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SEPTEMBER 1994

INCORPORATING ELECTRONICS MONTHLY

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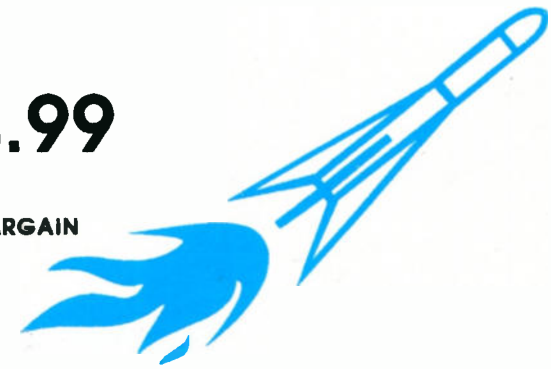

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MODELS
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COMMUNICATIONS
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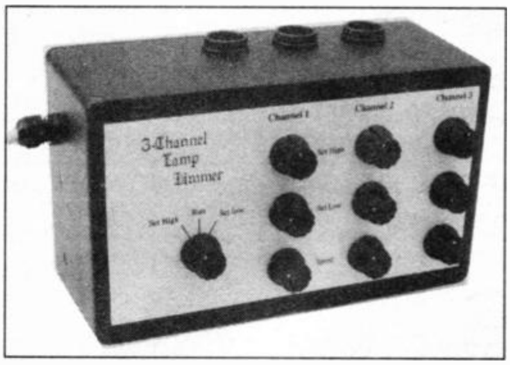
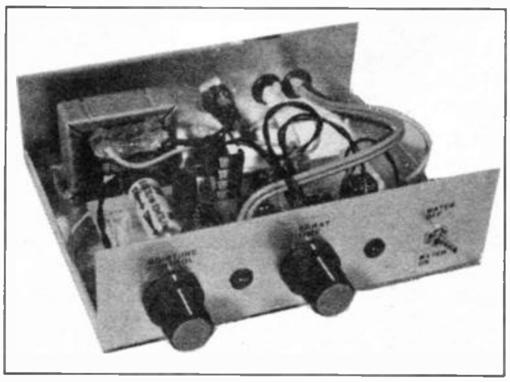
VOL. 23 No. 9 SEPTEMBER 1994

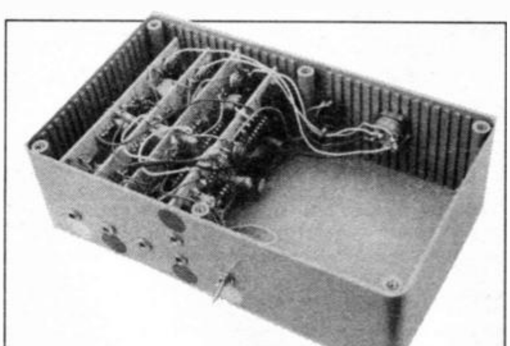
EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects







Projects

Series

Features

WE HAVE MOVED

Editorial, Subscriptions and Accounts Depts. are now at:
Allen House, East Borough
Wimborne, Dorset BH21 1PF

See page 657 for telephone numbers and addresses of other departments

Our October '94 issue will be published on Friday, 2 September 1994. See page 647 for details.

NEXT MONTH

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The series has been written by a well known author and regular contributor to Everyday with Practical Electronics. *Mike Tooley also has twenty-five years of experience in the teaching of electronics. He is Dean of Faculty at Brooklands College of Further and Higher Education in Surrey. His Faculty is responsible for the design and delivery of a wide range of electronics courses leading to NVQ, GNVQ, City and Guilds, and BTEC qualifications.*

DIGILOGUE CLOCK

The clock to be described takes a different approach to other electronic digital clocks in that the display is partly digital and partly analogue. The minutes are displayed on two, one inch high 7-segment displays while the hours are represented by l.e.d.s located around the clock face in the usual manner. The "face" of the clock is always visible even in the dark since the eleven l.e.d.s which are not "on the hour", are dimly lit at all times. This style makes readability easy since all you need do is find the hour l.e.d. then read off the minutes.

GUITAR TUNER

This guitar tuner has a flashing l.e.d. display which indicates whether the tuning error is sharp or flat. The display is actually a ring of eight l.e.d.s. With the guitar accurately tuned, four l.e.d.s will be switched on, the other four l.e.d.s will be switched off, and the display will be stationary. The block of four l.e.d.s that are on will "move" around the display in a clockwise direction if the guitar is slightly sharp, or a counter-clockwise direction if it is flat. Tuning the guitar to within 0·1Hz is very simple and straightforward, even for someone who is literally tone deaf.

Pressing a switch enables the selected tone to be produced via a built-in ceramic resonator. This enables tuning by ear if preferred, and it is also useful for getting a newly fitted string roughly in tune. The l.e.d. display can then be used to get the string precisely in tune.

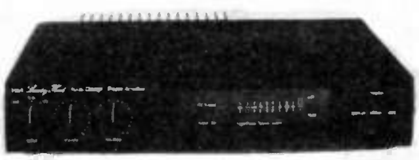
EVERYDAY WITH PRACTICAL ELECTRONICS

OUR OCTOBER ISSUE WILL BE ON SALE FRIDAY 2nd SEPTEMBER

HART AUDIO KITS – YOUR VALUE FOR MONEY ROUTE TO ULTIMATE HI-FI

HART KITS give you the opportunity to build the very best engineered hifi equipment there is, designed by the leaders in their field, using the best components that are available.
Every HART KIT is not just a new equipment acquisition but a valuable investment in knowledge, giving you guided hands-on experience of modern electronic techniques.
In short HART is your 'friend in the trade' giving you, as a knowledgeable constructor, access to better equipment at lower prices than the man in the street.
You can buy the reprints and construction manual for any kit to see how easy it is to build your own equipment the HART way. The FULL cost can be credited against your subsequent kit purchase.
Our list will give you fuller details of all our Audio Kits, components and special offers.

AUDIO DESIGN 80 WATT POWER AMPLIFIER.



This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hifi system. This kit is your way to get £K performance for a few tenths of the cost!. Featured on the front cover of 'Electronics Today International' this complete stereo power amplifier offers World Class performance allied to the famous HART quality and ease of construction. John Linsley Hood's comments on seeing a complete unit were enthusiastic:- "The external view is that of a thoroughly professional piece of audio gear, neat elegant and functional. This impression is greatly reinforced by the internal appearance, which is redolent of quality, both in components and in layout." Options include a stereo LED power meter and a versatile passive front end giving switched inputs using ALPS precision, low-noise volume and balance controls. A new relay switched front end option also gives a tape input and output facility so that for use with tuners, tape and CD players, or indeed any other 'flat' inputs the power amplifier may be used on its own, without the need for any external signal handling stages. 'Slave' and 'monobloc' versions without the passive input stage and power meter are also available. All versions fit within our standard 420 x 260 x 75mm case to match our 400 Series Tuner range. ALL six power supply rails are fully stabilised, and the complete power supply, using a toroidal transformer, is contained within a heavy gauge aluminium chassis/heatsink fitted with IEC mains input and output sockets. All the circuitry is on professional grade printed circuit boards with roller tinned finish and green solder resist on the component ident side, the power amplifiers feature an advanced double sided layout for maximum performance. All wiring in this kit is preterminated, ready for instant use!
RLH11 Reprints of latest articles.....................£1.80
K1100CM HART Construction Manual............£5.50

LINSLEY HOOD 1400 SERIES ULTRA HIGH-QUALITY PREAMP

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LINSLEY HOOD 'SHUNT FEEDBACK' R.I.A.A. MOVING COIL & MOVING MAGNET PICKUP PREAMPLIFIERS

Modern, ultimate sound systems are evolving towards built-in preamplifiers within or near the turntable unit. This keeps noise pickup and treble loss to a minimum. We now offer two units, both having the sonically preferred shunt feedback configuration to give an accurate and musical sound, and both having the ability to use both moving magnet and moving coil cartridges.
Kit K1500 uses modern integrated circuits to achieve outstanding sound quality at minimal cost. The very low power requirements enable this unit to be operated from dry batteries and the kit comes with very detailed instructions making it ideal for the beginner. K1500 Complete kit with all components, printed circuit board, full instructions and fully finished case.....................£67.99
Instructions only.....................£2.80
Kit K1450 is a fully discrete component implementation of the shunt feedback concept and used with the right cartridge offers the discerning user the ultimate in sound quality from vinyl disks. Can be fitted inside our 1400 Preamp, used externally or as a standalone unit. It has a higher power requirement and needs to be powered from our 1400 Series preamplifier or its own dedicated power supply.
K1450 Complete Discrete Component RIAA Phono Preamp.....................£109.58
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U1115 Power Interconnect Cable.....................£7.29

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Your chance to learn or try your soldering skills on a real Hart printed circuit board! This kit comes with a range of modern components, a typical Hart quality PCB, a roll of the correct grade of solder and your full learning guide. It enables the enthusiast who is uncertain of his, or indeed her, ability to put together and solder a printed circuit to try their hand first at minimum cost.
The Instructions explain the right technique and guide even an absolute beginner through the seemingly daunting, but in fact very simple, art of making a good soldered joint.
The Hart **Printed Circuit Board Soldering Practice Kit** represents excellent value for money at only **£4.99.**

TECHNICAL BOOKSHELF

The Following are a Small Selection of the Books we Offer. Full Details are in our Free List.

"THE ART OF LINEAR ELECTRONICS", John Linsley Hood.
Just Out! Hot Off the Press, the definitive electronics and audio book by the renowned John Linsley Hood. This 300+ page book will give you an unparalleled insight into the workings of all types of audio circuits. Learn how to read circuit diagrams and understand amplifiers and how they are designed to give the best sound. The virtues and vices of passive and active components are examined and there are separate sections covering power supplies and the sources of noise and hum. As one would expect from this writer the history and derivation of audio amplifier circuitry have an entire chapter, as does test and measurement equipment.
Copiously illustrated this book is incredible value for the amount of information it contains on the much neglected field of linear, as opposed to digital, electronics. Indeed it must be destined to become the standard reference for all who work, or are interested in, this field.
SPECIAL OFFER. With each book purchased you may request a **FREE** extended index, written by the Author, exclusively from HART.
0-7806-0868-4 .... £16.95
Don't forget most of our kits have reprints of articles by John Linsley Hood that you can purchase separately.

"TOWERS' INTERNATIONAL TRANSISTOR SELECTOR". This will give you the specification, pin connections, case outline, manufacturer, equivalents and substitutes for over 27,000 European, American and Japanese transistors. Latest update 4 offers over 2,000 new entries plus surface mount cross index.
1990 432 Pages. 247 x 173.
0-572-01062-1..................... £19.95

"DIGITAL AUDIO AND COMPACT DISC TECHNOLOGY" 2nd Edition. Baert, Theunissen and Vergult. (SONY Europe).
A thoroughly well written book covering the whole field of recording media starting with the Phonograph right through to modern professional PCM digital recording systems with particular and extensive coverage on the compact disc. All aspects of the recording and reproduction processes are explained with separate chapters on such things as compact disc encoding and the use of cross interleave Reed-Soloman error correction code (CIRC). This book is of course essential reading for engineers and students involved in the field but its very low prices makes it ideal for the enthusiast of recorded music who wants to know more about the hidden processes going on in his CD player.
1992/94 248 Pages. 247 x 190.
0-7506-0614-2 .... £17.95

INTRODUCING DIGITAL AUDIO CD, DAT AND SAMPLING 2nd Edition. Ian R. Sinclair.
For enthusiasts, technicians and students.
Covers CD and DAT, Philips DCC and Sony Mini Disc, the digital techniques involved are explained non-mathematically.
Digital audio involves methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory are avoided other than to state the end product. This second edition has been updated to include sections on oversampling methods and bitstream techniques. The opportunity has also been taken to add a glossary of technical terms.
1992 168 Pages. 217 x 138. 64 line drawings.
ISBN 1870775 22 8 .... £7.95

"THE ART OF SOLDERING", R. Brewster.
Absolutely essential reading for anyone who ever picks up a soldering iron. Written from knowledge gained in a lifetime in the field, this is the first book ever solely devoted to this essential and neglected skill for all electronic enthusiasts. Covers everything from the correct choice of soldering iron and solder to the correct procedures to follow with many illustrations and practical exercises.
0-85935-324-3 .... £3.95

"HOW TO USE OSCILLOSCOPES & OTHER TEST EQUIPMENT", R.A. Penfold, 112 pages. 178 x 111. Publ. 1989.
BP267 .... £3.50

Postage on Single Books is £1.50 except for The Art of Linear Electronics, Digital Audio and Compact Disc Technology and The Towers International Transistor Selector which are £3.50. Two, or more, books are only £4.50, any size, any quantity.

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Please add part cost of carriage and insurance as follows:–**INLAND Orders up to £20 - £1.50, Orders over £20 - £3.50. Express Courier, next working day £10.**
OVERSEAS – Please see the ordering information with our lists.

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The story behind these is that they were going to be sent to Metal Box shareholders to try and stave off a bid. However, before they could be posted, a takeover was announced - so now we've got them. The metal box measures 200x135x45mm and is finished in an attractive blue and gold pattern. Inside, the tie is English made 100% pure silk in royal blue (sample of material on request) with a small discrete logo (ideal if BM or MB are your initials!). Tin + tie for just

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IBM PS2 286 PC

Z9248 This PC is! The hard disk and floppy have been taken out, leaving only the motherboard intact, complete with 286 chip and 4 x 27256 EPROM's, but all the cards and memory removed. So what's left? Not a lot - but it does have a very nice totally enclosed 94 watt power supply with the following spec: -12V @ 410mA; +12V @ 1.2A; +5V @12A; So all we're asking for this magnificent lump of machinery is just

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SUPER PRICE: £14.95

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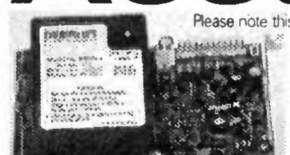

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- Low cost alternative to expensive bulky external PSU
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This essential piece of kit has a current list price of £213.85 - we have a few hundred only at just

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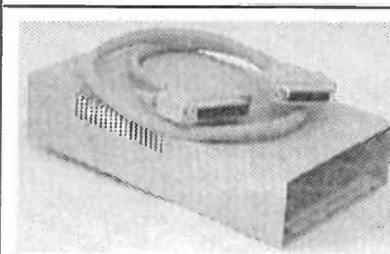

Z9253 Steel 2 part vented case 250x45mm with connectors inside leading to a 37W D plug. Supplied with a 1m lead with 37W D socket one end, 25W D slot the other.
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Z5834 Remote/hardwired transmitter only £12.95

£34.95

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*To obtain latest lists, info etc, just dial 0703 236315 from any fax machine and follow instructions.

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EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

VOL. 23 No. 9 SEPTEMBER '94

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Phone: Wimborne (0202) 881749
Fax: (0202) 841692. DX: Wimborne 45314.
See notes on **Readers' Enquiries** below – we regret that lengthy technical enquiries cannot be answered over the telephone. Due to the high cost **we cannot reply to overseas readers queries by Fax.**

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DEAD & BURIED

It is interesting to see Leo Simpson, the Editor-in-Chief of *Silicon Chip*, an Australian magazine much like *EPE*, condemning valve amplifiers as dead and buried. He actually says that "*Silicon Chip* will never publish a design for a hi-fi valve amplifier unless it is of academic interest only" and goes on to say "so unless you are an eccentric millionaire with a taste for esoteric hi-fi gadgetry you can forget all about 'special valve sound quality' or 'gentle overload', or other such rubbish. All these are just ways of describing valve distortion."

What he says is, of course, quite true but we guess that there are still quite a lot of readers who would like to build a valve amp., just for the fun of it, or maybe, because of the "valve sound" (even if it is a form of distortion) and I feel we should accommodate those readers. If that is what you want, so be it – who am I to judge what you should build. I do, however, feel that hi-fi addicts spending vast sums of money on valve hi-fi amps. should be quite sure of exactly what performance they are getting for their money and of the cost of maintaining that performance as valves wear out.

INTENT

On a similar front, we are often asked for small transmitter designs of one sort or another, usually for "bugging". While it is not illegal to advertise or sell these unlicensable products in the UK it is illegal to own them with the intent to use them. I feel it is wrong for us to encourage readers to break the law and we will, therefore, not publish designs for these devices. In a similar way we will not publish anything that connects directly to the 'phone line because of the need for type approval, which is not a sensible proposition for the home constructor.

There is, of course, still a vast range of items that can be built by the home constructor and this issue gives an idea of just how wide the range of possible projects is. On the subject of a valve amp. we have a contributor working on one which will be published in the not too distant future for all you eccentric readers with the readies!

PRICE RISE

Unfortunately the price of *EPE* will be increased to £2.15 with effect from the October issue. This is necessary to cover increased costs and we believe that *EPE* will still represent excellent value for money in comparison with our competitors. If you are a regular reader you can avoid this increase for a year by taking out a subscription now. At £22 a UK subscription taken before the end of August (the price goes to £24 on Sept. 1st) represents a saving of over 30p an issue. Act now – see below for details.

Mike Kenward

SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £22. Overseas: £28 (£45.50 airmail). From Sept. the price is UK £24, overseas £30, airmail £47.50. Cheques or bank drafts **(in £ sterling only)** payable to Everyday with Practical Electronics and sent to EPE Subscriptions Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 0202 881749. **Subscriptions start with the next available issue.** We accept Access (MasterCard) or Visa payments, minimum credit card order £5.

BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.20 (£3 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please.** Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar, May & Nov 89, Mar 90, April, Aug & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Aug 92 (excluding Mar 92) of Practical Electronics. Dec 92, Jan, Feb and March 93 Everyday with Practical Electronics are also unavailable.**

BINDERS

New style binders to hold one volume (12 issues) are now available from the above address for £5.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery.*

Payment in £ sterling only please.
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PROTECTOR-PLUS CAR ALARM

TERRY R. De VAUX-BALBIRNIE

Drive car thieves away with this no-frills alarm, includes hidden Panic switch.

Born out of the need to design a gimmick-free, inexpensive car alarm Protector-Plus is the answer. It had to be easily fitted to the vehicle, simple to use and immune from any tendency towards false-triggering. This latter point was important because the prospective user had experienced some embarrassing moments with a commercial alarm sounding in the middle of the night for no apparent reason.

The present alarm differs from commercial units in the way it is armed and disarmed. In Protector-Plus this is done by inserting a small plug – referred to as the key – into a socket mounted on some point of the car exterior or in the boot.

In use, the key is removed from its socket when the car is to be left unattended. On returning, it is replaced and the car may then be entered. If a door is opened while the key is removed from the socket, the alarm will sound immediately. If the owner should set off the alarm by mistake, replacing the key will stop it.

STANDBY

The alarm will normally be left switched on in standby mode. The current requirement is only 10mA approximately when armed and much less while disarmed.

However, when the car is left in a secure place such as a locked garage or when working on it, the alarm may be switched off using a key-operated switch on the main unit. The sounder used is of the familiar *yelping* type commonly associated with alarms – these are loud, fairly inexpensive and use only a small current.

One unusual feature of this alarm is that it may be triggered at any time from the driving seat by operating a secret *Panic* switch. This will work even when switched off at the main unit. This could be useful for warding off an attacker when travelling alone at night. When triggered in this way, the alarm will sound continuously until switched off – it is this facility which puts the *Plus* in Protector!

When the alarm is triggered by opening a door, an automatic timer is called into play. This is necessary because an alarm must shut-off automatically after a certain time to prevent undue disturbance. Without this, the alarm would sound continuously if an intruder ran away with the door left open. The timing is preset at the setting-up stage – two minutes was found to be sufficient in the prototype unit.

SOPHISTICATED SYSTEMS

In the author's opinion, some designs of car alarms have gone "over the top" in recent years and he sometimes wonders whether the buyer has really thought about the nature of car protection rather than being taken in by the glossy sales literature.

The first thing to realize is that *no* alarm provides 100 per cent protection. Although slightly better results may be obtained by using complex systems, simple ones are likely to be good enough for most people. Sophisticated systems tend to be expensive, more difficult to fit to the vehicle due to the additional wiring and some are prone to false triggering.

Most users need a *general purpose* alarm. That is, one which will guard the contents – radio/cassette, CD player, etc. as well as protecting the car itself from theft. A good alarm will sound a loud warning as soon as a door is opened.

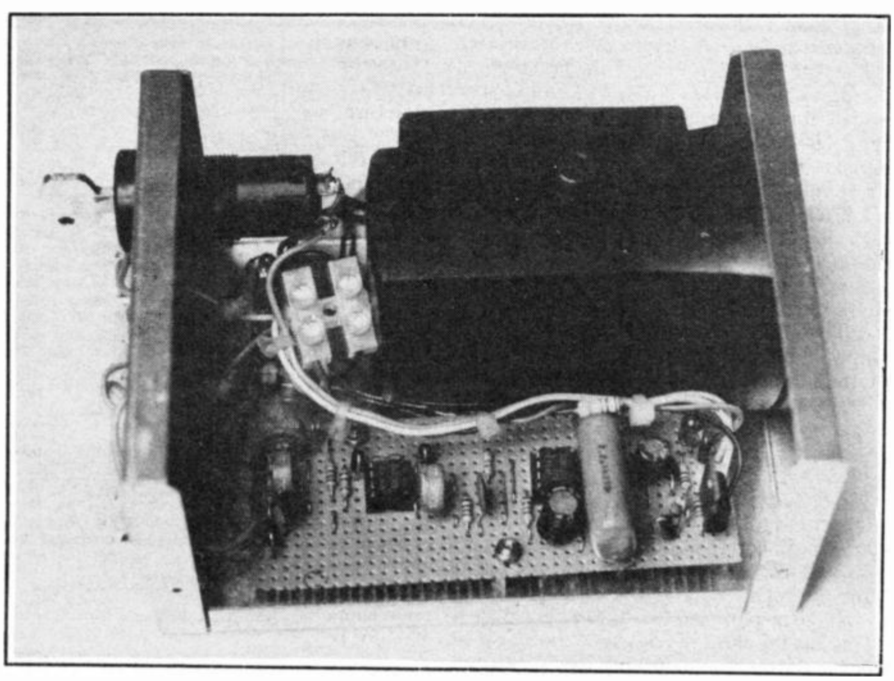
Even so, a petty thief who is after your stereo unit may not be deterred because a window can be smashed, the door opened and the goods taken away in only a few seconds. The thief will have disappeared before anyone is likely to pay attention to an alarm.

For this reason, leaving expensive goods lying around on a seat is simply asking for trouble and an alarm provides little protection in such cases. The trouble with an alarm is that the owner may be lulled into a false sense of security by having one.

A car alarm is most effective in thwarting the so-called joyrider and those who cannot afford the taxi fare home. If a warning sounds *instantly* on opening a door, it will also prevent theft of certain accessories which take more than a few seconds to remove. This is why the type of alarm which has an entry delay to allow the driver to enter and cancel using a secret switch is less effective because the thief could have removed the valuables even before the alarm has sounded.

FLASHING L.E.D.

To be an effective deterrent, the thief should be made aware that you have a car alarm fitted. Those up to no-good will look round the car first. In this system, a flashing red l.e.d. mounted in one corner of the windscreen clearly signals the presence of



an armed alarm. On seeing this, many casual thieves will leave well alone and try their luck elsewhere. A car alarm sticker will also help to re-inforce the message.

So that the alarm will sound when the door is opened, arming and disarming should be performed from *outside* the car to enable the driver to enter without setting it off. Commercial systems often do this by using a handheld low-power radio or infra-red transmitter.

Such alarms work well but tend to be expensive. The plug and socket method used in this design is inexpensive, reliable and effective.

TRIGGER HAPPY

The simplest method of triggering the alarm is to use the existing vehicle door-pillar switches which operate the courtesy light in most cars. If the car has no such switches, if they are unreliable or if there are switches on only some of the doors, then it is a simple matter to fit new ones. It is also straightforward to fit additional switches to the boot lid (unless the arming socket is situated in the boot), the bonnet and to external accessories such as spotlights, etc. to provide further protection as required.

The main unit containing the circuit panel and sounder is housed in an aluminium case situated under the bonnet. The case also has a piece of screw terminal block mounted on it and to which the external connections are made. The key-operated on-off switch is mounted on the side.

CIRCUIT DESCRIPTION

The entire circuit diagram for Protector-Plus Car Alarm is shown in Fig. 1, with the existing part for a standard courtesy light shown inside the dotted box. It will be seen that the design centres on two integrated circuits, IC1 and IC2. IC1 performs the key-coding function while IC2 provides the required operating time.

The unit draws current from the 12V car battery, B1, through fuse FS1, key-operated On-Off switch S1 and diode D8. Switch S2 and diode D5 are part of the *Panic* system and may be disregarded for the moment.

Consider the section of circuit based on IC1. IC1a and IC1b are identical operational amplifiers contained in a single integrated circuit. Here they are being used as *voltage comparators*. If the non-inverting (+) input voltage in either unit exceeds the corresponding inverting (−) one, the device will be on with its output *high* – that is, at positive supply voltage.

The track connections of preset potentiometers, VR2 and VR3 are connected directly across the nominal 12V car battery supply. The sliding contacts may then be set to provide any voltage from zero to 12V.

These voltages are applied to the non-inverting input (pin 5) of IC1b and the inverting input (pin 2) of IC1a respectively. For the sake of argument, suppose that VR2 and VR3 are adjusted so that 5V appears at pin 5 and 7V at pin 2.

THROUGH THE WINDOW

Now consider the potential divider consisting of preset potentiometer VR1, connected as a variable resistor in conjunction with fixed resistor R2 in the upper arm. Resistor R1 is connected inside key-plug PL1, and when the alarm is disarmed, this is inserted in socket SK1. The key, therefore, forms the lower arm of the potential divider.

Suppose VR1 is adjusted to mid-track position and R1 has a nominal value of 56 kilohms. Since the upper and lower arms of the potential divider have approximately equal values, the voltage at point *A* will be one-half that of the supply – nominally 6V. This voltage is applied to IC1b inverting input (pin 6) and IC1a non-inverting input (pin 3) via fixed resistor R3.

It will be noticed that in the case of IC1a, the non-inverting input voltage (6V) is less than that of the inverting one (7V). Its output (pin1) will therefore be off – that is, 0V or supply negative voltage. In the case of IC1b, the voltage at the non-inverting input (5V) is less that at the inverting one (6V) so this comparator is off too with the output, pin 7, also low.

It can be seen that so long as the value of the key resistor, R1, maintains the voltage at point *A* between 5 and 7V (the *window*), both comparators will be off. When the vehicle is left parked, the key is removed and IC1 pins 3 and 6 then assume the high (+12V) state through VR1, R2 and R3. The voltage at pin 3 exceeds that at pin 2 so IC1a switches *on*. This has the effect of triggering the alarm when a door is opened in the manner to be described presently.

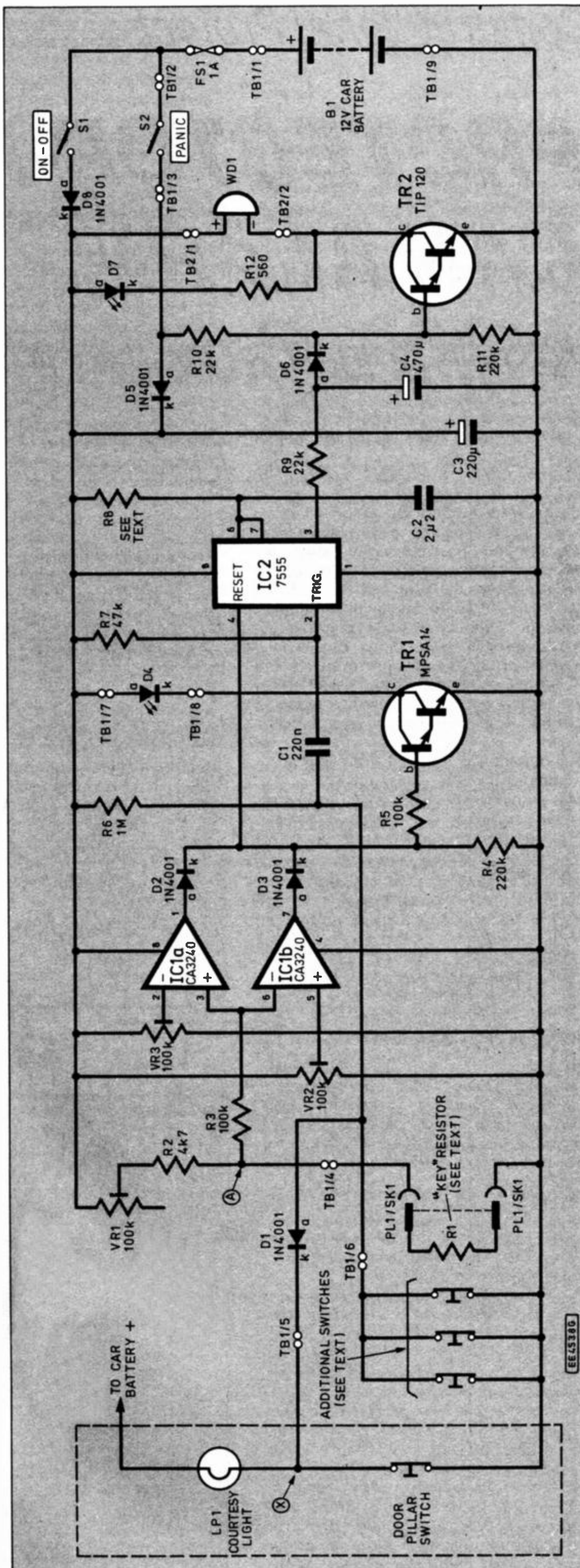


Fig. 1. Circuit diagram for the Protector-Plus Car Alarm.

ALARMING RESPONSE

If a piece of wire or similar object is inserted into socket SK1 in an attempt to disarm the system, this will make IC1 pins 3 and 6 low so now the voltage at pin 5 will exceed that at pin 6. IC1b will therefore switch on and this will also trigger the alarm when a door is opened. If a suitable plug but without the resistor is inserted in the socket, it will have no effect and both comparators will remain on – that is, the alarm remains armed.

Should any value of resistor R1 be used apart from that needed to provide the correct window, either IC1a or IC1b will turn on according to whether the resistor is too high or too low in value. Thus, the alarm will sound when a door is next opened. Any would-be thief – even if an electronics expert – is most unlikely to happen to make a key having the correct value resistor fitted.

In the above argument, presets VR2 and VR3 have been considered to be set to provide a fairly wide window voltage range. In real use, they would be set more critically so that the range of voltages over which both comparators will be off will be made fairly small. However, if it is set too finely, then any small change in the resistance of R1 due to drift with temperature, the presence of moisture, or simply as a process of ageing, would cause it fall outside the window values and the corresponding comparator would switch on thus allowing the alarm to trigger.

TIMING SECTION

The timing section of the circuit is centred around IC2, a CMOS timer i.c. which, in this application, is connected as a *monostable*. If either IC1a or IC1b is on (armed state), IC2 pin 4 – the *reset* input – is made high (+12V) and this enables the chip.

Nothing will happen, however, until a low pulse is applied to the trigger input, pin 2 (it is a characteristic of this i.c. that it requires a *low* pulse rather than a *high* one). Pin 3 then goes high for a time which depends on the values of capacitor C2 in conjunction with resistor R8. The value of this resistor is chosen to provide the required operating time and this is carried out at the testing stage.

Normally IC2 pin 2 is kept high via resistor R7 so preventing false triggering. However, when a door is opened, the courtesy light switch contacts "make" and apply a *low* trigger pulse to pin 2 via capacitor C1.

This capacitor is necessary since, otherwise, if the door were left open IC2 would be repeatedly triggered at the end of each timing cycle so sounding a continuous alarm. As it is, only a brief pulse is applied as C1 charges so if a door is left open, no further pulses will be applied.

Normally C1 will discharge ready for further operation via R7 and the courtesy light bulb. In case the bulb has failed, resistor R6 is included to provide an alternative path. This resistor is also needed when the *auxiliary* input (TB1/6) is used. This may be used to trigger the alarm using an additional switch or switches which may be used to protect fog lights and other accessories. Diode D1 prevents such triggering from operating the vehicle courtesy light since D1 would then be reverse biased.

HOLD-OFF

With the alarm triggered and IC2 pin 3 high, current enters the Darlington transistor, TR2, base (b) through current-limiting resistor R9 and diode, D6. The collector (c) current subsequently operates the audible warning device (solid-state siren), WD1. It also operates l.e.d. D7 through current-limiting resistor R12. This l.e.d. is used for testing and setting-up purposes. TR2 is adequately rated to suit any type of electronic siren.

The purpose of capacitor C4 is to hold off operation of the sounder for approximately one second when IC2 pin 3 goes high. This is because, when IC2 is powered-up in this type of circuit, there is a tendency for the output to go high momentarily. This could prove annoying.

To prevent this, capacitor C4 keeps TR2 base low in the following way. With IC2 pin 3 high, current flows through resistor R9 and charges capacitor C4. The voltage across this component rises until it reaches 2V approximately. At this point, transistor TR2 base allows current to flow – that is, the turn-on voltage for TR2 plus the forward voltage drop across diode D6. The transistor then operates the alarm in the manner already described.

PANIC ALARM

The panic feature mentioned earlier operates in the following way. When Panic switch S2 is *on*, current is applied to the whole circuit via diode D5 – this will happen even if key-operated on-off switch S1 is off. Current is also directed through resistor R10 and hence to the base of Darlington transistor TR2. This allows base current to flow and the alarm to sound until S2 is switched off.

While the alarm is armed, current flows through diode D2 or D3 as appropriate and hence to the base of Darlington transistor TR1 via resistor R5. Collector current then operates the flashing l.e.d. D4, in its collector circuit. Note the l.e.d. specified in the Components List – this is of the type which does not need a separate current-limiting resistor.

CONSTRUCTION

Construction of Protector-Plus is based on a main circuit panel made from a piece of 0·1in. matrix stripboard, size 15 strips x 39 holes. Full topside component layout and details of breaks required on the copper strip side are shown in Fig. 2.

Begin construction by cutting the material to size and drilling the three fixing holes in the positions indicated. Follow by making the track breaks and soldering the

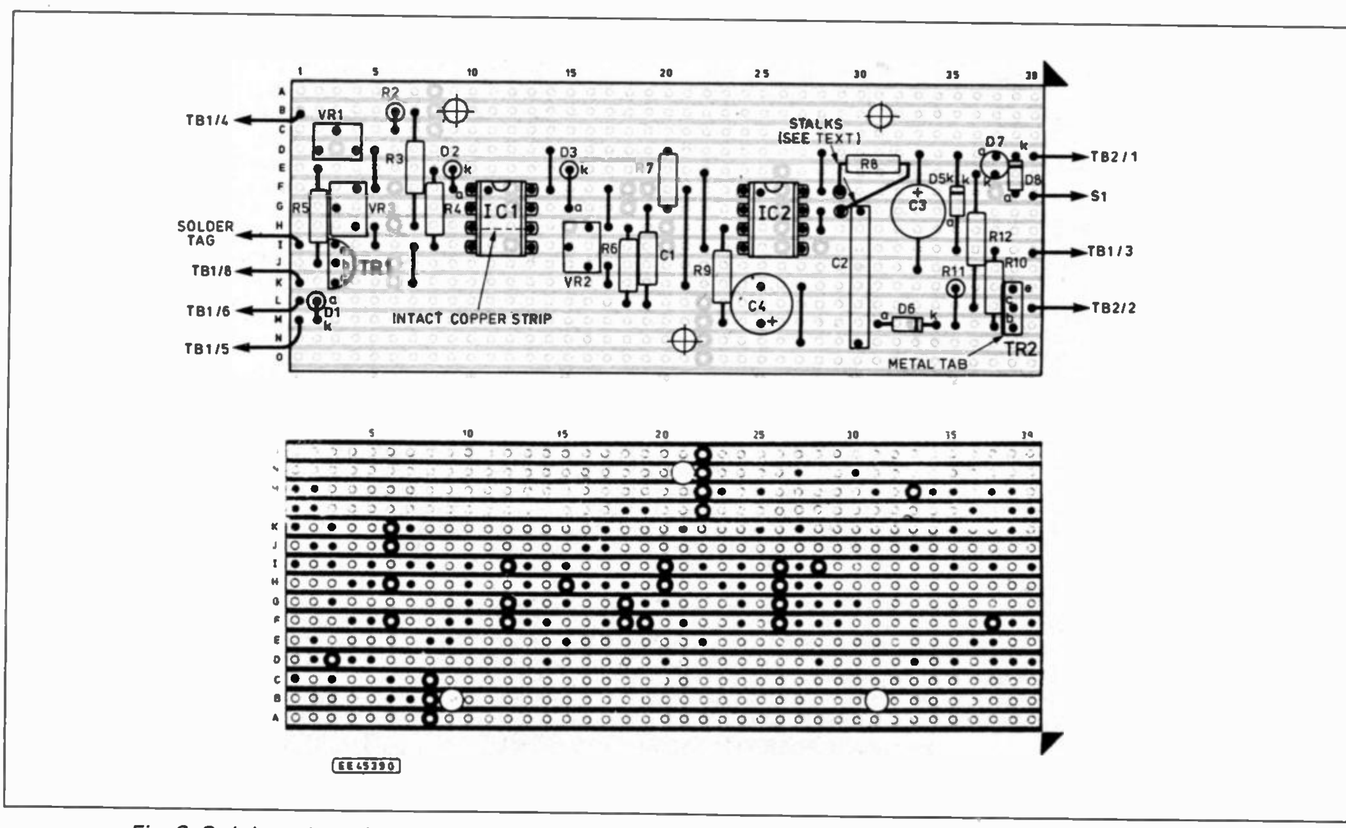


Fig. 2. Stripboard topside component layout and detail of breaks required in the underside copper tracks.

inter-strip link wires in position. Note that the track between IC1 pin 3 and pin 6 is left *intact*.

Solder the i.c. sockets into position but do not insert the i.c.s themselves yet. Add the soldered on-board components taking particular care over the polarity of all diodes, TR1, TR2 and electrolytic capacitors C3 and C4. Capacitor C2 is a bulky component and its end leads may need to be bent gently to fit the matrix positions indicated.

Solder the two 10mm long "stalks" at matrix positions *F29* and *G29* (R8 position) as shown. Bend them so that they take up a position clear of capacitor C2 (see photograph) for easy access. Solder a 2·2 megohm resistor to the ends of these stalks temporarily (this will provide a timing of five seconds, convenient for testing purposes).

Solder 20cm pieces of light-duty stranded connecting wire to copper strips *C, I, K, L* and *M* on the left-hand side of the panel and to strips *D, F, I* and *L* on the right. Using different colours here will greatly reduce the chances of making a wiring error.

Adjust the sliding contacts of presets VR2 fully *clockwise* and VR3 fully *anticlockwise* (as viewed from the left-hand edge of the circuit panel). Leave VR1 unadjusted to approximately mid-track position for the moment.

It is now necessary to choose the "Key" resistor. It is suggested that it falls in the range of 10 kilohms to 330 kilohms. For accurate setting-up purposes you will also need the next listed value *above* and *below* the chosen one. For example, if using a 22 kilohm resistor for the key, you will also need a 20 kilohm and a 24 kilohm one. Note that these resistors should be of the one per cent metal film type as specified.

Adjust preset VR1 in the following way. For any value of key resistor exceeding 100 kilohm, adjust it fully *clockwise* (as viewed from the top edge of the circuit panel). For values less than 100 kilohm match the value approximately, regarding fully anticlockwise as zero. For example, if a 33 kilohm resistor is used, turn VR1 sliding contact approximately one-third of the total travel clockwise. Do not try to be too exact here.

Complete board construction by inserting the i.c.s into their sockets observing the orientation. Do this without touching the pins since the devices can be damaged by static charge which may exist on the body. Alternatively, touch something which is earthed – for example, a water tap – before touching the pins.

COMPONENTS

Resistors

R1	Resistors for key and for adjustment purposes – see text
R2	4k7
R3, R5	100k (2 off)
R4, R11	220k (2 off)
R6	1M
R7	47k
R8	2M2 test resistor and timing resistor – see text
R9, R10	22k (2 off)
R12	560

See SHOP TALK Page

All fixed resistors 0·6W 1% metal film NB – this is important for the key. All others may be 0·25W 5% units if desired.

Capacitors

C1	220n ceramic
C2	2µ2 polyester
C3	220µ radial elect. 35V
C4	470µ radial elect. 35V

Semiconductors

D1, D2, D3, D5, D6, D8	1N4001 50V 1A rect. diode (6 off)
D4	3mm red flashing l.e.d. with internal current limiting
D7	5mm standard red l.e.d.
TR1	MPSA14 *npn* Darlington transistor
TR2	TIP 120 Darlington transistor
IC1	CA3240 dual operational amplifier
IC2	7555 CMOS timer i.c.

Miscellaneous

S1	S.P.S.T. key-operated switch
S2	Miniature S.P.S.T. slide or toggle switch
WD1	Electronic sounder (piezo siren) – nominal 12V operation. Sound output 115dB at 1m
PL1/SK1	2·1mm "power-in" type plug and matching socket
FS1	20mm chassis fuseholder, with 1A quick-blow fuse to fit
TB1, TB2	2A screw terminal block – 11 sections required.

Stripboard 0·1in. matrix, size 15 strips x 39 holes; aluminium box, size 102mm x 102mm x 64mm (AB23 box); 8-pin dil socket (2 off); plastic box for power-in socket if required – see text; plastic box (potting box), size 28mm x 18mm x 14mm for windscreen-mounted l.e.d; stranded wire; light-duty twin wire; auto-type wire; small fixings; solder tag; solder; epoxy-resin adhesive etc.

Approx cost guidance only **£24**

INITIAL TESTING

It is convenient to test the circuit board and set up the key using a 9V battery before fitting it into the case. In this way, any problems are more easily corrected. Note that the settings made using a 9V battery will still apply when using the car 12V supply. To protect the ears and prevent complaints from the neighbours, testing and adjustment is carried out *without* using the sounder.

Connect the flashing l.e.d. D4 to the wires leading to strips *D* (+) and *K* (−). Connect the battery – positive to strip *F* and negative to strip *I* on the left-hand side of the board. The l.e.d. should be *flashing*.

Trigger the circuit by touching the wire leading to strip *M* on to the negative terminal of the battery momentarily. The on-board l.e.d. D7, should light for around five seconds then go off. Test the auxiliary input in the same way by touching the wire leading to strip *L* on to the negative battery terminal. Test the Panic circuit by touching the wire leading to strip *I* on the right-hand side onto the *positive* terminal of the battery.

Now using a two-section piece of screw terminal block, connect the test resistor having the value *below* the "correct" one between the wire leading to strip *C* and the negative terminal of the battery. The l.e.d. should stop flashing. Adjust VR2 anticlockwise until it *just* begins to flash.

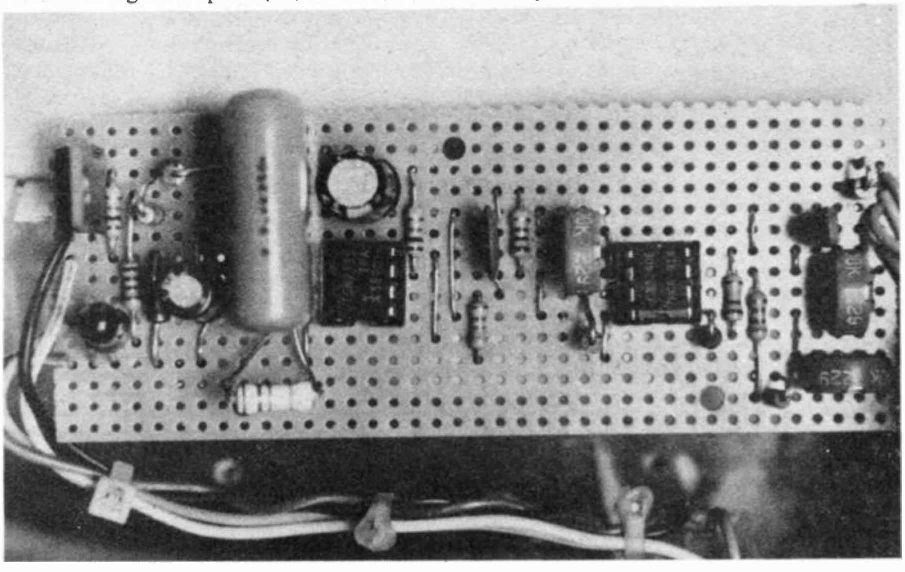
Swap the test resistor for the one *above* the key value. Again, the l.e.d. should stop flashing. Adjust VR3 clockwise until it just begins to do so. Now connect the correct value of resistor in position. It should be found that the l.e.d. does not flash – that is, the circuit is *disarmed*.

Spare keys may be made as required and tested. Note that once set, adjustment to all presets must be left alone unless the key resistor value needs to be changed for any reason.

OPERATING TIME

Some thought may now be given to the operating time. However, some readers will wish to leave the timing as it is until they have become accustomed to using the alarm and until it has undergone a period of trial in the car.

To set the time, the 2·2 megohm resistor, R8, should be removed from the stalks and replaced with one having a value of 10 megohms for each 20 seconds required. For example, if the alarm is required to sound for two minutes you will need 60 megohms. Since 10 megohms is the highest easily-available resistor value, it is necessary to connect a number of these – in this case six – in series to make up the value required. Alternatively, use a resistor listed by certain suppliers as a "high voltage" resistor – these are available in much larger values. If the resistor is too bulky, it may be necessary to abandon the stalks altogether and solder the resistor to the circuit panel *direct*. Trigger the unit as previously described and check that l.e.d. D7 lights for the required time.



CASE PREPARATION

Prepare the case for the circuit board and internal components. Make a large hole in the end panel for the sound to pass out from the siren WD1. This is best done by drilling a circle of holes, joining them together using a small hacksaw blade then filing the edge smooth. Measure carefully the position of one of the siren mounting bushes and drill a hole in the base of the box to correspond.

Drill a hole for the key-operated switch in the opposite end panel. Hold the circuit panel in position temporarily and mark the positions of the fixing holes already drilled in it onto the base of the box. Remove the panel and drill holes in the base to correspond.

Drill a further hole for fuseholder FS1.

Drill holes in the end panel to secure the 9-section piece of screw terminal block TB1 on the outside. Drill two holes nearby for the wires passing through the box to the terminal block. Fit these with rubber grommets.

At this stage is it wise to find a suitable site under the vehicle bonnet for the main unit. This must not be too near the road because the unit must remain dry in use. It must not be situated close to the exhaust system or anywhere where it could become hot. Also, it must be kept clear of moving mechanical parts and there must be plenty of clear space in front for the sound to pass out.

When the best position has been chosen, cut a piece of sheet aluminium to make a mounting bracket similar to the one shown in the photograph. The exact dimensions and shape will be determined by the particular car. Drill two small holes in the panel to bolt it to the box avoiding the site of internal components.

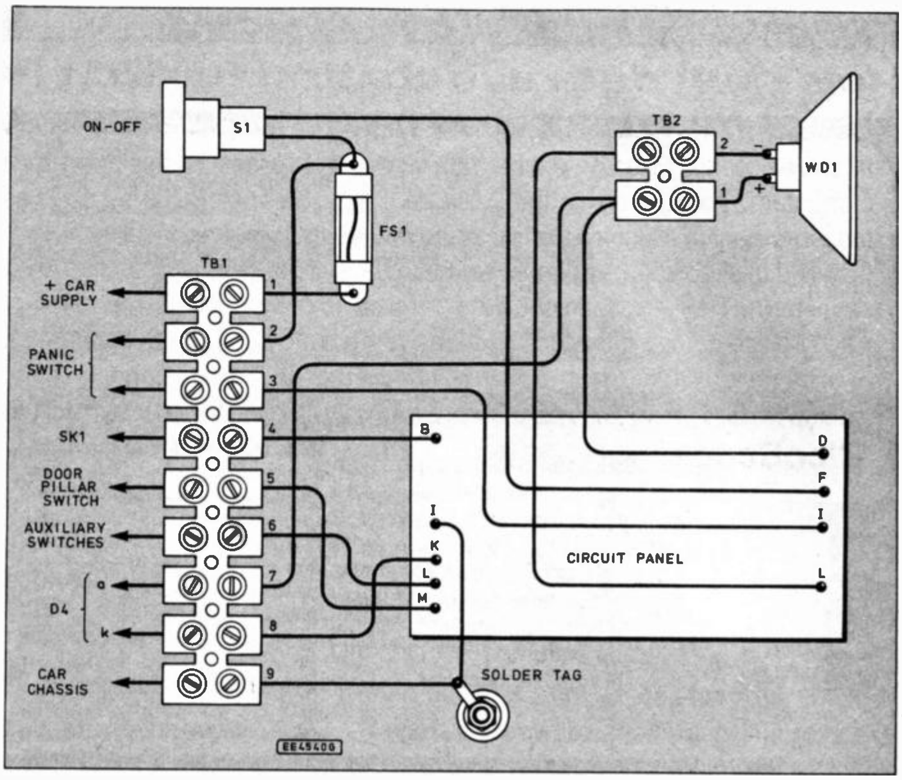


Fig. 3. Interwiring details.

INTERWIRING

Refer to Fig. 3. Mount the circuit panel on 5mm stand-off insulators. Attach the siren using the hole already drilled for the purpose – place some packing washers on the bolt shank so that it is held squarely against the box.

Mount the remaining components and complete all internal wiring shortening any wires as necessary. Connect the sounder positive wire to TB2/1 but leave the negative one disconnected for the time being. Note the solder tag at one of TB1 fixings. Finish by inserting the fuse in the fuseholder.

WARNING FLASHER

Mount the flashing led, D4, in a small box – a *potting box* was used in the prototype. Drill a hole in the front which is a tight push-fit for the l.e.d. Drill a hole in the side for the connecting wire to pass through. Attach the l.e.d. to the box using a little quick-setting epoxy resin adhesive so that its front surface is *just* higher than the plastic face.

Pass the connecting wire through the hole drilled for the purpose and tie a piece of string around it to provide strain relief. Solder the ends to the l.e.d. It is acceptable to use a piece of neat twin wire where it is on view then change to auto-type wire when it is hidden. Use proper auto-type insulated connectors for this. Make a cover for the rear of the box using cardboard or plastic and glue this into position.

Attach the small "warning" box to one corner of the windscreen so that the l.e.d. is clearly visible from outside. The best way to fix it is to use an adhesive pad of the type used for securing the driving mirror on the windscreen of many cars. Other methods tend not to adhere to glass satisfactorily.

These pads are available from car accessory shops. The pad should be cut to the exact size of the box and a hole cut in the centre for the l.e.d.

Decide on the best position for the Arm/Disarm socket, SK1 and mount it. A good place from the point of view of waterproofing is in the boot. If it is to be placed elsewhere, make sure that it will remain dry in use.

Note that the car body itself forms the negative return from here to the main unit. If the socket is of a type where one terminal connects directly to the metalwork of the car, scrape the paint from around the hole so that a good Earth connection is made. The connecting wire should be made to the non-earthed (pin) terminal and run back from here to the main unit position. If the socket is mounted in a plastic box, then the outer (sleeve) connection should be made to a nearby Earth (chassis) point.

INSTALLATION

Before fitting the alarm, disconnect the car battery completely. Note that ALL wiring must be made with ***auto-type*** stranded wire of 3A rating minimum. Remember also, that wherever wires pass through a hole made in metal, a rubber grommet must be used to protect it from cutting.

If there are any door switches to fit, or if any additional switches are needed – to protect the bonnet for example – it is a good time to fit them before proceeding. Note that switches placed outside need to be waterproof. Again, the car body forms the negative supply return for these.

If using the existing door switches, you will need to find the connection shown as *X* in Fig. 1. This may be picked up at one of the door pillar switches or, alternatively, at the courtesy light unit itself. Connect this to TB1/5.

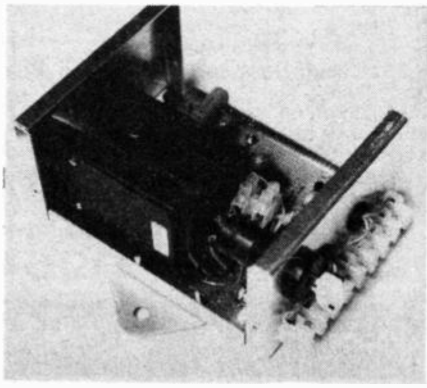
Connect wires to TB1/2 and TB1/3 and run them through to the Panic switch position. Connect the wire leading to "socket" SK1 to TB1/4. Connect TB1/6 to any additional switches used on the auxiliary circuit – these must have contacts which are held open by the item being protected. Connect TB1/7 and TB1/8 to the flashing l.e.d. anode (a) and cathode (k) end leads respectively.

Connect TB1/1 to an existing vehicle fuse which is live all the time – that is, not only when the ignition is switched on. Connect TB1/9 to a nearby chassis (earth) point. Do not connect the sounder positive wire to TB2/1 until the final test has been made.

Mount the main unit if this has not been done already.

Mount the panic switch on an aluminium bracket or in a small box and connect it up – ***neither connection must make contact with the car chassis.*** Re-connect the car battery. Check that the unit works correctly using the on-board l.e.d. and when satisfied, connect the sounder WD1 and fit the lid.

Everyone hopes their alarm will never be triggered in earnest. However, if it is *Protector Plus* will always be there to keep the intruder at bay! □



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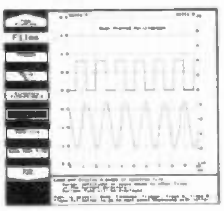

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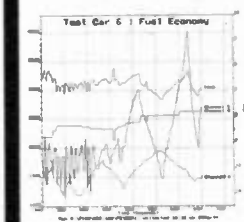
'Virtual instrument' software package.

PicoLog



Collect, store, display and print data from 1 sample per ms to 1 per day. Record average, min/max values or scaled values (linear, equation, table look-up). Report types: monitor (with min/max alarms), y-t graphs, x-y graphs, tabulation.

Advanced data logging software package

NEW *ADC 100* Virtual Instrument

Dual Channel 12-bit resolution

The ADC 100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general purpose test instrument either in the lab or in the field. A flexible input range (±200mV to ±20V) allows the unit to connect directly to a wide variety of signals.

NEW from PICO

- Digital Storage Scope
- Spectrum Analyser
- Voltmeter
- Frequency Meter
- Chart Recorder
- Data Logger

ADC 100 **with PicoScope £199**
PicoScope & PicoLog £209

ADC 10

1 Channel 8-bit

- Lowest cost
- Up to 22kHz sampling
- 0-5V input range

The ADC 10 gives your computer a single channel of analogue input. Simply plug into the parallel port and you're ready to go.

ADC 10 **with PicoScope £49**
PicoScope and PicoLog £59

ADC 11

11 Channel 10-bit

- Digital output
- Up to 18kHz sampling
- 0-2.5V input range

The ADC 11 provides 11 channels of analogue input in a case slightly larger than a matchbox. It is ideal for portable data logging using a 'notebook' computer.

ADC 10 **with PicoScope £85**
PicoScope and PicoLog £95

ADC 12

1 Channel 12-bit

- High resolution
- Up to 18kHz sampling
- 0-5V input range

The ADC 12 is similar to the ADC 10 but offers an improved 12-bit (1 part in 4096) resolution compared to the ADC 10's 8-bit (1 part in 256).

ADC 12 **with PicoScope £85**
PicoScope and PicoLog £95

ADC 16

8 Channel 16-bit + sign

- Highest resolution
- 2Hz sampling – 16-bit
- ± 2.5V input range

The ADC 16 has the highest resolution of the range, it is capable of detecting signal changes as small as 40µV. Pairs of input channels can be used differentially to reject noise. Connects to the serial port.

ADC 16 **with PicoLog £115**

PicoLog for ADC 10/11/12 £25. Oscilloscope Probes (x1, x10) £10. Carriage UK free. Overseas £6

PICO TECHNOLOGY

Pico Technology Ltd. Broadway House, 149-151 St Neots Road, Hardwick, Cambridge CB3 7QJ, UK
TEL: 0954-211716 FAX: 0954-211880

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

THE ELECTRONIC NOSE IS NOT TO BE SNIFFED AT!

A new use for Polymers – *By Hazel Cavendish*

The technology of electronic phenomena is carried a stage further with the development of the 'Electronic Nose' – an invention proving to have many applications, one of the most significant being its importance in environmental monitoring at a time when civilisation is being threatened by over-population with a proliferation of chemicals released into the atmosphere.

The invention is once again a British one, although the inventor is in fact a South American working in the Department of Instrumentation and Analytical Sciences at Manchester University's Institute of Science and Technology, in a team headed by Professor Peter Payne. Dr Krishna C. Persaud began his research into the possibilities of an electronic nose over 10 years ago, and today his electronic machine is the basis of a Stock Exchange launch by AromaScan – a company part-owned by the University – at the end of July, with share dealings opening on August 3.

While figures were still being prepared at the time of writing, the Company is expecting to be valued at a figure in the region of £28 million, with the coming flotation aiming to raise another £12 million. This figure would not appear unrealistic in view of the many applications of the invention which have already found a market.

Improving on Nature

Nature has endowed animal life with exquisitely sensitive chemosensory systems that allow organisms to react selectively to chemicals of significance to the environment. Now new sensor materials, coupled with advances in microelectronics and computer technology, signal the emergence of a range of chemical sensors capable of mimicking some aspects of the biological system. It has been noted that the latter often make use of individual sensors that have poor selectivity. Specificity is achieved by processing the signals obtained from many sensors that have broadly different ranges of selectivity for different classes of chemicals.

The sensors function by the absorption of a substance onto the polymer surface, causing a temporary change in electrical resistance. The extent of the change in resistance depends on the chemical compositions of the aroma and the polymer. High levels of discrimination and sensitivity are achieved by the selection of appropriate polymers and the chemistry of those polymers determined by monomer selection and polymerisation procedures. AromaScan has a library of over 50 polymers of which an important group are novel polymeric forms in the context of aroma sensing. These are the subject of patent applications.

Gas Sensing

One of the many problems tackled is the lack of an infallible gas sensor at present. Rapid progress is being made at the present time in array-based sensors which are proving versatile alternatives to conventional gas sensing techniques. The use of these alternatives has been made possible because of the revolution in microelectronics that has occurred in the last two decades. The sensor response may be nonlinear with gas concentration, as in the case of tin oxide sensors, so linearising circuitry is required.

Because it is necessary to sample the responses of all the sensors at a given time and almost simultaneously, multiplexing circuits are required in order to avoid replicating all the data acquisition circuitry for each sensor element. Intensive data processing is required and so the analog signals from the sensors need to be converted into digital signals, preferably at high resolution. Signal processing and pattern recognition play crucial roles in multisensor systems.

In developing sensor arrays there has been increasing interest in organic electrically conducting polymers derived from aromatic or heteroaromatic compounds. Polypyrrole, the most extensively studied of these polymers, was first prepared electro-chemically in 1968 and as a free standing film ten years later.

In a paper written jointly by Doctor Persaud and development chemist Paul Travers, attention is drawn to the specific needs for chemical sensing of volatiles which are extremely intense in the environmental monitoring of toxic or hazardous chemicals, where extremely low concentrations of chemicals need to be detected, identified and quantified.

"We still have some way to go in understanding (the) mechanisms, but we now have the preliminary data for designing polymers with desired characteristics for sensing (these) volatile chemicals and substituting appropriate chemical groups on the polymer backbone," says Dr Persaud.

The team believes the new sensing technology exemplified by conducting polymers can be miniaturised easily to include the data acquisition electronics into a single integrated sensor package, and this will lead to wearable monitors.

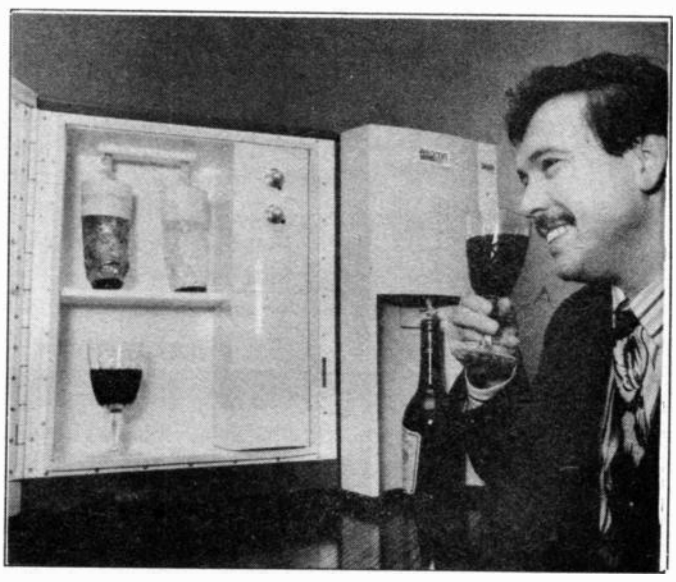
Outsmarting the Human

In the quality control of foods and beveridges the use of array-based sensors in key areas to identify instantly a characteristic odour note may be of considerable assistance to human odour panels, which the University team remarks are labour intensive, expensive and prone to error. The American Food & Drug Administration is using AromaScan's invention to detect taints in samples of fish, which they report tracks odorous fish in 30 minutes – a considerable advance on the day it was taking a human 'sniffer' to get the same result.

The same instrument proved itself in wine-tasting by accurately identifying different red wines, and proved more infallible than human tasters. It has been remarked that this could enable wine merchants to control the quality of individual bottlings of specific wines.

Early trials have demonstrated that an AromaScan instrument can detect infections in wounds at a very early stage, and can distinguish between certain types of infection. Such cost-effective wound care could be a valuable adjunct to today's Budget-obsessed hospitals, and save many lives.

The most exciting experiment of all is now awaited, and will result from the decision of the European Space Agency to launch the ArmoaScan technology into space for environmental monitoring. From small beginnings this University project looks like being a winner.



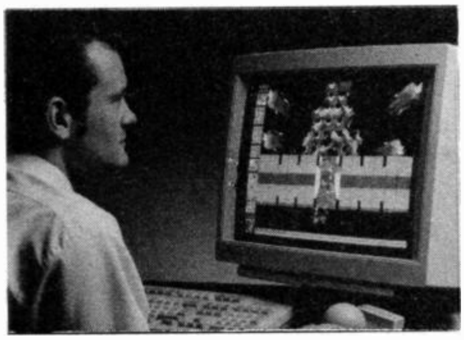
FIRING VIRTUAL REALITY

THE Fire Service College, based in Moreton in the Marsh, which is the national officer training college for the fire service and a centre of excellence for international fire service training, is using virtual reality as an integral part of its course programmes.

Based on Superscape Virtual Reality software from Superscape Ltd, the system is being used as part of the training programmes for both officer training and for the industrial and commercial courses run by the College.

Commenting, David Smethurst, Assistant Divisional Officer at the College said: "We are using virtual reality to demonstrate some of the principles of fire engineering, including means of escape theory, fire modelling, human behaviour and spatial awareness of a complex building. Many of the traditional theories for fire engineering are based on complex mathematical calculations. Virtual reality is the only way of visualising this type of data and showing the course delegates what can really happen in a fire. Until now, we have relied on paper-based diagrams and standard slide presentations."

In conjunction with the virtual reality software, the College is also using specialist software from Colt Virtual Reality, known as VEGAS (Virtual Egress Analysis and Simulation). Based on extensive research into the simulation of fire and egress scenarios, VEGAS provides a means of modelling human behavioural response under infinitely variable stress conditions, such as the spread of fire, increasing toxicity levels and physical containment factors. Used within a virtual world, VEGAS will visualise in real time the effects, for example of opening and closing doors, smoke extraction systems, different rates of combustion as well as an unlimited number of "what if" scenarios.



Mr. Smethurst concluded: "The key benefits of using virtual reality at the College is the level of interactivity which the course delegates can achieve with a simulated fire situation. This involvement aids the learning process and helps to keep the attention of the delegates throughout the six week courses."

Superscape virtual software is also used for a number of applications in markets ranging from education, marketing, design and military to commerce and entertainment. The company's clients include the Royal Air Force, British Telecom, Tyne and Wear Development Corporation, Logica, Westland System Assessment, Reuters and the Intel Corporation.

For further information, please contact: Superscape Ltd, Dept EPE, Zephyr One, Calleva Park, Aldermaston, Berkshire RG7 4QZ. Telephone 734 810077 or Mike Lyons, Colt Virtual Reality Limited, New Lane, Havant, Hampshire PO29 2LY. Telephone 705 451111.

IMPATIENT SURGEONS

VIRTUAL reality keyhole surgery training, smart cards for medical records usable worldwide and plastic highway safety barriers are just three of the 36 UK projects announced today at the twelfth EUREKA conference in Lillehammer, Norway.

EUREKA is a pan-European framework to promote collaborative R&D in civil advanced technologies. Its overall aim is to improve the productivity and competitiveness of European industry in world markets.

Trade and Technology Minister Patrick McLoughin said, "These are exciting projects which span a wide range of technologies from health care to road safety; from advanced digital television technology to deep water oilpipe repairs. I am particularly keen to encourage Small and Medium-sized Enterprises to participate fully in European collaboration and I am pleased that over half of the UK projects involve SMEs."

Through The Keyhole

The technique of keyhole surgery involves inserting a camera in the abdomen and using miniature instruments to carry out a variety of operations. However, because of the technical difficulty of the procedure there is an increased need to provide specialised training.

In response to this, Marconi Simulation and Training, based in Fife, Scotland is collaborating with organisations in France, Germany, Finland and Italy to develop a 3-D virtual reality training simulator using state of the art computer generated graphics. The simulator will allow surgeons to practice operations in a synthetic environment where hands-on skills can be safely acquired before moving on to assist in actual operations.

With 70 per cent of all surgical procedures forecast to be of the keyhole type by the turn of the century, the demand for the new simulator is expected to be high.

Medicard

A consortium led by the University of Exeter collaborating with Portuguese organisations are working on a project which involves medical "smartcard" technology. Similar in size to a credit card, smartcards may contain either complete medical records on an individual or more limited information, for instance on allergies or medication, encoded on a microchip. The consortium aims to develop a universal interface which will allow a patient's smartcard to be assessed by health care officals anywhere in the world.

Even though the technology is well established, the widespread use of medical datacards in Europe has been severely hampered by a failure to develop compatible systems which can be accessed by health care officials in whatever country or locality patients may find themselves.

BARNSLEY CALLING

THE Barnsley and District Amateur Radio Club will be holding its forth Amateur Radio Rally, in Barnsley, South Yorkshire on the 13th November 1994, at The Metrodome Complex in Barnsley Town Centre, less than two miles from Junction 37 on the M1.

This is a *new* venue all on one level with excellent facilities for the disabled. It has a licensed bar/restaurant and a separate cafeteria. The Rally will have all the usual amateur radio and computer dealers, with radio clubs, specialist groups, and bring and buy. There will be ample car parking at the Metrodome, easy access from the bus station and train station.

For further information, contact Ernie G4LUE QTHR, on 0226-716339 between 6pm and 8pm, except for Monday nights when it is 6pm to 7pm please.

LOW-DISTORTION AUDIO OSCILLATOR

NOW available from Thurlby-Thandar Instruments, is the AG203A low-distortion signal generator, covering 10Hz to 1MHz in five ranges.

Frequency accuracy is quoted as ±(3% + 1Hz), and sinewave distortion is less than 0·1% over the range 400Hz to 20kHz. Sinewave output is 7V r.m.s. minimum (open circuit), while output-voltage flatness from 10Hz to 1MHz is ±5dB.

In square-wave mode, open-circuit voltage output is 10V peak-to-peak minimum. At maximum output, the risetime is 200ns, with a duty cycle at 45:55 or better at 1kHz.

If the output is synchronised to an external signal, the generator can be used as a synchronised oscillator.

The output voltage can be set from 0 to 50dB in 10dB steps using a built-in attenuator. A fine-adjustment potentiometer allows accurate setting over the entire range.

Low distortion over the audio frequency range and output-voltage variation within ±0.5dB allows the instrument to be used for a broad range of applications, including distortion measurement, signal/noise ratio calculation and frequency-response measurements.

The AG203A costs £179 plus VAT.

For further information contact: Thurlby-Thandar Instruments Ltd, Dept. EPE, 2 Glebe Road, Huntingdon, Cambs. PE18 7DX.

PLYMOUTH HO!

The highly active Plymouth Radio Club has sent its latest list of events. They appear to have events occurring almost at weekly intervals, usually on Tuesdays, at 7.30pm for an 8pm start.

Club meetings are at the Royal Fleet Club, Devonport, Plymouth. For further information, contact the Public Relations Officer, F.P. Russell on 0752 563222. Mention EPE!

New Technology Update

Ian Poole reveals that Holographic Technology is progressing towards accurate high speed computer data storage.

HOLOGRAPHY is a technology which promises many revolutionary applications in the future. For the moment it is confined to a limited number of applications and some interesting laboratory demonstrations.

The technology allows 3-D images to be stored and retrieved on film by the use of coherent light from a laser source. For the future the possibilities seem almost boundless. Many seem to be more akin to science fiction than realistic developments for today. For the distant future there has been talk of 3-D television where an image can be displayed almost anywhere in the room.

Data Storage

It has long been realised that the current forms of computer data storage and retrieval will not be able to keep up with the increasing demands being placed upon them. Magnetic and optical disks have seen quantum leaps in performance in recent years. 100 and 200 M-byte storage disks are now relatively commonplace for personal computers, whereas only a few years ago a 20 M-byte drive was deemed to be very large. However, with further requirements being placed upon computer systems it is realised that it will not be many years before these technologies are reaching their limits.

It is in the area of data storage that the possibilities of using holographic technology are being investigated. Holography offers the possibility of storing vast amounts of data in very small volumes. However, some very fundamental hurdles have to be overcome before this becomes a reality.

Some of these hurdles are now starting to be surmounted. IBM recently announced that their San Jose Research Division has succeeded in recording several erasable holograms on the same spot on a specialised polymer film. Previously this had only been possible using expensive crystals.

Work is also progressing on developing the methods of storing computer-type data onto these films. The two basic operations of storage and retrieval both require different processes, although there is naturally a large degree of overlap in their requirements and the items needed for them.

Information is stored not by using a discrete location on the surface of the medium as in traditional technologies. Instead the data pattern is made up into an image which occupies the whole area or volume of the hologram.

The first stage in the process is to make up a two dimensional representation of the data in the form of an array or page with what is called a spatial light modulator. Using two laser beams, the signal beam and the reference beam, this information is transferred onto the storage medium. To make the maximum usage of the available space it is possible to store several images on the same spot. This is achieved by changing the angle of the image.

To retrieve the data, the recording medium is illuminated by an identical beam to the reference beam used in the recording. This generates a replica of the original data which can be converted into the original data pattern using an array of photodiodes.

Accuracy and Speed

It has already been mentioned that the new system has advantages in terms of the amount of data which it will be able to store. In addition to this, it has a number of other useful features which make the idea very attractive. Because the image of the page of information is not contained in a single location, but over a defined area, a small defect occurring on the surface of the recording medium will not destroy the data. Instead it will have the effect of reducing the intensity of the image. By providing sufficient latitude in the design of the system this should not corrupt the data. This is of great importance in increasing the product reliability, which is an item of major importance with ever larger amounts of data being stored, all of which have to be retrieved without error for the system to operate.

A further advantage is the possibility of tremendous speed increases. In conventional storage systems the data is recorded serially. With this new idea it can be seen that large amounts of data can be stored in parallel. If suitable I/O devices are used then it is estimated that data rates of around one Gigabyte per second should be achieved. A further speed increase is that of access time. The new system is not bound by the limits of mechanical movements as are conventional disk systems. Instead different pages are addressed simply by changing the deflection of a beam. As a result it should be possible to achieve access times of around 10μS.

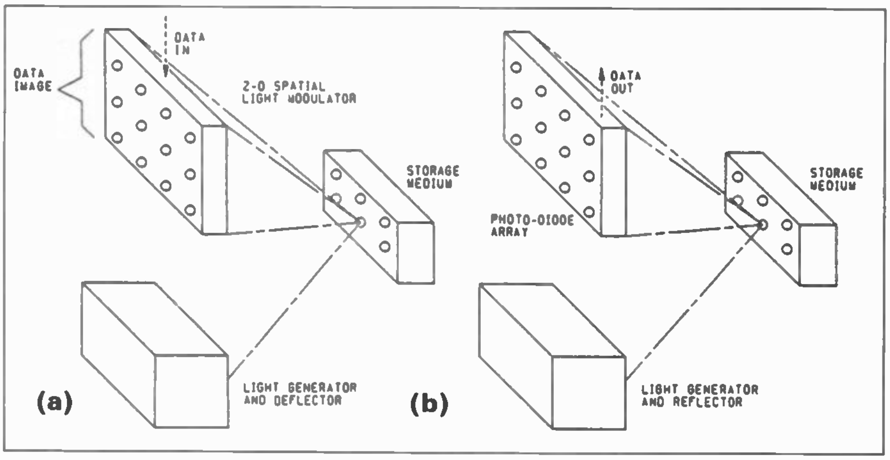


Fig. 1. Holographic storage system. (a) data storage and (b) data retrieval.

More Development

Before the complete system can be realised there is a large amount of development which needs to be undertaken. In particular the optical components associated with generating the holographic effects are not yet up to the standards which are required. However, work is progressing to address these problems and already many solutions and improvements can be seen.

One area of work in which very encouraging results are being seen even now is in the area of what is called the spatial light modulator which generates the image of the data for recording. Here liquid crystal displays have been made to demonstrate the operation of the system.

Although l.c.d.s are not fast enough to be used in a high speed storage medium, they have proved that the basic system can operate satisfactorily, leaving the way open for the next stages in the development of this item. Also, new high efficiency diodes have played their part. They have made the generation of the blue-green light needed for the system much easier.

Currently it appears that a ten year time frame is needed before the first units are available. It will obviously take a few more years before the technology matures sufficiently and can gain widespread acceptance. However, it could be the answer to many a programmer's dream. With PC based software becoming ever more hungry for storage and reduced access time, it sounds as if this new technology will not appear on the market a minute too soon.

Constructional Project

AUTOMATIC GREENHOUSE WATERING SYSTEM

MIKE RICHARDS

You may not win a first at your local show but your plants will certainly drink a toast to you.

IN SPRING and summer when growing seeds and plants in the greenhouse the soil or compost tends to dry out rapidly. When at work all day this results in over watering in the evening, and the compost getting very dry towards the end of the next day – depending on how hot and sunny it has been.

This can result in not too healthy plants, with a reduced growth rate. It would be better if the compost could be kept at a more even dampness, this being fine if you were at home all the time watering them when necessary, more on a sunny day and far less on an overcast cooler day. Also if you were to go on holiday for a few days you would have to arrange for a friend to come and water them every night.

The Automatic Greenhouse Watering System described here monitors the compost moisture content and when this falls to a user preset level opens a water solenoid valve for a preset time. The water solenoid valve lets water through to a mist irrigation system set up in the greenhouse over the seed trays and plants.

Such a mist irrigation system is widely, and cheaply available from garden centres or other large retail outlets such as B&Q etc. The actual irrigation system used is one manufactured by Hozelock.

Certain safety features have been built in to prevent over watering if the spray head over the moisture detector were to block or fail, then the system would lockout until the spray head was cleared, and normal watering took place.

—SAFETY NOTE—

Because the control unit is mains driven (not the solenoid valve 12V), it is absolutely ESSENTIAL for the Control Unit to be correctly EARTHED, and out of the area where the water spray will fall.

It is recommended that ALL electrical apparatus in the greenhouse are protected by a 30mA RCD trip and be correctly fused. If in doubt consult a qualified electrician before fitting this device.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Automatic Greenhouse Watering System is shown in Fig. 1. As can be seen from the circuit, the four basic functions are power supply; comparator; timer, and output driver.

The power supply comprises a 240V to 12V 6VA mains transformer whose output is fed into a 1A monolithic bridge rectifier REC1. Across the output of the bridge rectifier is a smoothing capacitor C1. This rough d.c. is fed into a 12V 1A three terminal voltage regulator (7812) IC1, the two small capacitors, C2 and C3, reducing voltage transients and stopping any self oscillations that might occur.

It should be noted that the output voltage required from the transformer was calculated as follows:

Voltage regulator output voltage + regulator drop out voltage divided by a.c. to d.c. voltage conversion (1·414)

$$= \frac{12+3}{1{\cdot}414} = 10{\cdot}6 \text{ volts}$$

The nearest preferred transformer voltage is one with 0V-12V, 0V-12V 0·25A twin secondary windings connected in parallel to give 12V at 0·5A. The water valve during operation takes 220mA at 12V and so it is safe to assume that the 0·5A output from the transformer is suitable (i.e. 6VA).

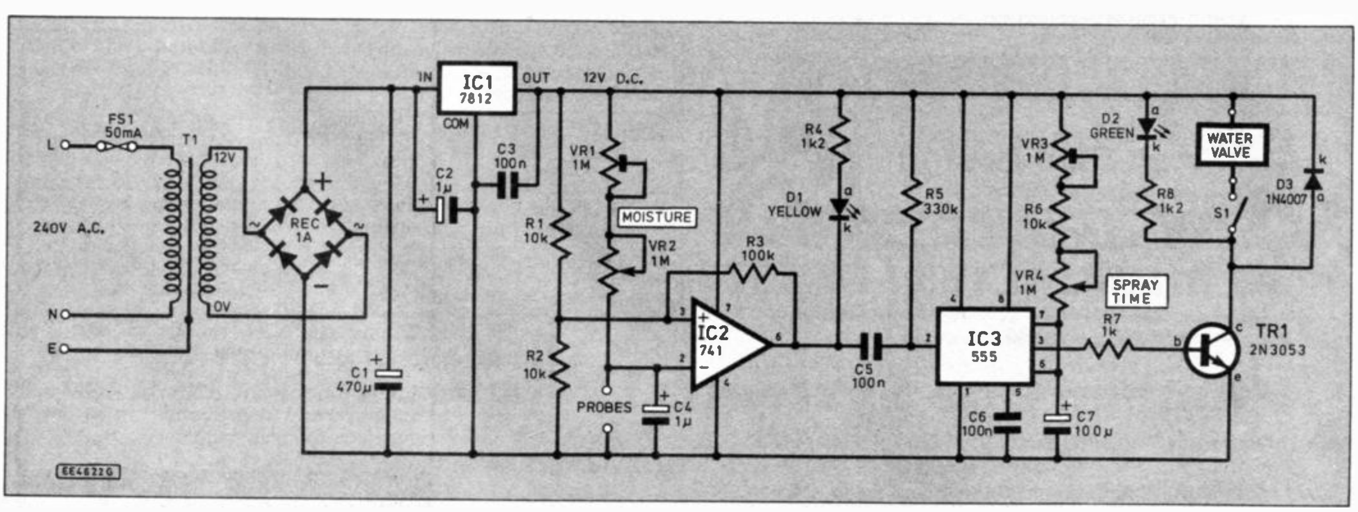


Fig. 1. Complete circuit diagram for the Automatic Greenhouse Watering System.

Power dissipation within the regulator was calculated as follows:

$(V_{in} - V_{out})$ multiplied by I out.

this equals: $(17 - 12) \times 0{\cdot}5 = 2{\cdot}5W$

The heatsink required for the voltage regulator therefore has to dissipate 2·5 watts. From calculations it was found that a heatsink rated at 21°C/W was required.

COMPARATOR

The comparator consists of a standard 741 operational amplifier IC2, with a positive feedback loop to apply hysteresis. Two resistors R1 and R2 are connected across the stabilised 12V rail as a potential divider.

The half-way or 6V point of R1/R2 is connected to IC2 pin 3, the non inverting (+) input of the op.amp. The inverting input (−) of IC2 is connected to the centre point of another potential divider network comprising preset VR1, moisture content control VR3 and the moisture content probe.

Also connected between the inverting input (−) and 0V is a capacitor C4. This provides stabilisation to the inverting input. When the inverting input voltage is higher than the non-inverting (+) input then the comparator's output changes from being 12V to 0V. The positive feedback provided by the resistor R3 provides hysteresis (clean switching).

When the output of the comparator goes to 0V it causes the "Moisture" l.e.d. D1 to illuminate via a current limiting resistor R4. This l.e.d. informs the user that the moisture in the compost has dried out to the point that has been chosen to activate the irrigation mist system. Also as the comparator output changes from 12V to 0V a negative going pulse is applied to the next stage via capacitor C5.

TIMER

The timer stage consists a standard 555 timer IC3 connected in the monostable mode. From the simple timing formula:

$$T = 1{\cdot}1 \times R_t \times C_t$$

where T = time, R_t = timing resistor and C_t = timing capacitor, it was found that using the values shown (C = 100µF and R = max. of 2·01MΩ) that the maximum time that could be selected was 221 seconds or just over three and a half minutes. This was found to be quite adequate during testing.

It can be seen from the circuit diagram that the start timing or trigger input (pin 2) is held at 12V via resistor R5. In this condition the timer circuit is in a quiescent state, and its output (pin 3) is at 0V. When the trigger pin receives a negative going pulse from the previous comparator stage, via C5, then the monostable timing period begins, so sending its output from 0V to 12V.

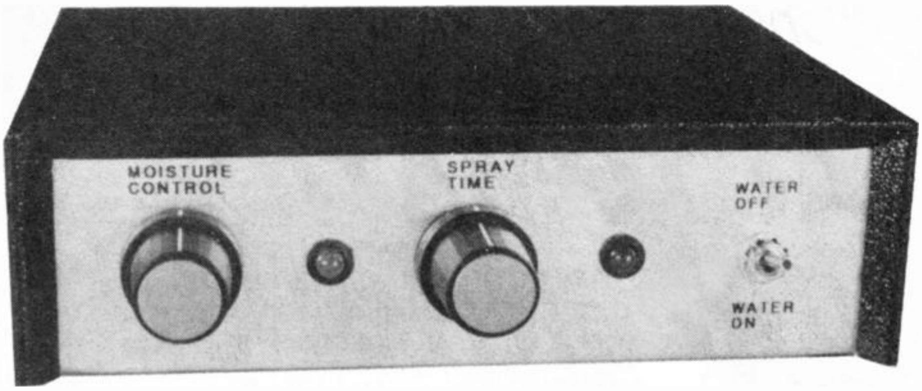
OUTPUT DRIVER

Because the water valve solenoid takes 220mA, and the maximum output of a 555 timer i.c. is only 200mA a buffer or driver stage, TR1, is needed. A 2N3053 *npn* medium power driver transistor was chosen for the job, but this device does need a small heatsink fitting to stop it getting too hot and approaching thermal runaway.

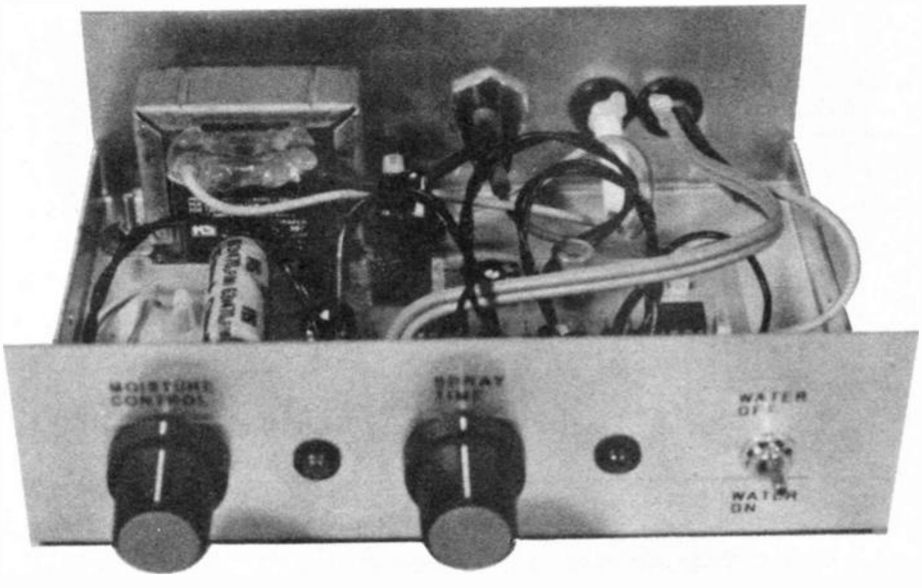
The input to TR1 is normally at 0V and as such is reversed biased, therefore its collector (c) is at 12V. When the 555 timer is in its timing mode the input to TR1 tries to go to 12V via resistor R7, therefore it is now forward biased and starts to conduct, its collector approaches 0V.

The l.e.d. D2 now illuminates via current limiting resistor R8, and the water valve opens, providing the output switch is closed. Diode D3 is connected across the water valve to stop any back e.m.f. appearing across the transistor TR1 and destroying it, when the water valve coil is switched off at the end of the timing cycle.

There are two points in the circuit worth mentioning, the first is that if the spray head above where the compost moisture detector is fitted becomes blocked the comparator output would remain at 0V and the water would spray continuously.



Front panel layout on the completed control unit.



COMPONENTS

Resistors

R1, R2, R6	10k (3 off)	See SHOP TALK Page
R3	100k	
R4, R8	1k2	
R5	330k	
R7	1k	

All 0·25W 5% carbon film

Potentiometers

VR1, VR3	1M enclosed carbon preset, lin. (2 off)
VR2, VR4	1M rotary carbon, lin. (2 off)

Capacitors

C1	470µ axial elect. 63V
C2, C4	1µ bead tantalum, 35V (2 off)
C3, C5, C6	100n polyester layer (3 off)
C7	100µ radial elect. 25V

Semiconductors

D1	Yellow high intensity l.e.d.
D2	Green high intensity l.e.d.
D3	1N4007 1A 1000V rec. diode
TR1	2N3053 *npn* medium power driver transistor
IC1	7812 12V 1A voltage regulator
IC2	LM741 op.amp
IC3	NE555N Timer
REC1	1A 200V Bridge rectifier

Miscellaneous

T1	6VA mains transformer: 240V a.c. primary, twin 12V secondaries
S1	Min. Off/On toggle switch
FS1	Chassis mounting fuseholder, with 50mA 20mm fuse

Printed circuit board available from the *EPE PCB Service*, code 895; metal case, size 152mmx 114mm x 44mm; 8-pin d.i.l. socket (2 off); 12V d.c. water valve solenoid and two ½in. to 15mm adaptors (see *Shoptalk*); 3-way screw-terminal block; twisted vane heatsink; TO5 heatsink; plastic p.c.b. mounting stand-offs (3 off); l.e.d. mounting clips (2 off); stainless steel rod, 2mm dia. x 15mm length for probes (2 off); 3-core 0·75mm flexible cable (approx. 2m length); approx. 6m twin flex; small rubber grommets (2 off); various crimps, tyraps, heslyn sleeves; multistrand connecting wire; solder etc.

Approx cost guidance only **£35**

This is protected from happening by capacitor C5. The 555 timer IC3 would receive one input pulse and would time out after its first spray cycle. It could not be triggered again until the output of the comparator returned to 12V, and then switched to 0V again.

The second point is the switch S1 fitted in the return leg of the water valve. This is included to enable you to set up the compost "moisture threshold" without spraying water every time, and also to switch of the water if you are working in the greenhouse in the proximity of the water mist spray jets – i.e. it stops you getting a sudden soaking!

CONSTRUCTION

The whole of the circuit for the Automatic Greenhouse Watering System, except the mains transformer, water valve, rotary controls, probes and "valve off" switch, is constructed on a single printed circuit board (p.c.b.). The printed circuit board component layout and full size copper foil master pattern is shown in Fig. 2. This board is available from the *EE PCB Service*, code 895.

The p.c.b. measures 112mm × 53mm and is housed in a box of dimensions 152mm × 114mm × 44mm. Before commencing work assembling the p.c.b. use the empty p.c.b. as a template for drilling the board mounting centres in the box.

It is as well at this point in time to position, mark and drill holes in the box for all the off-board components. See photograph for component layout guide.

Assembly of the p.c.b. should start with the smallest components first, these being the resistors and diodes. The two 8-pin d.i.l. sockets are soldered in place next.

Continue by fitting the rest of the components in size order, C1 being the last component to be fitted. Be especially careful when fitting the transistor, diodes, voltage regulator, bridge rectifier, and capacitors to get their polarity correct. Finish the p.c.b. assembly by soldering the connecting wires in place, and fitting the heatsinks.

After fitting all the "box" mounted components into the box, the p.c.b. can now be fitted by carefully installing it on the fully insulated p.c.b. mounts. The connecting wires from the board can now be connected to the various off-board components. It is good practice to use rubber Helsyn sleeves over the soldered joints to the l.e.d.s, potentiometers, switch, and mains fuseholder.

It is essential at this stage to make sure that the mains transformer and box are EARTHED, the earthing bolt (through one of the transformer mounting lugs) having shakeproof locking washers fitted to it.

Also make sure that all outgoing cables are mechanically secured. To insulate the exposed transformer 240 volt connections I use a clear silicon sealer, this when dry becomes an excellent insulator.

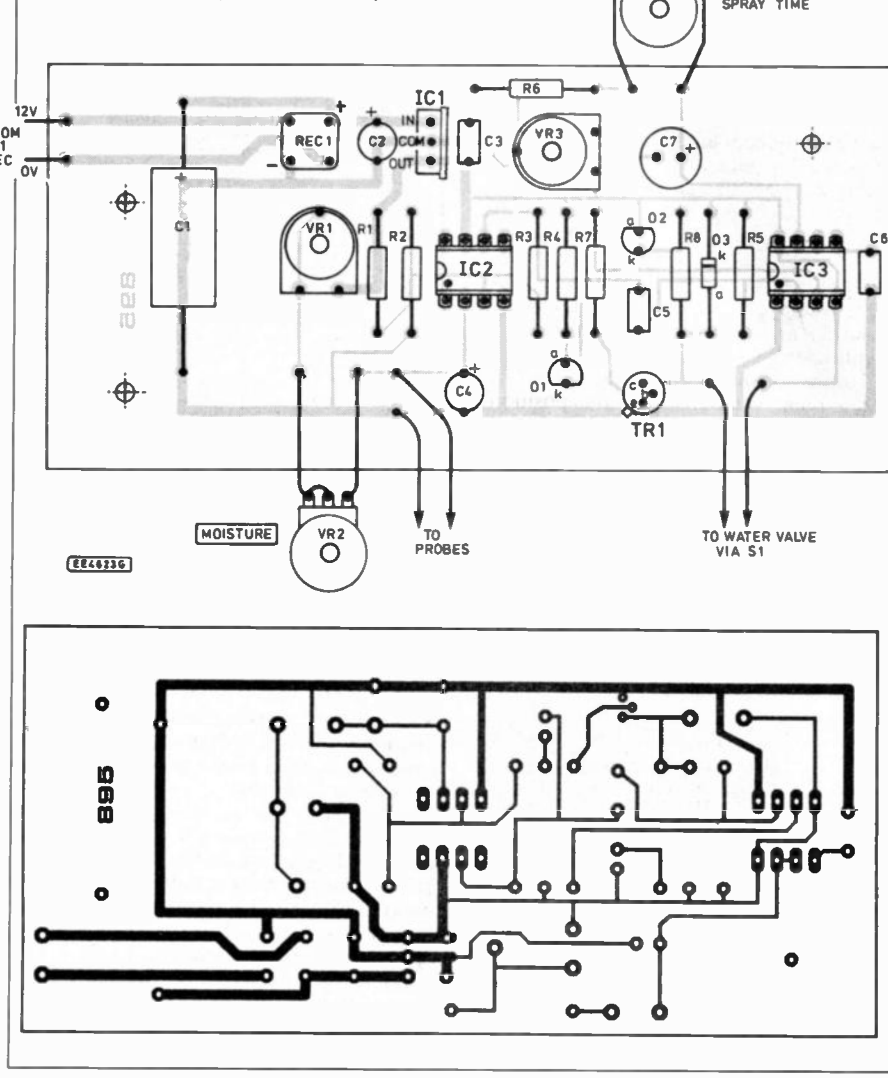
TESTING

EXTREME CARE MUST BE TAKEN WHEN UNDERTAKING THE FOLLOWING TESTS. SWITCH OFF BETWEEN EACH OPERATION!

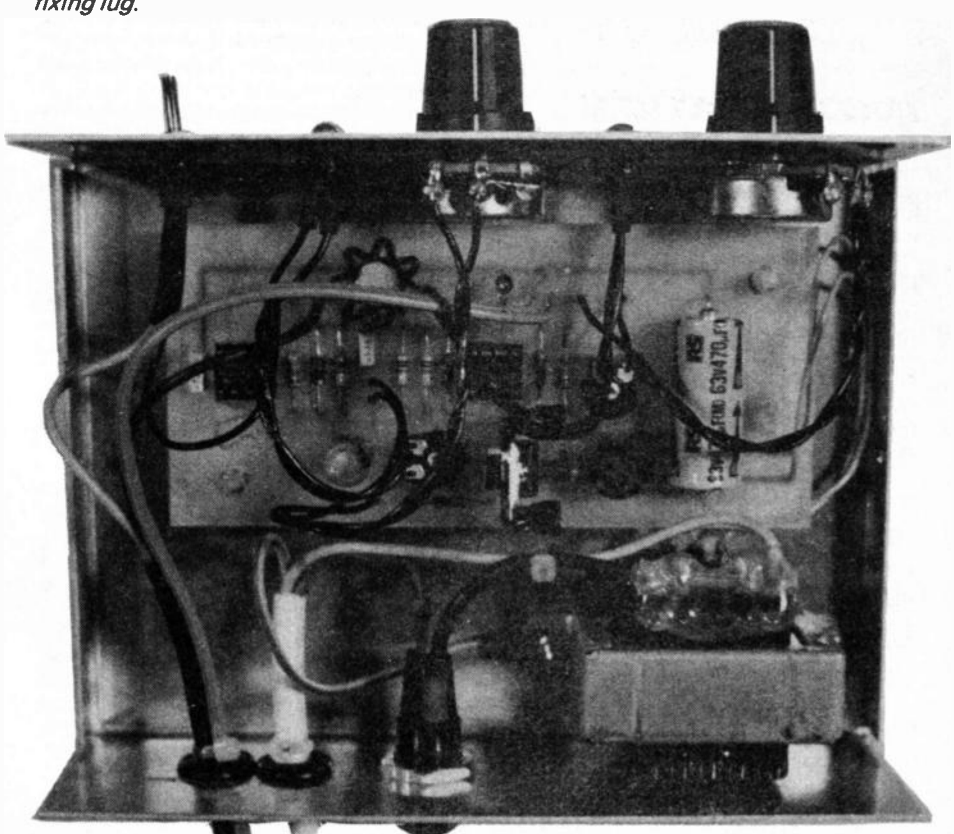
With the box lid off, the soil sensor probes temporarily shorted together, and the correct fuse (50mA) fitted, the unit can be plugged in and switched on. Apart from perhaps a gentle mains hum from the transformer nothing should happen.

Make sure that the spray enable switch S1 is in the *on* position. Remove the soil

Fig. 2. Printed circuit board component layout and full size copper foil master pattern.



Control Unit internal layout and wiring. Note the Earth tag bolted to the transformer fixing lug.



sensor short, l.e.d.s D1 and D2 should illuminate, and at the same time the water solenoid valve should operate. At the end of the preset timing period (determined by the position of VR3 and the timing control potentiometer VR4), the water valve should close.

The short to the soil sensor probes can now be re-applied, as the "soil" should be wet now. Try adjusting the Spray Time potentiometer VR3 and repeating the test until you are happy the timing circuit is working correctly.

Now temporarily connect a one megohm potentiometer across the soil sensor, with the resistance set to its minimum value. By slowly increasing the resistance of the potentiometer this is simulating the "dry out" of the soil in the greenhouse.

At a point determined by the position of preset VR1 and the Moisture control potentiometer VR2, the two l.e.d.s should illuminate, and at the same time the water solenoid valve should operate. At the end of the preset timing period (determined by the position of VR3 and the timing control potentiometer VR4), the water valve should close.

It should be noted that the resistance of dry soil is approximately 1·5 megohm, and the resistance of wet soil is approx. 150 kilohm across the 25mm gap of the soil sensor probe.

If the circuit fails to work, first check the a.c. voltage from the transformer on the p.c.b. at the bridge rectifier, this should be between 13V and 15V with no load on the transformer. If all is well measure the d.c. voltage across the power supply reservoir capacitor C1, this should be around 17V to 22V providing the transformer is off load.

If all is still well check the d.c. regulated voltage across the 741 op.amp IC2. Pin 7 being positive and pin 4 being negative, this should be 12V.

If all these voltages are correct re-check the p.c.b. for correct assembly, make sure that all the polarity conscious components are the correct way round, also check that all the resistors and capacitors are of the correct values. Check that all the soldering is sound and there are no "dry joints" or short circuits.

INSTALLATION

Installation in the greenhouse is reasonably straightforward. The main electronic control unit MUST be positioned away from any water sprays, and the best position is usually quite high up on a small shelf.

The 240V a.c. mains supply to the Control Unit is by a 13A plug. If the electrical installation in the greenhouse has been installed correctly and complies with the *15/16th edition of the IEE wiring regulations* this will be through a splashproof 13A socket which will be protected against earth leakage currents by a 30mA RCD. ***The importance of this device cannot be stressed too strongly.***

The Soil Sensor Probe is made up from a strip of three-way 5A plastic terminal block with 2mm × 45mm stainless steel rods fitted into the outer two connectors along with the sensor wires, this gives a gap of approximately 25mm between the sensor rods. The sensor rods can be angled down slightly if required.

The connection to the water supply is via a 15mm copper water pipe which in my greenhouse is tee'ed off the alkathine supply pipe before the greenhouse tap. It is a good idea to fit a stop-tap into this copper pipe so that the electronically controlled solenoid valve can be isolated if necessary, and in winter to

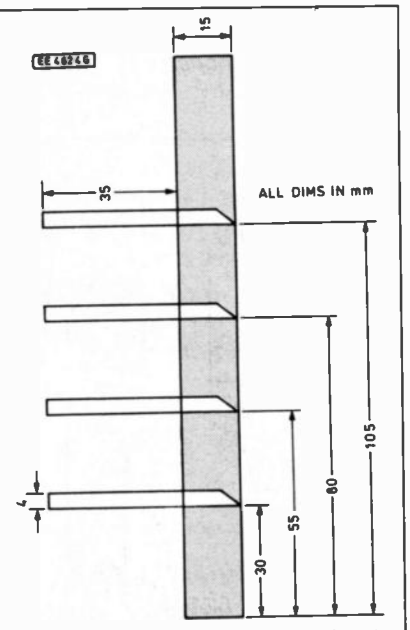


Fig. 3. Water distribution manifold.

stop freezing up if the main water supply to the greenhouse is left on.

After the 12V solenoid valve has been fitted in place a small home made water distribution manifold must be fitted. This is to allow the small plastic pipes to the spray valve lines to be fitted.

The manifold is made out of a 150mm piece of 15mm dia. copper water pipe with four small holes drilled into it, each with a 25mm spacing. Four small lengths of car brake pipe, with the ends that go into the copper pipe cut at 45 degrees, are now inserted into these holes and soldered.

The unused end of the copper pipe is now sealed off with a "Connex bung". See Fig. 3, and photograph.

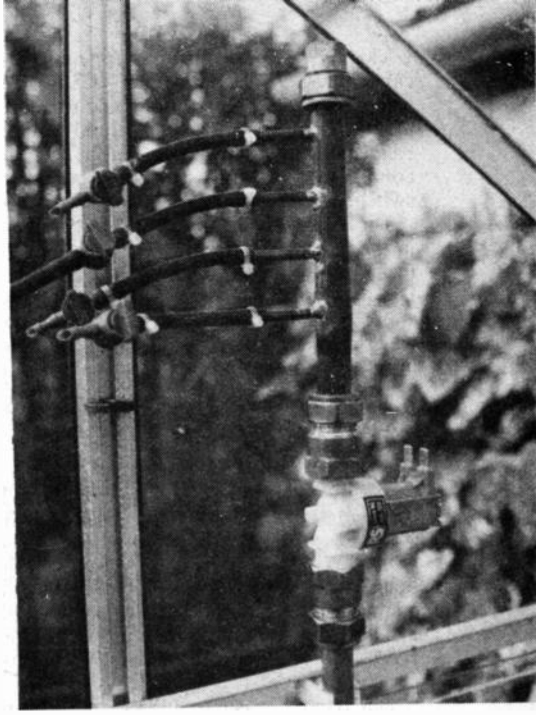
From the small manifold pipes the small plastic pipes to the spray jets can be run, these are held in place with small "tyraps". I recommend that a small plastic tap is fitted to each spray line so that any line can be isolated if required. I also recommend that no more than six spray heads are fitted to one line.

Once the plumbing part has been finished and the solenoid valve has been connected the water stop-tap can be turned on, and assuming that there are no leaks everything will be dry and water-tight. With the water switch S1 in the off position on the control module, the mains power can now be applied.

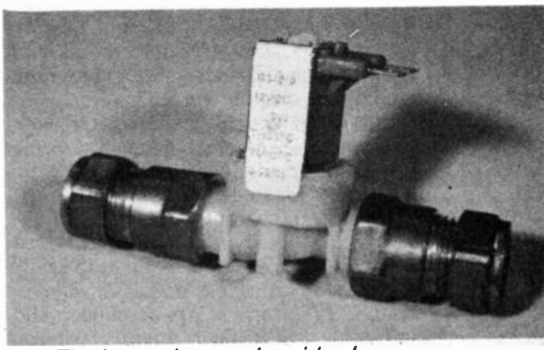
Fit the soil sensor into the soil or compost of one of the seed trays or plant pots to be monitored, and when the soil is at a "dryness" level to require watering adjust the Moisture control (also using the preset VR1 on the p.c.b. if required), until the Moisture l.e.d. illuminates, followed rapidly by the Spray l.e.d. This is now set.

The Spray Time control VR4 can now be adjusted to give the correct spray time, usually around one to three minutes. Again adjustments may have to be made using the board preset VR3. Adjustment of the unit is now complete, and the water switch S1 can be turned on.

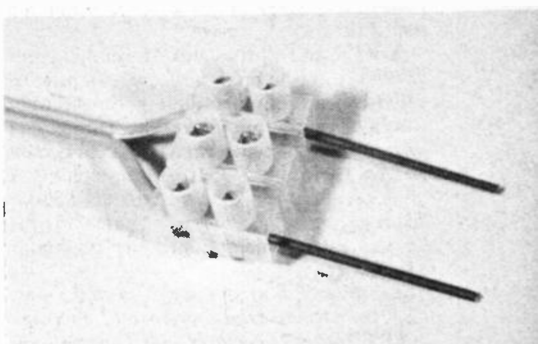
The unit will now commence to work automatically keeping the seedlings and plants watered when necessary. On entering the greenhouse to do work it is good practice to turn off the water switch on the Control Unit, this will stop you getting an unexpected soaking! □



The water mainfold connected to the water solenoid. Note the plastic taps attached between the spray line and manifold.

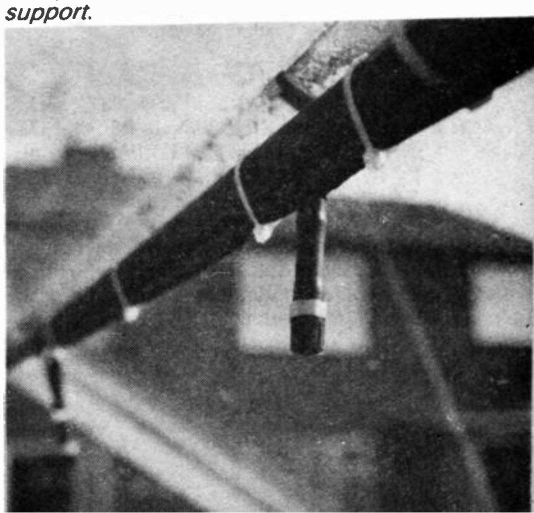


The low voltage solenoid valve.

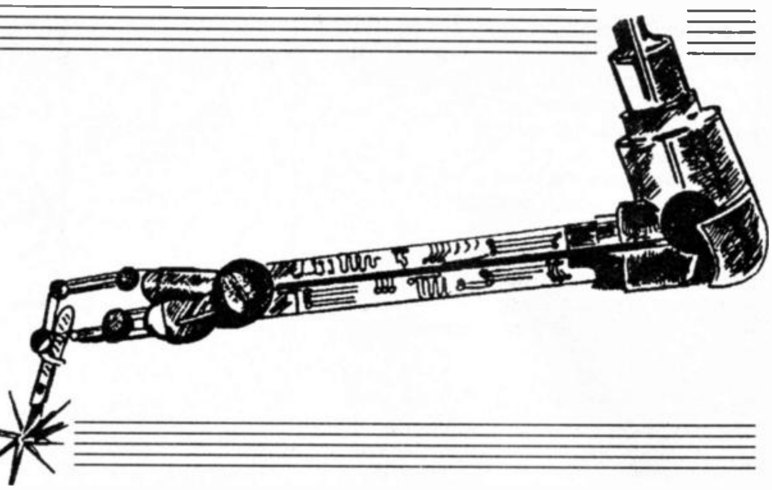


The moisture probe is made from a terminal block and stainless steel rods.

Spray jet running across a greenhouse support.



CIRCUIT SURGERY



ALAN WINSTANLEY

Our regular round-up of readers letters, hints and tips this month continues with a refinement of the Bilge Pump Controller. Also advice on water level detection probes plus readers' feedback.

Water Probe

Recently I suggested a circuit for a quick and easy electronic water level detector, designed with the boat owner in mind (*Bilge Pump Controller*, June and July issues). There was a mixed reaction amongst some of our ocean-going readers, some of whom preferred improvising with any materials to hand rather than adopting an electronic approach. I still reckon that the LM1830N i.c. fits the bill admirably and will offer a good reliable solution in what is quite a demanding application.

Mr. Frank Eltham of Wareham picked up the theme again, with our *Water Wizard* project (July *EPE*).

I read with great interest T.R. de Vaux-Balbirnie's Water Wizard *article. Some three or four years ago I had to design a similar system using the LM1830N i.c., though I used a programmable digital timer with l.c.d. display. I found myself in a slight dilemma as to the type of sensor to use, and over the weeks tested many designs.*

I tried a similar method to the author but encountered the problem of the soil losing contact with the sensor after a few weeks of wet/ dry soil cycling. [Probably worse with heavy clay soils, I would think.] *Eventually I arrived at the design shown in Fig. 1.*

I used some double-sided p.c.b. with a wire soldered on each side and embedded in a short length of 20mm conduit, to protect the cable after months of total immersion. I used a TNC coax connector so that I could disconnect the sensor in case of damage. The copper was initially nickel-plated but this corroded after a few months, so gold plating was used with success, as the probe had to remain in the soil for several years.

Thanks for the tip. Perhaps a local p.c.b. manufacturer could help with the gold flash-plating. Another suggestion might be to make one end of the probe pointed, to make insertion a little easier. As more and more Water Authorities install water meters – I've escaped so far in my native region! – I think we will be seeing more water-saving devices yet amongst our constructional articles.

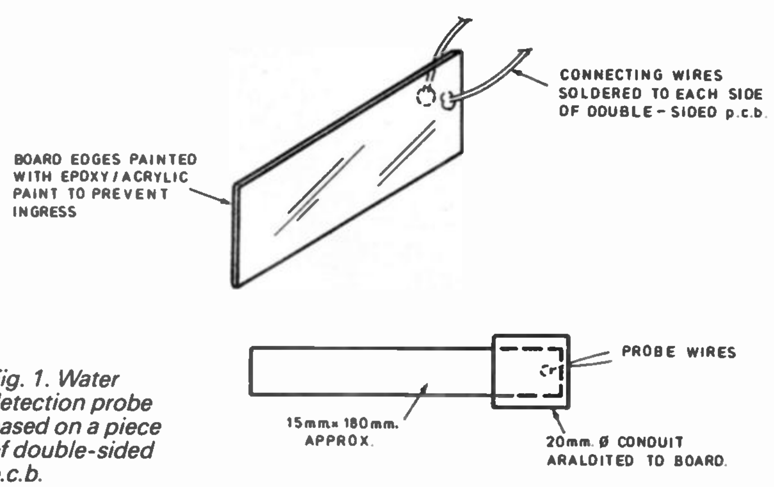


Fig. 1. Water detection probe based on a piece of double-sided p.c.b.

Power Factors

Whilst not wanting to become too involved with "electrical" topics, my piece on fluorescent lighting power consumption ("Shed Some Light", June issue) prompted ***Mr. L.G. Sutton*** of Burton on Trent to provide more information. Recall that the power consumption rating printed on a light tube does not fully account for the additional power losses incurred by the rest of the lighting circuit. My thanks to Mr. Sutton who says:

IEE Regulations quote that, where exact information is not available, provided the power factor of the circuit is not less than 0·85, the current demand of a discharge lamp can be calculated from the wattage of the lamp multiplied by 1·8. Therefore the steady current of a discharge lamp is given by $I = P/V \times 1{\cdot}8$. For example, if a circuit supplies five 65W 240V fluorescent fittings, the current demand would be 2·43A in total.

You might sometimes hear the term "power factor" of an a.c. circuit (such as a fluorescent lamp or motor), which is denoted by the expression "cos θ". This factor is relevant to power consumption values in a.c. circuits containing inductance or capacitance (or a combination of both).

The voltage and current cycles are up to 90° maximum out of phase in such a.c. circuits; only in a purely *resistive* circuit are the two perfectly in phase when the power factor is 1, in which case, $P = IV \times 1$ – in other words, all of the power drawn from the mains is being converted into useful work. However, in the inductive circuit of a fluorescent lamp or, say, an electric motor, the current *lags behind* the voltage waveform by the *phase angle* (θ) of the circuit. (Back-tracking to the resistive circuit, the phase angle there is 0° because both current and voltage are in phase: the cosine of 0° is 1, hence the power factor is 1.)

The greater this phase lag, the worse things become – for industrial users at any rate – because currents are flowing in between times which do no "useful" work such as driving the lamp or powering the motor. Instead these *reactive* currents cause unwanted heating effects in the circuit's capacitors and inductors (which after all, are not perfect components as they must contain an element of resistance).

As we know, the power a circuit seems to consume overall is simply $P = IV$ (this is often termed the "apparent power" in a.c. conditions), and is something you could maybe measure with a voltmeter/ ammeter. In reactive circuits this formula is modified by the power factor to account for those "idle" currents which don't do any useful work. The "real" power in a circuit is equivalent to IV cos θ. The ratio of real power to apparent power is another way of determining the power factor of a circuit, leaving you with cos θ once again. Heavy stuff!

You might also hear occasionally of "power factor correction capacitors". These add-on components are used to try to reduce the lag between the voltage and current cycles, making them nearer in phase with each other and increasing the power factor towards unity (1). This way, more of the power put into an a.c. circuit performs useful work.

As another example, my ultra violet exposure unit for developing p.c.b.s contains two fluorescent tubes and one ballast. The marks on the ballast are *I ≐ 0·165A Cos θ = 0·47*. The current is stated as 165mA. But on a nearby diagram it shows an optional power factor correction capacitor of 1·5µF 250V placed across the mains, in which case, it says, I = 0·092A and cos θ becomes 0·85. Hence the power factor could be improved nearer to 1 (when θ = 0°) if a p.f. corrector was added. On the whole, though, it's only an issue to larger industrial users and not those on a simple domestic tariff. Another reader seeks help with a UV Unit – see *Feedback* later on. Now back to electronics!

Controller Modifications

Meanwhile, rummaging through my "In" tray, ***Mr. Michael Price*** of Jersey, CI added a few pertinent comments on the Bilge Pump Controller, June issue.

I very much appreciated your column on the Controller, however I would like to suggest that it is not entirely suitable in that it will only maintain the bilge water at the level set by the probes. In an open boat this would result in the pump switching on and off frequently in a heavy shower. A better result in a boat with easily accessible bilges would be achieved by means of a submersible pump with a float switch.

In my own case, my sailing boat has a very deep and narrow bilge which won't accommodate the bulk of such a pump, so some form of electronic probe is essential if the bilge level is to be monitored automatically. I reckoned your circuit might again not be suitable because the bilge level may vary only temporarily, e.g. when the boat is heeled the water is different either side of the centre line and the motion of the boat may activate the pump too frequently, producing an unacceptable battery drain.

In actual fact, my original circuit ***did*** make some allowance for the motion of the boat, because I incorporated a time delay into its operation, though this probably wasn't entirely evident from the circuit schematic. Fig. 2 shows the output section of the LM1830N i.c. in more detail, extracted from the original

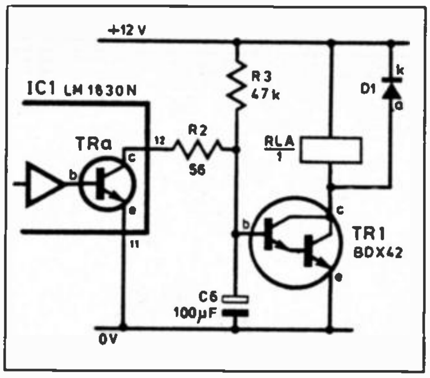


Fig. 2. Output section of original Bilge Pump Controller.

Bilge Pump Controller circuit diagram.

Internally, the chip has an output transistor TRa and the collector (c) is accessible at pin 12. TRa is switched on under "dry" conditions. Consequently, current flows through resistor R3 and R2 and sinks into TRa to 0V.

(Incidentally, with many types of i.c. the output transistor collector is "exposed" for external connection, just like pin 12. These are termed *open collector outputs*, notable because when they are conducting, the chip obviously *sinks* current, not sources it.)

With TRa conducting (dry probes), this prevents the Darlington transistor TR1 from turning on, because its base current is being shunted to 0V via pin 12. I added R2 to limit the peak current from the capacitor's retained charge to 20mA, which is the absolute maximum rating for TRa sink current.

What happens when the probes sense water? TRa switches off, and this permits base current to flow into TR1 through R3. However, I added the comparatively large electrolytic capacitor C6 (100µF), and this introduces a time delay of a second or two before TR1 is able to conduct (its base must be about 1·2V more positive than the emitter for the Darlington to conduct and operate the relay). So the probes have to detect moisture for a certain continuous time period before the pump can switch on.

All At Sea

I included this slight delay to allow for water slopping around in the bilges but there's no reason why this capacitor couldn't be increased in value to lengthen the switch-on delay. I would have thought that this delay would be adequate to prevent the pump switching on and off erratically – but there's no substitute for trying it out.

A large electrolytic capacitor has a very poor leakage current characteristic (see "Capacitor Selector", August issue) which will lengthen the delay even further. One danger is that if C6 is *too* large, (say several thousand µF) leakage may cause base current to be shunted through the capacitor straight to ground, and the Darlington may never turn on at all.

Whilst the original circuit might well be adequate for many readers, in an attempt to improve the circuit further, out came my *Mini Lab* and I eventually produced Fig. 3, which will probably give those "do-it-yourself" readers apoplexy! It divides into two sections – a "switch on delay" circuit and a second timer to drive the pump.

I modified the switch-on delay of the original controller design by adding an op.amp buffer configured as a Schmitt trigger to provide bounce-free triggering. IC2 provides a pre-settable switch-on time delay at VR1. Now the probes must detect moisture for a time period set by VR1, otherwise C6 remains discharged by the LM1830N (as before).

The inverting input (pin 2) is thus shunted to nearly 0V by the water sensor i.e. under "dry" conditions, and so pin 6 is high and remains high until the op.amp switches over after the time period generated by R3/ C6/ VR1. This adjustable switch-on delay could be the best part of a minute or even more.

When the op.amp IC2 times out, a negative-going pulse is transmitted through capacitor C7 which triggers IC3, a 555 timer configured as a monostable. Recall this needs a low signal at pin 2 to trigger (see "555 Timer Triggers", July issue). The timer chip powers a relay which switches on the bilge pump for a delay determined by VR2 – approximately three minutes or so, maximum.

Once the pump has switched on after the initial delay of IC2, any further trigger signals caused by water slopping about are ignored, since the 555 trigger is capacitively coupled. After the 555 period has expired, the pump switches off and the LM1830 must then detect the presence of water again *for a continuous period set by VR1*, otherwise the pump stays firmly off. So now you can deter-

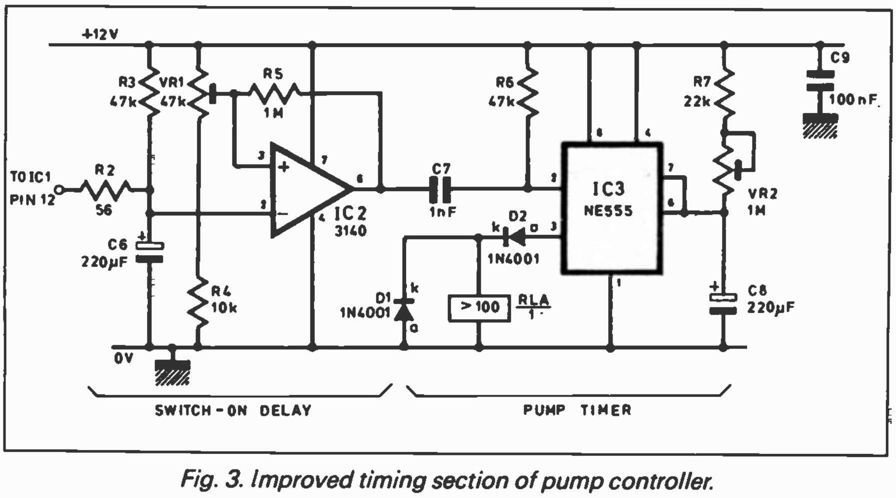


Fig. 3. Improved timing section of pump controller.

mine how long a time period must pass before the pump switches on – maybe have a switch instead of VR1 to adjust for fine or choppy seas? – and also determine how long the pump itself will be operating.

This modified circuit is more flexible and adaptable, the circuit has been breadboarded successfully and part types aren't too critical. It has not been tested at sea and as always, constructional details are left to the reader.

Hopefully, the text contains enough information for readers to adapt the circuit to fit their specific requirements. I would be happy to receive any more feedback from mariners to pass on to fellow readers.

Feedback

The very last word on our present nautical theme is from ***Mr. Gerald Taylor*** who asked for a marine battery back-up last month, for his GPS and Decca navigators. I'm always delighted to receive feedback from readers: Mr. Taylor has been experimenting with the ICL7673 and reported that the switch-over circuit hasn't caused any problems so far with the navigation equipment. In fact, Mr. Taylor had been using TIP2955 *pnp* power transistors, but these have a low gain and needed fairly low base resistors, and so I would still plumb for Darlingtons or MOSFETs.

More feedback, ***Mr. Robert Baker*** who enquired about the *Halogen Lamp Protector* (June issue) has built five of the suggested units and is delighted. "*After the first minute of operation the light loss is so small that one would hardly know the suppressor was there!*", he says. I'm sure the units will pay for themselves in the longer term.

Mr. S. Mercer of Retford, Notts., dropped me a line seeking help with a UV Light Unit, and also offered a simple design for a Car Electrics Probe (shown in Fig. 4).

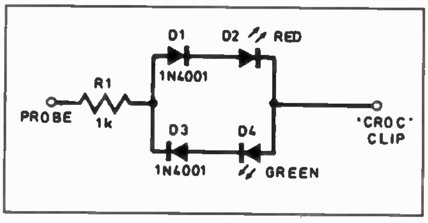


Fig. 4. Simple car electrics probe to determine presence and polarity of voltage.

Having started making printed circuit boards (p.c.b.s) for myself, I thought I would like to use ultra-violet sensitive boards, but UV exposure units are expensive. Any ideas? Also, following on from your Car Electrics Probe, I enclose a simple car probe which I have used for several years, in case this is of interest to others.

Thanks for your letter. I sympathise with the problem, those ready-made UV Exposure Cabinets aren't cheap, but checking back in the October 1991 issue of *Everyday Electronics* we published a design for a *UV Exposure Unit*. This has just the one tube and is built into a small box with a handle on it – you simple lay the box over the p.c.b. and UV light shines down onto the p.c.b. laying on the table. It's much more economical to build than one of the commercial versions and will be fine for smaller projects or for "cutting your teeth" on the UV technique.

You might also find of interest, our fully illustrated series *Making Your Own Printed Circuit Boards* which was published in *Everyday Electronics*, May to July 1992 and featured the hands of yours truly in the starring role. This series contains some valuable and essential fault-finding information which will be very handy when you try the ultra-violet exposure system the first few times. Based on my own experiences, the novice will particularly benefit from it.

Circuit Surgery is our "help line" column to exchange information with other readers, students and newcomers to electronics. We receive dozens of letters every month requesting help, say connecting together a hi-fi or hooking up a satellite receiver. We do our best but unfortunately we cannot guarantee to reply to every letter or advise on the repair or modification of commercial equipment, but we read every letter and listen to your views.

Next month: Another selection of readers' letters, including a quick look at simple nickel-cadmium charging. If you have any queries or potential ideas for discussion in this column, or anything you think will be of interest to fellow readers, then please drop me a line: Alan Winstanley, *Circuit Surgery*, Allen House, East Borough. Wimborne, Dorset BH21 1PF.

SHOP TALK

with David Barrington

Before we look at any possible component buying problems that are likely to be encountered when undertaking this month's constructional projects, we should like to add a word of caution. The Greenhouse Watering System, Lamp Controller, Dancing Fountains and Seismograph projects are all *mains* driven and extreme care should be taken at ALL times when wiring-up and testing these units. *If in any doubt, seek professional advice from a qualified electrician.*

An added risk with the Greenhouse and Fountain projects is water! In this instance, it is a MUST that a mains circuit breaker (RCD – residual current device) be included in the mains primary input line. Most of our components advertisers should stock RCD "plugs".

Three-Channel Lamp Controllers

It is most important that capacitors C2 and C3 used in the *Three-Channel Lamp Controller* are rated for continuous 240V a.c. mains voltage operation. These are usually sold as high voltage "class X" or "class Y" types and should be available from most component supplies advertisers.

Some difficulty may be experienced in finding a 100µH 4A choke. A fairly extensive range of chokes is stocked by **Cirkit** (☎ *0992 448899*) and they should be able to come up with the right item. The choke used in the model was purchased from **Maplin**, code UM15R (Ind. 1200/5/H). The surge protector across the mains also came from the same source, code HW13P.

The six-pin d.i.l. infra-red diode/transistor opto-isolator used in the model is the Maplin type, code WL35Q. This appears to be a fairly standard device and it is quite possible other types will work in this circuit – but they have not been tested in the unit.

The designer opted for a 4-pole 3-way rotary switch in the prototype model, and only used one section. The single-pole types are usually 12-way (position), with an adjustable limit stop.

The controller printed circuit board is available from the *EPE PCB Service*, code 893 – see page 711.

Greenhouse Watering System

The 12V d.c. water valve solenoid and ½in. BSP to 15mm pipe compression adaptors called for in the *Greenhouse Watering System* are RS devices and were ordered from **Electromail** (☎ *0536 204555*), order codes 342-023 (12V d.c. water valve) and 342-039 (pipe adaptors).

Note that when ordering the l.e.d.s they should be the "high intensity" types. Also, the choice of case is left to the individual but it should be a *metal* type so that it can be safely "Earthed". The one used in the prototype is the **Maplin** WB2 aluminium case, code LH37S.

The printed circuit board for the control unit is available from the *EPE PCB Service*, code 895.

Protector Plus Car Alarm

No real problems should present themselves when shopping for parts for the *Protector Plus Car Alarm*. The main decision will be the choice of electronic warning siren. The device shown in the article is a 12V d.c. miniature piezo siren giving a fast rising and falling sound output of 115dB at 1m. This was purchased from **Maplin**, code JK43W.

Don't forget, the "Panic" switch contacts must be isolated from the car chassis. Also, remember to use auto-type wire when installing the unit in the vehicle.

Experimental Seismograph

There are several options or set-ups available to constructors of the *Experimental Seismograph* and whichever course is taken the only "special item in the components listing is the Hall Effect sensor. The LOHET II Hall effect sensor is currently only listed by RS and was purchased through their mail order outlet **Electromail** (☎ *0536 204555*), code 650-548.

The rest of the components seem to be standard "off-the-shelf" devices. The printed circuit boards for the Seismograph are available from the *EPE PCB Service*, codes 896 (Sensor/Filter) and 897 (Clock/Mixer).

Dancing Fountains

The concluding part, this month, of the *Dancing Fountains* project features an add-on *PC-Compatible Interface* board. We are happy to report that, as far as we can see, all parts for the Interface are readily available items and should be stocked by most of our component advertisers.

The opto-isolators, used in the Pump Controller board (last month) are the only items that may be hard to track down. These appear to be RS devices and were purchased through Electromail (☎ *0536 204555*), codes 585-258 (transistor output) and 308-196 (triac output). The 4A 600V triac types BT134 or BT136 should be stock items or suitable alternatives may be offered.

The small double-sided printed circuit board for the Interface is available from the *EPE PCB Service*, code 892. Also available are the Preamp, Pump Controller and Filter boards, codes 889 (preamp), 8090 (pump) and 891 (filter) – see page 711. The choice of water pump is obviously left to the individual.

EXPERIMENTAL SEISMOGRAPH

JOHN BECKER

Tune in your computer to the seismic singing of intra-planetary rock and roll.

HAVING witnessed at first hand the results of earthquakes in regions around Greece and Morocco, it was with interest that I read the *Seismograph* constructional article in *Everyday Electronics* of October and November 1989. In the article, Tony Hopwood and Andy Flind described a single seismographic sensor whose output was monitored by a pen recorder.

The authors commented upon the possible difficulty of recording data on a computer and speculated about the use of Hall effect sensors instead of tuned coils. Reference was also made to the wide range of frequencies generated by earthquakes and other land movements, both natural and man-made.

Inspired by their article, I designed the seismograph described here to explore the earth movements referred to and the implications of the authors' comments. Throughout the design, much emphasis has been placed on versatility and adaptability.

DESIGN SCOPE

Although the term seismograph literally refers to the recording of earthquake activity, the scope of this design allows the recording and examination of a whole range of ground vibrations, including those generated by nuclear and volcanic explosions, avalanches and landslides, tidal movements, traffic and trains, quarrying and building sites, to name but a few.

The Seismograph can be built using up to eight Hall effect sensors, each responding to different earth movement frequencies and directions. Two types of pendulum sensor mount are described here, and the pendulum design from the original *EE* article could also be used with only minor modifications. The simplicity of the pendulum designs enables the system to be tuned to ground movement frequencies ranging from several cycles per second to three or four cycles per minute.

A computer is used to display the sensor output results, either as real-time or recorded data. The data may be recorded on to computer disk and also, if preferred, on to a long-play reel-to-reel tape recorder. Principally designed for use with a PC-compatible computer, the Interface circuit can probably be modified for use with other computers. It seems likely that the Interface can be used with the original *EE* seismograph circuit.

Also to be described is a software listing which gives a quite comprehensive example of how the outputs from the sensors can be screen-displayed, recorded continuously or in response to triggered seismic events, recalled, processed, time-condensed, and printed out to a printer. The listing has been written for use with either GWBasic or QuickBasic.

SEISMOLOGY

A detailed discussion of seismology is beyond the scope of this article (and of its author!), but it is pertinent to quote the following facts.

There are four principal wave motions generated by an earthquake, as shown in Fig.1. The P-waves (primary) and S-waves (secondary) travel through the body of the earth, while the Rayleigh and Love waves travel along the earth's surface. Best observations of the waves generated are made within the period range of 0·5 to 2·0 seconds for body waves, and 10 to 60 seconds for surface waves. (Source: *Understanding the Earth*, Artemis Press, 1975, Open University set book.)

These waves can be detected by using a variety of pendulum techniques, although fully electronic stress recorders are also practical. The pendulums support a large mass to which one half of a sensor system is attached. The other half of the sensor is solidly fixed to the ground, either directly, or via a rigid support. When earth movements occur, the mass is inhibited in its movement because of its inertia, consequently the relative positions of the two sensor halves are changed.

Because the mass is suspended, the movement of its suspension (pivot) point will cause the suspending wire to move from its vertical position relative to the mass. Gravity then tries to restore the mass/pivot angle to normality, and so the pendulum starts to swing.

The period of the swing is directly related to the distance between the pivot point and the centre of the pendulum's mass. (This distance is not necessarily the same as the distance to the centre of the weight at the end of the pendulum since the mass of the suspension apparatus also plays a part, especially with a near-horizontal pendulum as discussed below.)

By changing the distance between the centre of mass and its suspension point, the pendulum can be tuned to respond to different earth movement frequencies.

Essentially, the actual weight of the mass does not affect the swing rate. The mass is

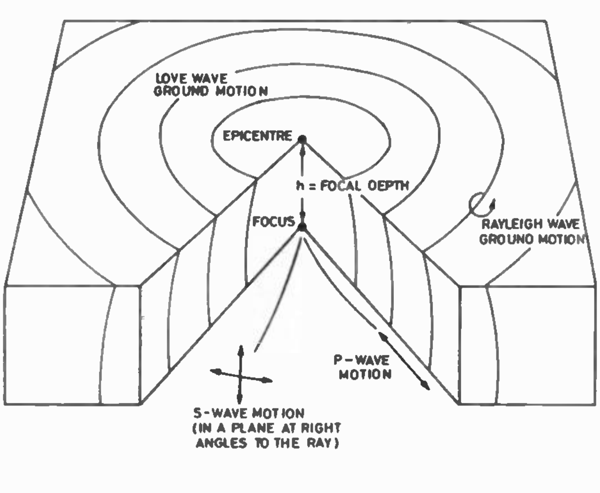


Fig. 1. The four principal wave motions generated by an earthquake.

only there to provide inertia for one half of the sensor. However, the physical size and shape of the weight will affect where the centre of total mass is actually located.

SENSOR MOUNTS

When first deciding to build a seismograph, I examined why it was necessary to use a comparatively complicated sensor mount such as the near-horizontal pendulum type described in the original article (referred to by the authors as a "garden-gate" type). Why couldn't a simple vertical pendulum be used? In fact it can, but the length of the pendulum determines its tuned frequency, and this has to be chosen to suit the type of earth movement that you wish to monitor, as referred to above.

The following formula for calculating the oscillation period of a simple vertical pendulum reveals that there are practical difficulties involved for monitoring the lower frequencies of the surface waves:

$T = 2\pi\sqrt{l/g}$

where T = period of oscillation, l = length of pendulum (from its pivot point to its centre of mass) and g = acceleration of free fall (often referred to as the acceleration due to gravity).

Taking g as its standard value of 9·80665 m/s^2, and calculating for different values of T, the following results are obtained:

PERIOD IN SECONDS	SWINGS PER MINUTE	PENDULUM LENGTH	
		METRES	FEET
2	30	0·99	3·26
2·5	24	1·55	5·09
3	20	2·24	7·33
3·75	16	3·49	11·46
5	12	6·21	20·37
7·5	8	13·97	45·84
10	6	24·84	81·50
15	4	55·89	183·37
30	2	223·56	733·48

Most households should be able to have installed a vertical pendulum of up to about 2·5 metres to cover the period range up to about 3·5 seconds, but obviously few will be capable of accepting a longer pendulum for monitoring surface waves (lighthouse keepers, perhaps?!).

However, if the angle of the pendulum relative to the earth's surface is reduced, longer oscillation periods can be achieved using shorter pendulum lengths. In other words, a near-horizontal, or garden-gate, pendulum provides the answer. It appears that, in seismographical applications, this type of pendulum may probably be called a Golitsyn (or Galitzin*) pendulum, and is referred to as such throughout this article. It is shown in simplified form in Fig. 2.

(*Source: *Penguin Dictionary of Physics*, although other references have been found as well.)

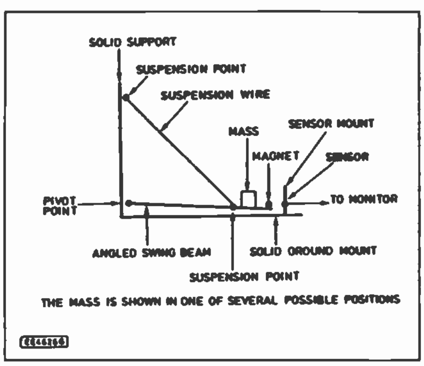
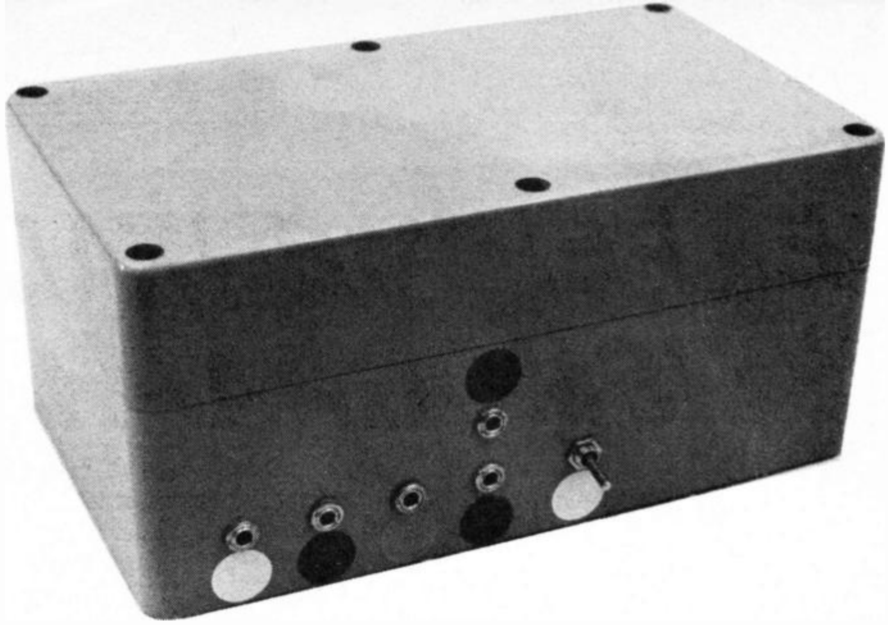


Fig. 2. Golitsyn-type Pendulum as modifed for EPE Seismograph.



Seismograph Interface housing, holding the sensor and mixer cricuits.

Regrettably, I have been unable to find the formula for calculating the behaviour of a Golitsyn pendulum. Perhaps a mathematically qualified reader might care to enlighten us.

Measuring the garage at home, it was found that there was just enough space to set up two vertical pendulums, and one Golitsyn. The vertical ones were given dissimilar lengths and their sensors mounted so that they respectively favour waves travelling roughly north/south and east/west. The orientation of the Golitsyn was determined by the garage wall position and is most sensitive to waves travelling in north-east/south-west directions. With a little bit of patience, it is possible to change the effective lengths of all the pendulums, so enabling different seismic frequency ranges to be examined.

Constructional details for the pendulums will be given next month. They are quite straight-forward to make, and not expensive.

HALL EFFECT SENSORS

Hall effect sensors, as used in this seismograph, produce an output voltage which varies with changes in the strength of a nearby magnetic field. In the seismograph, which ever type of pendulum mount is used, the sensor is attached to the fixed structure of the pendulum frame. A small magnet is attached to the pendulum, and the whole structure aligned so that the magnet and sensor are in close proximity. When the pendulum moves in response to ground vibrations, the sensor detects the resulting slight changes in the strength of the magnetic field.

The Lohet II sensor used in this design is a miniature three-pin high performance device with better temperature stability than the Lohet I or 634SS2 devices. It has an operational supply voltage range of 7·5V to 8·5V, a range which must not be exceeded.

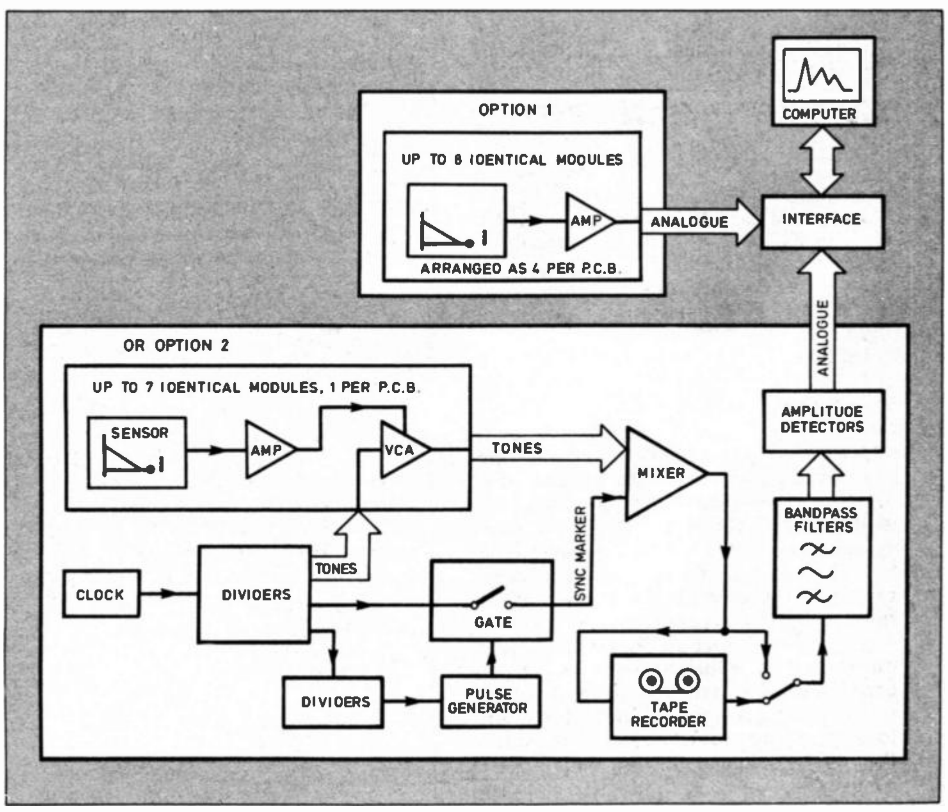


Fig. 3. Block diagram for the two main Seismograph monitoring options.

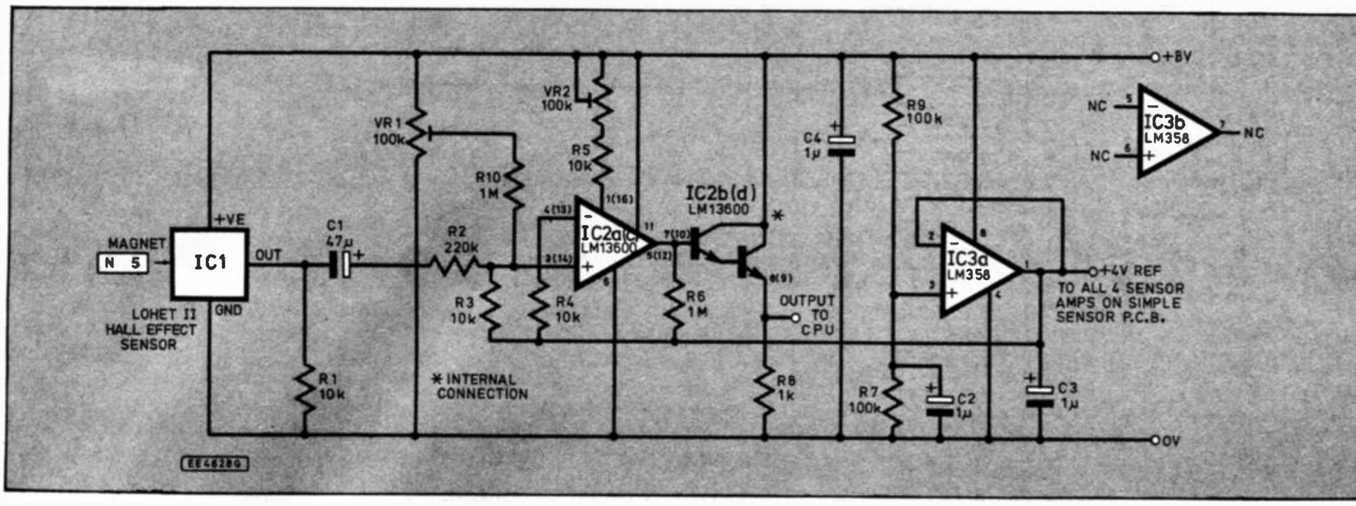


Fig. 4. Seismograph basic sensor amplifier circuit diagram.

In the absence of a magnetic field, the sensor's output voltage is half the supply line voltage. If the South pole of the magnet is brought close to the front of the sensor, the output voltage will decrease. The proximity of a North pole will cause a voltage increase. Magnetic fields behind the sensor have a reverse polarity effect. The device cannot be harmed by large magnetic fields.

CIRCUIT OPTIONS

The electronic circuits which monitor the sensors have been designed for assembly in one of two format options. The block diagram for these options is shown in Fig. 3.

In Option 1, the sensor's output is simply amplified up to a level which can be fed directly to the computer interface. With this option, only the computer can record the seismic data.

Option 2 allows the data to be recorded by a tape recorder as well as by the computer. The output from the sensor is amplified and controls the gain of a voltage controlled amplifier (VCA) to which a fixed-level audio frequency is sent and amplitude modulated. When more than one sensor is used, different frequencies are sent to each VCA. A separate circuit periodically generates a synchronisation marker pulse train at a different frequency. All the signals are combined in a mixer circuit and output to the tape recorder.

Bandpass filters separate the composite signal of Option 2 back into its different frequency bands. Via amplitude detectors, the signal data is then output to the computer Interface. A switch allows the computer to monitor the data either before or after recording.

OPTION 1 SENSOR CIRCUIT

Readers who do not wish to use a tape recorder should construct the simple sensor amplifier circuit shown in Fig. 4

The chip used for amplification is the dual transconductance op.amp type LM13600. In Fig. 4, the pin numbers for both halves of the chip are shown. The following description refers to chip stages IC2a and IC2b. The functional detail is identical to that for stages IC2c and IC2d.

The output of the sensor IC1 is a.c. coupled to IC2a via C1 and R2. Ideally, it would have been preferable to d.c. couple the sensor to the amplifier, so allowing extremely low frequencies to be handled by the circuit. To do so, however, would have made the setting-up of the sensor to magnet distance and the amplifier's balance too finicky to be practical. Nonetheless, the circuit still allows monitored seismic frequencies to be as low as at least four cycles per minute, and possibly lower, depending somewhat on the tolerance range of the input capacitor's value.

Amplifier IC2a has its gain set by the current flowing through preset VR2 and resistor R5 into its control pin 1, and through R6 from output pin 5. Stage IC2b is a high impedance buffer with an emitter load provided by R8, from where the amplified signal is sent directly to the computer interface.

Since the amplifier is a high-gain stage, its d.c. bias conditions need to be balanced to prevent output saturation. Preset VR1 provides the bias control via R10. The bias setting range provided by VR1 is in practice wider than would have been preferred, but printed circuit board space available was too small to allow additional range-reduction resistors to be placed either side of VR1.

The printed circuit board has been designed to hold four identical sensor amplifiers, formed around two LM13600s. Op.amp IC3a provides a midway reference voltage (+4V) to all of them. If fewer than four sensors are used, the unrequired amplifier components may be omitted. Conversely, since the interface circuit can accept eight inputs, two of these boards can be fully assembled.

OPTION 2 SENSOR CIRCUIT

The sensor amplifying stage for Option 2, as detailed in Fig. 5, is identical to that for Option 1, with the exception that the emitter of IC2b is fed via resistor R8 into the control node of IC2c.

To the signal input of IC2c is fed a fixed frequency and amplitude tone (clock) signal via resistor R15. Current changes through R8, as caused by relative movements of the sensor, vary the gain of IC2c, so varying the amplitude of the signal passed through. Capacitor C2 removes

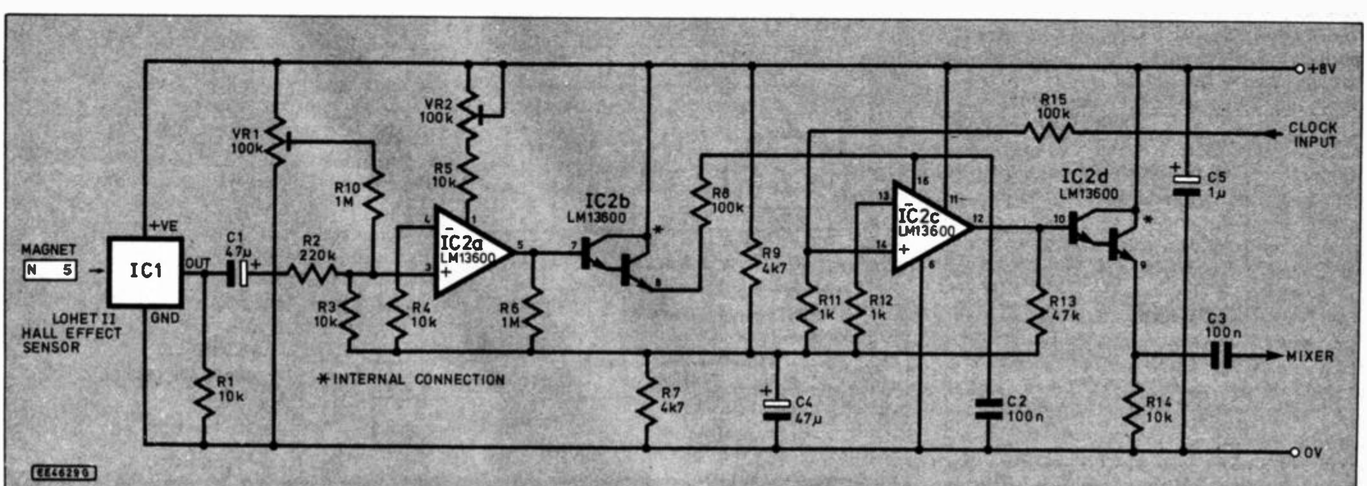


Fig. 5. Circuit diagram for sensor amplifier with VCA modulator.

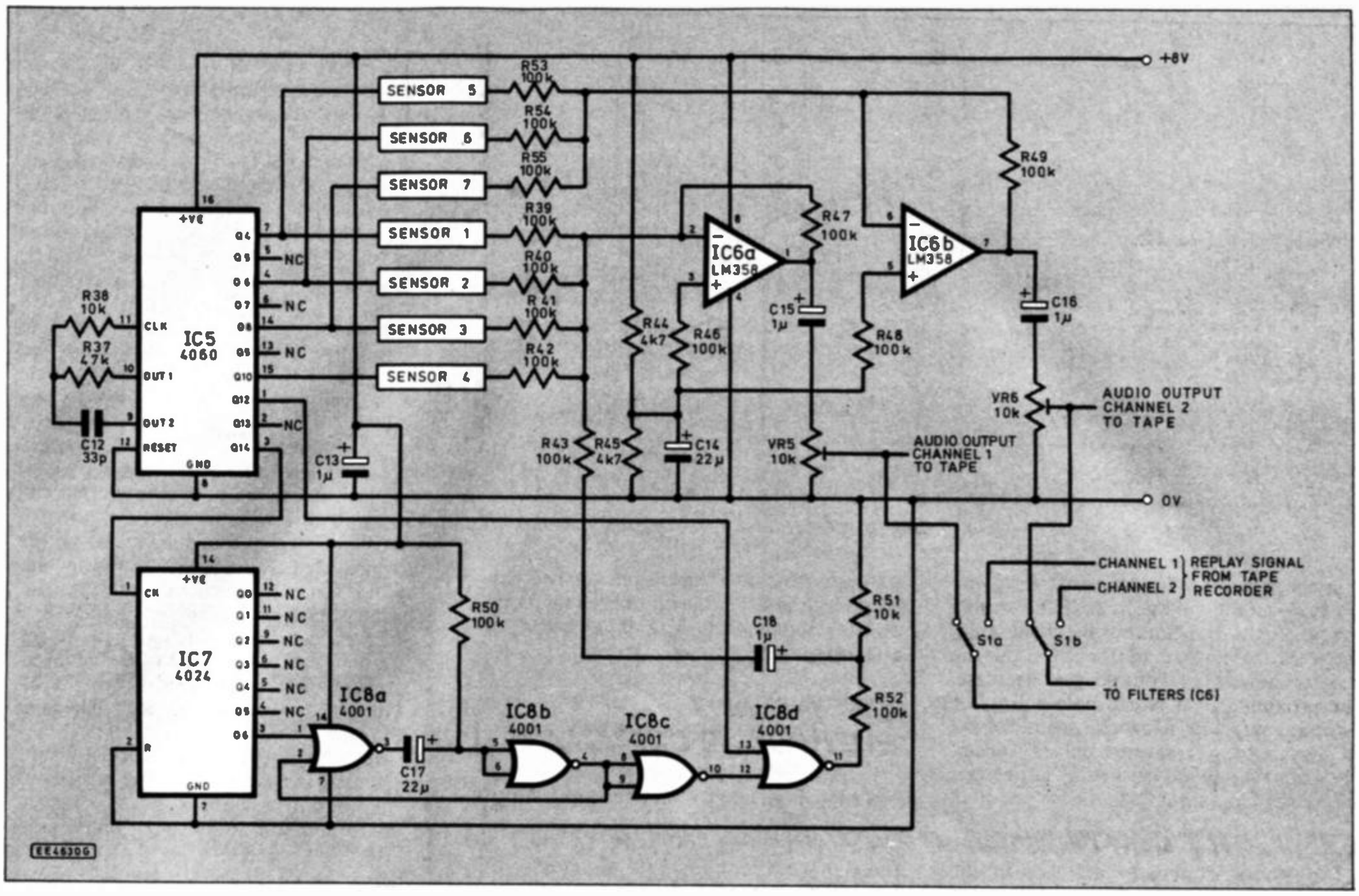


Fig. 6. Circuit diagram for the Seismograph Clock and Mixer stages.

unwanted higher frequency signal fluctuations.

The gain range of IC2c is set by the value of resistor R13. IC2d is a high impedance buffer from whose emitter output the amplitude-modulated tone is fed to the mixer stage shown in Fig.6. Midway bias voltage (+4V) for the circuit in Fig. 5 is set by R7, R9 and C4.

From here-on, the circuit around IC2c and IC2d is referred to as the VCA (voltage controlled amplifier).

CLOCK AND MIXER CIRCUITS

Frequency tones for the circuit in Fig. 5 are produced by IC5 in Fig. 6. This chip is a 14-stage binary counter with an integral clock oscillator whose frequency is set by the values of resistor R37 and capacitor C12. A higher frequency range may be set by decreasing the value of either component.

Alternate outputs of IC5 provide the individual tones for the circuit of Fig. 5. Adjacent tapped outputs supply frequencies two octaves apart from each other.

Passing through the VCAs of the sensor circuits, shown in Fig. 6 as numbered sensor blocks, the amplitude modulated tones are brought, as appropriate, to resistors R39 to R42 and R53 to R55. The two respective blocks of signals are summed at the corresponding mixers IC6a and IC6b, which are two halves of a dual op.amp.

From the mixers, the composite signals are output to the line inputs of the left and right channels of a stereo tape recorder. Preset controls VR5 and VR6 set the required maximum output levels to suit the tape recorder inputs.

It is not necessary to retain the same numbered sequence of frequencies and detectors as shown in Fig. 6. The signal routing order may be changed, and if fewer than seven sensors are used, unrequired components may be omitted, such as R53 to R55, R48, R49, C16 and VR6 for example.

An optional synchronisation pulse marker circuit has also been included. This is formed around IC7 and IC8.

The final clock output of IC5 is routed to IC7, which is a 7-stage binary counter. Output Q6 of IC7 is connected to one input of the NOR gate IC8a, Between them, IC8a and IC8b form a monostable circuit whose timed period is set by the values of R50 and C17. Each time IC7 Q6 goes high, the output of IC8a goes low, generating a negative-going voltage across C17, causing the output of NOR gate IC8b to go high.

Since this output is fed back to IC8a, the circuit remains in this semi-stable condition while C17 is being recharged via R50. When the charge on C17 reaches the trigger threshold, the monostable reverts to its previous state.

Buffered by NOR gate IC8c, the changing states of the monostable control the gating of the clock signal from IC5 Q12 though NOR gate IC8d. During the time that the monostable remains triggered, the clock signal passes through IC8d, is attenuated by R52 and R51, and capacitively fed via C18 and R43 to mixer IC6a.

The master clock frequency at IC5 pin 9 is approximately 233·6kHz, resulting in output frequencies of about 14·6kHz, 3·65kHz, 912Hz, 228Hz and 57Hz at outputs Q4, Q6, Q8, Q10 and Q12 respectively. These frequencies should be well within the acceptance range of most long-play reel-to-reel tape recorders, such as the Revox 10-inch spool machine used with the prototype.

When setting-up the sensor stages using VR1 and VR2, the maximum modulated signal strengths from the VCAs should be kept low enough to prevent the combined signal processed by the mixer from reaching saturation or clipping levels.

FILTER CIRCUIT

The combined audio signal, either direct from the mixer or as a replay signal from the tape recorder, is split back into its separate frequency bands by several identical bandpass filters, the circuit diagram for which is shown in Fig. 7.

One filter is needed for each sensor, plus an additional filter for the sync marker signal. Switch S1 selects between the pre- or post-recording routes.

Note that alternative switching arrangements could allow the tape recorder to record real-time data from the sensors on to one track while previously recorded data on the other track is replayed through to the computer. Further switching could allow the computer to display live and pre-recorded data simultaneously.

The filter is formed, in standard configuration for an LM13600 bandpass filter, around IC3a, IC3b, IC3c and IC3d. The centre frequency range is set by capacitors C7 and C8 and by the current flowing into the control nodes at IC3a pin 1 and IC3c pin 16, as set by resistor R19 and preset control VR4. The filter's *Q* or rejection factor is set by the feedback through resistor R20. The range of control provided by VR4 covers the full frequency spectrum of the signals generated by IC5 in Fig. 6.

A small amount of adjacent channel data can just be detected by an oscilloscope after filtering, but its effects were found to be insignificant. The use of tones two octaves apart helps to optimise filter rejection.

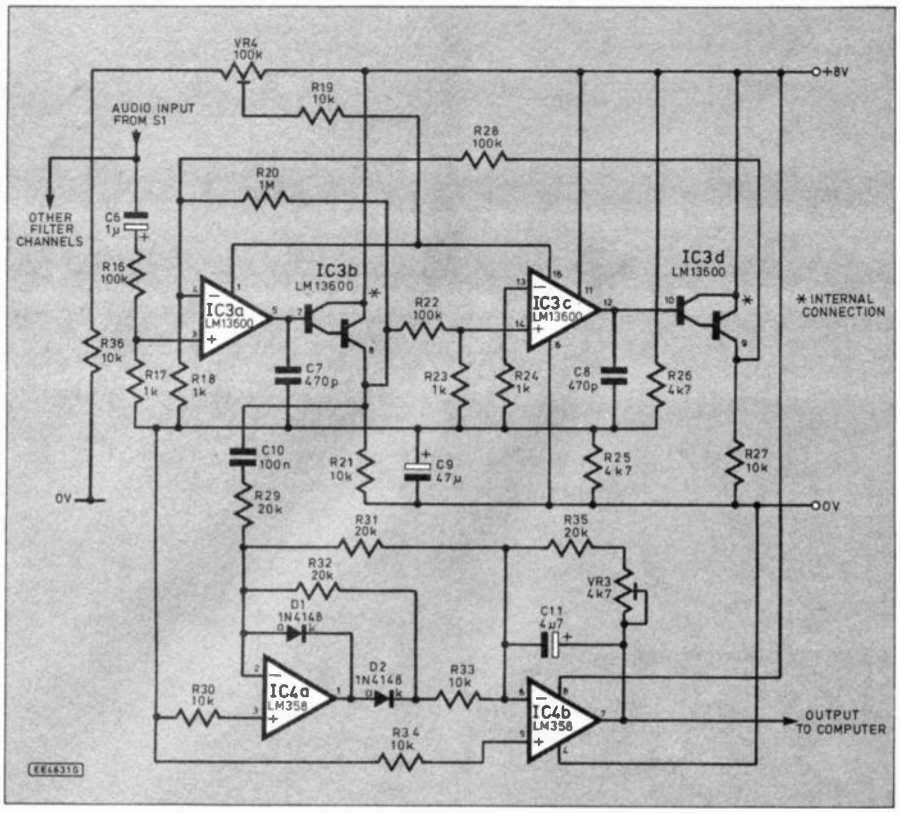


Fig. 7. Circuit diagram for the Filter and Amplitude Extractor.

From the bandpass output of the filter at IC3b pin 8, the signal is routed via C10 and R29 to the amplitude detector circuit around op.amps IC4a and IC4b. The signal is positively rectified by diodes D1 and D2 and smoothed by capacitor C11. Preset VR3 is used to slightly vary the gain of inverting stage IC4b so that the outputs of all sensor channels can be matched. Note though, that the basic matching between the channels should be done by adjusting the distance between the sensors and their magnets and then by adjusting VR1 and VR2 in Fig. 5.

The output signal from IC4b pin 7 is fed to the computer Interface, which will be described next month.

Midway reference voltage (+4V) for the filter and the amplitude detector is set by R25, R26 and C9.

The components for the sensor amplifier, VCA, filter and amplitude detector are all mounted on the same board. One of these boards is required for each complete sensor channel, plus an extra one for the sync marker filter. Only one Clock/Mixer board is required irrespective of the sensor quantities.

POWER SUPPLY

The prototype is powered from a 12V d.c. bench power supply unit, regulated down to the required +8V by the circuit in Fig.8, in which the output voltage of regulator IC16 is set by resistor R66 and preset VR9.

Alternatively, the power may be supplied from a 12V battery, or from a 12V mains adaptor (battery eliminator) module, or from the mains rectifier circuit of Fig. 9. The latter has not been used with the prototype, and is a suggestion only.

Although the output of rectifier REC1 is nominally shown as +12V, the actual voltage at that point, when connected to capacitor C32 in Fig. 8, will depend on the load which is being powered and may be somewhat higher, but *must not* exceed +16V (the maximum voltage rating of capacitor C32).

With the circuit for Option 1, the components of Fig. 8 and the rectifier of Fig. 9 are mounted on the quad-sensor printed circuit board. With Option 2, the same components are mounted on the Clock and Mixer board, from where the 8V supply is routed to all sensor and filter boards.

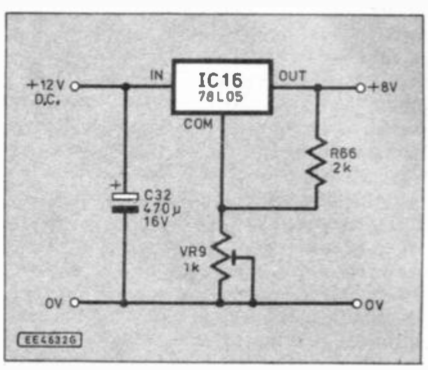


Fig. 8. Circuit diagram for +8V regulator.

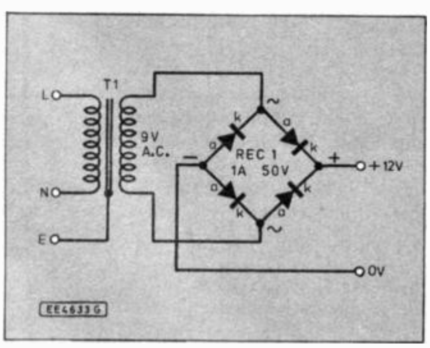


Fig. 9. Circuit diagram for +12V d.c. mains rectifier.

PRINTED CIRCUIT BOARDS

With all printed circuit boards, it is probably easiest to assemble components in the order of on-board wire links (for which 24 s.w.g. tinned copper wire is recommended), i.c. sockets, resistors and diodes, presets, capacitors in size order, regulator and rectifier, jack sockets, and then 1mm terminal pins to which interconnecting wires can be soldered.

Following assembly of all boards, check the tracking thoroughly with a close-up magnifying glass (watchmaker's type), ensuring that no solder shorts exist. Careful use of desoldering braid will remove any found.

A dual-purpose printed circuit board (p.c.b.) is used for both Option 1 and Option 2. Its component layouts and full size copper foil master pattern are shown in Fig. 10b. This board is available from the *EPE PCB Service*, code 896. The com-

COMPONENTS

SIMPLE SENSOR CIRCUIT

See SHOP TALK Page

Resistors

R1, R3 to R5	10k (4 off)
R2	220k
R6, R10	1M (2 off)
R8	1k
R7, R9	100k (2 off)*
R66	2k*

All 0.25W 5% carbon film or better

Potentiometers

VR1, VR2	100k sub min cermet preset (2 off)
VR9	1k sub min cermet preset*

Capacitors

C1	47µ 16V
C2 to C4	1µ 63V (3 off)*
C32	470µ 16V*

All radial electrolytic

Semiconductors

IC1	LOHET II Hall effect sensor
IC2	LM13600 dual transconductance op.amp**
IC3	LM358 dual op.amp*
IC16	78L05 +5V 100mA regulator*
REC1	bridge rectifier 1A 50V (see text)*

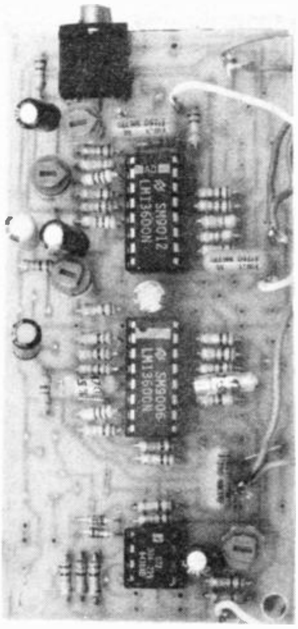
Miscellaneous

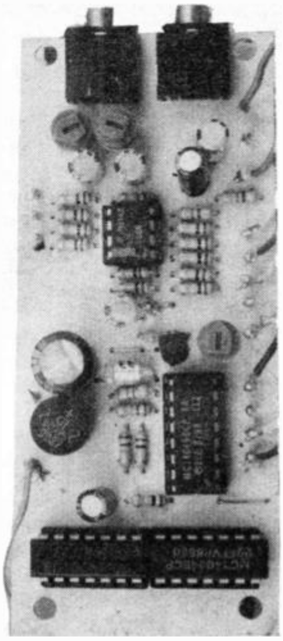
Printed circuit board available from *EPE Service*, code 896*; 3·5mm stereo p.c.b. mounting jack socket and plug; 3·5mm mono chassis mounting jack socket and plug (or PSU socket and plug)*; 5-pin DIN socket and plug*; 8-pin d.i.l. socket*; 16-pin d.i.l. socket **; bar or disc magnet (see text); 9V a.c. mains transformer 100mA (see text)*; plastic box 150mm × 80mm × 50mm (L × W × H); 1mm terminal solder pins; 3-core signal cable (length to suit application); connecting wire; solder etc.

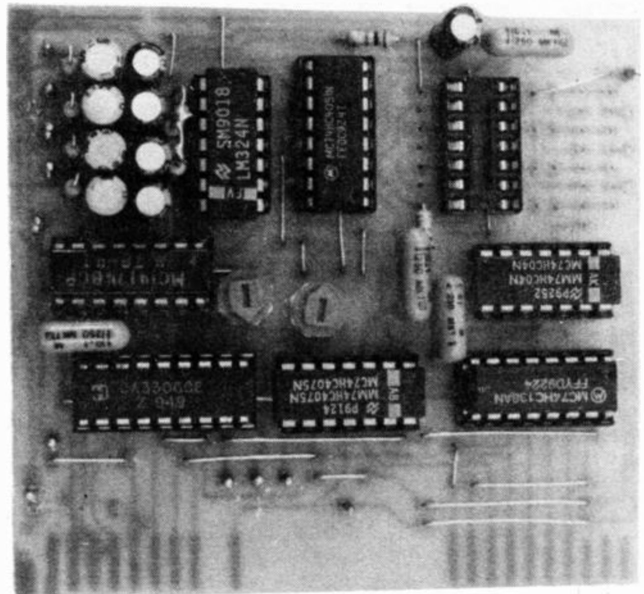
NOTES: Items marked with a single* are needed once per set of four sensor circuits.

Items marked with a double** are needed once per pair of sensor circuits.

Approx cost guidance only **£33**







Prototype Interface Board – Next month.

COMPONENTS

SENSOR AND FILTER CIRCUIT

(One set of components for each sensor required)

See SHOP TALK Page

Resistors

R1, R3 to R5, R14, R19, R21, R27, R30, R33, R34, R36	10k (12 off)
R2	220k
R6, R10, R20	1M (3 off)
R7, R9, R25, R26	4k7 (4 off)
R8, R15, R16, R22, R28	100k (5 off)
R11, R12, R17, R18, R23, R24	1k (6 off)
R13	47k
R29, R31, R32, R35	20k (4 off)

All 0.25W 5% carbon film or better

Potentiometers

VR1, VR2, VR4	100k (3 off)
VR3	4k7

All sub min cermet presets

Capacitors

C1, C4, C9	47µ radial elect. 16V (3 off)
C2, C3, C10	100n polyester (3 off)
C5, C6	1µ radial elect. 63V (2 off)
C7, C8	470p polystyrene (2 off)
C11	4µ7 radial elect.

Semiconductors

D1, D2	1N4148 signal diode (2 off)
IC1	LOHET II Hall effect sensor
IC2, IC3	LM13600 dual transconductance op.amp (2 off)
IC4	LM358 dual op.amp

Miscellaneous

Printed circuit board available from *EPE PCB Service*, code 896; 3·5mm stereo p.c.b. mounting jack socket and plug; 8-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); bar or disc magnet (see text); 1mm terminal solder pins; 3-core signal cable (length to suit application); connecting wire; solder, etc.

Approx cost guidance only **£30**

COMPONENTS

CLOCK AND MIXER CIRCUIT

See SHOP TALK Page

Resistors

R37	47k
R38, R51	10k (2 off)
R39 to R43, R46 to R50, R52 to R55	100k (14 off)
R44, R45	4k7 (2 off)
R66	2k

All 0.25W 5% carbon film or better

Potentiometers

VR5, VR6	10k (2 off)
VR9	1k

All sub min cermet preset

Capacitors

C12	33p polystyrene
C13, C15, C16, C18	1µ radial elect 63V (4 off)
C14, C17	22µ radial elect 16V (2 off)
C32	470µ radial elect 16V

Semiconductors

IC5	4060 14-bit binary counter and oscillator
IC6	LM358 dual op.amp
IC7	4024 7-stage binary counter
IC8	4001 quad 2-input NOR gate
IC16	78L05 +5V 100mA regulator
REC1	bridge rectifier 1A 50V (see text)

Miscellaneous

S1 min d.p.d.t. toggle switch

Printed circuit board available from *EPE PCB Service*, code 897. 3·5mm stereo p.c.b. mounting jack socket and plug (2 off each); DIN socket and plug for computer output (number of pins to suit application); 8-pin d.i.l. socket, 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; mains transformer 9V a.c. 100mA (see text); plastic box, 190mm × 110mm × 60mm (L × W × H); 1mm terminal solder pins; connecting wire; solder; etc.

Approx cost guidance only **£24**

ponent layout for this board's role in Option 1 is shown in Fig. 10a. Four mentions of each sensor component number are shown on the layout since four identical sensor circuits are catered for. Roughly speaking, the positioning of the numbers indicates with which sensor channel the component is associated. Inspection of the tracking will clarify the situation where there might be doubt. If fewer than four sensors are to be used, unrequired components may be omitted, and a DIN socket having fewer than five pins used to suit.

If the mains power supply of Fig. 9 is not used, omit REC1, then solder the 12V supply wires to the pins of capacitor C32, observing the correct polarity.

For its role in Option 2, the p.c.b. of Fig. 12b has its component layout shown in Fig. 12c. This layout holds the components for the sensor amplifier, VCA, bandpass filter and amplitude detector. There is no duplication of numbers on this layout.

With both the above layouts, be sure not to insert components into holes which are intended to be left unused.

There are no special points to made about the Clock/Mixer board whose component layouts and full size copper foil master pattern are shown in Fig. 11. This board is also available from the *EPE PCB Service*, code 897.

TESTING ADVICE

If at any stage during checking, circuits do not behave as expected, immediately switch off and visually recheck the area affected, looking especially for solder shorts or omissions and incorrect component polarity. It is most unlikely, though still possible, that faulty components are to blame for incorrect operation. Before inserting or extracting components, switch off the power supply.

Most checks can be carried out directly or indirectly using a multimeter, although in some cases the use of an oscilloscope will be helpful. All voltages are quoted with reference to the 0V power line.

Always allow a few minutes settling time after switching on before taking any measurements, allowing the capacitors to reach their correct charge levels. As the circuit has been a.c. coupled for very slow signal rates, the settling time is inevitably also a bit slow.

FIRST POWER-UP CHECKS

For the first checks, do not insert any of the d.i.l. chips or connect the sensors. Also, if the mains transformer and rectifier circuit has been built, do not yet plug this into the mains.

When the mains power supply is in use, normal mains safety procedures must be observed. If in any doubt, consult a qualified electrician.

Connect the circuit to a 12V battery or bench power supply unit. Switch on and adjust VR9 of the regulator circuit until the output of regulator IC16 delivers a voltage reasonably close to +8·0V (a 0·2V difference to either side is not especially significant).

After inserting all remaining chips, recheck that regulator IC16 is still delivering +8V. Now connect the sensors via short temporary wires to the unit and again check the +8V line.

With sensors well away from any magnets, check that their outputs are at about +4V. Set preset VR1 to a midway wiper position, and set VR2 for minimum resistance (resulting in a voltage of +8V at the junction of VR2 and R5), so setting the amplifier for maximum gain. Monitor IC2b pin 8 of Option 2. With Option 1 monitor the relevant output of IC2, either pin 8 or pin 9, depending on which sensor circuit is being checked.

The monitored output is likely to be in a fully saturated state of either 0V or about 6·8V. Very carefully adjust VR1 until the output voltage is set for about 2·5V to 3·5V, preferable near to 2·8V (about 1·2V below the midway reference voltage of 4V). As commented earlier, the range provided by VR1 is wider than preferred and a little patience is needed in setting it for the correct bias voltage.

Slowly move a magnet around near the sensor's upper surface (the little square plate in the middle) and check that the sensor's output voltage varies slightly as the magnet moves. Check that a much-amplified voltage change occurs at the relevant output of IC2. (Gross movement of the magnet too close to the sensor could saturate the circuit, making it necessary to wait a while until the capacitor levels have re-stabilised.)

Again monitor the sensor's output. Hold one pole of the magnet steadily close to the sensor. If the sensor's output voltage is greater than the original +4V, turn the magnet so that its other pole faces the sensor. This time the output voltage should be below +4V. Mark this face of the magnet; this is its polarity when fixed to the pendulum construction.

CLOCK CHECK

Option 2 users should now check the clock oscillator circuit of Fig. 6.

With the meter, check that IC7 pin 3 changes back and forth between 0V and 8V at a rate of roughly one full cycle every ten seconds or so. This check proves that the oscillator is functioning and that it is being divided by IC6 and IC7. Oscilloscope users can check the tapped output points of IC6 as well.

The four outputs of IC8 can be similarly checked. The voltages here should change in response to the trigger pulse from IC7 pin 3 and correspond to the logic described earlier. The output of IC8d pin 11 may be a little difficult to check on a meter. If IC8c pin 10 changes state, assume that IC8d is behaving properly.

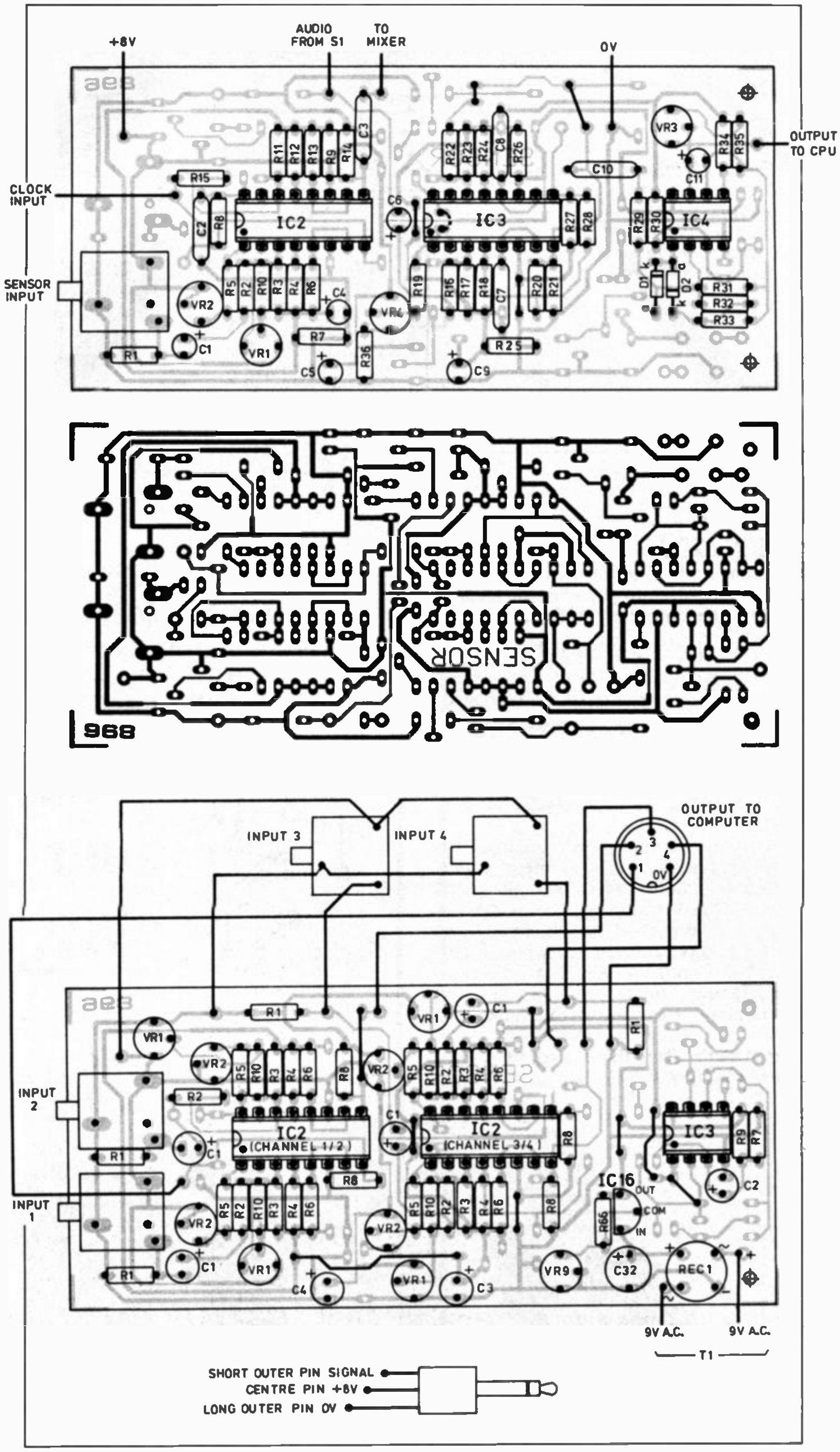


Fig. 10. Printed circuit board component layouts and full size copper foil master pattern for Option 1 and Option 2.

Checking of the sensor's amplitude modulators (VCAs) and the mixer can be done using the tape recorder. Plug the mixer into the line input (high signal level input) of the recorder. With only one sensor VCA connected to the mixer at any time, observe the recorder's VU meter. Changes in the tone signal level should be clearly evident when the marked face of the magnet is moved repeatedly past the sensor. The periodic pulsing of the sync marker should also be apparent.

When the sensors and magnets are finally mounted on the pendulums, adjustments to their relative positions, and to the settings of presets VR1 and VR2, should be made so that when the pendulum is at rest, the audio output level at each VCA is about 1·0V peak to peak. The output level controls of the mixer, VR5 and VR6, should be adjusted to suit the tape recorder input requirements. Further observation of the recorder's VU meter will help here.

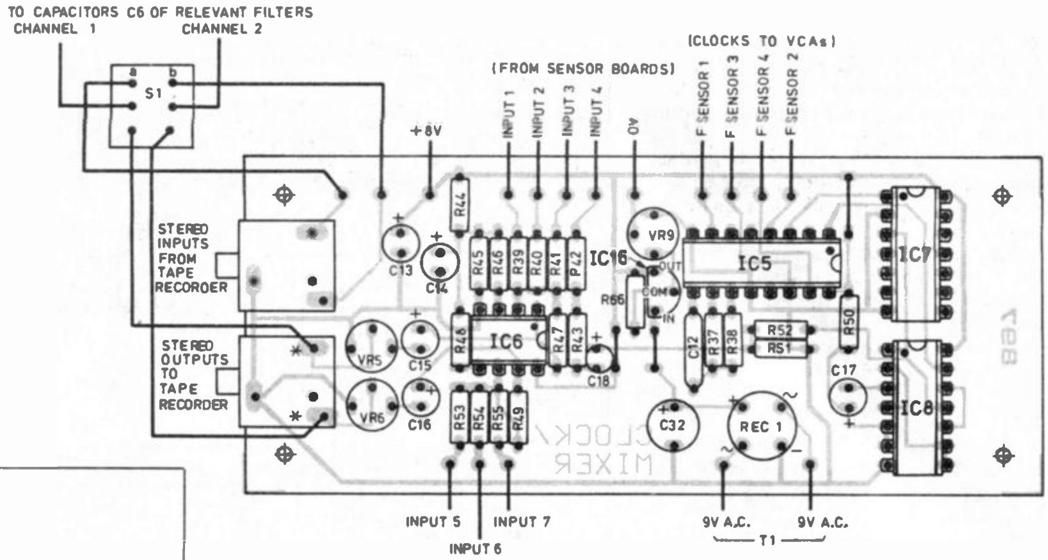


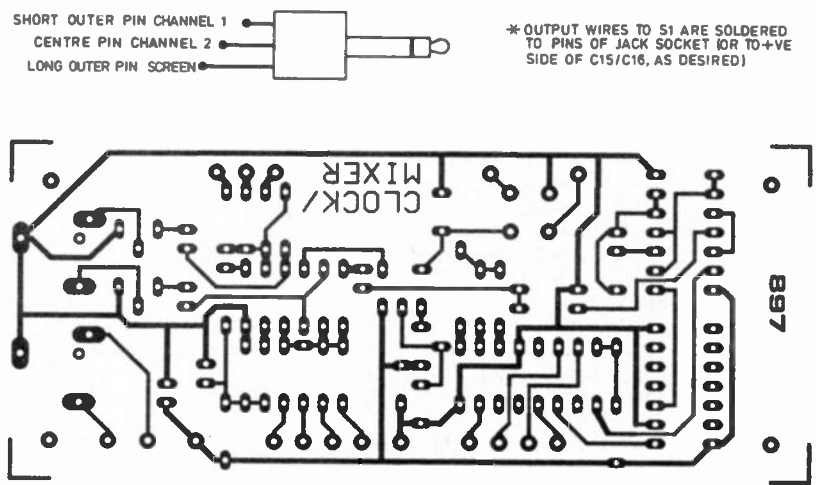
Fig. 11. Printed circuit board component layout and full size copper foil master pattern for the Clock/Mixer circuits.

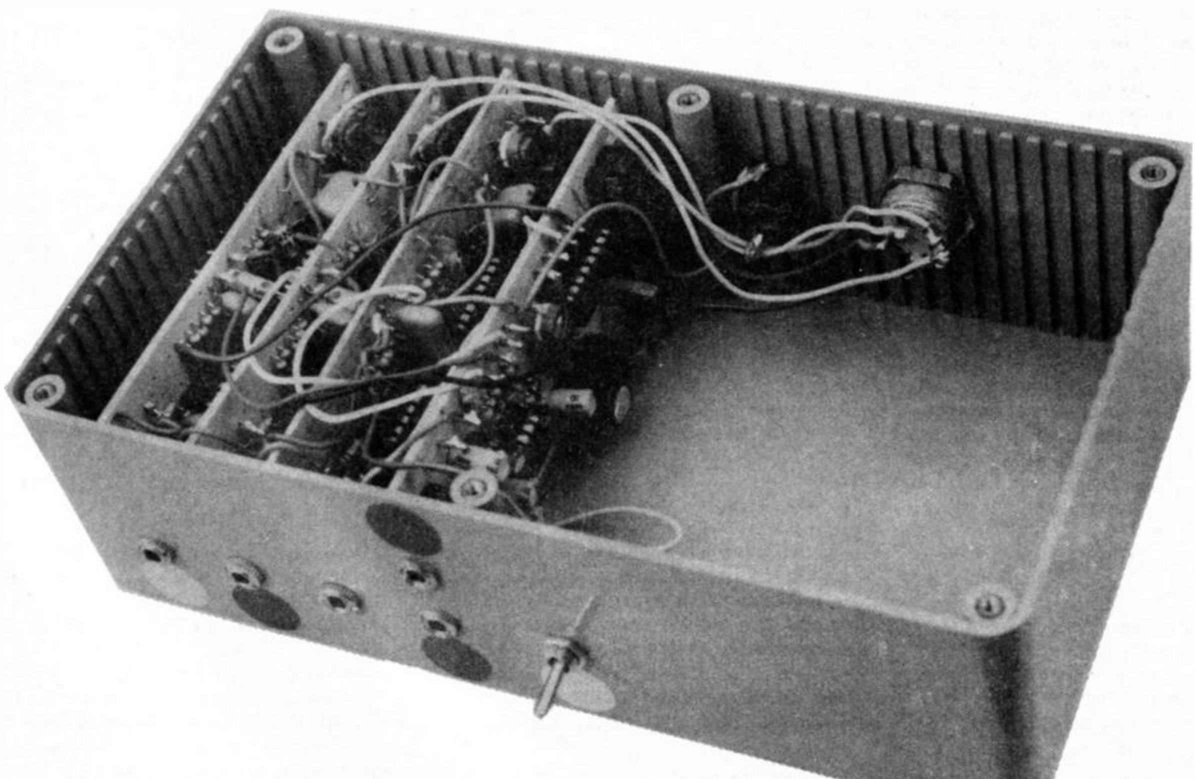
FILTER SETTING-UP

To tune each filter, place the magnet's marked face close to the relevant sensor. Monitor the output at IC4b pin 7 (the computer output point). Set the wiper of VR3 midway. Very carefully turn VR4 until the meter shows the lowest output voltage. In the prototype, the untuned voltage was about 3·6V, falling to about 2·5V at optimum tuning. Note, though that these voltages were read from the fully installed and aligned system and that they may differ in your system at this time.

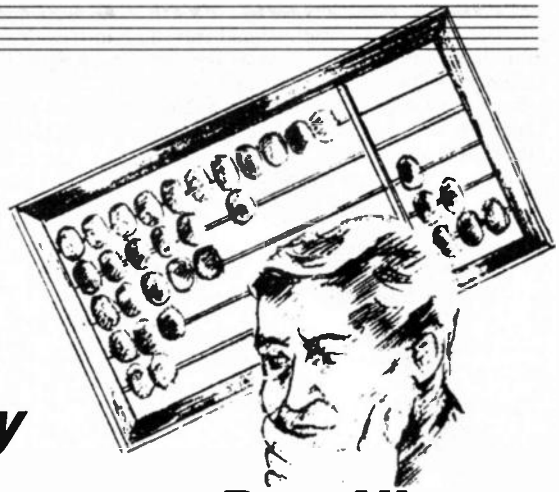
Once the computer is running the software, optimum filter tuning could perhaps be done while swinging the pendulum and observing the computer screen trace. Best of all though, if you have an oscilloscope, monitor IC3 pin 8 and adjust VR4 until the largest waveform is seen. Ignore the appearance of any sub-harmonic frequencies while adjusting VR4.

Next Month: Pendulums and PC-Compatible Interface.





CALCULATION CORNER



An introduction to A.C. theory

STEVE KNIGHT

Part Nine

This series is designed to help you make your way, at your own pace, through the often imagined fears of mathematics, as this is applied to electronic and electrical engineering matters.

ELECTRONIC circuits are energized by direct current supplies, either from batteries or from d.c. power units. Such supplies simply make the circuits operational and provide the energy to permit the functioning of things like transistors, integrated circuits, loudspeakers, digital displays and so on. What is of more concern to us in such circuits, however, are the various **signals** and **signal levels** which are inputted, outputted, generated, amplified, attenuated, clipped or modified in some way to provide us with the output signals we require.

In general, all such signals are varying or changing quantities and the way in which they vary or change with time is known as the **waveform** of the signal.

THE SINUSOIDAL WAVE

The fundamental waveform is the **sinusoidal** wave; all other waveforms can be mathematically expressed in terms of sine waves. Fig. 9.1 shows two possible signal waveforms. The first of these is a pure sinusoidal voltage wave and the second a more complex current wave. Such waveforms can be viewed on an oscilloscope and generally show us how the voltage or the current is varying in a circuit system.

Both of these waves are seen to increase from zero to a maximum or **peak** value, $\hat{V}$ or $\hat{I}$, in a positive direction before falling to zero again; they then increase once more to a peak value in the reverse direction before again falling to zero. These quantities, in other words, *periodically* change their direction of action in the circuit, quite unlike a direct current which, even though it may fluctuate in magnitude, flows always in *one direction* only.

FREQUENCY AND PERIOD

One complete series of values is called a **cycle** of the wave and the number of cycles occurring in one second is the **frequency**. Frequency is measured in **Hertz**, where one Hertz is one cycle per second.

The time for one cycle to occur is called the **period** or **periodic time** (T), hence this time is equal to 1/frequency or 1/f seconds. Thus for mains frequency, the time for one cycle is 1/50 or 0·02 seconds.

Here are a couple of worked examples to clarify things:

1. An audio signal has a periodic time of 15ms. What is it frequency?

Since $T = \frac{1}{f}$, $f = \frac{1}{T} = \frac{1}{0{\cdot}015}$ Hz

Notice that the time T has been expressed in seconds to provide the answer in Hertz. So, using our 1/x (or x^{-1}) key on the calculator, we find that **f = 66·67Hz.**

2. A signal travels along a certain cable at a speed of 250×10^6 metres/second. What is the wavelength of this transmission if its frequency is 100kHz?

Here we can introduce the notion of **wavelength**, that is, the length of cable occupied by one complete cycle of the transmission. The symbol for wavelength is λ (lambda), so we can say

$$\lambda\ (\text{metres}) = \frac{\text{distance travelled in 1 second}}{\text{number of cycles in 1 second}}$$

$$= \frac{\text{velocity of the wave (m/s)}}{\text{frequency (Hz)}}$$

Here then $\lambda = \frac{250 \times 10^6}{10^5} = 2500$ metres or **2·5km**

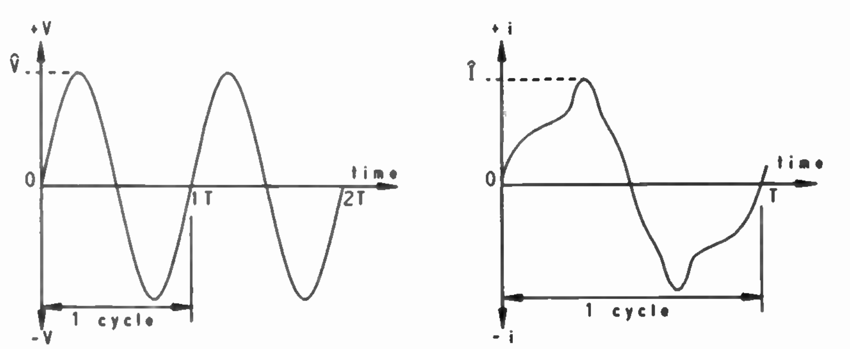


Fig. 9.1 A sinusoidal and a complex wave showing the meaning of peak value, one cycle and the periodic time.

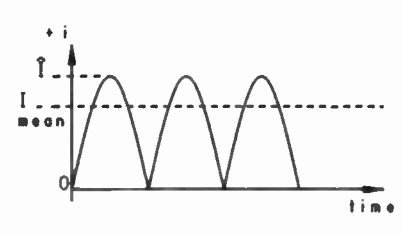


Fig. 9.2. A rectified sine wave has a mean or average value which is 0·637 of the peak value.

FREE SPACE WAVELENGTH

The velocity of a radio signal travelling in free space (or in air for that matter) is the same as the velocity of light, that is, very close to 300×10^6 metres/second. The speed of an electric signal through a cable is always *less* than this, in some cases, considerably less. The wavelength of a free space wave is therefore found from the simple relationship

$$\lambda = \frac{300 \times 10^6}{f} \text{ metres}$$

3. A BBC radio station broadcasts on a frequency of 693kHz. What is the wavelength of this transmission?
   Here the frequency is given in kHz or 693×10^3Hz.

$$\text{Then } \lambda = \frac{300 \times 10^6}{693 \times 10^3} = \frac{300 \times 10^3}{693} = \textbf{433 metres}$$

Notice from this example, that the expression for λ becomes

$\lambda = \frac{300 \times 10^3}{f}$ when f is in kHz. What will it be if f is in MHz?

MEASURING A.C. QUANTITIES

In measuring the value of an alternating current (or voltage) it is not convenient to measure the peak value. The average or **mean** value over one half cycle might be more attractive in this respect. This value is of importance when we consider a moving-coil meter connected by a rectifier to a source of alternating current. The meter receives pulses of current every half-cycle of the waveform and the deflection of the pointer is proportional to the mean value of the now unidirectional current. This mean value is found to be $2/\pi$ or 0·637 percent of the peak value (see Fig. 9.2). The mean value is usually only of importance in such electro-chemical work as electro-plating and battery charging.

THE R.M.S. VALUE

When an alternating current is passed through a resistor, heat is produced and energy is consumed. Since the *direction* of the current does not affect this heating, a logical way of measurement would seem to be in terms of the energy dissipated or the work done. An alternating current changes in magnitude from instant to instant and the measurement value assigned to it is made equal to the value of that *direct current* which will produce the *same* amount of work or heating effect in a resistive load.

This value is known as the **r.m.s.** (root-mean-square) current or voltage which is found to be (for sinusoidal waves)

$$\frac{\text{peak value of the wave}}{\sqrt{2}} = \text{peak value} \times 0{\cdot}707$$

Hence $\quad$ peak value = 1·414 × r.m.s. value

R.M.S. voltages and currents are symbolised as V and I respectively in a.c. problems exactly as they are for d.c. circuits. The r.m.s. value is always used in calculations involving alternating quantities unless otherwise indicated.

Here are some more basic calculations to illustrate what we have just covered.

4. What is the peak value of the 240V mains supply? The stated mains voltage of 240V is given in r.m.s.

Now $\quad$ peak voltage $\hat{V} = \sqrt{2} \times$ r.m.s. voltage
$= 1{\cdot}414 \times 240$V
$=$ **340V**

A "shock" from the mains supply places this high voltage across your body every 1/100th of a second! So take care.

5. An alternating, voltage of *peak* value 36V feeds a small soldering iron. What battery voltage would replace the a.c. supply and deliver the same heating power?

We are given the peak value of the supply; we must first find its r.m.s. value:

Now $\quad$ r.m.s. = peak × 0·707
$= 36 \times 0{\cdot}707 =$ **25·4V**

A battery with a terminal p.d. of **25·4V** would therefore supply the resistive element of the iron with the **same** heating power as the a.c. source.

6. A moving-coil multimeter, switched to an a.c. range, indicates the r.m.s. value of a sinusoidal current or voltage. How is this, when the deflection of the pointer is proportional to the **mean** value of the input?

Although the pointer of an analogue meter is deflected by the mean level of the input, the scale is calibrated during manufacture, not in mean values but in r.m.s. values. This correction is done by effectually multiplying the scale by a factor of 1·11 which is obtained from the ratio

$$\frac{\text{r.m.s. value}}{\text{mean value}} = \frac{0{\cdot}707}{0{\cdot}637} = 1.11$$

This ratio is known as the *form factor* for sinusoidal waves.

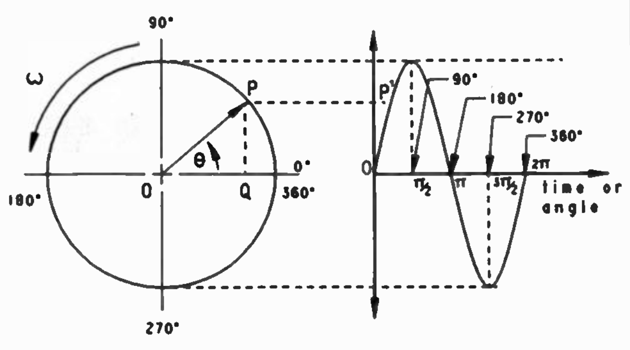


Fig. 9.2. How a sinusoidal wave can be represented by a rotating arm or phasor.

PHASOR REPRESENTATION

The sinusoidal wave is so called because the current or the voltage it represents is proportional to the sine of an angle.

By interpreting a rotating arm (or **phasor** as it is called) in terms of generating a sine wave, we get a very convenient method of representing alternating quantities which enables the solution of many a.c. problems to be easily resolved.

If P is a point moving *anticlockwise* in a uniform circular motion as in Fig. 9.3, the height of P above the horizontal axis, PQ, varies as the angle θ since PQ/OP = sin θ. Hence, if PQ is plotted against angle, a sine curve is generated, one cycle of this curve corresponding to one rotation of 360° of the phasor OP.

We need a way of expressing angle θ not in degrees but in terms of time; 360° per cycle does not vary whatever the frequency or speed of rotation of the phasor, but time gives us a value for the period which is a function of frequency as we have already seen.

RADIAN MEASURE

The rate of rotation of phasor arm OP is normally expressed in radians per second, symbol ω (omega), where the **radian** is the angle subtended at the centre of a circle by an arc on the circumference equal in length to the radius, see Fig. 9.4.

Since the circumference = 2πr, a rotation of 360° is equal to 2π radians, or 1 radian (1^c) = 360/2π = 57·3°. Angular velocity ω then is the number of radians passed through per second; but the number of revolutions per second of phasor OP is equal to the frequency of the generated sine wave, hence

$$\text{frequency } f = \frac{\omega}{2\pi} \text{ or } \omega = 2\pi f$$

The radian equivalents for the angle θ have been added to the axis of Fig. 9.3.

THE SINE EQUATION

Let the length of the line OP in Fig. 9.3 be equal to the peak value of the current it represents, $\hat{I}$. After a time t secs from its horizontal starting position, the line has turned through angle

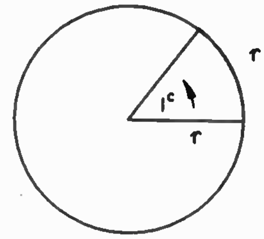


Fig. 9.4. The radian $1^c = 57{\cdot}3°$ and is a measure of angular velocity.

$\theta = \omega t$ radians. The vertical projection $PQ = \hat{I} \cdot \sin \omega t$ and this is the expression for the *instantaneous* value of the alternating current corresponding to the point P^1. Instantaneous values of current or voltage are indicated by small letters *i* or *v* respectively. So we have

$$i = \hat{I} \cdot \sin \omega t = \hat{I} \cdot \sin 2\pi f t.$$

as the equation for the sine wave shown in Fig. 9.3.

For a voltage wave we have similarly

$$v = \hat{V} \cdot \sin \omega t = \hat{V} \cdot \sin 2\pi f t$$

These are the basic expressions for a sinusoidal waveform. They may seem a little daunting at first, but with a bit of practice in using them, you will find them no more difficult than any of the other formulae we have been through. Here are some examples to make you familiar with them.

7. An alternating current is expressed as $i = 10 \sin 314t$ A. Determine the peak and r.m.s. value of this current. Also find the frequency, the periodic time and the *instantaneous* current after a time equal to 4·5ms.

From the expression given we see at once that $\hat{I} = \mathbf{10A}$, hence the r.m.s. value $I = 10 \times 0{\cdot}707 = \mathbf{7{\cdot}07A}$. No problem there!

Now we know that the term 314t corresponds to $2\pi ft$ in the basic equation, therefore $2\pi f = 314$ and

$$f = \frac{314}{2\pi} = \mathbf{50Hz}. \text{ Then } T = \frac{1}{50} = \mathbf{0{\cdot}02} \text{ sec}$$

Now when t = 4·5ms = 0·0045sec we get

$$314t = 314 \times 0{\cdot}0045 = 1{\cdot}413 \text{ radian}$$

But $1{\cdot}413 \text{ radian} = 1{\cdot}413 \times 57{\cdot}3^\circ = 81^\circ$

$$\therefore \quad i = 10 \sin 81^\circ = 10 \times 0{\cdot}9876 = \mathbf{9{\cdot}876\ A}$$

We need a note at this point about the last step in the above calculation. There we turned the radians back into degrees by multiplying by the degree equivalent to 1 radian, i.e. 57·3°. This is convenient enough for most purposes, and by converting to degrees, the sine can be found on most of the inexpensive calculators e.g. enter the angle in degrees and press the SIN key. However, a lot of calculators have provision to go into a radian mode so that the radian value can be entered directly and the sine (or any of the other trig. ratios) found without conversion to degrees. Use whichever method your calculator (or you) can manage.

8. Write down the equation representing the instantaneous level of a voltage having an r.m.s. of 1·5V and a frequency of 250Hz.

The peak value $\hat{V} = 1{\cdot}5 \times \sqrt{2} = 1{\cdot}5 \times 1{\cdot}414 = 2{\cdot}12$V

$$\omega = 2\pi f = 2\pi \times 250 = 500\pi \text{ rad/sec}$$

Then $v = 2{\cdot}12 \sin 500\pi t$ or $\mathbf{2{\cdot}12 \sin 1570t\ V}$

9. A sinusoidal voltage has an r.m.s. value of 20V and a frequency of 500Hz. Commencing from zero in the cycle, find the time taken for the voltage to reach a value of 14·14V.

Peak value $\hat{V} = 20 \times 1{\cdot}414 = 28{\cdot}3$V

Let t be the time taken from the instant the voltage is zero and rising positively in the cycle, then the basic equation becomes:

$$v = 28{\cdot}3 \sin(2\pi \times 500)t = 28{\cdot}3 \sin 1000\pi t = 14{\cdot}14\text{V}$$

Then $\sin 1000\pi t = \frac{14{\cdot}14}{28{\cdot}3} = 0{\cdot}5$

The *angle* whose sine is $0{\cdot}5 = 30^\circ$ or $\frac{\pi}{6}$ radian

Hence $1000\pi t = \frac{\pi}{6}$

from which $t = \frac{\pi}{6000\pi} = \frac{1}{6000}$ sec

$$= \mathbf{0{\cdot}166ms}$$

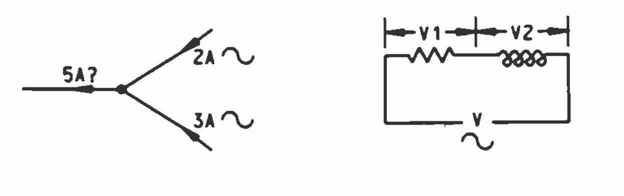


Fig. 9.5. The simple addition of currents or voltages in a d.c. circuit is not applicable to a.c. circuits except in a particular case.

Notice most carefully that when equating $2\pi ft$ to the angle, this angle *must* be expressed in radians.

Another calculator note at this point: when you have to find "the angle whose sine is x" use either the **arcsin** key or the **$\sin^{-1}$** key, depending upon your machine. In the above case, enter 0·5 and then press the appropriate key, making, sure you are in the degree mode; 30° should appear on the display.

PHASE ANGLE

In Fig. 9.5 two separate currents of 2A and 3A combine into a single conductor at point P. If these are *direct* currents we simply add them to find the outgoing, or resultant current, namely, 2 + 3 = 5A. If they are alternating currents, however, we cannot necessarily make a straightforward summation such as this and, in fact, can only do so for one particular circumstance. The same applies to alternating voltages as in Fig. 9.5(b) where $V_1 + V_2$ does *not* equal the supply voltage V.

This comes about because although two alternating waves may be of the same frequency they may well have different peak (and r.m.s.) values and be "out of step" with each other. This last condition means that the waves **differ in phase**. When there is a phase difference between two waves, they have their peak values at different instants of time.

In Fig. 9.6 we have two such voltage waves, v_l and v_2, generated by the rotating phasors shown on the left. Phasor v_2 is seen to be ahead or **leading** phasor v_l by $\pi/2$ radians or 90°, though we could equally well say that v_l is **lagging** behind v_2 by the same angle. This angle is known as the **phase** angle of **lead** or **lag** and is symbolized ϕ (phi).

If $v_l = \hat{V}_1 \sin \omega$, then $v_2 = \hat{V}_2 \sin(\omega + \pi/2)$ since the v_2 wave has a different peak value and when t = 0, its value is $v_2 = \hat{V}_2 \sin(\pi/2)$ or $\hat{V}_2$

It is important to appreciate that *all* the information we need about the amplitudes of the two waves and how they differ in phase is all contained in the simple phasor diagram on the left of the figure. We do not have to draw sinusoidal waves every time we want to investigate things. So study the phasor representation carefully; we will be going into such diagrams next month.

PROBLEMS

1. The peak value of an a.c. wave is 15V. What are the mean and r.m.s. values of this wave?
2. The wavelength of a certain BBC transmission is 330m. What is its frequency and periodic time?
3. If the time taken for a sinusoidal current to rise from zero to its peak value is 2·5ms, what is its frequency?
4. An alternating voltage is represented by the equation $v = 25 \sin 157t$. What is the peak value, the r.m.s. value, the frequency and the periodic time for this voltage?
5. Express the following angles in radians using, only the fractions and multiples of π e.g. 45°π/4 radians: 15°, 60°, 75°, 120°, 150°, 180°, 225°, 270°, 330°, 360°.
6. Sketch a phasor diagram showing clearly the angle between the given alternating quantities:

   (a) $i_1 = 2 \sin \omega t$ and $i_2 = 4 \sin(\omega t + \frac{\pi}{3})$

   (b) $v_1 = 6 \sin(\omega t + \frac{\pi}{4})$ and $v_2 = 6 \sin(\omega t - \frac{\pi}{2})$

Last month's answers

1. x = 0·5A, y = 1·5A. **2.** Top branch 0·26A, lower branch = 0·58A; total 0·84A; 0·45V. **3.** AB = 8·5A, BC = 5·5A, CD = 3·5A. **4.** 2A, 4A. **5.** 0·556A. **6.** 4·36A from F to A; 3·1A from C to D; 1·26A from B to E.

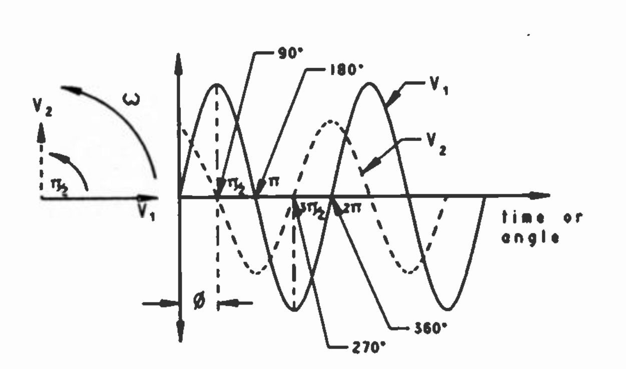
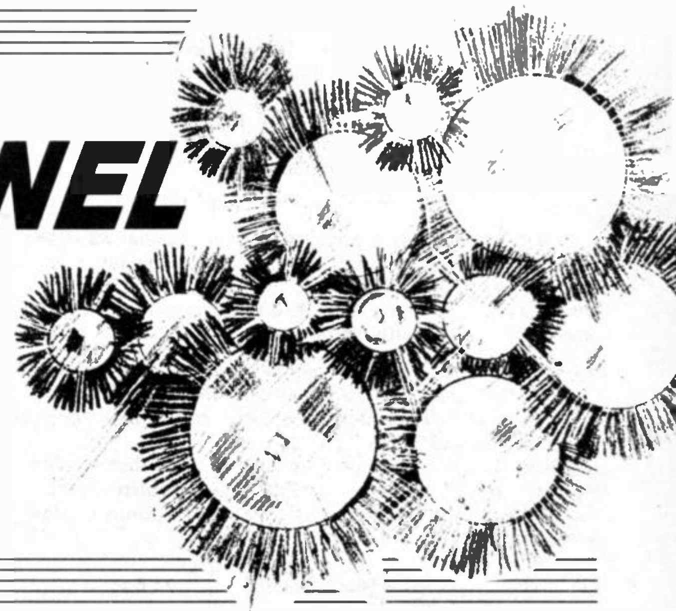


Fig. 9.6. This illustrates the meaning of phase difference. The maximum value of v_2 occurs earlier by 90° than the maximum of v_1, hence v_2 leads v_1.

Constructional Project

THREE-CHANNEL LAMP CONTROLLER



ANDY FLIND

Create your very own lighting spectacular. Can easily handle 100W per channel, making it ideal for home discos, parties and advertising displays.

THIS controller can drive up to three lamps, or sets of lamps, continuously varying their brilliance up and down between two pre-set brightness levels. The speed of variation and the high and low brilliance levels are independently adjustable for each channel, allowing many different and interesting effects to be achieved.

Although originally intended to drive the lights on the author's Christmas tree, it can easily handle over 100W per channel, making it suitable for home discos, parties, advertising displays and a host of other applications where a colourful light display is required. This, perhaps, is just as well, as it is a little complicated for a mere "tree lights" controller.

Construction and use of the unit is very simple. Output adjustment is particularly easy as a switch forces all three channels to their high or low set points for easy setting. Since independent "high", "low" and "speed" controls for each channel means there are nine controls plus the function switch, a design requirement was that the switch and control potentiometers should all be mounted on the printed circuit board (p.c.b.).

PHASE CONTROL

The circuit uses the familiar phase control method for dimming the lamps of each channel, with triacs controlling the loads (lamps). Each triac is switched on at a variable point of each half cycle of the mains supply voltage, and turns off at the next zero-crossing. This action, where the load is being driven at about half power is shown in Fig. 1.

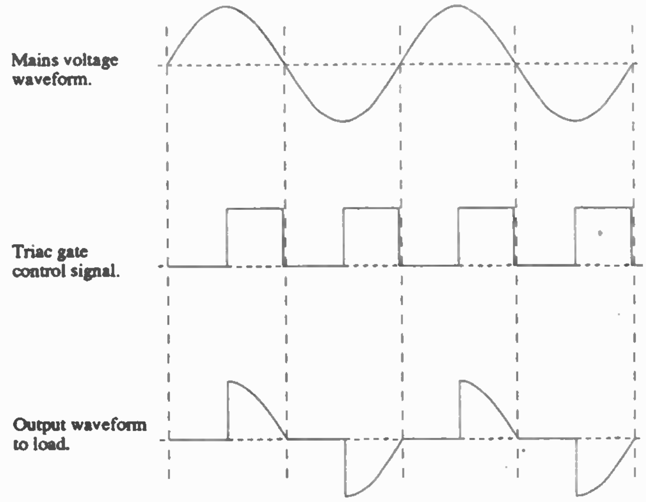


Fig. 1. Phase angle power control waveforms.

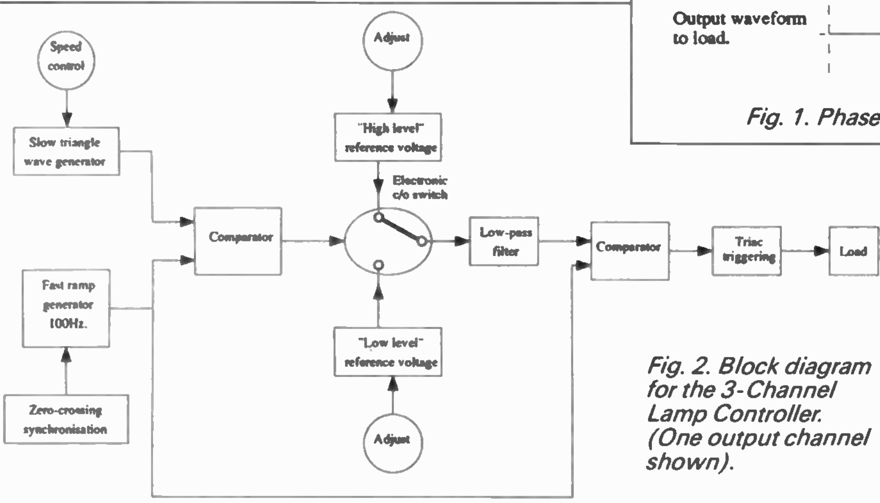


Fig. 2. Block diagram for the 3-Channel Lamp Controller. (One output channel shown).

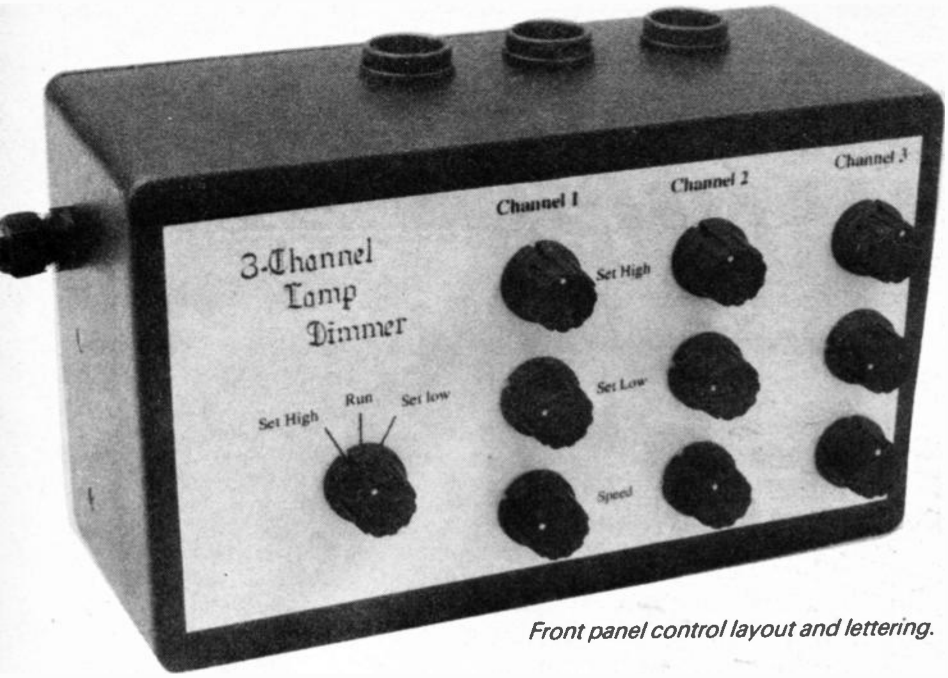
The basic block diagram for the 3-Channel Lamp Controller is shown in Fig. 2. Only one output channel is shown.

A triangle-wave signal of very low frequency is used to control the output from each channel. So that the control "high" and "low" settings can be adjusted independently of each other and of frequency, this is first compared with a ramp waveform of much higher frequency.

The output of the comparator is a series of pulses of varying mark space ratio, which control an electronic changeover switch between the "high" and "low" reference voltages. The output of this switch is a series of pulses which have an average d.c. value swinging between the references in time with the original triangle-wave.

Low-pass filtering extracts this d.c. voltage, which is then compared with a ramp synchronised to the mains zero-crossings to determine the triac triggering point for each half-cycle.

The synchronised 100Hz ramp generator is used by both comparators, and is common to all three channels, as are some power supply components. All other parts of the circuit are duplicated three times, to provide the three channels.



Front panel control layout and lettering.

CIRCUIT DESCRIPTION

The full circuit diagram for the 3-Channel Lamp Controller appears in Fig. 3. Starting at the top, a signal for the zero-crossing synchronisation is obtained from diodes D1 to D4 with IC1 and IC2.

The diodes full-wave rectify the mains whilst current through them is limited by resistors R1 and R2. Their output voltage is limited by Zener D6 to a maximum of 12V and capacitor C1 is charged to this value.

Whilst the instantaneous mains voltage is greater than half of this, the input to IC1a is seen as "high", so the output from the three parallel-connected gates IC1b to IC1d is high. As each zero-crossing is approached, resistor R4 pulls the voltage from D1 to D4 low so the output goes low and powers the diode in the opto-coupler IC2 for about 300µS. Thus the transistor in IC2 is conductive for this period at each zero-crossing.

Power to pulse the diode in IC2 is provided by capacitor C1, diode D5 prevents "back-feeding" of the 12V to the input during zero-crossings. Because of this diode, IC1a's input is slightly higher than it's supply for most of the time. This is handled by the internal protection diodes in the chip, with resistor R3 to limit input current.

Power for the rest of the circuit is provided by transformer T1, a 12V-0V-12V 100mA type. The output of this is rectified by diodes D7 and D8 and regulated to 12V by IC3. A reference voltage of half the supply, required by the three slow triangle-wave generators, is provided by IC4a and associated components.

The synchronised 100Hz ramp is generated by IC4b, configured as an integrator with a reference input of about two-thirds of the supply from resistors R9, R10, R11 and R13. When the transistor inside IC2 conducts the output resets to this value, then it ramps downwards due to the positive input from resistor R12.

With the component values shown it falls to about one-third of the supply in 10mS, the period of a half-cycle of the mains. The output goes to both sets of comparators, but in the case of the first switch S1 allows selection of a continuous High or Low level to allow setting of the high and low channel output levels. These components are common to all three channels.

IN COMPARISON

Taking the first channel, this begins with the slow triangular-wave control voltage generator built around IC5. IC5a is an integrator, with a reference input of half the supply voltage. This drives the Schmitt trigger IC5b, which in turn supplies the input to IC5a through the Speed control VR1.

By altering the proportion of output voltage from IC5b which is fed back to the integrator, this controls the rate of variation of the output, from about one to twenty seconds per cycle. The TL072 op.amp used for this stage has fairly equal offsets from the supply rails at each end of it's output swing which ensures an even ramp rate in each direction.

The output is compared with the 100Hz ramp by comparator IC6a and the output of this drives IC7, a CMOS 4007 connected to form an electronic changeover switch. The "pull-up" resistor R22 is required as IC6 is a true comparator, having an output transistor which can sink but not source current.

The "electronic switch" IC7 switches between the two reference voltage levels for "high" and "low", set by the user with rotary potentiometers VR2 and VR3. Low pass filtering of IC7 output consists simply of capacitor C14, which, with the input resistances to the switch, is adequate.

Comparison of IC7 output with the 100Hz ramp (IC4b) is made by IC6b which then drives the gate (g) of triac CSR1 through resistor R26. Once again a "pull-up" resistor, R25, is used. The specified triacs operate more reliably when controlled by *negative* gate current so this is supplied by IC6b in preference to a positive drive arrangement.

Capacitors C2, C3 and the choke L1 prevent the interference noise associated with this type of power control from reaching the mains, to prevent malfunction of other equipment sensitive to such noise. VDR1 is a mains voltage surge suppressor. The mains can be subject to high-voltage spikes capable of damaging triacs, so incorporation of this protection is generally worthwhile.

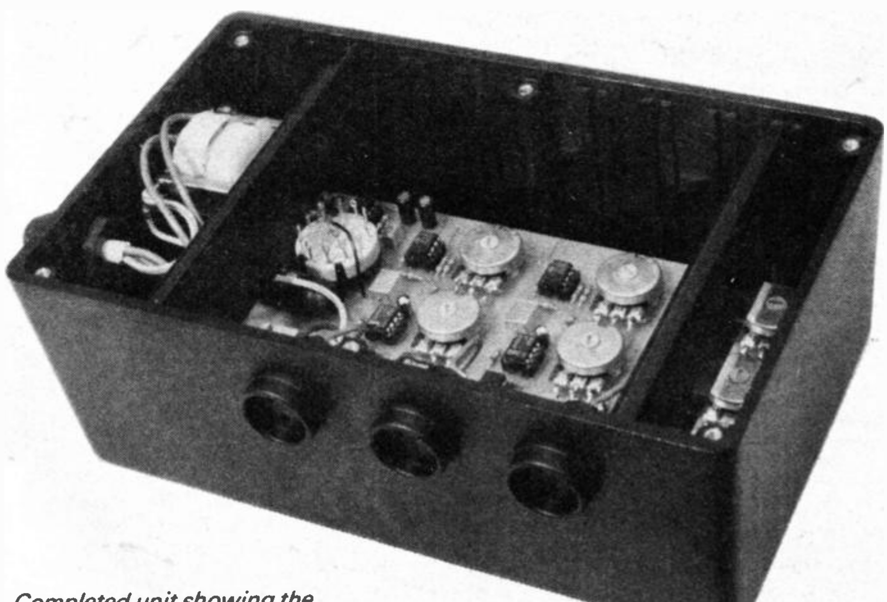
SAFETY FIRST

The two links LK1 and LK2 that can be seen in the Live and Neutral rails in the circuit are provided to facilitate testing. Most of the circuit is safely powered by the isolated low voltage from the transformer.

The synchronising signal for the 100Hz ramp generator is also isolated, by IC2, so with these two links *removed* most of the circuit can be handled and tested with comparative safety. This is a useful feature for initial testing, especially if problems are encountered.

Before construction, some consideration should be given to the final assembly of the project into the case which is to house it. As the potentiometers and Function switch are all mounted directly on the p.c.b. and their shafts are intended to project through holes drilled in the case, it follows that the positioning of these holes must be fairly precise.

One way to achieve this is to place the bare p.c.b. on top of the case and use it as a guide for marking the hole locations. Another would be to make a pattern from paper or thin card from the p.c.b. before construction, for use as a template later. With either method, ensure the board is the right way up when doing this!


Completed unit showing the three channel sockets

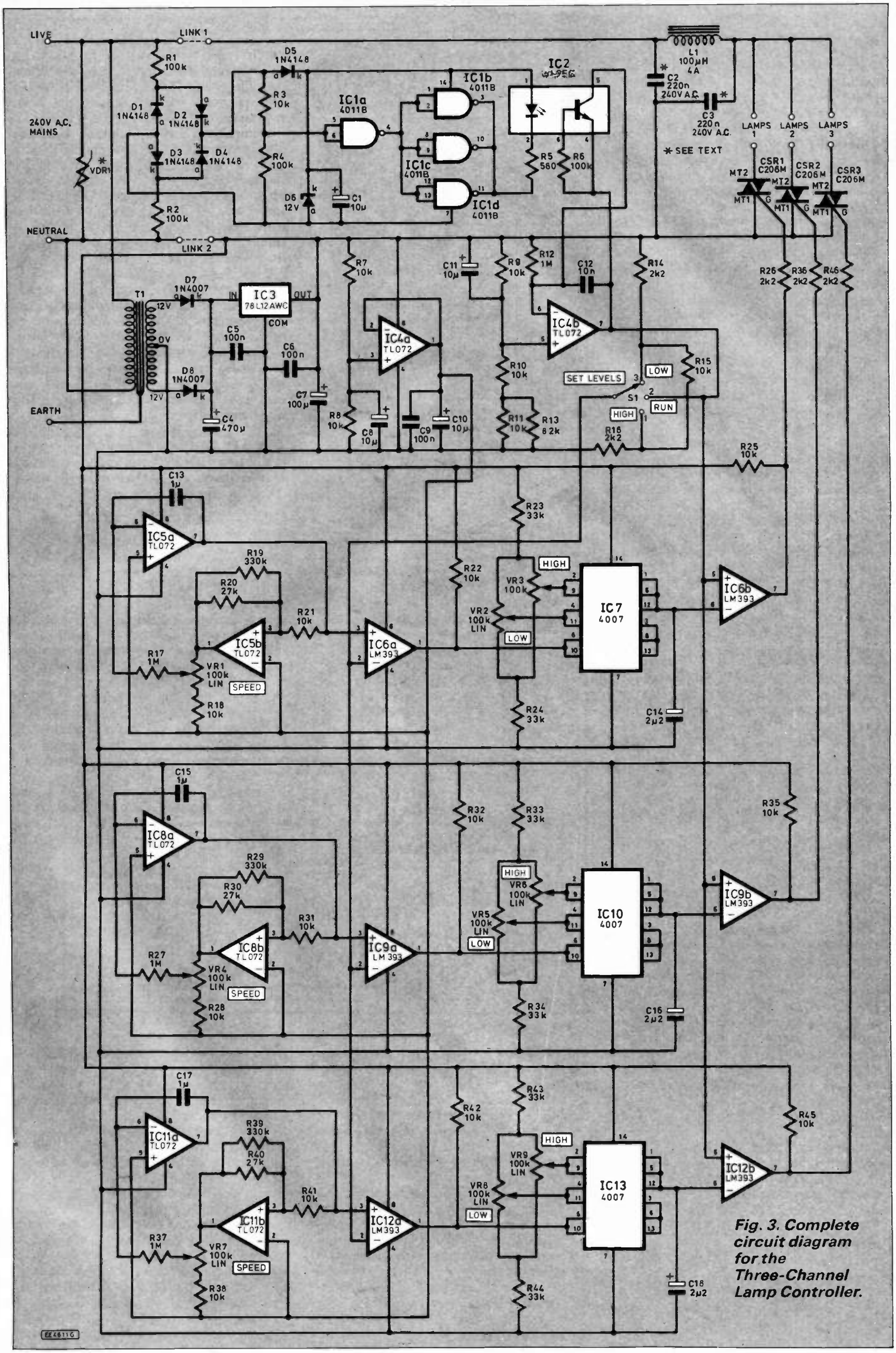


Fig. 3. Complete circuit diagram for the Three-Channel Lamp Controller.

CONSTRUCTION

All the components except the transformer are mounted directly on the printed circuit board as shown in the component layout, Fig. 4. This board is available from the *EPE PCB Service*, code 893.

They can be fitted in any order preferred by the constructor, though the two links LK1 and LK2 should be *omitted* at this stage. All the other links should be in place, however. No i.c.'s should be fitted yet either, with the exception of the three-lead voltage regulator IC3. These will be added during testing.

Use of d.i.l. sockets for the other i.c.s are advised as this makes life a lot easier. The opto-isolator IC2 is a six-pin device, but as six-pin sockets are sometimes hard to obtain an eight-pin socket has been used. If a six-pin is available, it may, of course, be used instead.

The nine rotary control pots. must first have short lengths of bare tinned copper wire soldered to their tags, pointing forward, then they are fitted to the board with these wires passed through the appropriate holes. Their securing nuts are then tightened and the wires soldered and cropped. This method of assembly takes far less time than wiring them out to a panel in the usual way, and the possibility of errors is virtually eliminated.

The rotary "Level" switch S1 is also mounted directly on the board. It has a moulded locating pin to prevent rotation, and a hole can be drilled in the board to accomodate this. The four connections to the switch are made as shown with short lengths of insulated wire.

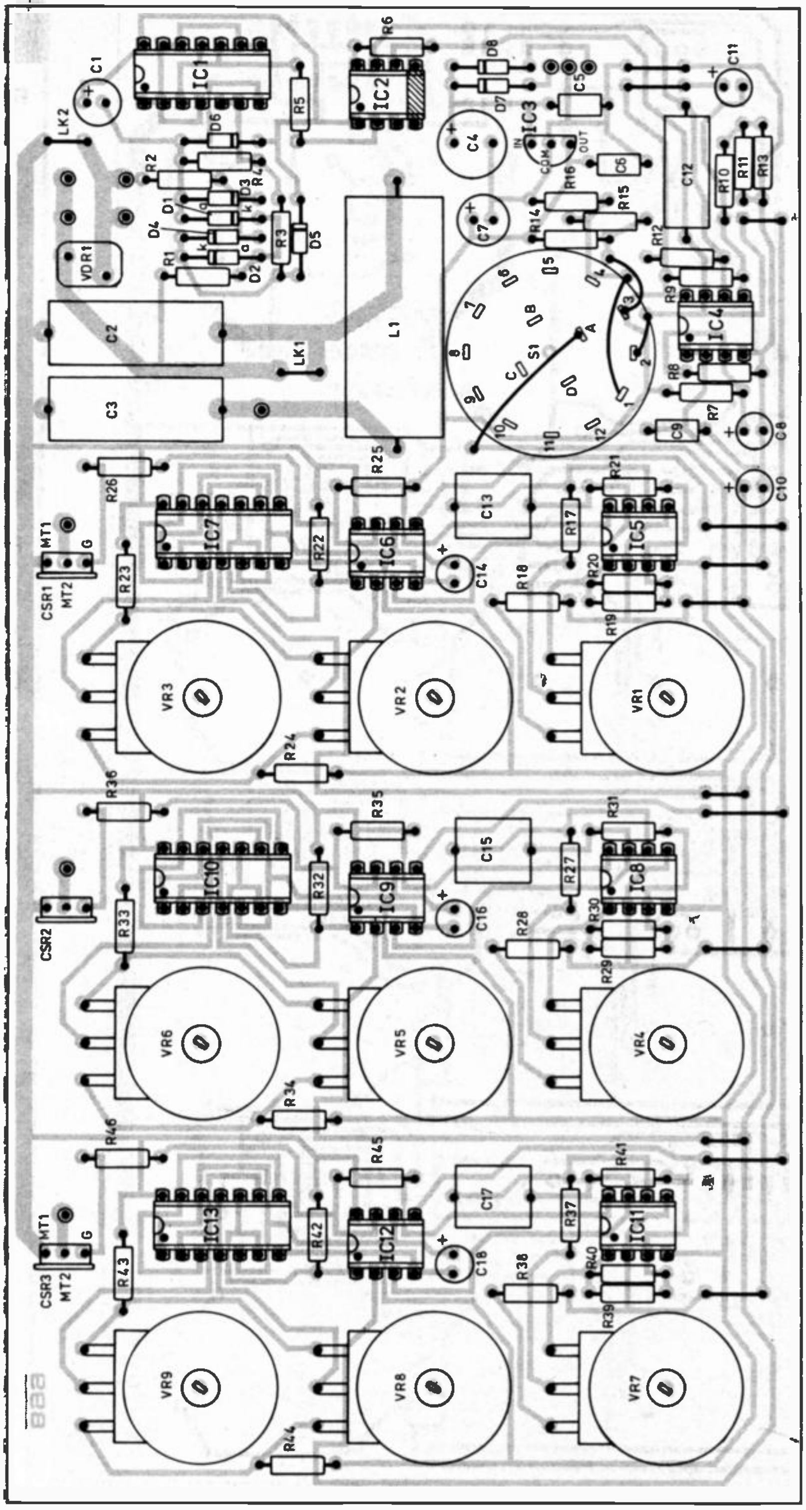


Fig. 4. Printed circuit board component layout. The full size copper foil master for the 3-Channel Lamp Controller is shown on the opposite page.

TESTING

The board is now ready for testing. It is advisable to test a circuit like this in stages, rather than simply powering up and hoping for the best, so here is a procedure that should detect any problems relatively painlessly.

Firstly, the transformer should be temporarily connected, and provision made for supplying mains power to the board. This is a suitable point at which to discuss the subject of safety.

SINCE SOME OF THE TRACKS ON THE BOARD ARE CONNECTED DIRECTLY TO THE MAINS, THERE IS OBVIOUSLY A RISK OF ELECTRIC SHOCK UNLESS SUFFICIENT CARE IS TAKEN. Until the links LK1 and LK2 are fitted, the "live" tracks are restricted to the top right-hand corner of the board, in the area around IC1, IC2 and the group of components between IC1 and capacitor C2.

The rest of the board is safe to handle until the links are fitted, allowing testing to be carried out safely. For additional safety during this stage of construction, it is wise to insulate the copper side of the board beneath this area with some layers of insulating tape.

Once suitable precautions have been taken, the board can be powered up. The unregulated d.c. supply from the transformer and rectifiers can be checked across capacitor C4, and will probably be around 16V. If this is present, the regulated supply across C7 can be checked, this should be 12 volts plus or minus a few per cent.

The voltage supply for IC1, approximately 12 volts, could be checked across pins 7 (negative) and 14 (positive) of it's socket, but as these points are connected to the mains some constructors may prefer to omit this step and trust that this part of the circuit will be OK. Also very little power is available at this point, so unless a meter with a high input impedance, such as a DVM, is used the reading obtained may be misleading.

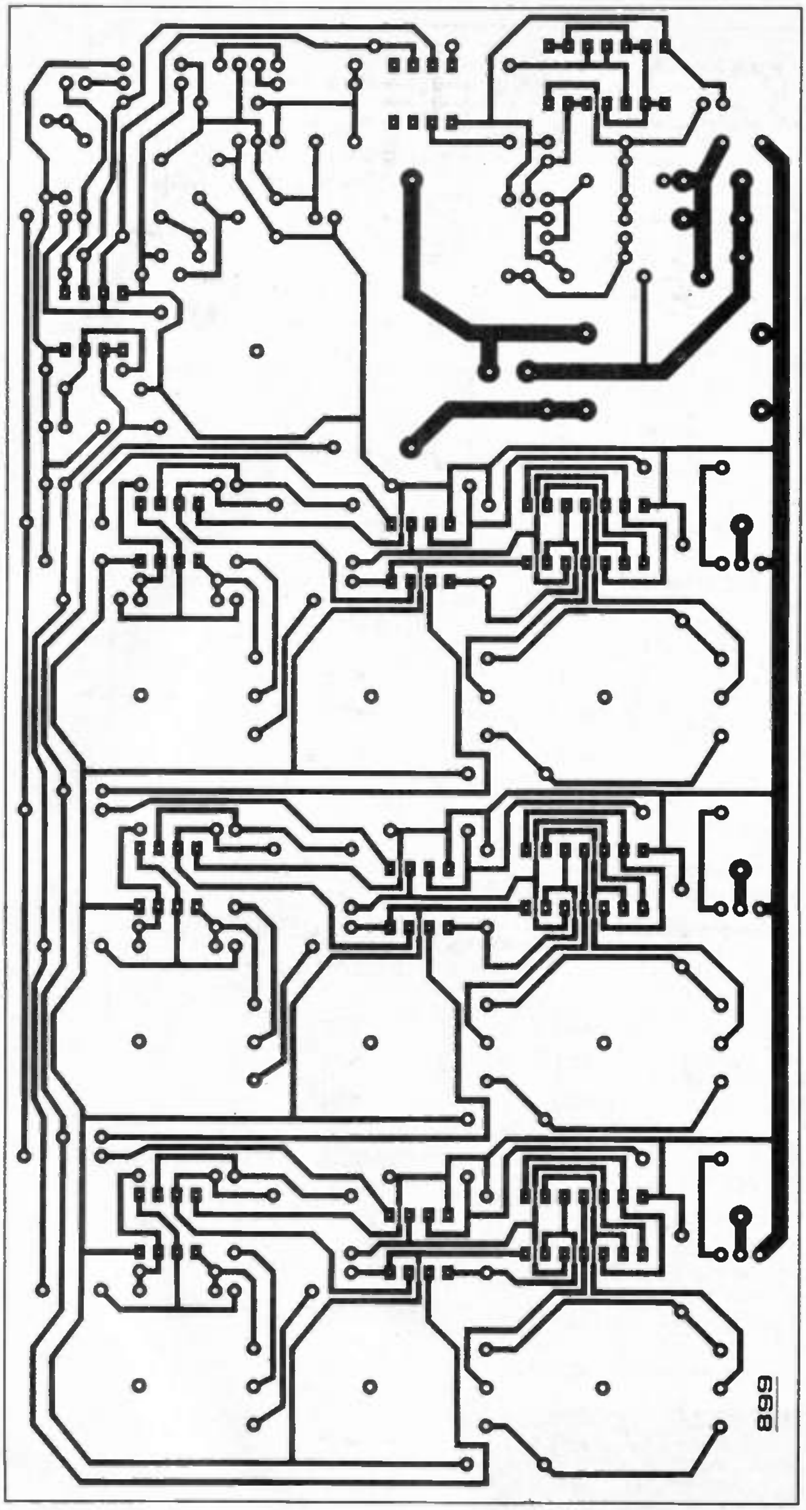
The next step is to fit IC1, IC2 and IC4, turning *off* the power before doing so of course. If an 8-pin socket has been fitted for IC2, note that the i.c. is located towards the top of this, leaving the lowest pair of connections unused.

A check of the d.c. voltage at pins 1 and 7 of IC4 should reveal around half the supply at both points. Pin 7 is the 100Hz ramp output however, so a check here with an a.c. voltmeter will show around one volt r.m.s., whilst there should be no a.c. component at pin 1. If an oscilloscope is available, the 100Hz sawtooth waveform with a peak-to-peak value of around four volts can be viewed at pin 7.

Following this, IC5 should be fitted. The slow ramp voltage should be present at pin 7, swinging between 4V and 7·5V. If so, pin 1 should be switching between approximately 1·5V and 11V.

The comparator IC6 is next. With switch S1 set to "high", pin 1 of this i.c. should be close to the supply voltage, when S1 is set to "low" it should be close to zero. With S1 set to "run" the d.c. level of the output as measured with a meter should ramp between zero and supply, though in fact it is switching at 100Hz with a continually varying mark-space ratio.

The electronic switch for this channel, IC7, can now be fitted. With S1 set to High, the upper control VR3 should control the potential at pins 1,5 and 12 of IC7 between 3V and 7·5V; whilst the lower control VR2



should have no effect. This voltage should be set and left at six volts.

With S1 turned to Low, VR2 should now control the output from IC7, which should be left at four volts. If S1 is now set to Run, the output from pins 1,5 and 12 should ramp between 4V and 6V.

Pin 7 of IC6 should now be ramping between about 3V and 8V as viewed with a d.c. voltmeter, though in fact it is switching at 100Hz, synchronised to the mains, and the apparently changing voltage reflects the varying switching point. If all these tests give the expected results, there is every chance the first channel of the circuit is working correctly. The other two channels may be checked in a similar manner to the first.

FINAL RUN

With the board testing complete, the two links LK1 and LK2 can be fitted. Suitable loads, such as 60-watt lamps, can be connected to the outputs and the board powered again, ***remembering of course that none of it is now safe to touch.*** It may be advisable to find some safe way of holding the board still whilst final testing is undertaken.

The action of the various controls for each channel, "set High", "set Low", and "Speed" can be tried out to ensure they are working correctly. It will be seen that both the level setting controls for each channel cover the entire range of brilliance

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R4, R6	100k (4 off)
R3, R7 to R11, R15, R18, R21, R22, R25, R28, R31, R32, R35, R38, R41, R42, R45	10k (19 off)
R5	560
R12, R17, R27, R37	1M (4 off)
R13	82k
R14, R16, R26, R36, R46	2k2 (5 off)
R19, R29, R39	330k (3 off)
R20, R30, R40	27k (3 off)
R23, R24, R33, R34, R43, R44	33k (6 off)

All 0·6W 1% carbon film

Potentiometers

VR1, VR2, VR3, VR4, VR5, VR6, VR7, VR8, VR9	100k rotary carbon, linear (9 off)

Capacitors

C1, C8, C10, C11	10µ radial elect. 50V (4 off)
C2, C3	220n rated for continuous 240V mains use (2 off)
C4	470µ radial elect. 35V
C5, C6, C9	100n polyester layer (3 off)
C7	100µ radial elect. 25V
C12	10n polystyrene, 1%
C13, C15, C17	1µ polyester layer (3 off)
C14, C16, C18	2µ2 radial elect. 100V (3 off)

Semiconductors

D1, D2, D3, D4, D5	1N4148 signal diode (5 off)
D6	BZY88C12V 12V 1·3W Zener diode
D7, D8	1N4007 1A 1000V rec. diode (2 off)
IC1	4011B quad NAND gate, CMOS
IC2	Opto-isolator
IC3	78L12AWC 12V 100mA regulator
IC4, IC5, IC8, IC11	TL072 dual op.amp (4 off)
IC6, IC9, IC12	LM393 dual comparator (3 off)
IC7, IC10, IC13	4007 CMOS Complementary pair Plus Inverter (3 off)
CSR1, CSR2, CSR3	C206M 600V 4A triac (3 off)

Miscellaneous

VDR1	240V surge protector (Maplin HW13P)
L1	100µH 4A choke
S1	3-way single-pole rotary switch, make-before-break
T1	Min mains transformer. Primary: 240V a.c. Secondary: 12V-0V-12V 100mA

Printed circuit board available from the *EPE PCB Service*, code 893; plastic ABS case, size 216mm x 130mm x 85mm; 8-pin d.i.l. socket (8 off); 14-pin d.i.l. socket (4 off); miniature 3-pin mains chassis socket, with plugs (3 off each); knobs (10 off); multistrand and single-core connecting wire; solder etc.

Approx cost guidance only **£50**

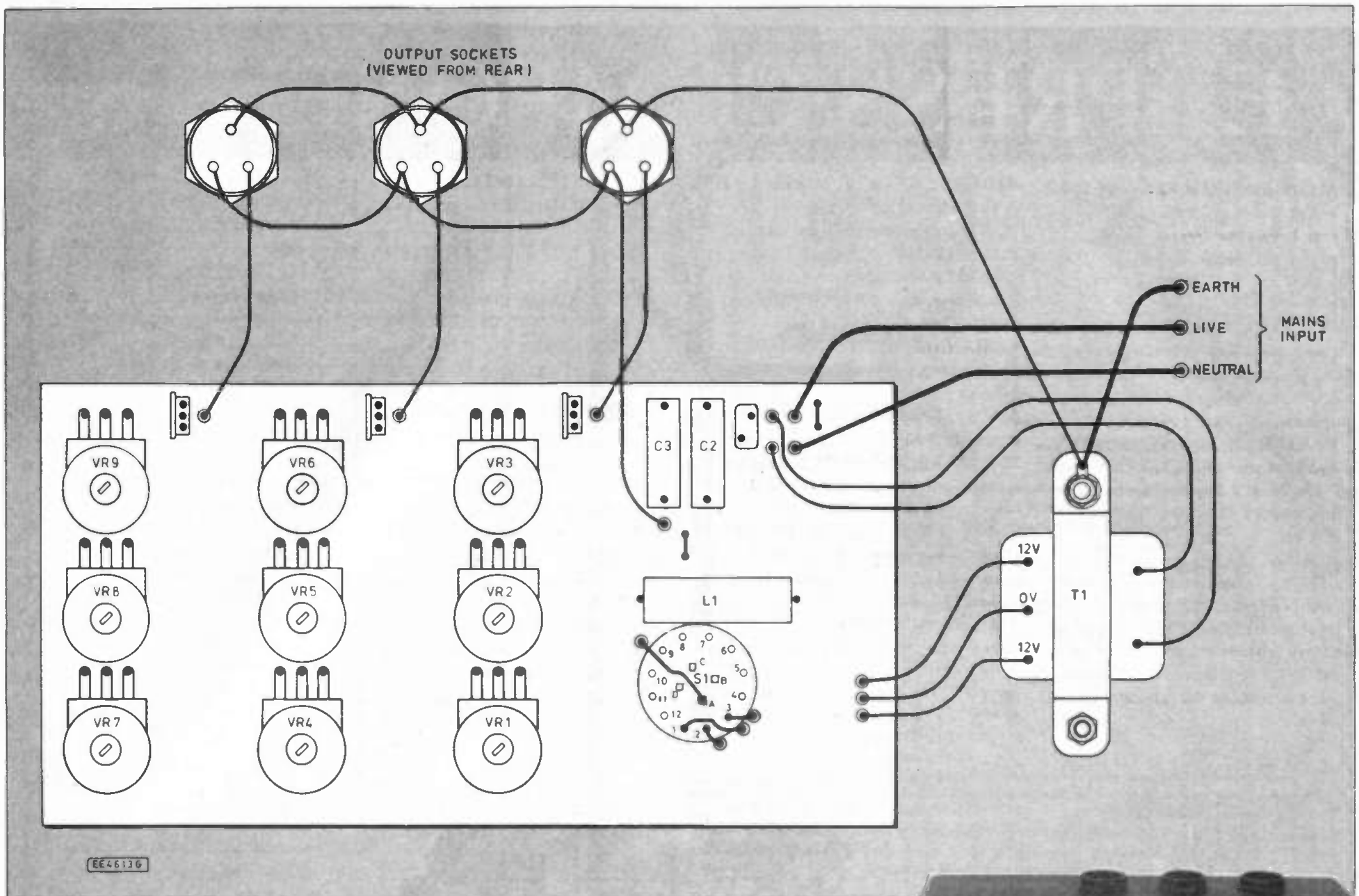


Fig. 5. Interwiring from the circuit board to the mains transformer, mains input and output sockets.

from completely "off" to fully "on" so they are in fact interchangeable. The reason for this is to allow channels to be set, if required, to operate continuously at very low or high levels.

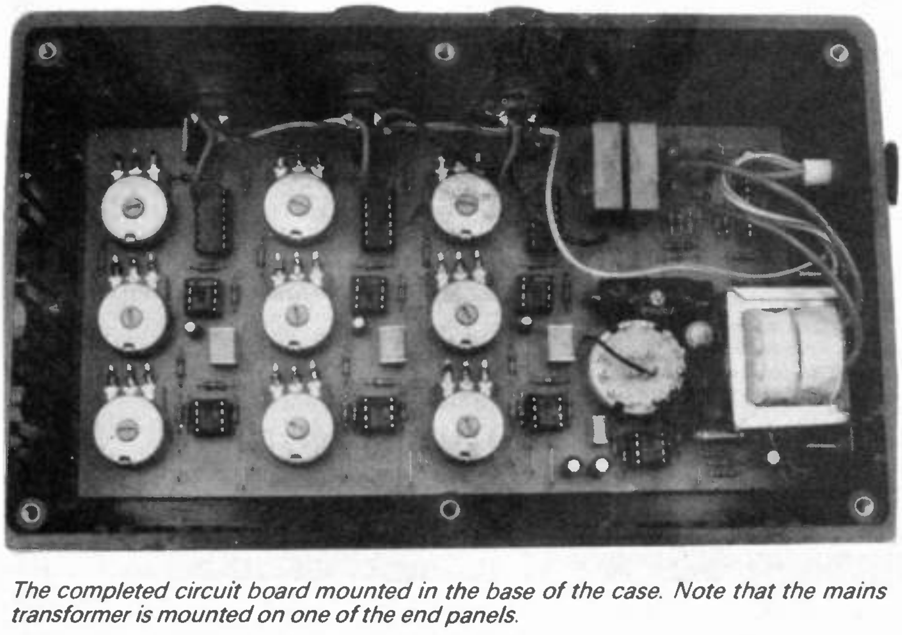
FINAL ASSEMBLY

The choice of case is up to the individual constructor. The one used for the prototype is a standard ABS plastic type, but the board and other components are a fairly tight fit.

Holes for the control shafts had to be drilled with some precision, and plastic was trimmed here and there to allow the board to drop into place. Two pieces of 15mm wide plastic sheet were cut and glued into each end of the case for the board to rest on, then two more pieces were cut to fit into the moulded case slots and, with central cut-outs to clear the components, press the board into place when the lid was fitted.

The mains transformer, mains lead and connections for the output sockets were connected before the board was finally fitted, after which the transformer and output sockets were screwed into place and the output connections completed.

The wiring of the board, transformer and sockets are all shown in Fig. 5. Note the Earthing, taken to the transformer external metalwork and to the sockets so that safety earthing is available from the outputs if required.



The completed circuit board mounted in the base of the case. Note that the mains transformer is mounted on one of the end panels.

FINAL DRIVE

It should be noted that this project is intended only for driving ***resistive loads*** such as filament lamps; fluorescent types MUST NOT be used with it. The load driving capability of the three channels is limited mainly by the fact that the three triacs are not provided with heatsinks.

As most of the time the three channels will not be at full brilliance, half an ampere per channel, or 120W in round figures, is a fairly conservative rating, giving 360 watts overall. This should provide a sufficiently spectacular display for parties, advertising and many other uses which will undoubtedly occur to our imaginative readers.

However, more power could be utilised if the triacs were to be mounted on heatsinks located elsewhere in the case and connected to the board with short leads. If this is done, it should be noted that the tabs on the triacs are connected to their output terminals, so *separate* heatsinks or reliable tab insulation will be required.

Depending upon the efficiency of the heatsinks, just over an ampere per triac should be useable, the current now being limited by the 4A rating of the choke L1. This should provide a truly spectacular display. □

THE INVISIBLE FORCE

MIKE CROW

Ancient in origin, magnets pull power for the future

IF one is tempted to ask a knowledgeable person how a compass needle, a solenoid, and countless electric and electronic components work, the chances are, that somewhere in the explanation will be the word "magnetism." Or ask an atomic scientist how the basic particles of life and matter operate and the phrase "forces of attraction" will almost certainly emerge.

When used to describe the performance of other phenomena we tend to take "magnetism" and "magnetic" for granted, but ... how do they work? Furthermore, those of us who spend time (and money) delving into the mysteries of TVs, communications equipment, CBs and radar, are often foremost in the "take it for granted" department.

ANCIENT MAGNETS

Obviously, knowledge, but not understanding, of magnetic forces goes back into antiquity. It was accepted that the name "magnet" came from the discovery of magnetically active "loadstones" in ancient Greece, found in the Magnesia region of Thessaly as far back as 800BC. On the other hand, it is claimed that the Chinese were using lodestones several thousand years before that!

Loadstones were investigated by one, Petrus de Manicourt, in 1269. He wrote a treatise thereon, and in England William Gilbert wrote *De Magnete* around 1600 and dutifully then advised Elizabeth I of their properties. The *Mary Rose*, flagship of Henry VIII which foundered in 1545 off Portsmouth, and was recently salvaged, had a sophisticated magnetic compass.

What then was this "loadstone"? Essentially a naturally occurring black iron oxide, containing 72·4% of iron, and often traces of titanium and magnesium. Normally highly magnetic itself, and strongly attracted to other magnets, if suspended freely it would orient itself in a North-South magnetic axis, and thus its rumoured use for maritime navigation is probably true.

Lodestone material is also known as black rouge, magnetic ore, ferric oxide, and can exist as a black powder, but it is always basically Fe_3O_4. There is another iron ore which is naturally magnetic, but only slightly so. This is the mineral "pyrrhotite", so-called "magnetic Pyrites", otherwise Iron Sulphide. It is usually found mixed with small quantities of nickel and cobalt.

ADVANCING TECHNOLOGY

These then were the basic products which first became associated with that strange power of invisible attraction, soon noticed with considerable awe by the ancients, but in no way understood then or even much later, and relatively neglected until this century or so, as a potential and powerful source of immense technological advances. Yet ... within a few centuries, the controlled use and specialised application of the powers of magnetism, in conjunction with electricity itself, undoubtedly formed the basis of the electrical, telephone, radio, television and associated industries.

Furthermore, it is now appreciated that magnetic forces lie at the very heart of our understanding of the structure of matter, and in conjunction with other branches of nuclear physics are opening up new technologies or incredibly complex application and achievement. It was the close study of the structure of magnetisable and magnetising substances, for example, that led to developments like the following, already widely used in industry:

1. To produce by premeditated design (and not by former trial and error system) new alloys and powder metellurgy compounds, for the production of "permanent" magnets of incredible magnetic strength.
2. To produce ultra-pure needle-like crystals of iron (microscopically laid down in parallel "bundles". See later notes on structure) from which magnets of fantastic strength and permanence can be made.
3. To produce a class of complex compounds called "ferrites" (mixtures of iron oxides and other metallic oxides) by powder metallurgy, to be used for high-powered magnets having immense electrical resistance (over one million times the normal level). A great advance when used in transformer coils for high temperature applications, some of which include radar, radio, and TV systems, and also space engineering. Some are the only known materials to withstand the very high frequency of field reversal in some specialised microwave communications (approximately one million times per sec.). Also used in high speed computer memory systems.
4. The development of silicon-steel magnets having the unique property of being magnetisable in four directions simultaneously (along length and across breadth), and hence of considerable value in transformers. Another unusual example (produced by General Electric Research, USA) was a cobalt-cobalt oxide blend magnetisable in one direction only, and aimed at the production of a truly permanent magnet.

The importance of magnets to industry and scientific advancement is obvious. The once humble magnet, in earlier days almost at best a schoolboy curiosity, is now out there at the forefront of space technology and atomic physics, especially, for example, in the design and performance of "particle accelerators".

These extraordinary devices and the magnets which are essential to their operation are involved today in programs of mindbending complexity and ambition, but before taking a closer look at what may be regarded as the ultimate peak of magnetic power, let us go back to basics for a moment.

NEAR MONOPOLY

Years of practical experience had indicated that certain metals, and components and alloys of them, were relatively easy to magnetise. Specifically, these were known to be iron, cobalt, nickel, chromium and a relative newcomer gadolinium (which has the unusual quality of exhibiting high magnetism even at low temperatures). This raised the question of why these few, and not others have this strange characteristic?

Research found the answer lay in the "spin" of their essential electrons around their atomic nuclei, provided certain other requirements were met. The unique factor was the spin of one odd electron in atoms having an odd number of orbits, a key factor which opened the door to unusual magnetic characteristics in the five metals listed. Other elements apparently have an even number of electrons in their atomic structure, with one of each pair spinning in opposite directions to its "mate" thus neutralising one another's effect, in this context.

This is not quite the end of the story! These five "special" metals are not spontaneously magnetic (unless found naturally as a component of a magnetic ore). They have first to be magnetised e.g. by the passage of another magnetic field or current, or "stroked" by another magnet.

Now another question arises, we are now aware (from the orbit theory mentioned) that they can be magnetised, but what happens "inside" them when they are. This remained very much a mystery until the theory of "domains" was produced.

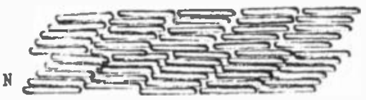


Fig. 1a. Magnetised material. Microscopic dipoles and domains in complete alignment.

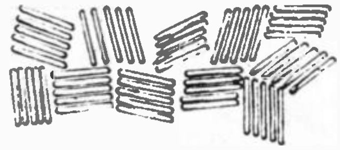


Fig. 1b. Unmagnetised material. Microscopic dipoles in alignment but only in their own domains. Domains themselves randomly distributed.

POLAR DOMAINS

A French scientist called Weiss suggested that iron and other magnetisable materials were composed (in their unmagnetised state) of many infinitely tiny regions or "domains" (each containing millions of atoms) whose lines of potential magnetism ran in random directions in the metal, and resembling therein an unorganised assembly of tiny dipole magnets. When magnetised the variously oriented domains (and their minute dipoles) would suddenly be realigned in one direction, to produce the characteristic directional pull (or polarity) of a true magnet.

This theory was eventually proved in the Bell Laboratories USA in 1946, using magnetic material immersed in extremely fine iron oxide powders. They succeeded in making the tiny domains visible on the metal surface, and thus open to further study. They were seen to follow the crystals structure of the metal. Other experiments proved the magnetising process had resulted in swivelling or reorienting the odd electron spins (already mentioned) of all the domains into a single direction, thus producing the familiar characteristic magnetic pull. The simplified illustration shown in Fig. 1 indicates the principle.

PARTICLE ACCELERATOR

It will be appreciated that the above summary of the principles involved is, of necessity, a simplified explanation of the very complex physics actually involved. Some of the industrial advances springing from it have already been described, but perhaps the most momentous contribution to our scientific knowledge will come from the almost mind-bending advances that may materialise from the usage of magnets in the "particle accelerators" already briefly mentioned. This complex and incredibly expensive equipment, perhaps more accurately described as an "installation" (since some linear accelerators are effectively over a mile long), relies on magnetic power for its operation.

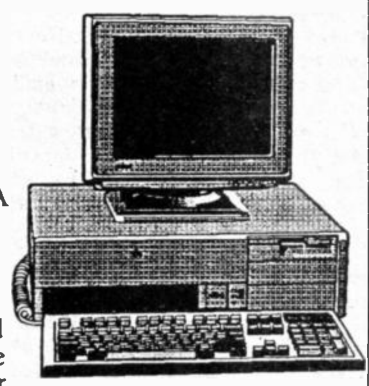
The atomic research programs of World War II resulted in fantastic advances in the knowledge of sub-atomic particles and a realisation that the door was only just opening on the incredibly complex alignment of forces and particles that are present at the heart of the atom itself. At the moment, the particle accelerator is probably the major tool in the quest for the identification and possible separation of as yet unknown particles of unknown size and possible immense potential power.

Basically, the accelerator can be regarded as an ultra-highspeed atomic gun, which can shoot a particular high energy particle at chosen atomic nuclei, with facilities for the ultimate separation and study of the potential products of such bombardment.

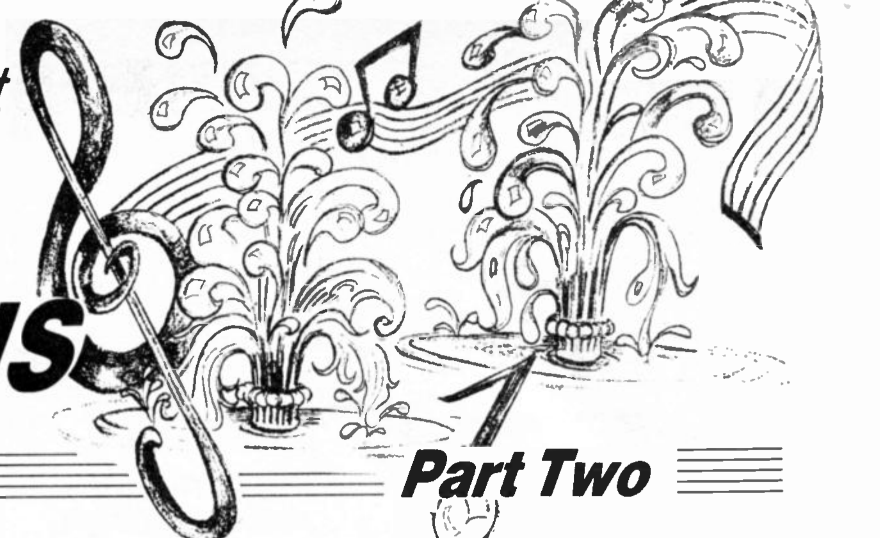
PARTICULARLY FANTASTIC

Quite a change when one considers that within a half-century or so, some of us were taught to believe that a molecule contained "atoms" . . . end of story! Now we already have hyperons, mesons, nucleons, leptons, and even quarks!

Furthermore, if one considers the fairly recent theory that "every particle is accompanied by an anti-particle" it may be difficult for a writer in the future to cope with the multiplicity of as yet unknown particles that may be spawned by these fantastic magnetically powered accelerators. □



Constructional Project



DANCING FOUNTAINS

JOHN BECKER

Part Two

Join the musical jet set at the pool and let the fountains dance the day away.
Plus optional PC-Compatible Interface to let your computer call the tune.

LAST month we covered the circuits and introduced the various printed circuit boards that go to make up the "fountain" design. This month we conclude with the final wiring, choice of options and setting-up. We also include an optional PC-compatible Interface add-on.

Three examples of housing and wiring the boards are shown in Fig. 7 to Fig. 9. Other configurations can be used if they suit your needs better.

It is intended that the microphone insert should be glued behind a hole of suitable size drilled into the box. A hot-melt glue gun was used with the prototype units.

MAINS SAFETY

Connecting of the Mains leads should only be undertaken by a competent person familiar with the potential hazards of Mains a.c. power. All Mains power plugs should be fitted with fuses of a rating suited to the application.

Pumps will have their amperage rating clearly marked on them. Allow about one amp to meet the potential peak demands of the complete electronic control system. ***If you are in any doubt, seek professional electrical advice.***

Cable clamping glands should be used to secure the Mains cables at their entry points to the boxes.

All units should be kept well out of the range of potential water soaking. If the connectors are to be SITUATED OUTDOORS, it is strongly recommended that waterproof Mains connectors should be used and that a Mains circuit breaker (RCD – Residual Current Device) MUST be included in the primary Mains power supply line.

ROVING PREAMP ASSEMBLY

The housing details for the Roving Preamp unit (from hereon referred to as unit PC1) are shown in Fig. 7. This unit may be connected to any of the other units. If it is connected only to the Slave Pump Controller (unit PC2) in Fig. 8, d.c. power has to be supplied from a 12V battery (or other 12V d.c. supply) via socket SK2 or SK3, which are identically wired.

If connected to the unit in Fig. 9 (PC3, or its shortened version PC4), d.c. power to PC1 is automatically supplied via the connecting cable. PC1 may be placed within "earshot" of a loudspeaker or directly plugged into the signal output of an audio source via SK1.

An additional Slave Pump Controller may be plugged into socket SK2 or SK3 if either is otherwise unused.

SLAVE PUMP CONTROLLER

The housing details (PC2) for a single pump controller board are given in Fig. 8. PC2 may also be connected to any of the other units. It may be used on its own with PC1 if the latter is d.c. powered from an external 12V source.

Pump Controller PC2 must always be plugged into a Mains power socket irrespective of which other units it is used with. The pump is plugged/screwed into PC2's triac-controlled output socket TB1.

Capacitor C26 and the rectifier are omitted from this unit. P.C.B. points 23, 27, 29, 35, 36, 38, 39 are not used.

MULTIPLE PUMP CONTROL UNIT

The housing and wiring details for the Multiple Pump Controller unit (PC3) are shown in Fig. 9. This can control five pumps, three responding to separate filtered frequency bands, and two responding

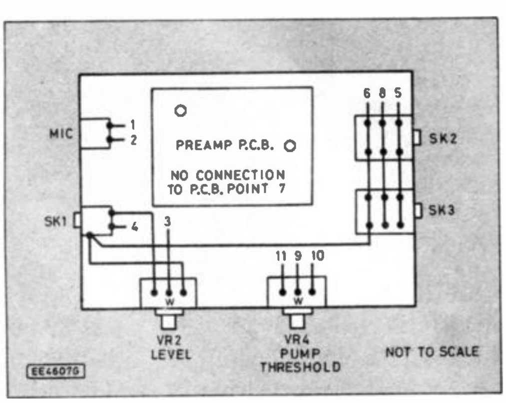
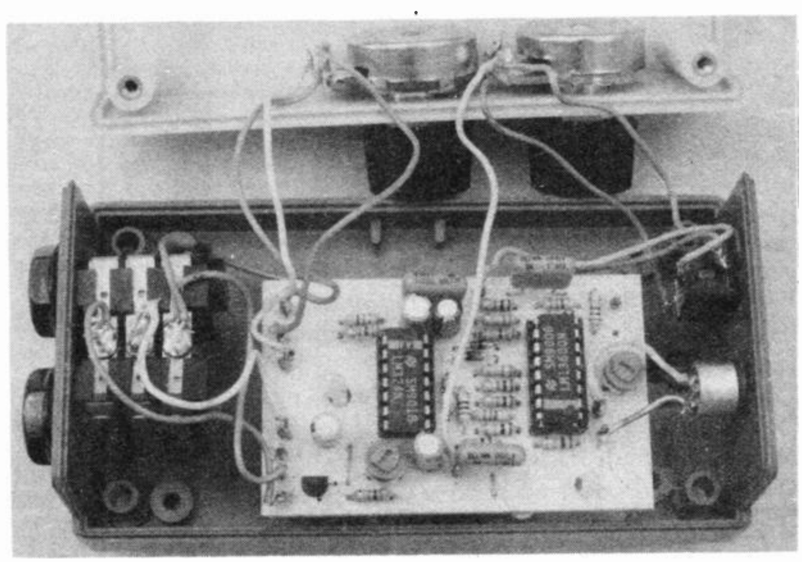


Fig. 7. Interwiring from the off-board components to the Preamp p.c.b. The numbers refer to board points given last month.



Completed Roving Preamp Module (PC1)

in unison to the full audio signal spectrum. PC3 contains one Preamp, one Filter, one Pump Controller and a mains transformer powering the integral d.c. PSU.

With the prototype PC3 unit, a 20VA transformer was used since it is also used to control a bank of solenoid-operated fountain jets which require a lot of current. It is likely that a 6VA transformer will suffice for the published PC3 and PC4 units. *(Let us know if you would like the solenoid system published – nine jets individually controlled, all supplied by one Lotus Mermaid 1200 pump – Ed).*

Four Slave Pump Controllers (PC2) can be plugged into PC3, one for each frequency band output socket (SK5 to SK7), plus one for the full audio control output at SK3. The fifth pump is plugged into PC3's own triac-controlled mains socket.

The audio signal can be input via the internal microphone, or via the external input socket SK1, or from PC1, or from the Computer Interface. D.C. power to PC1 and the four units PC2 is supplied via the connecting cables.

COMPONENTS

Approx. cost of complete system from **£25** excluding pumps

BOXED UNITS ADDITIONAL COMPONENTS

See SHOP TALK Page

UNIT PC1 – ROVING PREAMP

Dual-tone plastic case, size 120mm x 54mm x 40mm (L x W x H); p.c.b. supports, short, self-adhesive (2 off); plastic stereo jack plugs and 3-core signal cable as required to suit interconnection needs.

UNIT PC2 – SLAVE PUMP CONTROLLER

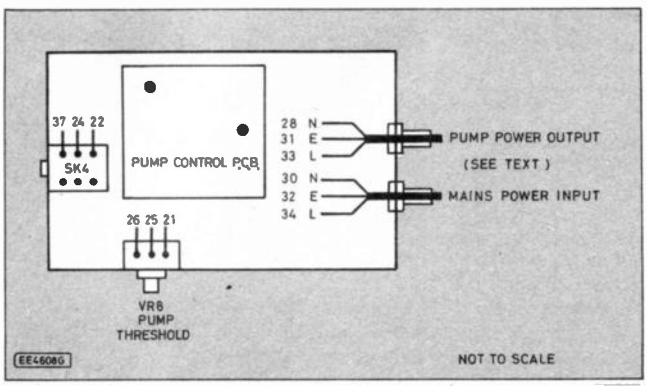
SK4	0·25 inch plastic stereo jack socket

Mains cable clamp glands (2 off); mains plug and socket (see text); dual-tone plastic case, size 120mm x 54mm x 40mm (L x W x H); p.c.b. supports, short, self-adhesive (2 off); plastic stereo jack plug; 3-core signal cable and 3-core Mains cable as required to suit interconnection needs.

UNITS PC3 AND PC4 – COMBINED CONTROLLERS

C26	470μ radial elect. 16V capacitor
REC1	1A 50V bridge rectifier
T1	9V (or twin 4·5V) a.c. mains transformer (6VA – see text)

Mains cable clamp glands (2 off); Mains plug and socket (see text); dual-tone plastic case, 190mm x 108mm x 60mm (L x W x H) (PC3 only); dual-tone plastic case, 150mm x 80mm x 50mm (L x W x H) (PC4 only); p.c.b. stacking pillars (2 off); p.c.b. supports, short, self-adhesive (2 off plus 2 extra for PC3); plastic stereo jack plugs, 3-core signal cable and 3-core Mains cable as required to suit interconnection needs.



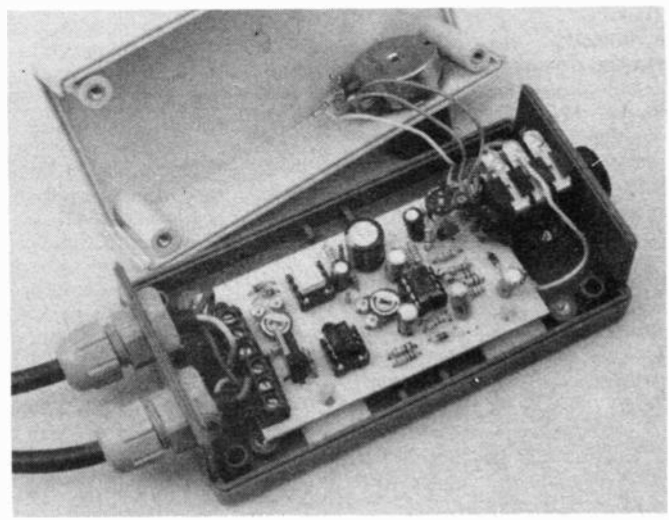


Fig. 8. Single Slave Pump Controller wiring guide and (right) completed PC2 unit.

Omit the following components from the PC3 assembly: R19, R20, R33, R50, R51, VR3, VR4, VR8, IC3, IC4. Link p.c.b. points: 7 and 13 to 23, 14 to 24, 25 to 36. There is no connection to p.c.b. points 5, 12, 15, 20, 21, 28.

If PC1 is to be used, the Preamp board of PC3 may be omitted.

SHORTENED VERSION

A shortened version of PC3 can be assembled in a smaller case (PC4), omitting the filter board and sockets SK3 to SK5. Two pumps can be controlled in unison, one directly from PC4's triac-controlled Mains socket, and one via a PC2 unit plugged into SK3.

With PC4, the controller board is mounted above the preamp, both aligned lengthwise within the case.

SETTING UP

Before connecting any unit to the Mains or other power supplies, *double-check* the assembly for faulty soldering, incorrect wiring, and incorrect orientation of semiconductors and electrolytic capacitors.

From now on in this section, "check" or "monitor" means check with a multimeter or an oscilloscope.

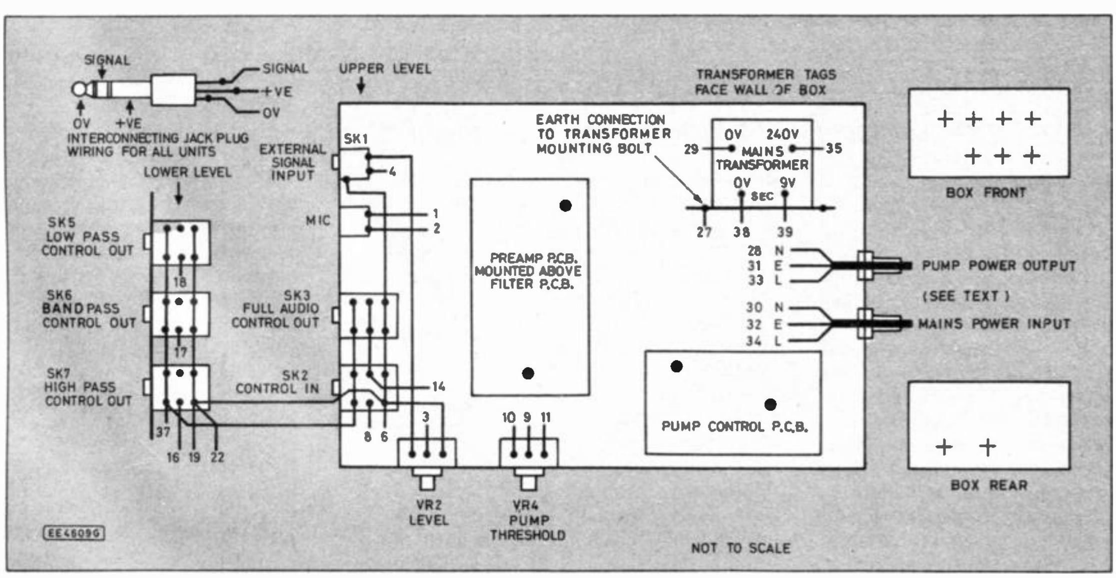


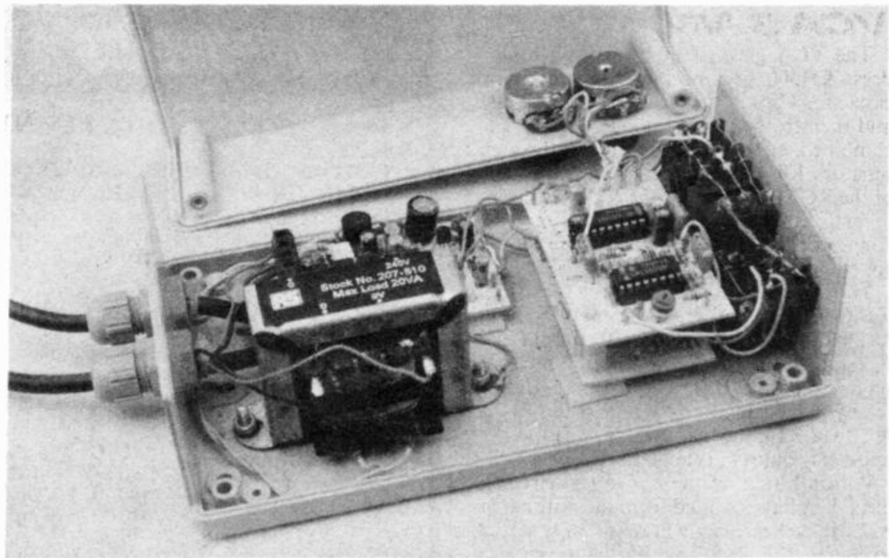
Fig. 9. Interwiring details for the Multiple Pump Control Unit – PC3.

Switch on the power and immediately check that the voltage at the inputs to all regulators used (IC3, IC4 and IC10) is about 12V d.c. Adjust the preset pots (VR3, VR5 and VR9) of each regulator so that the output voltage is set for 9V.

Preamp

With the Preamp board, and in a silent room (Mic pick-up!), carefully adjust VR1 until the voltage at IC1 pin 8 is set for about 3V (approximately 1·5V below half the 9V power line level). Also check that about 4·5V is present at the junction of resistors R16 and R17.

Play a music track with a good dynamic range near the preamplifier. With VR2 set for maximum signal input level, monitor IC2 pin 14 and check that the output voltage varies in sympathy with moderately-rapid changes in the music level. Check that the audio output signal is present at SK2 and SK3, and that VR4 adjusts the d.c. bias level. (A multimeter should be set to a low a.c. range for checking the presence of the audio signal).



Completed Multiple Pump Controller showing layout of components and stacking of the various p.c.b.s.

Filter

With the Filter board, check that about 4·5V is present at the junction of resistors R36 and R37. Check that the audio signal reaches the board and then that it reaches the three filtered outputs. The amplitudes at the outputs will depend upon the frequency content of the input signal. Check that the d.c. bias level at each output can be adjusted by VR4 of the Preamp.

Pump Controller

Move on to the Pump Controller Board. **Beware that Mains voltages are present on this board. Use an insulated tool when adjusting the presets, even though the presets have plastic cases. Tools can slip!**

Check that the d.c. bias level at the junction of R48 and C21 can be varied by VR4 of the Preamp. Similarly check that VR8 adjusts the bias level at IC8 pin 5. Check that the voltage at the junction of D5 and C19 varies with changes in audio signal levels. Set presets VR6 and VR7 to midway positions.

Alignment of the 100Hz waveform by VR6 is best done using an oscilloscope, adjusting the preset until the most evenly balanced waveform is seen. However, if the output at IC8 pin 1 is monitored on a low a.c. range of some multimeters, it may be apparent when the best average signal level has been set by VR6. If no change is obvious, leave VR6 set midway.

Monitor IC8 pin 7. In the absence of an audio signal, vary the d.c. bias settings of VR4 and VR8. Observe that the output voltage at pin 7 can be swung fully between about 7·5V and 0V in response to different bias settings. With an audio signal present, check that VR4 and VR8 can set the bias so that the output at pin 7 shows well-defined pulses and that their mark-space ratios can be changed.

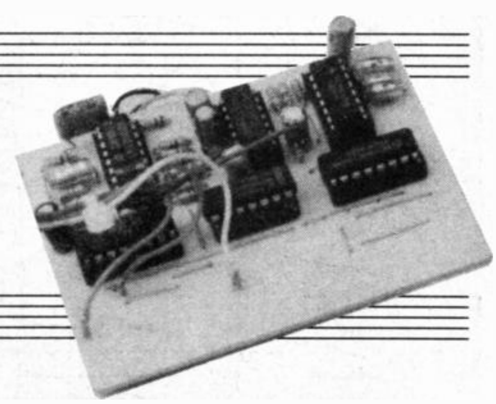
Plug a table lamp into the Pump Output socket.

Again vary the bias and audio signal levels. The brilliance of the lamp should be capable of being set fully on and off by the bias controls.

It should become apparent that there are intermediate bias setting points which allow the lamp brilliance to vary with the music beat. The range of bias levels within which the lamp responds may be changed using preset VR7.

The Fountain Controller system is now ready to be used with a pond pump. Note, though, that some pumps do not like being operated out of water. Take the plunge, and try out the system with the pump in the pond.

PC-COMPATIBLE INTERFACE



Let your computer call the tune.

COMPUTER CONTROL

Since the author enjoys putting circuits under computer control, it was decided to design a PC-compatible Interface for use with the fountains in addition to normal audio control. The interface is an optional extra and does not need to be used. The circuit diagram for the PC-Compatible Interface is shown in Fig. 10.

The circuit allows the computer to control the frequency and amplitude of a simple signal generator, and to set the d.c. bias level for the Pump Controller circuit. It can be used in place of the Preamp circuit.

Using a p.c.b. inserted into one of the several interface sockets with which PC-compatibles are provide, the circuit is controlled by Data Write calls to any of addresses &H300-&H302, &H308-&H30A, &H310-&H312 or &H318-&H31A. The calling address group is determined by which of the Y1, Y3, Y5 or Y7 outputs of IC1, in sequence, is connected to link point *Z*. The control addresses quoted below assume that *Z* is linked to Y1.

Group address selection is carried out by OR gate IC3 and data demultiplexer IC1. The selected Y output of IC1 controls the output enabling pins of analogue multiplexer IC2 and digital-to-analogue converter (DAC) IC4, labelled INH and $\overline{EN}$ respectively.

Write calls to any of the selected addresses causes the DAC to convert a binary code on its data inputs to an equivalent d.c. output voltage, which is routed to the X input of IC2. The address on IC2's control inputs routes the X input to the selected output, X0 to X7.

When selected, output X1 routes the d.c. level to capacitor C1 and the sample-and-hold (S and H) buffer IC5a. The output of IC5a is connected, via resistor R3, to the control node of the voltage controlled oscillator (VCO) formed around TCA IC6a.

The VCO frequency is dependent upon the control current and the feedback coupling through capcitor C3, diode D1 and diode D2. The somewhat peculiarly shaped VCO output waveform is buffered by IC6b and fed to the voltage controlled amplifier (VCA) formed around TCA IC6c.

VCA GAIN

The VCA gain is set by writing to address &H300, routing the DAC output to capacitor C5 and the S and H buffer IC5b, and then to the control node of IC6c. The combined effect of the currents through resistors R9 and R12 determines the gain of the VCA, and thus of the VCO level sent to buffer op.amp IC5c. The signal can be connected, via C8, to any of the pump controlling circuits.

The d.c. bias level required for the Pump Controllers is set by writing to address &H302, so routing the DAC output via IC2 output X2, to C7 and the d.c. amplifier stage around IC5d. The gain of this stage is set by the ratio of R17 and R18. From IC5d via R16, the bias level is added to the frequency output at capacitor C8.

With all three of the above sub-circuits, the d.c. voltages routed from the outputs of IC2 will be held briefly at reasonably stable levels by the inclusion of the respective capacitors C1, C5 and C7. The charge decay rate of the capacitors is slow enough for the circuit to be controlled from Basic without significant changes in the output function levels between successive calls, though the calls must be frequent.

COMPONENTS

Approx cost guidance only **£20**

PC-INTERFACE

Resistors

R1, R2, R7, R8	4k7 (4 off)	R6, R9, R13, R14	10k (4 off)
R4, R18	47k (2 off)	R10, R11, R16	1k (3 off)
R3	220k	R15	33k
R5, R12, R17	100k (3 off)		

All 0.25W 5% carbon film or better.

Capacitors

C1, C5, C7	220p polystyrene (3 off)
C2, C6	22µ radial elect. 16V (2 off)
C3	1n polystyrene
C4	100n polyester
C8, C9, C10, C11	1µ radial elect. 63V (4 off)

See SHOP TALK Page

Semiconductors

D1, D2	1N4148 signal diode (2 off)
IC1	74HC138 1-of-8 digital demultiplexer
IC2	74HC4051 1-of-8 analogue multiplexer
IC3	74HC4078 8-input NOR/OR gate
IC4	ZN559E 8-bit latched-input digital-to-analogue converter
IC5	TL084 quad op.amp
IC6	LM13600 dual transconductance opamp

Miscellaneous

Printed circuit board (double-sided) available from *EPE PCB Service*, code 892 (Interface); 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket (4 off); 0·25 inch plastic stereo jack socket and stereo jack plug; 2-way cable to suit requirements; terminal pins; connecting wire; solder, etc.

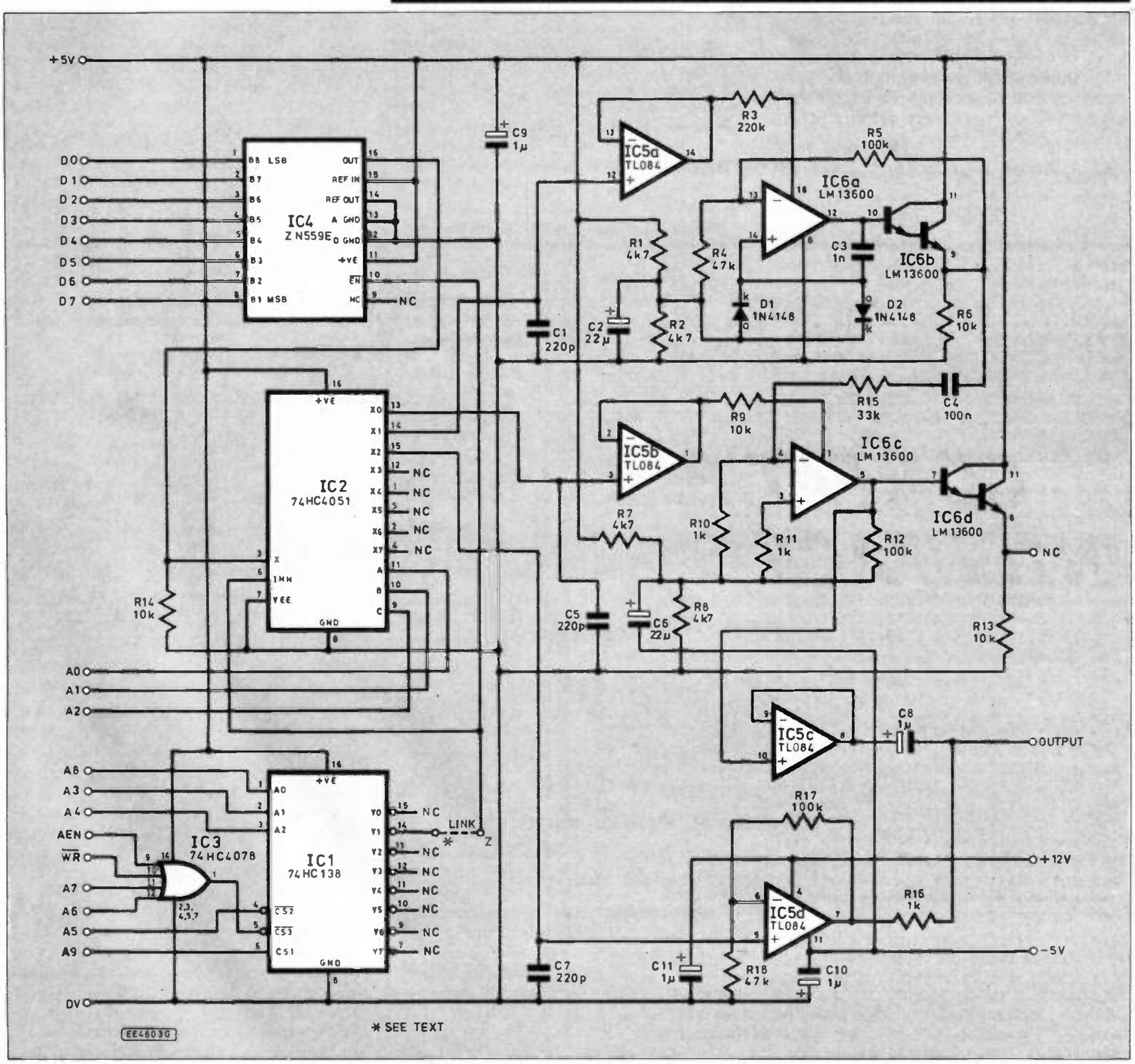


Fig. 10. Completed circuit diagram for the PC-Compatible Interface.

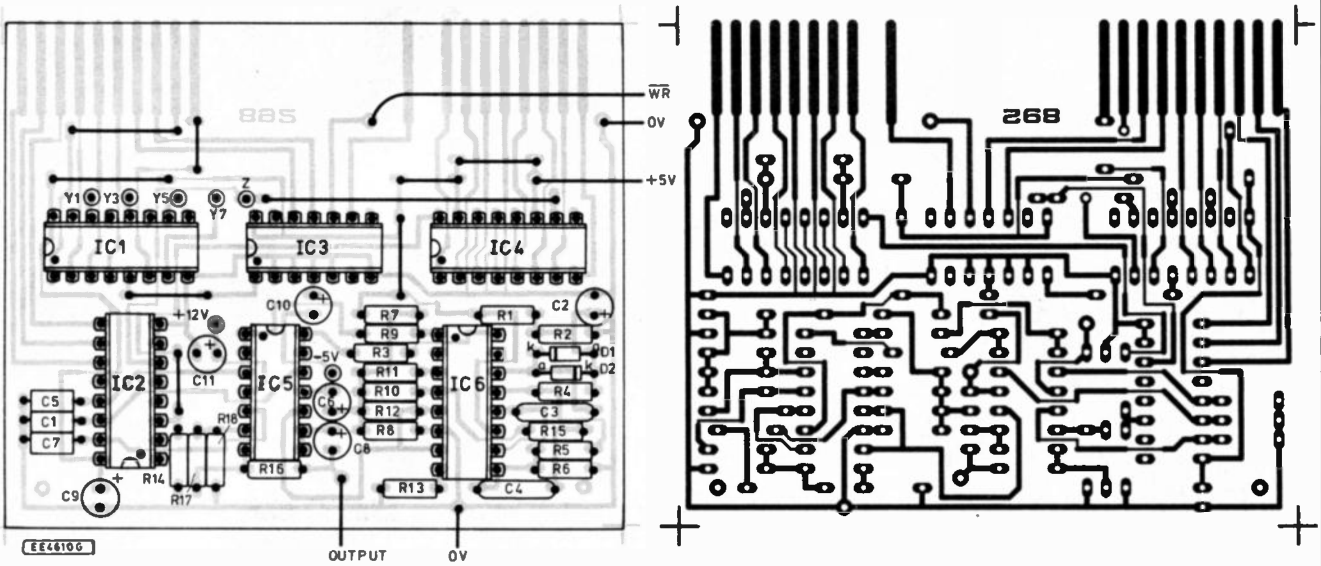
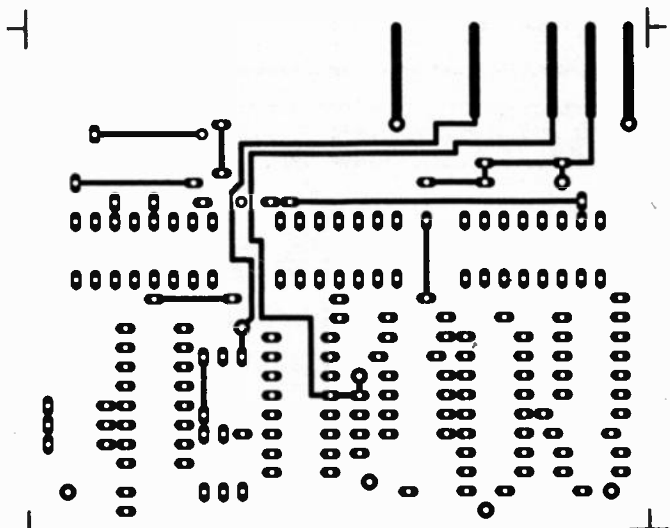
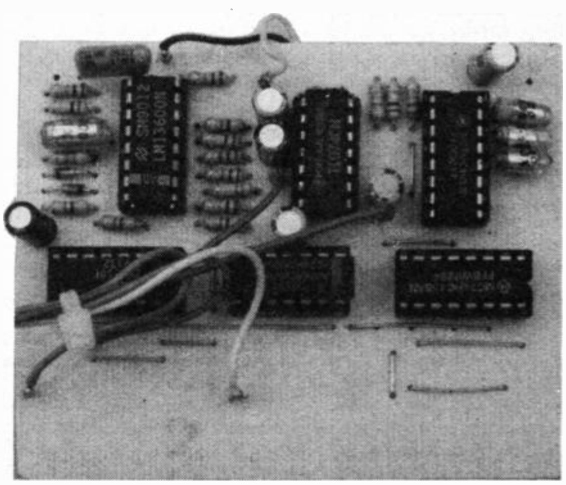


Fig. 11. Printed circuit board component layout for the Interface. The topside view shown above left is for a single-sided version with link wires. The final double-sided layout is identical, without the links, and the underside and topside copper foil master patterns are shown above right and below.

LISTING 1: EXAMPLE FOUNTAIN CONTROL PROGRAM

```
10 REM FOUNTAIN CONTROLLER F77 02DEC93
20 CLS:P(0)=&H300:P(1)=&H301:P(2)=&H302:S$="     "
30 P$(0)="AMP ":P$(1)="FREQ":P$(2)="PUMP":P$(3)="RATE"
40     GOTO 270:REM FILE INPUT ROUTINE
50 :
60 REM KEYBOARD INPUT ROUTINE
70 D(0)=0  :D(1)=0 :D(2)=255:GOTO 90
75 REM EXPERIMENT WITH DIFFERENT D(0) TO D(2) VALUES
80 Z$=INKEY$:IF Z$="" THEN 130
90 GOSUB 160:FOR C=0 TO 2:A(C)=D(C):IF A(C)<0 THEN A(C)=0
100 IF A(C)>255 THEN A(C)=255
110 LOCATE 3+C,4:PRINT P$(C);A(C)"  "
120 LOCATE 3+C,20:PRINT D(C)"  ":NEXT
130 FOR D=0 TO 2:OUT P(D),A(D):NEXT:GOTO 80
140 :
150 REM KEYSTROKE INTERPRETATION SUB-ROUTINE
160 IF Z$="a" THEN D(0)=D(0)-1:RETURN
170 IF Z$="A" THEN D(0)=D(0)+1:RETURN
180 IF Z$="f" THEN D(1)=D(1)-1:RETURN
190 IF Z$="F" THEN D(1)=D(1)+1:RETURN
200 IF Z$="p" THEN D(2)=D(2)-1:RETURN
210 IF Z$="P" THEN D(2)=D(2)+1:RETURN
220 IF Z$="r" THEN D(3)=D(3)-R:IF D(3)<-90 THEN D(3)=-90
230 IF Z$="R" THEN D(3)=D(3)+R:IF D(3)>90 THEN D(3)=90
240 RETURN
250 :
260 REM FILE INPUT ROUTINE
270 CLS:OPEN "R",#1,"FOUNTAIN.BAS",128:L%=LOF(1)/76
280 FIELD 1,76 AS A$:D(0)=200:D(1)=110:D(2)=150:D(3)=-10:R=1
290 FOR A=1 TO L%-1:GET 1:B$=A$:FOR C=1 TO 76:REM SEE LINE 315
300 IF MID$(B$,C,1)=CHR$(12) THEN 320
310 IF MID$(B$,C,1)<>CHR$(10) AND MID$(B$,C,1)<>CHR$(30) THEN 330
320 B$=LEFT$(B$,C-1)+"@"+MID$(B$,C+1)
330 NEXT:LOCATE 1,5:PRINT B$:LOCATE 2,77:PRINT S$
315 REM ABOVE C LOOP CAN PROBABLY BE OMITTED FOR TEXT FILE INPUT
340 FOR B=1 TO 73 STEP 4:LOCATE 2,B:PRINT "    ----"
350 FOR C=0 TO 3:A(C)=(ASC(MID$(B$,B+C,1)) AND 31)+D(C)
360 IF A(C)>255 THEN A(C)=255 ELSE IF A(C)<0 THEN A(C)=0
370 LOCATE 3+C,4:PRINT MID$(B$,B+C,1)" ";P$(C);A(C)"  "
380 LOCATE 3+C,20:PRINT D(C)"  ":NEXT
390 FOR C=1 TO A(3)*20
400 Z$=INKEY$:IF Z$<>"" THEN GOSUB 160:GOTO 350
410 FOR D=0 TO 2:OUT P(D),A(D):NEXT:NEXT:NEXT
420 NEXT A:CLOSE 1:GOTO 270
```





Prototype Interface board.

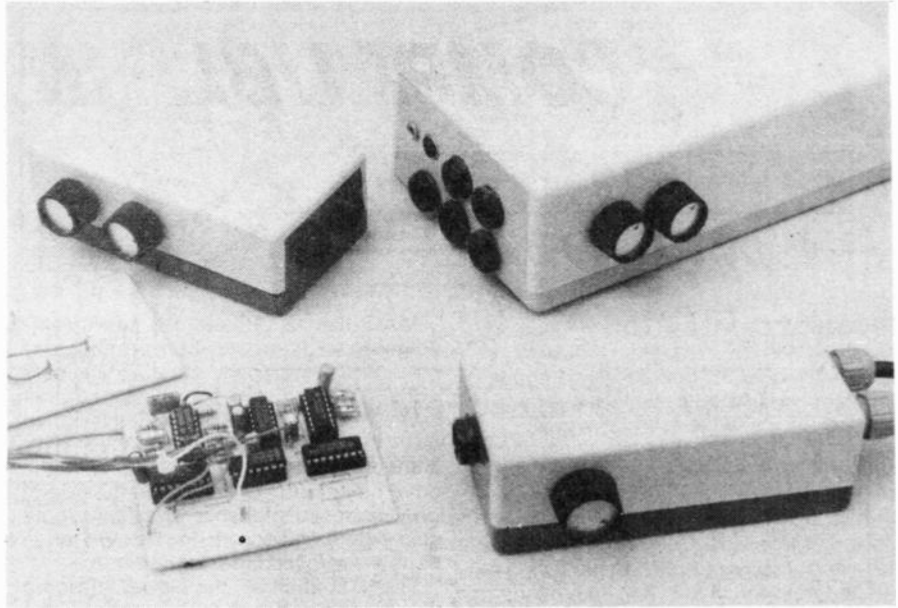
COMPUTER INTERFACE CONSTRUCTION

The printed circuit board component layout and full size, double-sided copper foil master patterns for the PC-compatible Interface are shown in Fig. 11. This board is also available from the *EPE PCB Service*, code 892.

Construction of the Interface is fairly straightforward and should commence with the link wires followed by the i.c. holders and the rest of the components. Link point *Z* to the desired numbered Y output point as discussed earlier. Make sure you get the polarity of the diodes and electrolytic capacitors the right way round.

A 2-core cable terminated in a standard *stereo* jack plug connects the computer-generated audio signal from the Interface to any of the Control Input sockets of any of the control boxes. Do NOT use a *mono* jack plug with these sockets. Alternatively, the signal could be plugged into the External Signal socket of any unit, although the computer-generated d.c. control bias would then be ineffective.

Connections to interface sockets are standard for all PC-compatible computers, though the orientation of the sockets within the computer may vary with different models, as shown in their manuals. The Interface is powered by the computer's power lines.



The prototype Interface board and completed control units.

SOFTWARE

An example of a fountain controlling program is shown in Listing 1. It has been written in GWBasic, but is compatible with QuickBasic.

The program may be refined to suit personal preferences. Studying and running the program will clarify its intentions.

Two routines are shown. The first allows the fountains to be controlled in response to direct entries from the computer keyboard. The second routine shows how a file containing any data can be used as the control sequence.

In this latter instance it is the data codes of the program itself that are the controlling numbers. Other control files can be created using a word-processing program.

JET SET

There are many types of fountain head made for pond pumps, and it is worth owning a selection of different ones, from straight jets to delicate sprays. With the more powerful pumps, several types of jet may be simultaneously connected, making really attractive displays.

As hinted at earlier, garden lights can also be controlled by the units. Musical lights and fountains are ideal for evening barbecues! □

FOX REPORT

by Barry Fox

Mode of Contention

Visiting the US last year I bought a fax modem card for under $50, complete with fax and electronic mail (Email) communications software. It works a treat.

Back in the UK I needed a portable fax modem of similar specification and the cheapest on offer was the Microlin from British company Pace, for around £120. It came with Delrina WinFax Lite software but no instruction manual.

I had to send away for the manual, which gives Delrina my address to try and sell me an upgrade to WinFax Pro. Is there any other product on the market that is sold without the manual needed to work it?

The Pace worked for a while, then failed. Pace replaced it but the securing screws for the serial socket fell off, leaving metal retaining clips bouncing around inside over the circuit board. This had also happened on the original, so perhaps that was what killed it. I had to take the casing apart and secure the mounts.

All this time I was getting publicity mail for an organisation called the Modem Approvals Group. This seeks support for ten British modem-makers, including Pace.

MAG's argument is that the UK price of modems is inflated because firms must follow guidelines set by the DTI and Oftel, the Office of Telecommunications, and submit all telephone equipment for approval by the British Approvals Board for Telecommunications before selling it.

BABT charges around £5000 to test a modem, and authorise the green sticker label which signals approval. Testing can delay sale by three months.

To pass the test the manufacturer must make factory modifications to block some features, for instance to stop the modem working with the communciation tones needed by some North American online systems and to stop the modem "nagging" at an engaged number by re-dialling it many times in rapid succession. This makes the modem less desirable for many users.

This, incidentally, is why some modems come with a "dongle " in the middle of the cable which connects it to the PC or phone socket. By using a different dongle for each country the manufacturer need make only one modem for the world, and just change the connector. Some owners think the dongle is just an electrical isolator and either cut it off or use a different lead. They then wonder why the modem no longer works.

Oftel can control the marketing of approved modems, but a loophole in the law leaves it powerless to stop anyone selling unapproved modems, provided that they make the lack of approval clear with a red triangle warning. It is not even illegal to use an unapproved modem. In practice no-one will know anyway.

MAG has for 18 months been campaigning for tight, pan-European legislation. British company Dataflex believes nothing will happen for at least another two years. So in March Dataflex resigned from the MAG and gave Michael Hesletine and the DTI an ultimatum. If the government did not act to ban the sale of non-approved modems, Dataflex would start selling and advertising its own range of non-approved modems.

The DTI ducked the issue, pleading that it cannot change the law to make the sale of non-approved modems illegal, because this would stop people buying modems for use on private telephone networks for which no BABT approval is needed.

"There is nothing in the regulations which prevents someone selling non-BABT approved equipment" admits David Hendon, Director of Technical Affairs at the Telecommunications and Posts Division. "There is no regulation for us to enforce which would prevent the sale of imported non-BABT approved equipment".

"I'm not King Canute", Philip Benge, Marketing Director of Dataflex, told Michael Heseltine, President of the Board of Trade. "I can't stop the commercial tide of non-approved modem sales. We can no longer afford the luxury of missing out on these sales."

Liberty

Dataflex has now created a new company, called Liberty, which sells non-approved modems for under £50. Hedging bets Dataflex also sells approved units for twice the price. Liberty's first adverts taunted the DTI by reproducing the standard non-approved triangle warning that "action may be taken against anyone connnecting " with the cheeky addition "Or Not!". But MAG members complained and Liberty's adverts have now been toned down.

"We have proved there is a market" Dataflex told me after one month's sales. The company is now waiting to see how many other manufacturers can afford to stay out of the market.

MAG says that the total market for modems in the UK is now worth £2,000,000 a year, and growing fast. MAG claims to represent 80 per cent of the legitimate market. This puzzles me. If the market for modems is growing so fast, why does the cost of BABT approval still more than double the shop price?

Small wonder that MAG estimates that sales of unapproved modems in the UK now exceed 15,000 a month, are already half the market for approved modems and growing fast. Sales of unapproved modems are at a similar ratio in France, and now account for 70 per cent of the German market.

Why on Earth would anyone now buy an approved modem, if an unapproved one is available from a UK source for half the price, with guarantee and the bonus of banned features like nagging? How can a phone company, or Michael Heseltine for that matter, possibly know what modem someone is using on their line?

Tel-Me Now

IBM has signed a deal with British company PhoneLink of Birkenhead to sell the software and hardware needed to use the new Tel-Me on-line information service. This deal has already shot the company's shares from 155p at flotation a year ago to 405p and put founder, Trevor Burke, into the list of the UK's richest five hundred.

Tel-Me relies on two clever tricks to let users access an on-line database much more quickly than ever before. PhoneLink has persuaded the owners of existing databases, including the Automobile Association, British Rail, Ordnance Survey, Infocheck, British Weather Services and Press Association, to copy their data into a master store in Birkenhead. So all the databases can be accessed by the same search software, which subscribers to Tel-Me will have on their PC.

This software makes searching quick and easy, only making the on-line connection to the database when the user has keyed in the question, and responded to any prompts and questions generated by the local software. The PC then downloads a block of data which the user can access at leisure after the line has diconnected.

The modem, which connects the PC to the telephone line, is non-standard. Because it is always talking to the same database it does not need to waste time on handshaking routines, to establish data exchange protocols. Once connection is made the PC squirts the pre-prepared question at the database and gets an answer back in seconds.

Or more accurately, this is how Tel-Me tell me their modem works. At the company's press launch at IBM's HQ on London's South Bank, rows of PCs were answering keyed queries and displaying data in the twinkling of an eyelid. Even with the new modem tricks, they surely can't be running on ordinary analogue phone lines, I thought.

Sure enough they weren't. Although no-one had thought to tell the press, and first answers were misleading, I finally got the admission that there were no modems yet available and the system was working on leased digital lines. Hence the blistering speed.

Although rapid access should keep telephone charges low, the Tel-Me service is not cheap. A user pays a licence fee of £300 a year for the software, plus £160 for the modem, and then pays for information accessed. Reading news headlines costs 5p, checking BR's timetable is 15p, getting a road map of an area to be visited costs around 50p and the charge for a full company profile is up to £24.

This is just one more thing to remember when you read the next gee whiz article about the wonders of the information superhighway.

KARE ELECTRONICS

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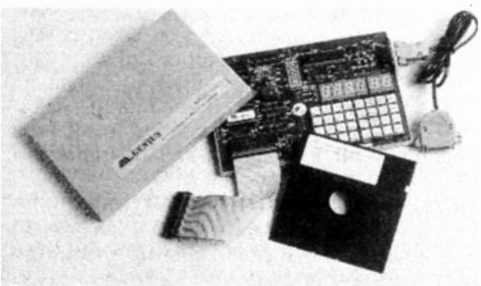
Cost-effective ICE, Assembler and Source-Level Symbolic Debugger for 8051 family devices



Supported Devices:
8051/52
80C51/52
8031/32
80C31/32
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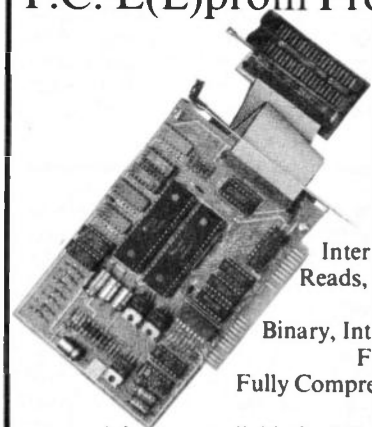

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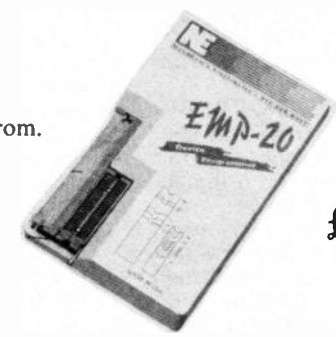

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INTERFACE

Robert Penfold

IN LAST month's article the basic principles of a simple method of speech recognition were described. This month we continue on the same theme with some practical circuits for a speech recognition interface.

The first requirement is a speech signal at a high enough level to drive the filter, rectifier, and smoothing circuits. This application does not require the use of a high quality microphone, since it is only frequencies from about 100Hz to 3kHz or so that are processed by the system. In a normal speech signal there is little output at frequencies outside these limits anyway.

An inexpensive low impedance dynamic microphone of the type used with cassette recorders is therefore perfectly adequate. However, it is probably best if the same microphone is used when producing the reference samples stored in memory, and when using the system in earnest. Any slight distortions introduced by the microphone should then be the same in both cases, and should not affect the reliability of the system.

Preamplifier

The output level from a low impedance dynamic microphone is quite small, and is unlikely to exceed a few millivolts peak-to-peak. As a signal at a few volts peak-to-peak is needed to drive the filter stages, etc. properly, the output from the microphone must be boosted by a high gain preamplifier. Fig. 1 shows the circuit diagram for a suitable preamplifier.

The circuit is based on a LM358N dual operational amplifier, and IC1a is used as an inverting mode amplifier at the input of the circuit. Resistor R1 sets the input impedance of the circuit at one kilohm (1k). This should give good results with any low impedance dynamic microphone, and the preamplifier should work equally well with electret microphones. The closed loop voltage gain of IC1a is 47 times.

The output from IC1a is coupled to the gain control (VR1) and then to the input of a non-inverting amplifier based on IC1b. This has a closed loop voltage gain of 48 times, which gives an overall voltage gain in excess of 2000 times (66dB). This should be more than sufficient to provide an adequate output level to drive the subsequent circuits properly.

There is little point in using an expensive low noise device in this application, since a dynamic range of about 40dB is sufficient. Also, most of the noise at the output of the amplifier may well be due to stray direct pick-up of electrical noise, and should be kept a reasonable distance away from the computer and monitor. It is actually the monitor which is likely to be the most prolific generator of electrical noise.

The LM358N specified for IC1 will work well on a 5V supply, but most other dual operational amplifiers will not. The circuit incorporates "hum" filtering, so it does not require a low noise supply. The computer may well be able to provide a suitable 5V supply, but if not, a 9V battery can be used. The current consumption of the circuit is only a couple of milliamps or so, and a small (PP3) size battery is therefore perfectly adequate.

Capacitor C8 rolls-off the high frequency response of the circuit, and the input and

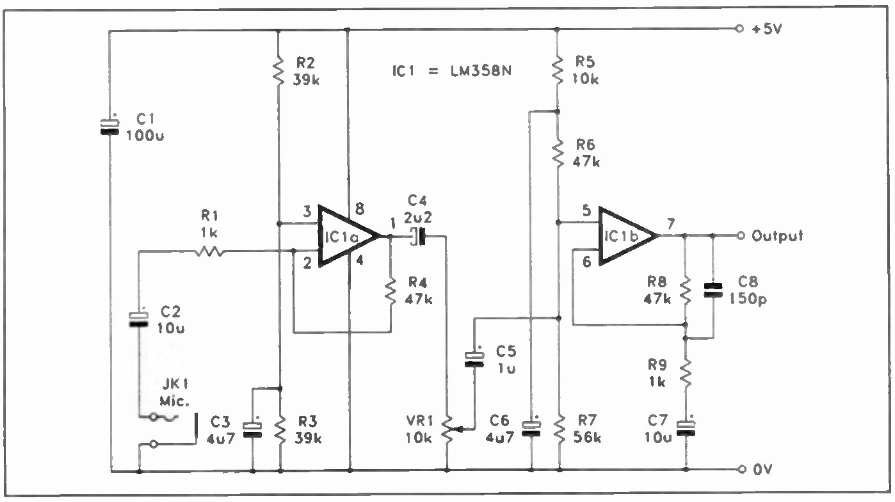

Fig. 1. Circuit diagram for the microphone preamplifier.

pick-up of digital noise from the computer and monitor, rather than "hiss" from the preamplifier.

By virtue of the way they function, dynamic microphones are vulnerable to output of the circuit are out-of-phase. Consequently there should be no major problems with instability due to stray feedback, but with any high gain circuit a reasonable degree of care must be exercised when designing the board layout.

Highs and Lows

An experimental four-channel filter and rectifier circuit for a speech recognition system was described in the April 1987 issue of *Everyday Electronics*. The circuit of Fig. 2 is for a two-channel filter and rectifier circuit that is basically just a simplified version of the original design.

A simple bandpass filter, using IC2a, operates at a centre frequency of around 2kHz. The response of the filter is necessarily rather broad.

As the system only uses two channels there is no need to have narrow bandwidth filtering with high roll-off rates in order to obtain good channel separation. Also, with narrow bandwidth filtering there would be a risk of some voices not containing strong components at suitable frequencies, which

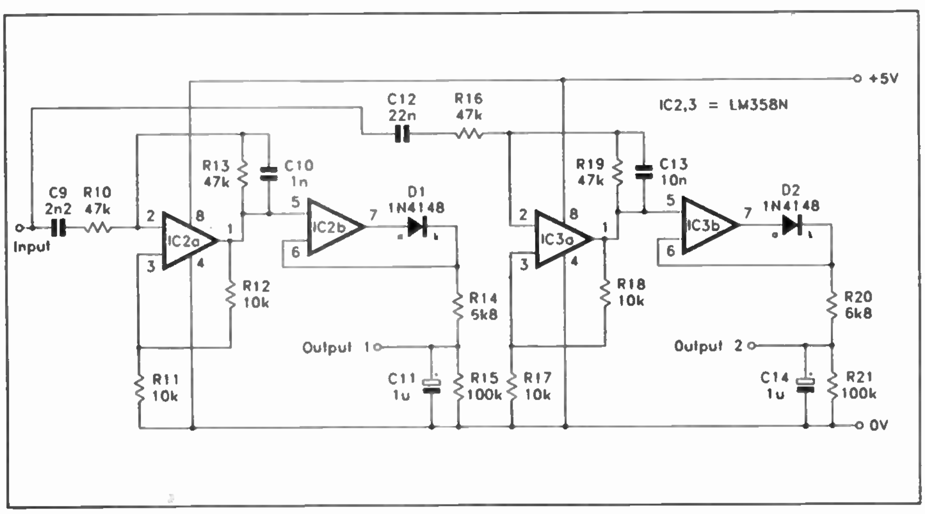

Fig. 2. Circuit diagram for the two-channel filter/rectifier.

would give no significant data for the pattern recognition program to work on.

The output from IC2a is coupled to a simple active rectifier based on IC2b and diode D1. This half-wave rectifier feeds into a smoothing circuit which is comprised of resistors R14, R15, and capacitor C11.

The attack time of the circuit is quite short, but the decay time is substantially longer. However, the decay time is still short enough to permit the circuit to accurately track the envelope shape of the input signal.

Both the filter and rectifier circuits are single supply types having the inputs and outputs referenced to the 0V supply. This is acceptable because it is only positive output signals that are of importance. The lack of negative output half cycles from IC2a is therefore of no relevance.

Bear in mind though, that the circuit will only work properly using a dual operational amplifier that is designed for use in *single* supply d.c. circuits. The LM358N works well in this type of circuit, as should the CA3240E, but most other dual operational amplifiers will not work at all in this circuit.

The filter and rectifier circuit for the other channel is built around IC3. This circuit is essentially the same as the high frequency buffer amplifier should be used at each output of the unit.

Interfacing to a PC could be achieved via an add-on digital-to-analogue converter, but a much lower cost option is available. These days virtually all PCs are supplied complete with a "games port", and this has four analogue inputs.

As explained in previous *Interface* articles, these inputs are not suitable for applications that required a high degree of precision, or high resolution. But, in this case we do not really require either, and around seven to eight-bit resolution is perfectly adequate.

Linearity is not really of any great importance. Any distortions in the digitising process when generating the reference samples will be matched by identical distortions when using the system. The PC's analogue converter will not operate at high conversion rates, but its speed is adequate for digitising an envelope shape.

The main problem in using the joystick inputs for anything other than their intended purpose is that they respond to resistance, not to an input voltage. A resistance range of around 0 to 200 kilohms is required, and readings returned from the joystick port are very roughly equal to one per kilohm of resistance.

In order to use the joystick inputs with the speech recognition interface a couple of voltage-to-resistance converters are required. Fig. 3 shows the circuit diagram for a simple but effective voltage to resistance converter.

Of course, a separate converter is needed for each output of the speech interface, and two of these circuits must therefore be constructed. There are four analogue inputs on a PC games port, so it should be possible to use the original four-channel circuit with a PC plus four of these converter circuits.

The circuit is a slightly modified version of one featured in a previous *Interface* article. The coupling to the PC is via an opto-isolator (IC2), which can be a TIL111, 4N27, or any "bog standard" opto-isolator.

The base terminal of the transistor in IC2 is externally accessible, but it is simply left unconnected in this case. It is the collector-to-emitter resistance of this transistor that is used to drive the analogue input of the PC. Note that the circuit will only work properly if IC2 is connected to the games port with the polarity shown in Fig. 3.

The input stage IC1 acts as a buffer amplifier, but it also has non-linear negative feedback provided by l.e.d. D1. This compensates for the high forward threshold voltage of the l.e.d. at the input of IC2. A forward bias of around 1·8V is needed before an l.e.d. will begin to conduct significantly.

Due to the inclusion of D1, the output voltage of IC1 is equal to the input voltage plus about 1·8V. This ensures that the l.e.d. in IC2 starts to turn on as soon as the input voltage starts to rise above 0V. A five millimetre red l.e.d. was used for D1, but virtually any l.e.d. should give the desired result.

Preset potentiometer VR1 is given any setting that produces a good range of values from the games port during the course of each sample. First adjust the preamplifier's gain control to obtain a reasonable range of output voltages from the smoothing circuits, and then use some trial and error to find a good setting for VR1 in each converter circuit.

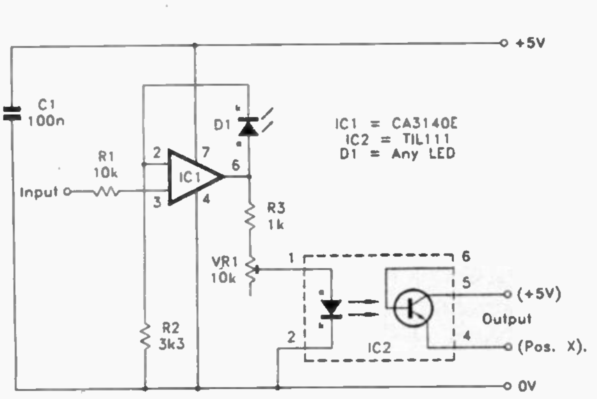

Fig. 3. The voltage-to-resistance circuit diagram.

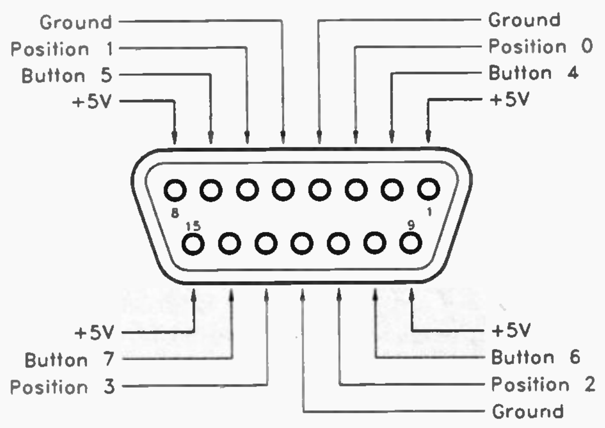

Fig. 4. Connection details for the PC's games port. The "Position" terminals are the analogue inputs.

channel, but the higher values for capacitors C12 and C13 give a much lower centre frequency. This channel operates with a centre frequency of around 200Hz, but like the other channel, it has a fairly wide bandwidth.

The circuit can be powered from a standard 5V logic supply, or from a 9V battery if preferred. The circuit's current consumption is only about 3 to 4 milliamps.

Interfacing

The outputs from the smoothing circuits will interface directly to the inputs of most analogue-to-digital converters, including the analogue inputs of the BBC computers. The maximum output voltage is about three volts, which is enough to fully drive a converter based on one of the popular Ferranti analogue-to-digital converters.

Bear in mind that the outputs from the smoothing circuits are at a fairly high impedance, and should feed into an input resistance of a few hundred kilohms or more. Where necessary, a high input impedance

Connection details for the PC's joystick port are provided in Fig. 4. You need a 15-way D-plug to make the connections to this port. "Position 0" to "Position 3" are the analogue inputs. It does not matter which two inputs you use, but it would seem to be logical to use "Position 0" and "Position 1".

Next month: We will consider the software side of speech recognition.

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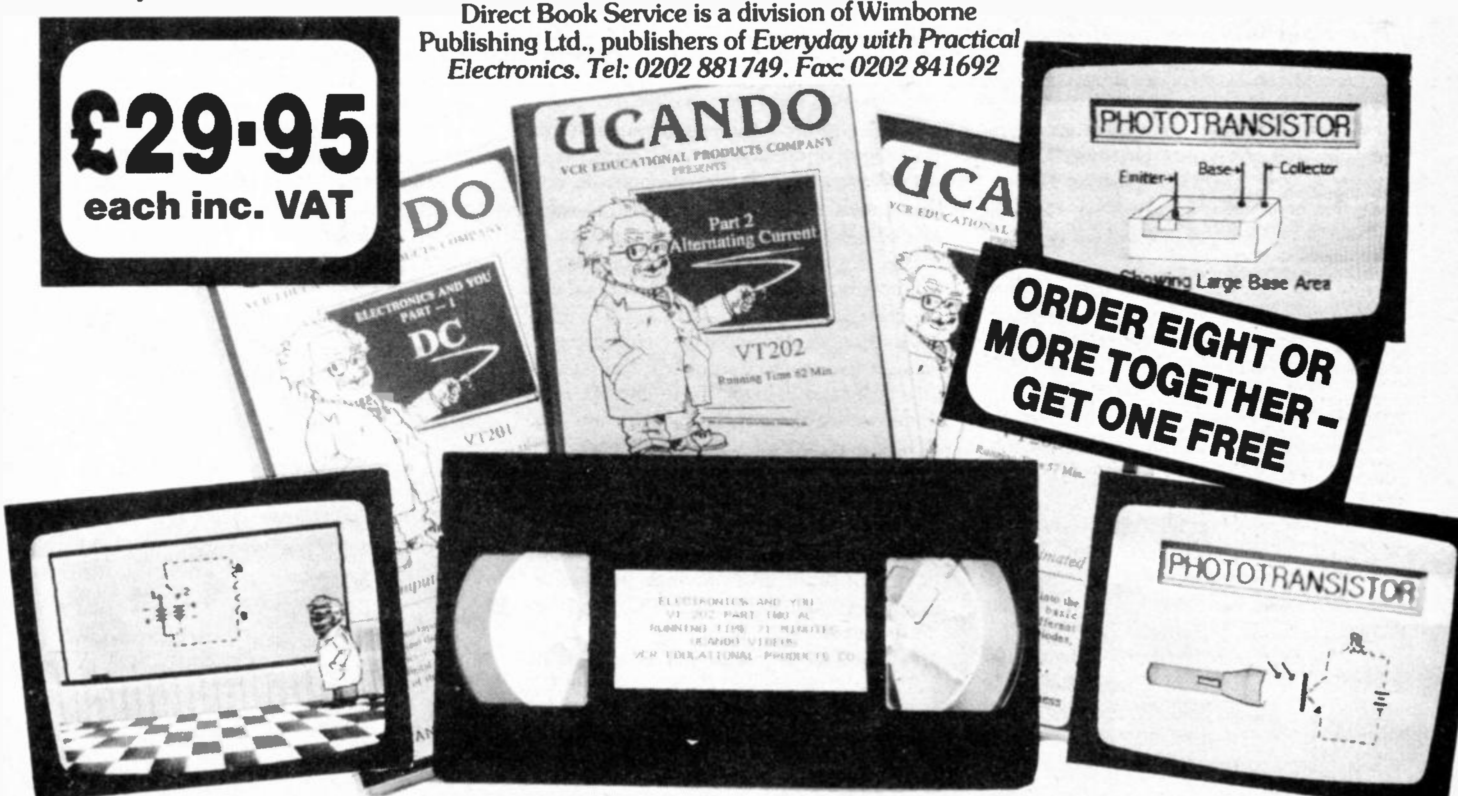

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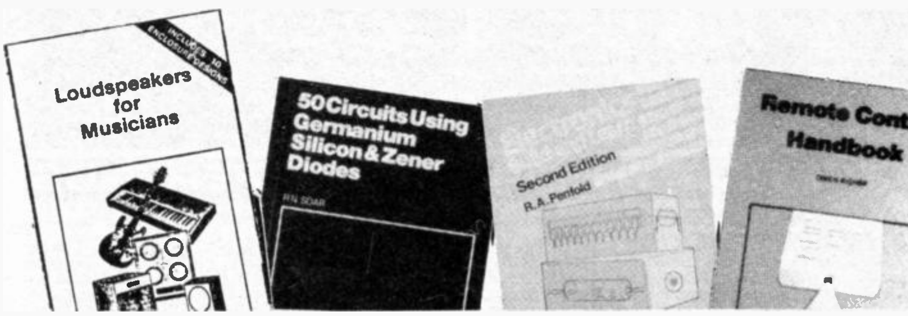

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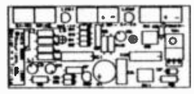

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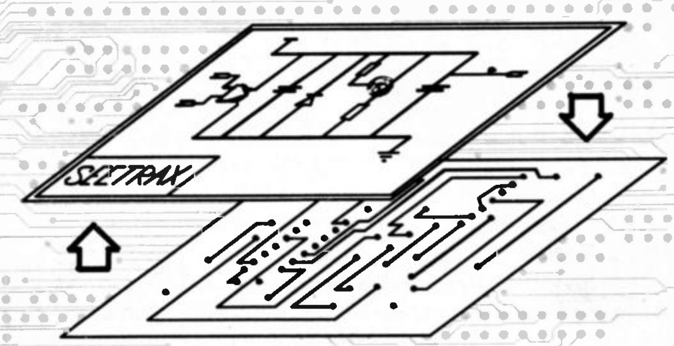

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Unpopulated printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday with Practical Electronics,* Allen House, East Borough, Wimborne, Dorset BH21 1PF.** Cheques should be crossed and made payable to *Everyday with Practical Electronics* **(Payment in £ sterling only). Boards can only be supplied on a payment with order basis.**

NOTE: While 95% of our boards are now held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the Editorial page for details.

Please check price and availability in the latest issue.

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The individual sub-menus are changed to selection buttons, this makes all those topics available within a module, clearly visible to the user. The layout of the calculations is considerably enhanced, firstly by providing the formulae used and secondly by showing the calculation steps, exactly as in a textbook; the advantage here being that you can input your own values.

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Having reviewed a dozen, or more, educational software packages designed to "teach" electronics, I was more than a little sceptical when I first heard about Electronics Principles: *there seemed to be little that could be done that has not been done elsewhere. When I started to use the package my views changed. Indeed, I was so impressed with it that I quickly came to the conclusion that* Everyday with Practical Electronics *readers should have an opportunity to try the package out for themselves!* – MIKE TOOLEY B.A. Dean of Faculty of Technology, Brooklands Technical College

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

VALVE GUIDES REPRINTED

While there are an increasing number of people taking an interest in the radio technology and circuitry of the past, obtaining specific information on valve circuits can sometimes be difficult. In the absence of service data, the next best thing is data on the valves themselves. Base connections, typical working voltages and currents can all be helpful in working through and tracing out a circuit.

With this in mind, G.C. Arnold Partners, publishers of *Radio Bygones*, have recently reprinted a set of five Radio Valve Guides originally published by Bernard Babani (Publishing) Ltd in the 1950's and 1960's.

With base diagrams printed on the same page as the characteristic tables, and a reputation for providing information on valves not always found elsewhere, the Guides cover the following years and types of valve:

Book 1 – English and American, 1934-1951. Book 2 – English, European and American, 1951-1954. Book 3 – the same, 1954-1956. Book 4 – English, European, American, USSR and Japanese, 1956-1960. Book 5 – the same, 1960-1963.

Also of value to the "valve era" enthusiast is a further publication, the *Handbook of Radio, TV, Industrial & Transmitting Tube & Valve Equivalents*. This reprint of the 1974 third edition of the booklet of the same title (again originally published by Babani) includes CV and Armed Forces sections which are very helpful when trying to identify types originating from military sources.

Obtainable from *G.C. Arnold Partners, 9 Wetherby Close, Broadstone, Dorset BH18 8JB*, the books cost £2.95 each. If ordered together, the set of five Radio Valve Guides costs £14.00. All prices include postage. When ordering, please mention that you read about these publications in *EPE*.

FIRST STELAR COURSE

I mentioned previously that STELAR (Science and Technology through Educational Links with Amateur Radio) had arranged its first crash course, at Kenwood UK's headquarters in Watford, for teachers from schools with no current amateur radio programme.

I have now received, via STELAR, a report on the course written by Martin B. Brown, Head of Technology at Farlingaye High School in Suffolk. Lack of space prevents full reproduction but the following (edited) is part of what he says:

"Twelve other teachers attended (from across the UK). We were welcomed at Kenwood where we were presented with tea and a folder. The Radio Society of Great Britain had prepared a pack which included textbooks and the licensing documentation needed for the course.

"We were invited to see the "shack", a comfortable room with a selection of radio and computer equipment. Given a spare twenty-five minutes before we were due to go and see our accommodation, our first lecturer decided to get started. This was the pattern for the rest of the course, every minute filled with constructive and well prepared tuition.

"The first evening we returned to the shack for an introduction to amateur radio. I was surprised by the diversity of the available media. We looked particularly at packet radio and satellites. The one thing all the systems have in common is the use of the radio spectrum as a medium.

"This is free to use and regulated by the need for all operators to hold a UK licence which is only available after passing a City & Guilds radio amateur's examination (RAE). Once these exams have been passed you can apply for a 'B' licence which gives limited access to frequencies. The full or 'A' licence requires one further hurdle to be breached, a 12 words per minute Morse test.

STUDENTS CAN TALK TO THE WORLD

"We had all enrolled for the examination on 9th May 1994. We were left to our own devices to tackle the Morse, although we were assured there are many willing amateurs waiting to help in our own regions.

"The course was well planned and the lecturers who were all volunteers, made every effort to ensure each of us understood the topics. These were as follows: Basic electrical theory; Rules and regulations; Operating practices and procedures; Safety; Solid state devices; Propagation and antennas; Transmitters; Transmitter interference; Measurements and Electro-magnetic compatibility. We had a total of 15 lectures and four evening sessions, a mock examination and a presentation/reception on the final evening.

"My purpose in writing this report is to make other teachers aware of this initiative. Richard Horton, a teacher from Harrogate Ladies College, had the vision and determination to establish the STELAR group. He is supported by an excellent team who understand the value of amateur radio in its broadest sense, whether 'packet', 'data from satellites", 'radio astronomy', 'weather broadcasts', 'telephony' or 'Morse'.

"He hopes to run the course as an annual event and any teachers from schools with no amateur radio club are eligible to apply (the whole course is funded by Kenwood UK). Richard can be contacted on his FAX number, 0423 871027, or by writing to him at *Harrogate Ladies College, Dept EPE, Clarence Drive, Harrogate, North Yorks, HG1 2QG.*

"I would like thank ***Kenwood UK*** on behalf of everyone involved for their hospitality and their investment in the whole scheme. I am sure it will move from strength to strength (especially if teachers find out about the free T-shirt, world map, lapel badge, log book and most importantly the framed certificate).

"We hope to pass our exams and gain our callsigns later this year, then we'll meet on the air. *Networks* – the word has a whole new meaning. Our school networks will extend across Europe, we will be able to talk to the world and more importantly so will all our students."

DISRUPTIVE GLITCHES

In July I reported that Subscription Services Ltd (SSL), whose contract to issue Amateur and CB licences on behalf of the Radiocommunications Agency expires next March, were concerned at criticisms levelled at them from users and the media about the way they run their service.

I invited them to tell me about their problems as they see them and I received the following statement from Diane Liddicoat, SSL's Business Account Manager:

"SSL are still concerned about the level of complaints and criticism from a small percentage of Radio users.

"As the Post Office company responsible for administering this and many other significant contracts, with 1600 staff and an annual turnover of some £60 million, we are more used to praise for our ability to process major tasks of this nature efficiently and with the minimum of error.

"We have experienced a number of unique problems but have been working since Day One to iron them out, making a number of computer system revisions to achieve success. Ever since we took over the RA contract, in fact, we have been working hard to eradicate a number of extremely annoying and disruptive glitches.

"Perhaps our communication channels with licensees could be improved, which we are progressing, but please remember that SSL were the company who gave telephone access directly to your own records.

"All our staff are trained to be courteous and to handle both telephone and written enquiries promptly. Sometimes, however, investigations do have to be undertaken in order to present a full reply to a customer which may cause a slight delay.

"In summary, of course we want to give you our customers an excellent service, matching precisely what is wanted and needed. Critically, we understand Amateur Radio and Citizens' Band Radio and its people better than we did, and we are confident that we can satisfy your expectations. We look forward to continuing to get to know you better in the years to come."

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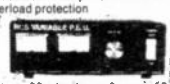

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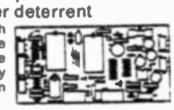

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