Not only will you save time but it has also been estimated that the savings in shoe leather and carpet wear alone would pay for this unit in approximately 1.3697 years or more!!



This unit has, of course, considerable practical uses, especially for the old, infirm and disabled. It works like a conventional dimmer, enabling you to switch the lights on or off, or to dim them to whatever brightness you require, by touch or remotely using the hand-held infra red transmitter. When assembled, it fits into a plaster depth box to replace your conventional switch or dimmer with no rewiring.

TDR300K Dimmer Kit **£14.30** and MK6 Transmitter Kit **£4.20.** We also still sell our highly popular TD300K Touch Dimmer Kit at **£7.00** and the LD300K rotary controlled Dimmer Kit at only **£3.50** (plus VAT to above prices).

All kits contain all necessary components and full assembly instructions. You only need a soldering iron, cutters and a few hours.

INTEGRATED CIRCUITS

555 Timer	21p
556 Dual 555 Timer	40p
741 Op. Amp.	19p
AD590 Constant current Temperature Sensor	2.75
AY-5-1224 Clock	2.60
AY-5-1230 Clock/Timer	4.50
AY-3-1270 Thermometer	8.20
CA3080 Transconductance OpAmp	72p
CA3130 CMOS Op. Amp.	75p
CA3140 CMOS Op. Amp.	43p
ICL7106 DVM (LCD drive)	7.00
ICM7555 CMOS 555 Timer	79p
LM377 Dual 2W Amp.	1.45
LM379S Dual 6W Amp.	3.50
LM380 2W Audio Amp.	80p
LM382 Dual low noise pre-amp.	1.00
LM386 250mW low voltage amp.	75p
LM1830 Fluid Level Detector	1.50
LM2917 F-V converter (14-pin)	1.60
LM3909 LED Flasher/oscillator	60p
LM3911 Thermometer	1.20
LM3914 Dot/Bar driver (linear)	2.10
LM3915 Dot/Bar driver (log.)	2.20
LS7220 Electronic Combination Lock with "Save" feature	2.75
LS7225 Electronic Combination Lock with tamper output	2.60
MM74C911 4-digit display controller	6.50
MM74C915 7-segment BCD converter	96p
MM74C926 Counter/7 seg. output	4.50
S566B Touchdimmer	2.50
SL440 AC Power Control	1.75
SL441 Burst Fire Controller	1.35
SN76447 Complex Sound Generator	1.75
TBA800 5W Audio Amp.	68p
TBA810AS 7W Audio Amp.	1.00
TMS1121 Clock/7 day Timer	8.50
Data for TMS1121	50p

MEMORIES & MICROS

2114	1.35	Z80A CPU	5.00
2708	2.25	M6802P	5.50
2716	2.65	8035L	8.00
2732	7.60	Z80A CTC	4.00
4116	1.40	Z80AP10	4.00
6810	1.40	6850P	1.85
6821P	1.85	6852P	3.00

NOT JUST ANOTHER CLOCK

NEW

but a PROGRAMMABLE TIMER KIT which can run your central heating, burglar alarm, lighting, taperecorder/radio and lots more. Designed to control four mains outputs independently, switching these on and off on selected days and times in a seven day cycle.

Features include:

★ 0.5" LED 12 hr. display.
★ Day of week, am/pm and output status indicators.
★ Zero Voltage Switching Outputs.
★ 50/60Hz mains operation.
★ Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied).
★ Display blanking during power failure to conserve battery power.
★ 18 programme time sets.
★ Powerful "Everyday" function enabling output to switch everyday but use only one time set.
★ Useful "sleep" function – turns on output for one hour.
★ Direct switch control enabling output to be turned on immediately or after a specified time interval.
★ 20 function keypad for programme entry.
★ Programme verification at the touch of a button.

To control your central heating, for example, (including different switching times at weekends), just connect it to your system, programme it, set it and forget it. The clock will do the rest. There has never been a clock capable of so much at this price.
CT5000K Timer Kit (includes all components, assembly and programming instructions, and an attractive black case) **£45.00**

MINI KITS

These kits form useful subsystems which may be incorporated into larger designs or used alone. Kits include PCB, short instructions and all components.

MK1 TEMPERATURE CONTROLLER/THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater. 1KW **£4**

MK2 SOLID STATE RELAY
Ideal for switching motors, lights, heaters, etc. from logic. Opto-isolated with zero voltage switching. Supplied without triac. Select the required triac from our range. **£2.60**

MK3 BAR/DOT DISPLAY
Displays an analogue voltage on a linear 10-element LED display as a bar or single dot. Ideal for thermometers, level indicators, etc. May be stacked to obtain 20 to 100 element displays. Requires 5-20V supply. **£4.75**

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Based on a new zero voltage switch IC, this kit may be wired to form a 'burst fire' power controller, enabling the temperature of an enclosure to be maintained within 0.5°C. Thermistor failure causes output to switch off. Temperature range ambient to 90°C. 3KW. **£5.55**

MK5 MAINS TIMER
Based on the ZN1034E Timer IC this kit will switch a mains load on (or off) for a preset time from 20 minutes to 35 hours. Longer or shorter periods may be realised by minor component changes. Maximum load 1KW. **£4.50**

DVM/THERMOMETER KIT

£13.50 + VAT

Based on ICL7106 DVM chip and a 3½ digit liquid crystal display. The kit will form the basis of a digital multimeter – only a few additional switches and resistors required (details supplied) or make a sensitive digital thermometer (–50°C to 150°C) reading to 0.1°C. The basic kit has a sensitivity for full scale of 200mV, automatic polarity and runs from a 9V PP3 battery.

£13.50 + VAT

REMOTE CONTROL COMPONENTS AND KITS

LD271 IR Emitting Diode	.36
SFH205 Photodiode detector	.90
SL480 IC Pulse Amp	1.70
SL490 32 command encoder/transmitter	2.40
ML922 10-channel receiver +3 analogue outputs	4.20
ML926 16-channel receiver 4 momentary binary outputs	1.40
ML927 16-channel receiver 4 momentary binary outputs	1.40
ML928 16-channel receiver 4 latched binary outputs	1.40
ML929 16-channel receiver 4 latched binary outputs	1.40
Clip-on Plastic reflector for IR LEDs, increases range.	0.20

ML925 A decoder designed for model/toy control, providing a 2-speed drive motor and three position latched steering system or a vehicle with momentary action steering and a third motor, e.g. gun, turret, winch, etc. Outputs also available for other facilities such as horn, turn indicators, headlights, etc. 2.10

KITS *** KITS *** KITS *** KITS

MK6 – Simple Infra Red TRANSMITTER. A pulsed infra red source which comes complete with a hand held plastic box. Requires a 9V battery. 4.20

MK7 – Infra Red RECEIVER. Single channel, range approximately 20 ft. Mains powered with a triac output to switch loads up to 500W at 240V a.c. but can be modified for use with 5-15V d.c. supplies and transistor or relay outputs. 9.00

***Special Price* MK6 & MK7 together. Order as RC500K** 12.50

MK8 – Coded Infra Red TRANSMITTER. Based on the SL490, the kit includes 2 IR LEDs, measures only 8×2×1.3 cms. and requires a 9V (PP3) battery. 5.90

MK9 – 4-way KEYBOARD. For use with MK8 Kit. 1.90

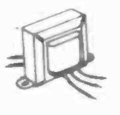
MK10 – 16-way KEYBOARD for use with MK8 kit, to generate different codes for decoding by the ML928/926 receiver (MK12 kit). 5.40

MK11 – 10-on/off Channel IR RECEIVER with 3 analogue outputs (0-10V) for controlling such functions as lamp brightness, volume, tone, etc. Other functions include an on/standby output and a toggle output, which may be used for sound muting. Based on ML922 decoder IC, includes its own mains supply. 12.00

MK12 – 16-channel IR RECEIVER. For use with the MK8 kit with 16 on/off outputs which, with further interface circuitry, such as relays, will switch up to 16 items of equipment on or off remotely. Outputs may be latched or momentary, depending on whether the ML926 or ML928 is specified. Includes its own mains supply. 11.95

MK13 – 11-way KEYBOARD. For use with MK8 and MK11 kits. Transmits programme step + and –, analogue + and – (3), mute, normalise analogue outputs, and on/standby. 4.35

MINI TRANSFORMERS



Standard mains primaries 240V a.c.
100mA secondaries

6-0-6V	80p
9-0-9V	85p
12-0-12V	90p
1A 9-0-9V	210p

LEDs

0.1" Red	9p
0.1" Green	12p
0.1" Yellow	12p
0.2" Red	9p
0.2" Green	12p
0.2" Yellow	12p
0.2" clips	3p
Rectangular Red	16p
Rectangular Green	17p
Rectangular Yellow	17p
Flat Face rectangular, Triangular, Arrowhead or Square Red	17p
Green	20p
Rec. Yellow	20p

DISCO LIGHTING KITS

Each unit has 4 channels (rated at 1KW at 240V per channel) which switch lamps to provide sequencing effects, controlled manually or by an optional opto isolated audio input.

DL1000K
This kit features a bi-direcitonal sequence, speed of sequence and frequency of direction change being variable by means of potentiometers. Incorporates meter dimming control. **£14.60**

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a preset pot. Outputs switched only at mains zero crossing points to reduce radio interference to minimum. **£8.00**

Optional Opto Input DLA1 **60p**

DISPLAYS

CQX87A 0.5" dual, c.a. Red	1.80
DL340M 0.1" 4-digit c.c.	4.50
DL500 0.5" c.c.	0.75
DL507 0.5" c.a.	0.75
MP463 4-digit 0.5" multiplexed display. 25 × 9mm	1.30
Liquid Crystal Display. 3½ digit, 0.5" digits, d.i.l. package	6.00

TRIACS

400V Plastic Case (Texas)

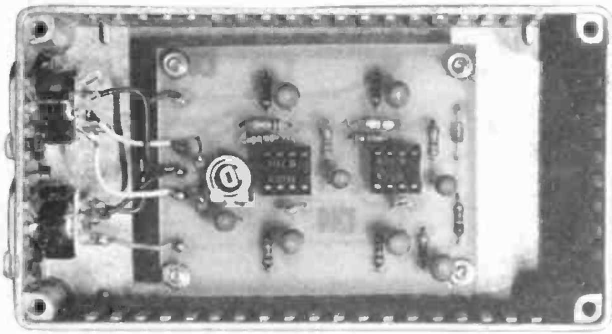
3A TIC206D	49p
8A TIC226D	58p
12A TIC236D	85p
16A TIC246D	96p
25A TIC263D	190p
6A with trigger Q4006LT	80p
8A Isolated tab TXAL 226B	65p
Diac	18p
Opto isolated triac MOC3020 0.6A/400V	110p

AUDIO ANALYSER

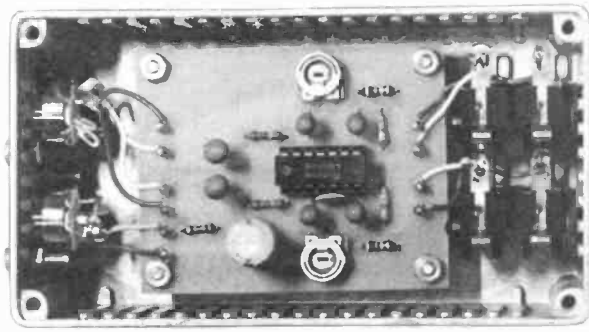
Michael Tooley B.A. **David Whitfield** M.A. M.Sc.

PART 3

Noise Source and Microphone Preamp—Ancillary Modules



Interior of Noise Source



Interior of Microphone Preamplifier

THE Noise Source and Microphone Preamplifier described in this article were designed primarily to form two additional modules for use with the Audio Analyser described last month. The two ancillary modules may, however, be readily used in conjunction with other equipment such as amplifiers, tape recorders and synthesisers.

The Noise Source provides a pseudo-random electrical signal which has an even energy distribution over a wide range of frequencies. It may thus be used as a signal source for testing and adjusting the Audio Analyser. The Microphone Preamplifier is designed to interface most types of microphone with the Audio Analyser. The performance of a complete system may thus be investigated taking into account the effects on sound colouration imposed by room acoustics. In this case the Noise Source is used as an auxiliary input to the amplifying system and the Audio Analyser is used in conjunction with a pair of microphones and the Microphone Preamplifier.

SPECIFICATIONS

MICROPHONE PREAMPLIFIER

Input impedance	50k
Output impedance	600
Gain (max)	x 4000
(min)	x 250
Frequency range	30Hz–100kHz at –3dB
Total harmonic distortion	0·1% max typical
R.m.s. noise voltage referred to the input	1µV typical
Maximum output voltage (open circuit)	3V r.m.s.
Supply	+15V at 15mA

NOISE SOURCE

Output impedance	600 typical
R.m.s. noise output voltage (max)	1V*
(min)	70mV*
Supply	+15V at 125mA
	–15V at 30mA

*These are open-circuit values, 600 terminated voltages will be approximately half these values.

NOISE SOURCE

All Zener diodes generate a significant amount of electrical noise when operated in their breakdown region and, whereas this noise is usually removed by the presence of additional de-coupling components, in this application the noise produced is a wanted rather than unwanted signal. Fig. 23 (a) shows the conventional arrangement of a Zener voltage reference with a parallel connected de-coupling capacitor. If this circuit is modified to that shown in Fig. 23 (b) the noise signal alone is passed on to the following stage where its level is amplified to a useful value.

The complete circuit diagram of the noise source is shown in Fig. 24. R1 and R2 supply current to the Zener diode and C1 is used to provide some additional supply de-coupling. The noise signal generated by the diode is coupled to the amplifier by means of C2 which also removes the d.c. level (approximately 6V) produced by the Zener diode. The amplifier employs a two-stage arrangement of high slew rate operational amplifiers. The gain of the first stage is set by R3 and R5 to approximately 50. The gain of the second stage is made variable by means of VR1 and can be adjusted over the range 500 to 5000 approximately. Naturally with this high value of gain considerable attention has to be given to adequate supply de-coupling of both the positive and negative supply rails to each i.c. The operational amplifiers also require external frequency compensation and this is provided by C5 and C9. Twin outputs are available and these are matched to 600 ohms by means of R13 and R17.

MIC PREAMP

The Microphone Preamplifier uses a single 14-pin DIL integrated circuit. The LM382 was designed specifically for the amplification of low-level signals and incorporates two completely separate low-noise amplifiers. Each amplifier has its own internal power supply decoupling and regulating arrangement thus ensuring a high degree of supply rejection (typically some 120dB) together with a channel separation of 60dB or more. A variety of closed loop gain and frequency response options are made possible by means of a resistor matrix within the i.c. However, in this particular application, the device is used in its 'flat' frequency response configuration with preset gain control.

The complete circuit diagram of the Microphone Preamplifier is shown in Fig. 25. R1 and R2 (R3 and R4) provide input matching and attenuation. The values may be chosen to suit the particular microphone (or other signal source) and some typical examples are given in Table 2. R7 together with C7 and C8 provides supply decoupling over a wide range of frequencies while C3 and C4 are the major factors in determining the low frequency cut off of their respective amplifier stages. VR1 and VR2 pre-set the stage gain by varying the amount of negative feedback applied to each channel. The output impedance is raised to around 600 ohms by means of R5 and R6.

Table 2. Input matching network

Microphone Type	Input Impedance	R1 and R3	R2 and R4	Sensitivity for 1V RMS output
High-Z Dynamic	50k	3·3k	47k	0·25mV
Medium-Z Dynamic	5k	3·3k	1·8k	0·625mV
High-Z Crystal	2M	2·2M	47k	12·5mV
Low-Z Dynamic	600	33	560	0·25mV

CONSTRUCTION

With the exception of the input and output sockets all the components for both the Noise Source and Microphone Preamplifier are mounted on single sided p.c.b.s measuring approximately 50 × 65mm. Due to the high values of gain and wide bandwidth of both units instability may result where constructors depart from the recommended p.c.b. layout. It is essential, therefore, that the layouts given are followed closely, particularly with regard to the amount of earth plane and the location of the decoupling components. The use of low-profile DIL sockets for the integrated circuits is recommended and it is also essential that, where specified, tantalum capacitors are employed rather than conventional axial lead electrolytic types.

The p.c.b. track patterns for the Noise Source and Microphone Preamplifier are shown in Fig. 26 and 28 respectively. Corresponding component layouts are given in Fig. 27 and 29. Once complete the p.c.b.s should be carefully examined and then mounted using stand-off pillars in their respective diecast enclosures. The internal layout and wiring diagrams are shown in Fig. 30 and 31. In the case of the Microphone Preamplifier, care should be taken to keep the input and output connections physically separated and, in both units, the connections to the sockets should be kept as short and direct as possible.

COMPONENTS

MICROPHONE PREAMPLIFIER

Resistors

R1	3·3k	see text
R2	47k	see text
R3	3·3k	see text
R4	47k	see text
R5	560	
R6	560	
R7	220	

All are ¼W carbon 5%

Potentiometers

VR1 220Ω min. horizontal pre-set
VR2 220Ω min. horizontal pre-set

Capacitors

C1 10µ 16V tantalum
C2 10µ 16V tantalum
C3 22µ 16V tantalum
C4 22µ 16V tantalum
C5 22µ 35V tantalum
C6 22µ 35V tantalum

C7 4.7µ 16v TANT
C8 4n7 DISC CERAMIC

Semiconductor

IC1 LM382N

Miscellaneous

Diecast case measuring 120 × 65 × 40mm approx. 14-pin DIL socket. Stand-off pillars (4 off). 5-pin 180° DIN socket. Terminal pins. 4-pin DIN socket. p.c.b. ¼" standard jack sockets (2 off).

NOISE SOURCE

Resistors

R1 680
R2 470
R3 1k
R4 1k
R5 47k
R6 220
R7 220
R8 1k
R9 1k
R10 10k
R11 220
R12 220
R13 470
R14 470

Capacitors

C1 10µ 16V tantalum
C2 10µ 16V tantalum
C3 22µ 35V tantalum
C4 22µ 35V tantalum
C5 5·6p ceramic
C6 10µ 16V tantalum
C7 22µ 35V tantalum
C8 22µ 35V tantalum
C9 5·6p ceramic
C10 10µ 16V tantalum

Potentiometer

VR1 100k min. horizontal preset
All fixed resistors are ¼W carbon 5%

Semiconductors

D1 BZX85 C6V2
IC1 NE531N
IC2 NE531N

Miscellaneous

Diecast case measuring 120 × 65 × 40mm. 8-pin DIL sockets (2 off). Stand-off pillars (4 off). 5-pin 180° DIN socket. Terminal pins. 4-pin DIN socket. p.c.b.

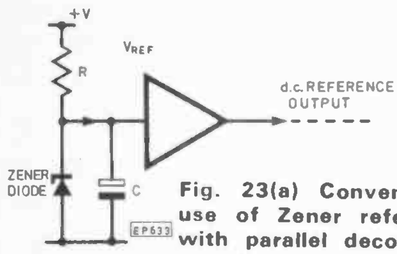


Fig. 23(a) Conventional use of Zener reference with parallel decoupling capacitor

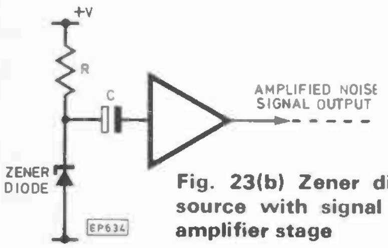


Fig. 23(b) Zener diode used as a noise source with signal coupled to following amplifier stage

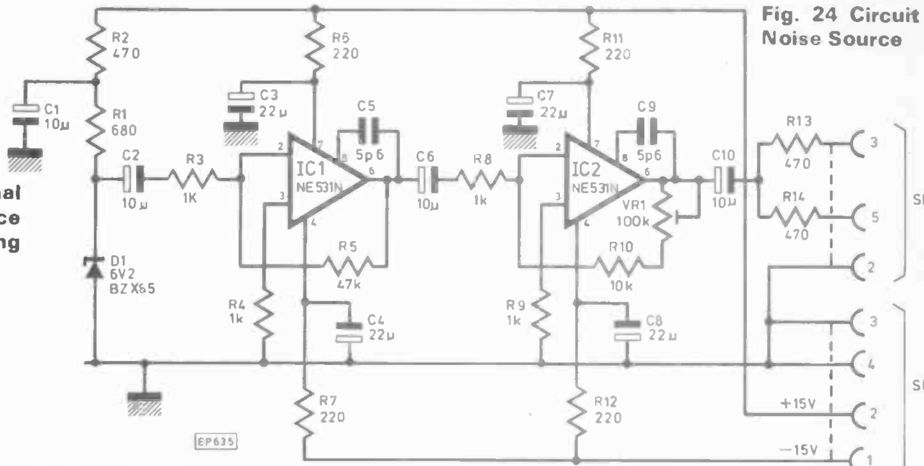


Fig. 24 Circuit of Noise Source

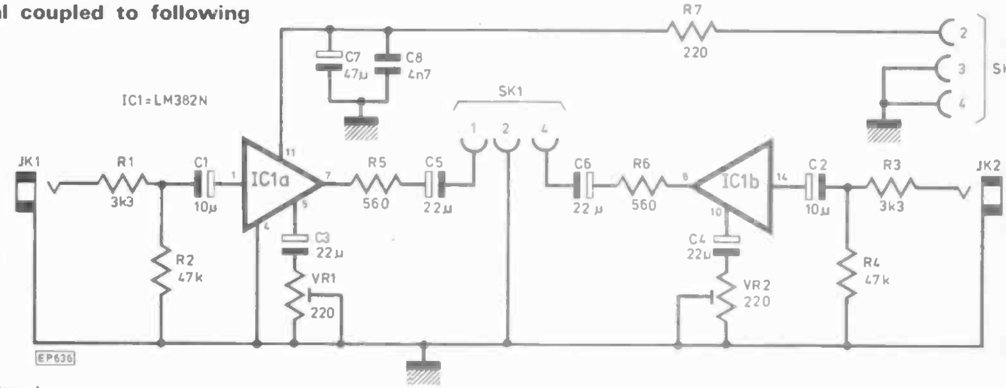


Fig. 25 Circuit of the Microphone Preamplifier

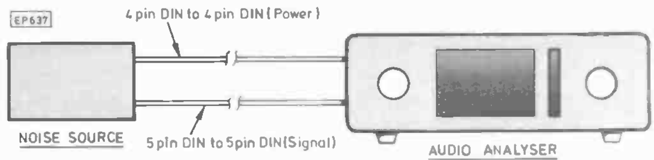


Fig. 32 Using the Noise Source to adjust the Analyser

TESTING AND INITIAL ADJUSTMENT

The Noise Source unit should preferably be tested with the aid of an oscilloscope. If no oscilloscope is available an audio amplifier may be used to provide audible confirmation of the functioning of the noise source. Connect the supply from the Audio Analyser using a 4-pin DIN connector. Set VR1 fully anti-clockwise (corresponding to minimum output level) and observe the output on the oscilloscope. This should appear as a random noise signal of several hundred millivolts peak-peak (although it will not be readily possible to measure the peak-peak voltage of this non-repetitive noise signal). Rotating VR1 clockwise should increase the level of the noise. It is recommended that VR1 be set to about mid-position and final adjustment left until the Noise Source is connected to the input of the audio system under test. Some experimentation may be required to establish the correct output level. In any event, VR1 should be used to reduce the level of the output signal from the Noise Source in order to minimise the risk of overdriving the input stages of the amplifier under test as might be the case with such equipment as tape replay amplifiers.

If the Noise Source fails to function check that the voltage drop across D1 is between 6V and 6·4V and that the positive and negative supply currents are approximately 125mA and 30mA respectively.

For the Microphone Preamplifier set both VR1 and VR2 to approximately mid-position (corresponding to a voltage gain of 500). Connect the supply from the Audio Analyser using a 4-pin connector and the output of the Microphone Preamplifier to an audio amplifier or tape recorder. Check that there is no excessive noise produced by the unit and then connect microphones to the input sockets. The effect of varying VR1 and VR2 can then be checked and the setting should then be returned to about mid-position. If the unit fails to function check that the supply current is in the range 12 to 18mA, double check the p.c.b. and external connections.

USING THEM

Set up the arrangement shown in Fig. 32. Adjust the gain control of the Audio Analyser to produce an adequate displayed signal level and observe the shape of the frequency response characteristic. This should, of course, be substantially 'flat'. If there is a marked deviation from the 'flat' response (say more than 6dB) it may be necessary to trim the gain of the appropriate channel amplifier; this may be accomplished quite simply by following the procedure outlined earlier.

To investigate the overall performance of an audio system follow the arrangement shown in Fig. 33. The Noise Source is connected using a 5-pin DIN connector to the 'auxiliary' or 'tape replay' input of the audio amplifier. Note that there may be some variations in the pin numbering systems used for audio connectors and that, in some cases, it may be necessary to make up alternative connecting leads to suit the input terminations of the equipment under test. Adjust

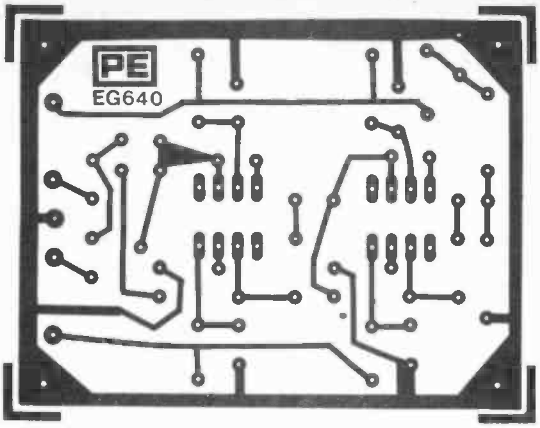


Fig. 26 P.c.b. for Noise Source

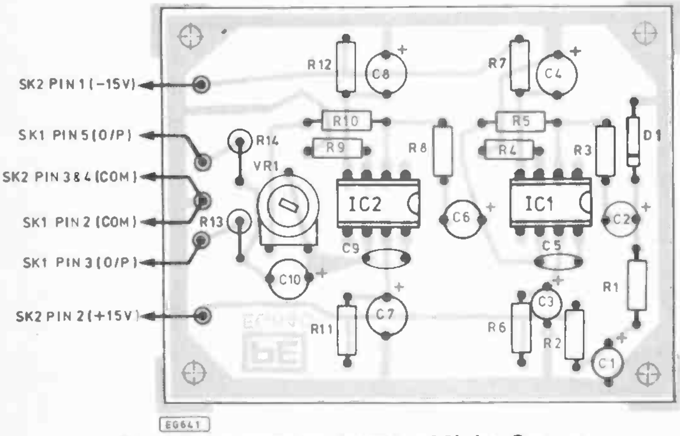
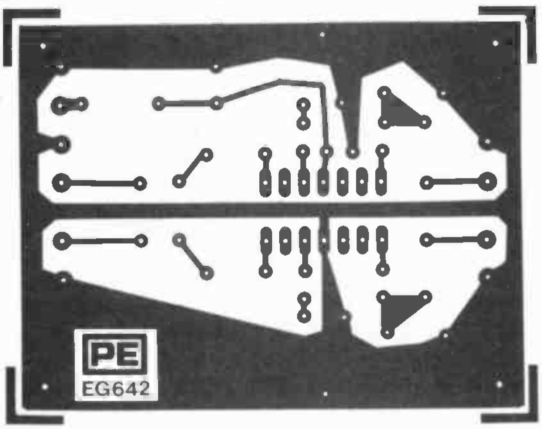


Fig. 27 Component layout of Noise Source

Fig. 28 P.c.b. for Microphone Preamplifier



REVERSE INSERTION OF IC1.

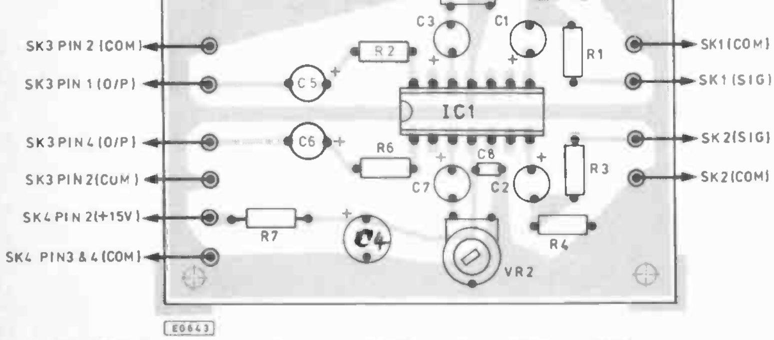
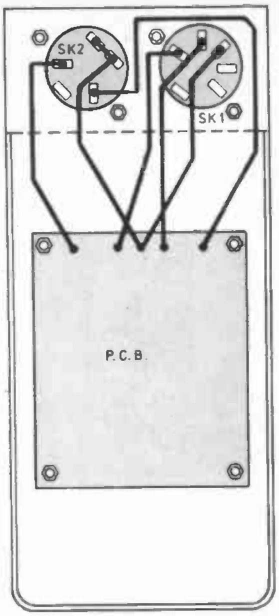


Fig. 29 Component layout of Microphone Preamplifier



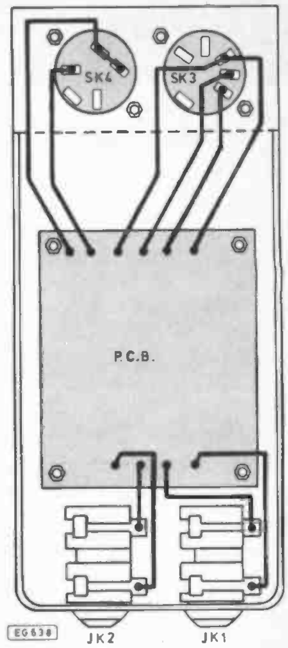


Fig. 30 Noise source wiring **Fig. 31 Preamplifier wiring**

the volume control of the audio system to produce a reasonable signal level from the loudspeakers (sufficient to overcome external noise whilst not overdriving the amplifier) and observe the display produced by the Audio Analyser. If there is insufficient display level (even with the Analyser's gain control set at maximum) increase the settings of VR1 and VR2 accordingly within the Microphone Preamplifier. Note that the two microphones should be placed at the normal listening position. This occurs at the apex of an equilateral triangle formed by the two speakers and the microphones. The microphones should be raised approximately 3 to 4 feet above the floor and they should subtend an angle of between 90 and 120°. The tone controls of the audio system may then be adjusted to obtain as near a flat display as is possible. The effect of loudspeaker positioning and the placement of soft furnishings may also be readily demonstrated. The audiophile will certainly find many hours of fascination with the Analyser and its ancillary modules! ★

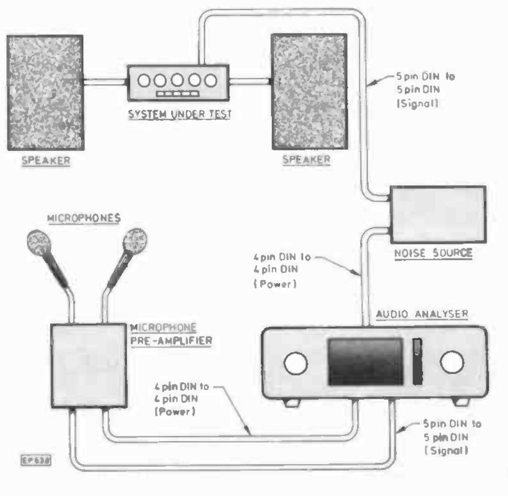


Fig. 33 Measurement of system performance

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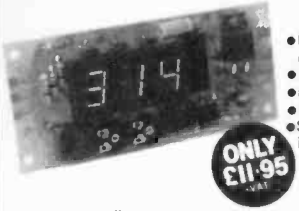

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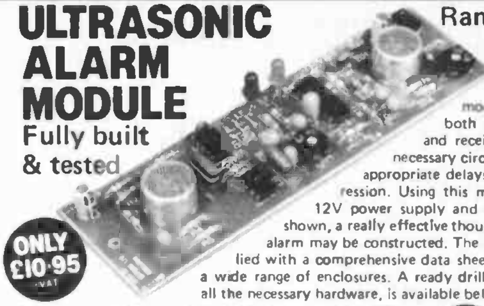

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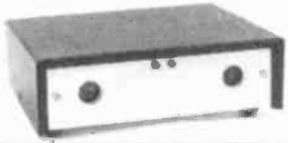

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Prices subject to change without notice.

PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1·45 each.

OVERLOAD PROTECTION

Rudolph Goebel of West Germany has patented (BP 1 586 495) an overload protection circuit for loudspeakers. The patent, which dates back to 1976, is aimed at safeguarding a speaker driver against damage or destruction by signal overload. Although protection circuits are well known the inventor claims that his design has a more precise point of response.

By way of reference a circuit previously patented in BP 1 407 824 is shown in Figure 1. When the breakdown voltage of zener diode ZD is reached, it becomes conductive to charge capacitor C via resistor R1. Relay S then pulls in and the audio signal is fed to the loudspeaker via resistor R2 which prevents overload.

The new circuit is shown in Figure 2. The audio signal is rectified by diode D1 and when relay S is at rest capacitor C1 charges via resistor R1. Zener ZD conducts when the DC across divider R4, R3 reaches its breakdown voltage. R4 is then shunted and relay S pulled in. Capacitor C1 now connects to the base of switching transistor TR to hold it in conductive state for a duration depending on the time constant of C1, R3. The loudspeaker is meanwhile connected to the audio signal by way of resistor R2. The relay returns to its normal state when the signal drops and the Zener and transistor become non-conductive after C1 has discharged.

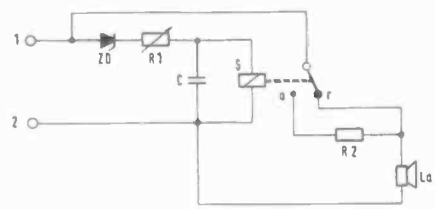

Fig. 1

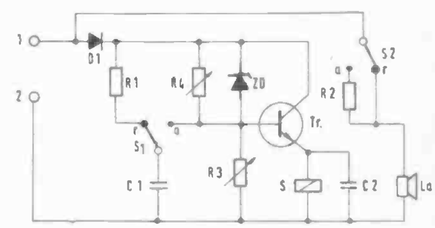

Fig. 2

20 POWER AMPS 19 FUNCTIONAL MODULES DAWN

POWER UP TO 480 WATTS RMS SINGLE CHANNEL

Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want – home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.

AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.O. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w/4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (–3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω 100Hz)>400

HEAVY DUTY with heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.O.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE	WT	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

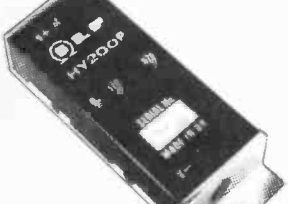

PLATE TYPE

MOSFET Ultra-Fi, with heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.O.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE	WT	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (–3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω:100Hz)>400

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67	£4.50	£0.68
	The following will also drive the HY6/66 series except HY67 which requires the PSU30.		
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/ 1 x MOS400P	£21.46	£3.22

All models except PSU30 and PSU36 incorporate our own toroidal transformers.

PSU

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