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see page 38

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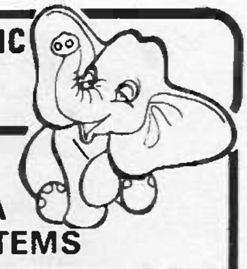

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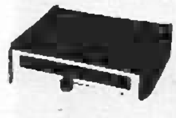

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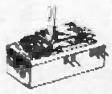

LP1171

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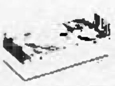

LP1179 and LP1171 £4 each or £7.50 pr.

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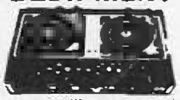

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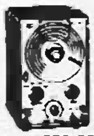

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electronics today international

MAY 1975 Vol. 4. No. 5.

main features

SCIENCE IN ART 10
Science can prove that the Raphael shown on the cover is an original.

UNDERSTANDING COLOUR TV – PART 4 51
Caleb Bradley explains the PAL Colour Signal

ELECTRONICS IT'S EASY – PART 15 57
Simple Power Supplies

projects

ELECTRONIC IGNITION SYSTEM – FINAL PART 22
Constructional details for our CDI/tacho/rev limiter system

TTL SUPERTESTER 30
IC tester/logic trainer/breadboard unit/digital trouble shooter

ETI 3600 SYNTHESISER 42
ETI's Portable Music Synthesiser

DOUBLE QUAD 44
What's better than a Quad ESL Speaker?

TRAFFICATOR FLASHER 46
Reliable solid state flasher unaffected by load and voltage changes

ELECTRONIC WIN–DICATOR 47
To indicate who pressed the button first

LOW BATTERY WARNING 48
A device to give a flashing signal when the battery starts to go

AUTO AMP 55
Use a portable cassette or radio in the car . . . . to give 5W of audio

main features

QUAD ESL LOUDSPEAKERS 34
After 20 years they are still ahead of the field

news & information

NEWS DIGEST 6
PREVIEW OF JUNE'S ETI 37
INPUT GATE 40
ELECTRONICS TOMORROW 64
TECH–TIPS 66

ETI–BI-PAK FIVE-IN-ONE OFFER 38
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Cover: Portrait of Pope Julius II by Raphael (1438–1520). Today science can prove this is the original. Picture reproduced by permission of the National Gallery.

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

Published by: Modern Magazines (Holdings) Ltd 36, Ebury Street, London SW1W 0LW.
Electronics Today International is published on the second Friday in the month prior to the cover date.
Distributed by: Argus Distribution Ltd.
Printed by: Alabaster Passmore & Sons Ltd. London and Maidstone.

International Associates:
Australia: Modern Magazines (Holdings) Ltd, Ryrie House, 15 Boundary Street, Rushcutters Bay 2011, Sydney, Australia.
France: Electroniques Pour Vous International, 17 Rue de Buci, Paris, France.
USA: ACP, Room 401, 1501 Broadway, New York, USA.
European News Bureau: H. Dvoretsky, Manager, 107 Fleet Street, London EC4.

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

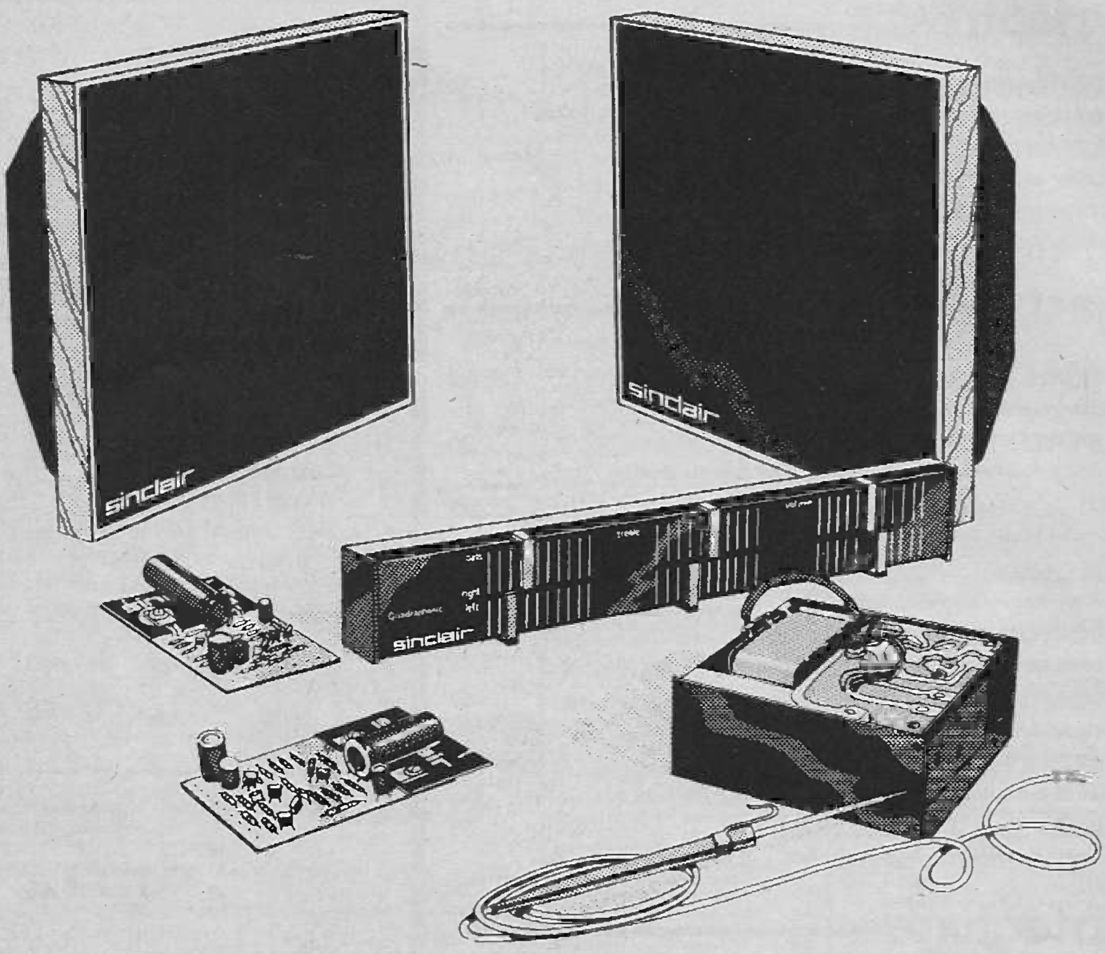
BACK NUMBERS: Back numbers of many issues are available for 30p each plus 10p postage.

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

TRANSISTOR SELECTION TROUBLES? SEE PAGE 65

Go quad for around £50

(including the speakers!)



Sinclair Project 80 hi-fi modules

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

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

How does Sinclair Project 80 work?

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

You can even build a quad amp entirely from Project 80 modules. Two power amplifiers, a control unit and a power supply give you a stereo amp for as little as £31.80 plus VAT. The necessary add-on quad modules cost only £36.80 + VAT. Together, they make up a true hi-fi quad amp for only £68.60 + VAT!

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

Is it difficult to build?

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

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

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

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

news digest

SINCLAIR OXFORD

Sinclair have introduced a new range of calculators featuring mains/battery operation. Initially three models are available in the 'Oxford' range, the 100, 200 and 300 at £13.99, £21.55 and £32.35 including VAT. The launch of the new range is hoped to increase Sinclair's share of the UK calculator market to 35% by the end of the year.

The 'Oxford' 100 has the same functional specification as the 'Cambridge' (4 function, constant and floating decimal point). A percentage key and full functional memory are added for the 'Oxford 200'.

The 'Oxford 300' is an advanced scientific calculator with algebraic logic, 4 arithmetic functions, full memory, constant, Log_e and e^x, trig and inverse trig functions which are available in degrees or radians (switch selectable), square root, reciprocal and pi. It gives the added facility of either floating point or scientific notation for both number and entry result.

Power is from a 9 volt PP3 battery which gives around 10 hours use or direct from the mains via a Sinclair adaptor which will cost you another £3.19 (inc. VAT).

VIDEO ON SOUND TAPES

A prototype video system has been built up by a computer specialist of an American company, SRI of Menlo Park, CA94025, USA; The system uses one track of audio tape to record computer generated text and graphics (in the form of line drawings) while the other track carries the commentary of an audio-visual programme.

The display is on a computer terminal, but the computer itself is not used during playback. The developer of the system believes the principle application will be in education. Audio tape costs about a tenth of what video tape costs, but a computer terminal is much more expensive than a video player or film projector.

Perhaps when Ceefax/Oracle is established we will have educational audio visual tapes and a tape input on the decoder which will be suitably modified.

LISTEN TO THE COSMONAUTS

The latest newsletter of the "Link Scheme" (for schools and the electronics industry) carries an interesting piece of information from the Senior Science Master of Kettering Grammar School. The details of the voice communication between the cosmonauts and their ground control are given. The carrier frequency is 121.75MHz and modulation is broadband FM. A 3-element Yagi at an elevation of 5^o and an azimuth of 100^o should be all that is needed to pick up the cosmonauts as they come over the horizon. The call word used for voice communication is 'Zaria' which is Russian for 'Dawn'.

School teachers interested in the Link Scheme should contact Peter Noakes at the Department of Electrical Engineering Science, University of Essex, Colchester, CO4 3SQ, Essex.

FIVE-KILOWATT, SOLID-STATE TRANSMITTER

The first five-kilowatt, totally solid-state, AM broadcast transmitter is "on the air" at WIND radio station, Chicago. Westinghouse Electric Corporation developed the solid-state transmitter and claim that it is easier to maintain, lighter, smaller, more efficient, safer and simpler than current valve-type transmitters. The WIND transmitter has an excellent frequency response between 30Hz and 15kHz and very low audio distortion.

ARTIFICIAL 'NORTHERN LIGHTS'

An Aurora Borealis, lasting several minutes, was recently created artificially by Soviet and French scientists. A French rocket, carrying a Soviet miniature accelerator, discharged particles along a line of magnetic force running from the Indian Ocean to the Soviet Arctic. The purpose was to gain a better understanding of the Earth's Magnetosphere to enable better space-weather forcasting the prediction of radio conditions.

LEDs FOR FIBRE OPTICS

Plessey have introduced high radiance gallium arsenide IR LEDs for use with optical fibre. Modulation rates up to 80MHz can be achieved using one of the microwave packages available. From Plessey Optoelectronics & Microwave, Wood Burcote Way, Towcester, Northants.

PIEZOELECTRIC HEADPHONES

The Pioneer SE-700 are the first high fidelity headphones to use the piezoelectric effect. As the audio signals reach the headphones, the driver elements of ultra-thin aluminium-coated high-polymer film expand and contract accordingly, creating "breathing" motion. Tonal characteristics are comparable to those of the electrostatic type headphones, but the SE-700 require no matching transformer.

GLOBAL EXPAND MAIL ORDER

Global Audio, the discount Hi-Fi people, have moved their entire mail order operation to new premises at 50 Stamford Hill, London, N16. The move will double their warehouse facilities and will enable Global to expand their mail order service for Hi-Fi equipment and tape cassettes to help the enthusiast in the provinces.

CARTRIDGE PERCUSSION UNIT

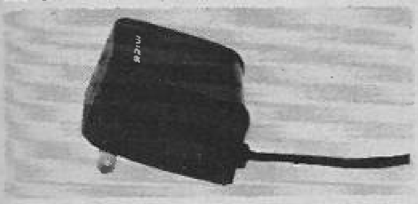
Bandmaster Limited of Gloucester Street, Glasgow, have designed a rhythm unit called the Powerhouse which uses multi-track continuous tape loop to produce multi bar synchronised "live" percussion rhythms.

The Powerhouse features an electronic speed governor, two automatic rhythm change selectors, two mute mechanisms, a monitoring facility and a mix control. A musician with a fixed pitch instrument can tune the tapes to play in perfect pitch by adjusting the speed control.

When a musician wishes to change rhythms or to mute the machines he can do so either by using a button on the front of the Powerhouse or by using the special rhythm control foot pedal. Two recordings of the same rhythm (one basic, one complex) can be combined with the mix control. The equipment provides mono or stereo output and can be used with standard cartridges as a hi-fi 8-track player.

32 rhythms come with the machine which will cost about £140.00.

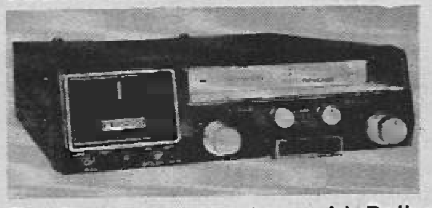
NI-CAD CHARGER FOR 85¢



In the US a range of wall-plug Battery Chargers, for charging 2, 3 or 4 cell ni-cad batteries, has been announced with a unit price of 85¢. This is felt to represent an industry breakthrough.

These chargers are rated for 14 to 16 hour charging, and are provided with a customer's or manufacturer's hot-stamped logo. They are produced by Rowe Industries, Inc., Horseblock Road, Yaphank, N.Y. 11980, USA.

DOLBY IN THE CAR



The first car cassette player with Dolby noise reduction has been marketed by Pioneer. The KP-301 features an automatic reverse cassette deck (which eliminates the need to take out the cassette and turn it over at the end of one side), an FM Stereo Radio and the Dolby 'B' system.

The player costs £130.30 from Autocar Electrical, Chantry Road Estate, Kempston, Bedford, MK42 7SD.

BEE'S RADIO?

Scientists in Russia are investigating the hypothesis that bees communicate by electromagnetic waves. It has been established that there is a weak electric field around flying bees. A moving electric charge will produce electromagnetic waves. So maybe these play a role in communication.

Recorders have been set up in bee hives to study the changing pattern of the electric fields and to record the sounds made by a family of bees.

CEEFAX & ORACLE = TELETEXT

A term has been coined to describe the technology behind the Ceefax and Oracle services being developed by the BBC. Defined more generally as data transmission by television, the term 'teletext' also covers the system used on cable TV in the U.S. to give up-to-date financial information.

The Business Enterprises Division of the Financial Times have just published a book, "Teletext: Data Transmission by Television", which analyses the systems used and looks at applications and prospects. The main points made in the book are that teletext allows the viewer wide selection and that the data can be up-dated as soon as news is received. The cost of the 180 page book is £80 and the address is 10 Bolt Court, Fleet Street, London, EC4A 3HL.

MICROPROCESSORS MAY GIVE 40% EXTRA MPG

Robert W. Sarnoff, the Chairman of RCA, says that, on the basis of preliminary tests it is estimated that a microprocessor will boost mileage by up to 40 per cent in standard size and large cars. Working with the automotive industry the electronics industry should be able to mass produce suitable microprocessors by the millions at a cost of around $100 a unit.

Installed in a car with the appropriate link-ups, it will automatically adjust both choke and throttle for maximum starting efficiency; it will run the engine at the right fuel mixture for highest fuel savings, and automatically shift gears at precisely the right time for optimum fuel efficiency.

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news digest

NEW HEATHKIT PRODUCTS

The latest catalogue from Heathkit is now available, free, from Heath Ltd, Bristol Road, Gloucester GL2 6EE. The catalogue introduces 15 new kits.

The new **Colour Organ** is a three channel sound-to-light display for £48.80 (inc. VAT & UK delivery).

There is an **Electronic Workshop** with 35 circuits to build up, for £24.50 (inc. VAT & UK delivery).

For the motorist Heathkit have a new gadget for £7.80. This is a **Windscreen Wiper Delay** which provides a 5 to 30 second interval between wipes.

There are six new audio products, starting with a **Dolby Cassette Deck** for £149.90. The other hi-fi products are what Heathkit call their Valu-System Audio Line. These are an **AM/FM Stereo Receiver**, an **AM/FM Stereo Receiver with 8-track Player**, an AM/FM **4 channel Receiver with 8-track Player**, a **4 channel Amplifier with 8-track Player** and a **10W speaker system**. Prices are £78, £99.80, £139, £99.80 and £21.60 (pair). The amplifiers give 4.5W rms per channel.

There are kits for the radio enthusiast, too. Two are for CW operators, the beginner can spend £7 and build up a **Code Practice Oscillator** while the CW fanatic can build a solid state **Electronic Keyer** for £29.70. For £26.50 you can build a solid state **Dip Meter** to cover 1.6 to 250MHz.

Other test-equipment includes a **Portable Digital Multimeter** (£118.80) and a new **Oscilloscope** (£176). For measuring TV tube voltages there is a new **40kV High Voltage Probe Meter** kit for £12.00.

Finally a kit for the boat builder — a **Digital Radio Direction Finder** kit for £124.

'TWO IN ONE' SUPERBRAIN

The Bowmar MX120 Superbrain is a rechargeable 8-digit calculator with a memory which converts to a 5-digit mantissa with 2-digit exponent scientific calculator providing 11 additional scientific functions.

A conversion key converts the 8-digit display into the scientific version at the press of a button and also reverses the process. The MX120 comes complete with rechargeable battery and charger unit for £39.95 including VAT. Bowmar Instrument Ltd., 41-45 High Street, Weybridge, KT13 8BB, Surrey.

PRICE OF ETI

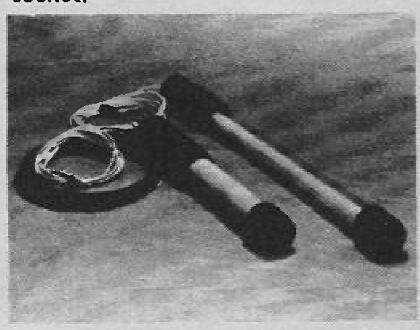
Rapid inflation is affecting ETI in the same way as other publications. Continuing increased sales have enabled us to put off an increase for several months after many other magazines.

The next issue, June 1975, will go up by 5p to 30p. We hope that readers will still consider it good value for money.

Subscriptions are unaffected by this rise and remain at £4.25 (UK) and £4.75 (Overseas, Surface Mail).

NEW IGNITION SYSTEMS

Electronics Design Associates have introduced two new models as a development of their "Sparkrite" system. The new systems, the "Sparkrite GT" and the "Sparkrite GT3". These new systems offer a new feature; the accessory output socket.



This is a high voltage AC supply, taken from the ignition supply, to power two optional extras: the Sparkrite GT 8 watt Fluorescent Inspection Light and the "Sparkrite GT" Xenon Dynamic Timing Light.

As well as the features of the GT model, the GT3 has two more extras: a light which comes on when the contact breaker opens for static timing, and an electronics system for burning dust and oil off the points without causing pitting or wear. The prices are £19.87 inc. VAT for the Sparkrite GT ignition, £23.95 for the Sparkrite GT3 ignition (neg earth only) £4.30 for the Sparkrite GT inspection light, and £8.60 for the Sparkrite GT timing light. from Electronics Design Associates, 82 Bath Street, Walsall, WS1 3DE.

Continued on page 70

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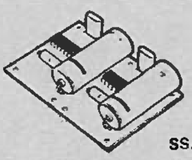
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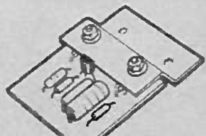
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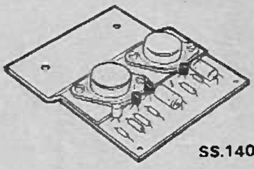
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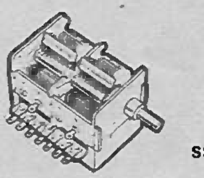
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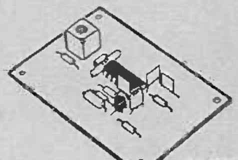
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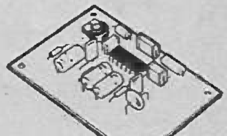
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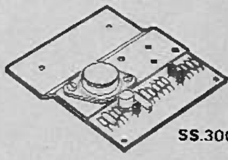
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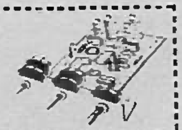

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SCIENCE IN ART

– proving that Raphael changed his mind – nearly five centuries after.

by Dr. Peter Sydenham

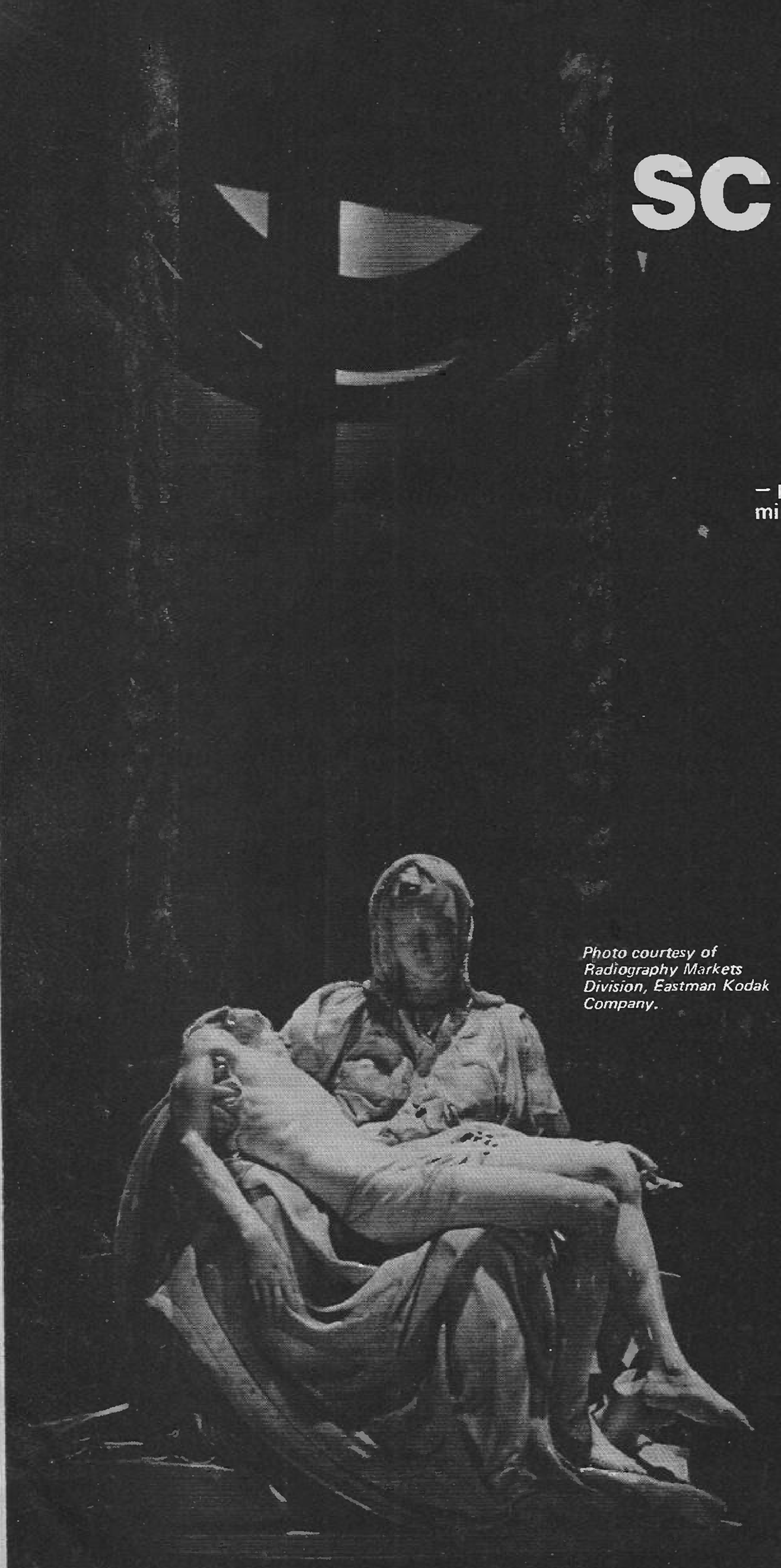
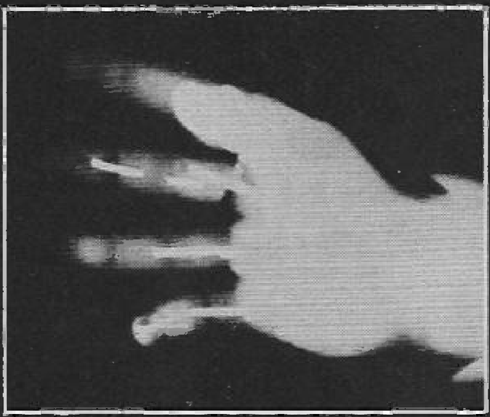
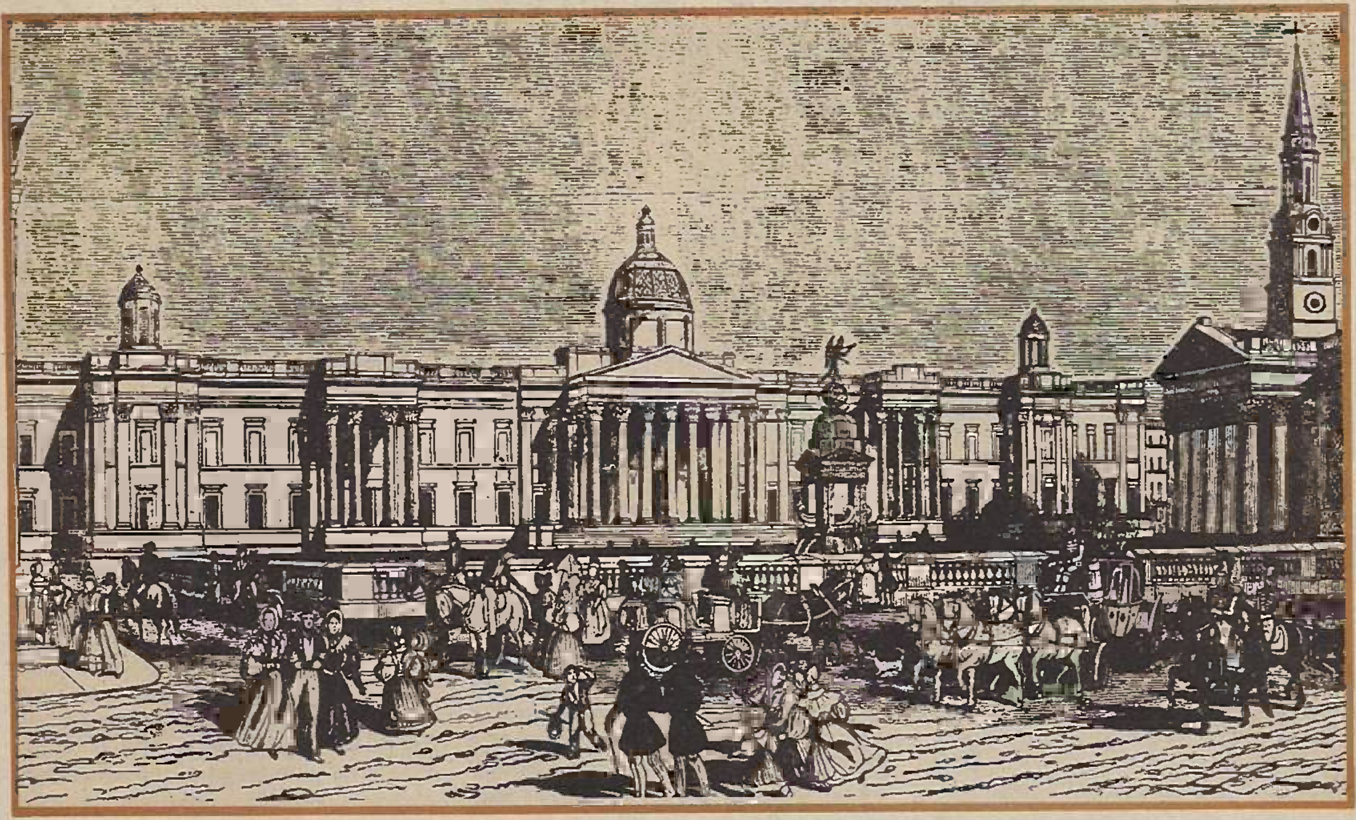


Photo courtesy of Radiography Markets Division, Eastman Kodak Company.





▲ *Fig. 1. The National Gallery was built in 1837 — Nelson's column had not yet been erected.*

COLLECTIONS of antiquaria usually grow from the personal interest of one or more people who are interested in some intrinsic quality of the collection. It may be so that they can view the items on demand, or research the growth of a discipline. Others collect items just for the sake of collecting — or assemble a collection to make money. But regardless of the original intention, seldom are the collectors expert at maintenance or preservation. And all too often there are too little funds for adequate conservation anyway. So at some stage the collection is broken up by sale or moved as a whole into the care of a larger Institution where, we might

AN IMAGE LOCKED IN MARBLE

Michelangelo's definition of sculpture was "to free the image hidden in the block." This he did in his majestic La Pieta, a statue of dense Carrara marble that remained unmoved from St. Peter's Basilica in Rome until it was displayed in the Vatican Pavilion at the 1964 World's Fair in New York. Prior to moving the priceless sculpture, however, the Vatican Pavilion Committee asked Eastman Kodak to conduct an exhaustive x-ray examination to determine the extent of damage and repair which La Pieta was known to have incurred. The results were unexpectedly beautiful, as in the ghost of a face that appears above. Radiography also revealed much about the physical condition of Michelangelo's creation. They showed that (above) metal pins had been used to rejoin the broken fingers on the hand of the Virgin, and that at one time a "pious vandal" (to use one ecclesiastic's phrase) had drilled shallow holes (seen above) in the top of the Virgin's head for the purpose of affixing a halo, later removed. This and other information assured the custodians of La Pieta that the voyage to America would not be dangerous, and has proven useful in subsequent maintenance and repair of the sculpture.

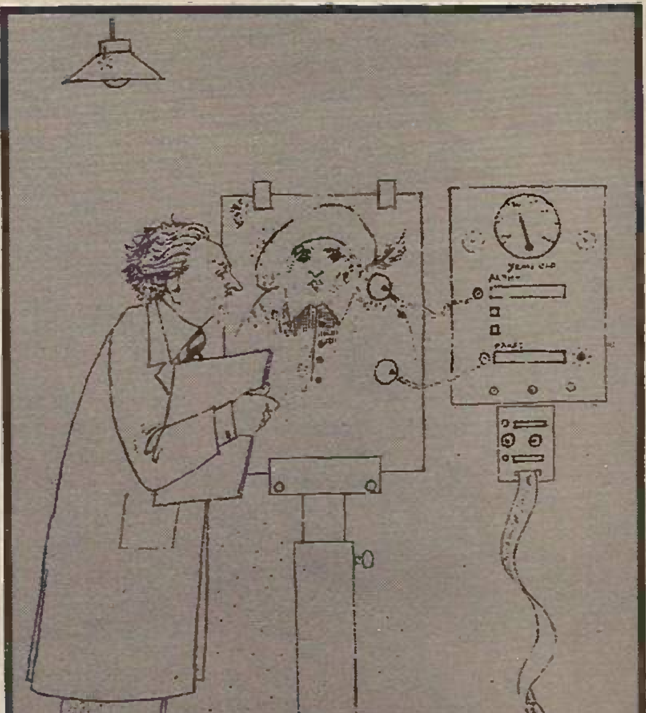


Fig.2. The museum scientist is rarely involved in detecting forgeries — the main role is to provide information that assists restoration and conservation. (Cartoon drawn by Marcus Rees-Roberts for a National Gallery publication).

SCIENCE IN ART

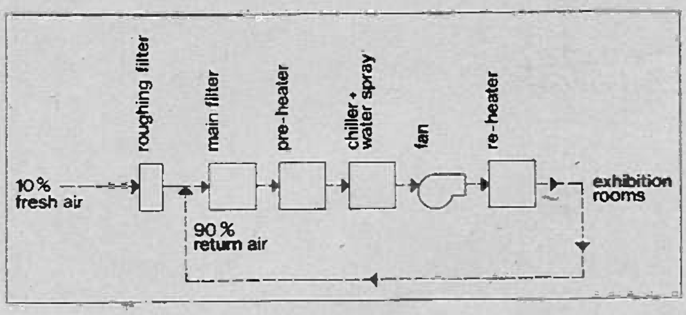


Fig.3. Block diagram of arrangement used to clean and correct humidity and temperature of air.

naively imagine, things are then done properly with the right priorities being allocated.

Large Institutions, although better endowed financially in the absolute sense, often face even more difficult problems in the setting of priorities; they must always make decisions in the light of current circumstances. Take, for example, the National Gallery in London where a large proportion of Britain's art treasures are stored. Its history typifies what has often happened to valuable collections of old works.

In 1777 John Wilkes, a member of Parliament, proposed the erection of a modest "Noble Gallery" to house a certain collection of pictures then put up for sale. Wilkes' idea fell on sterile ground (at that time). It was not until the early nineteenth century that the idea was actually realised.

Then, John Angerstein, a rich merchant-collector, had built up a superb collection which was housed in a house in Pall Mall. On his death in 1823, various public-spirited noblemen, successfully lobbied the Government to buy the collection and its premises as the "foundation of a National Gallery". Sir George Beaumont and Rev. Howell Carr also donated their works to the cause.

So, in 1824 a new tradition began. The rooms in Pall Mall soon became overcrowded with the continually arriving new acquisitions and the Trustees began a search for a better home. By 1838 a new building (the one used today which was designed by William Wilkins) had been built and brought into use as the National Gallery. This was not the end of the accommodation difficulty because the new building, shown in Fig.1., was originally shared with the Royal Academy. The lack of space and unenlightened public habits of the times rapidly turned the still-cramped rooms into feotid, miserable places wherein damage to the artworks became rampant – dust "an inch thick accumulated on the frames". The need for conservation was realised slowly and gradually various moves were taken in the right direction. In 1869, the Royal Academy moved to Burlington House overlooking the Mall – leaving the Wilkins designed building to cater solely for art.

Until 1855 the Trustees had little technical knowledge in their midst so truly scientific approaches to the problems of conservation were scant indeed. In that year, Sir Charles Eastlake became the first Director (rather than just the "Keeper") and this brought, because of his experience, some semblance of scientific approach into the Gallery's control. Eastlake, as a visionary buyer, provided the Gallery with 137 new priceless pictures at a time when costs were reasonable – the Director must play both art selector and conservator roles.

Some sound and potentially far-reaching advice on scientific matters had often been forthcoming before Eastlake's new appointment but usually to no avail. Faraday, for instance, in 1850, wrote of the dangers of the air pollution sources existing around Trafalgar Square – they used urine in those times to wash clothes and raw materials! The same report suggested air conditioning (which included humidification as well as temperature control) should be adopted; it had already been in use in the Houses of Parliament for 20 years but the Committee, in its wisdom, decided to merely cover a few of the

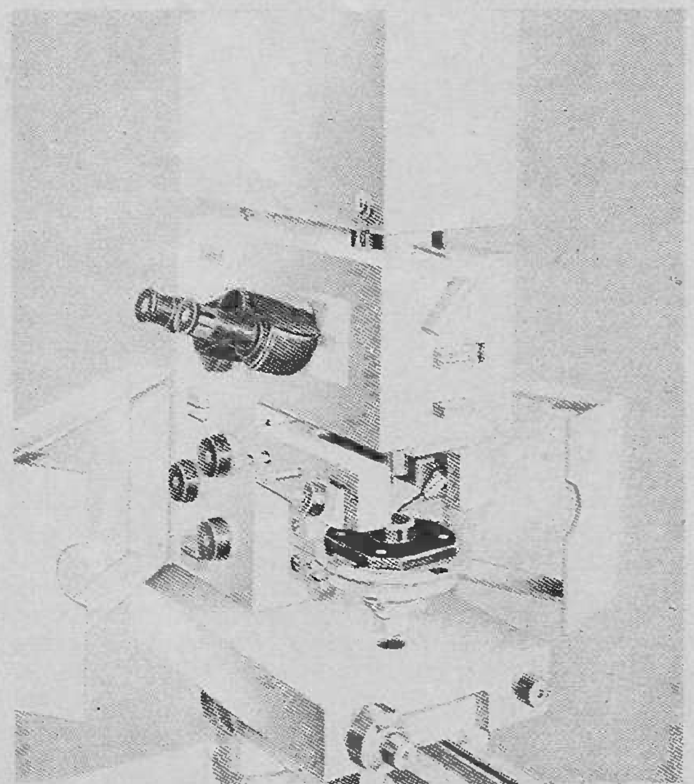
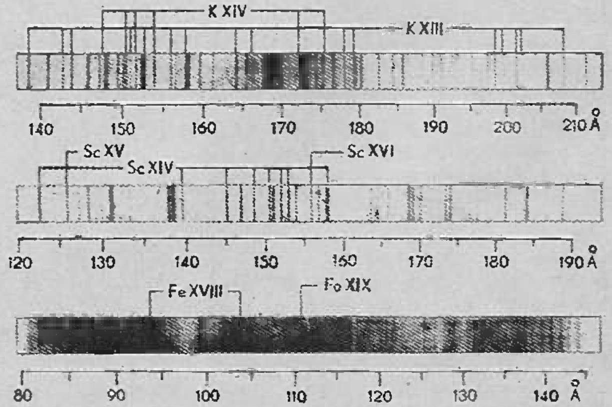
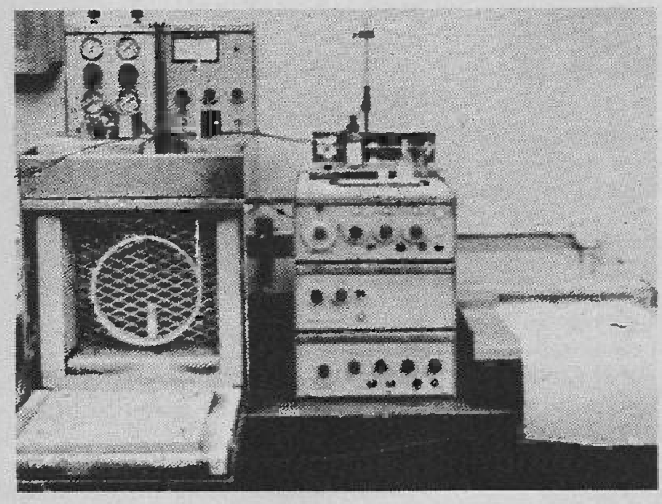


Fig.4. Laser end of the Ziess (Jena) LMAI, laser microspectral analyser. Emission produced at the central pointed spark electrode is viewed by a spectrophotometer that provides a spectrum photograph like that shown here.





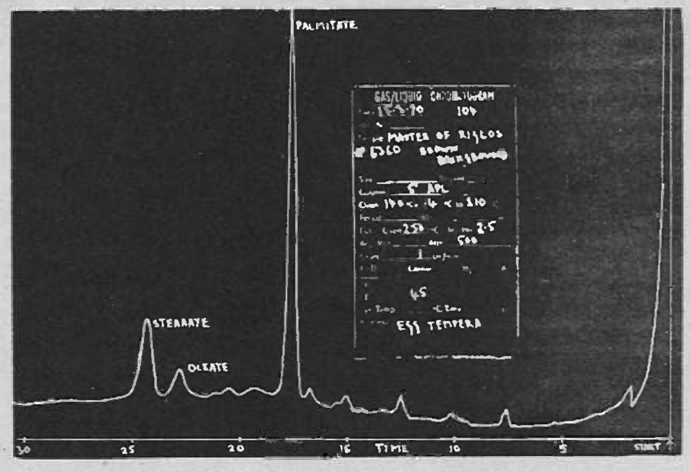


Fig. 5. This Pye gas-chromatograph is used to provide chemical analyses of painters' media. Its chart output for egg tempera is given here (as recorded for an analysis of "The Crucifixion" by the Master of Ruglos).

works in glass as the improved preservation measures.

Science did eventually become recognised in the National Gallery for, in 1934, F. Rawlins was appointed as its first Scientific Adviser. Recommendations were again made for climate control but storage of the works in slate-mines during the Second World War did more to prove the point about climatory conditions than learned advice, and climate control gradually was introduced into the Gallery. Today, climate control is nearly total in the National Gallery – few collections anywhere else enjoy proper climate control.

The National Gallery now has a specific Scientific Department wherein three trained scientists devote their entire time to providing scientific assistance for the many kind of problems that arise in the Gallery. From the scientist's point of view there is need for more staff but the Trustees see that other priorities should use any spare funds. No doubt, with time, the ratio of scientific effort to total maintenance and acquisition costs will increase. How much effort should be expended for a collection with 2550 pictures of which many are purchased at over a million pounds each is the leading question.

Looking back on this account it is easy to suggest that unimaginative people were in control. Current opinion must, however, be tempered by the recognition that science, as we know it today (especially the electrical branch) was then in a stage of a gradual development running concurrently with the National Gallery's maturity. Modern measurement and control, adequate to handle many of the problems involved were not even close to reality until the turn of this century.

Compounding the problem of blending science and art is the fact that scientists and artists/art lovers often lie at the extreme ends of the physical knowledge and attitude scales. It was not surprising to hear in the past (and the situation still continues) such statements as "the pictures must breathe" and that "they will not stand the shock if climate control should break-down putting the picture back in the uncontrolled environment to which it is unaccustomed". Even now it is held by critics that 'daylight' is essential for viewing – scientists certainly could not agree as to what 'daylight' the artists are implying so how can there be a basis for such an argument.

For all of this, science is now allowed to play an important role in conservation, not only in the art gallery but in any kind of museum. Today, plenty of science can be brought to bear on art problems that the Trustees of the National Gallery have inherited from the past. For instance, the building looks fine as a monument but what was adequate in 1836 does not entirely suit today's overall requirements.

Although there is clearly need for improved scientific effort at the National Gallery it still enjoys the distinction of being one of the most advanced galleries in the World in this respect. Much of the work of the modest scientific group is setting the pace for other galleries to follow.

Where can science help?

An art gallery, or any similar treasure-house, has to perform several simultaneous functions. It must house the collection in a suitable fashion, ideally with climate control; it must provide a secure environment not only against obvious theft but also against natural disaster and man-made destruction; it must provide experts and facilities for conservation, restoration, original research and, less commonly, for the identification of and the discovery of new finds.

As science is the systematic approach to gaining new information about a subject, virtually every aspect of an art gallery programme could benefit from the application of scientific effort. This fact is being recognised more and more with time.

On the use of the building, science can provide measurements such as climate variation and pollutant level but having figures is only part of the story, for the cost of control may not be acceptable – it is hard to imagine visitors being clad in sterile garments, entering via air locks to view works hanging in clean-air rooms like those used in the manufacture of semiconductors.

Similarly, with security; the collection must be safe-guarded against theft and damage yet not appear to be over safe. Over-zealous security measures can detract from the visitors' experience. Theoretically the collection should also be in an atomic-bomb proof type shelter for we are the custodians of treasures which are also the right of the future generations.

Anyone who has been into the Pergamon Museum (The Eastern-blocs' equivalent to the British Museum) in East Berlin will know how a concrete block house structure spoils the overall experience of visiting works of art.

Matters of security and the building, therefore, tend to lie more in the hands of government bodies rather than the museums' scientific staff. At the National Gallery, the latter are only able to advise and suggest what is needed – the rest is left to the Department of the Environment.

SCIENCE IN ART

When it comes to assisting the professional art work of the gallery the scientist's role becomes vital.

The scientists' main work is in providing information about restoration and conservation processes to the highly skilled restorers. Rarely is there need to play judge (as depicted by the cartoon given in Fig. 2) in cases of forgery. Fakes usually fail to convince on points that are picked up by the art expert — scientific methods (those using instruments) are secondary in making decisions. Occasionally, but not often, as we shall see at the end of this feature, science can act detective and point to more discovery.

The restorer is greatly assisted in his or her task — which can take up to several years to complete — by knowledge of pigment composition, of corrosion removal methods and of material structure. These points are, and have been, accepted for many decades now by nearly everyone as the vital requirements of the restorer. There is little glamour in this work and gradually improved chemical analytical methods which require little actual microchemistry procedure are finding application.

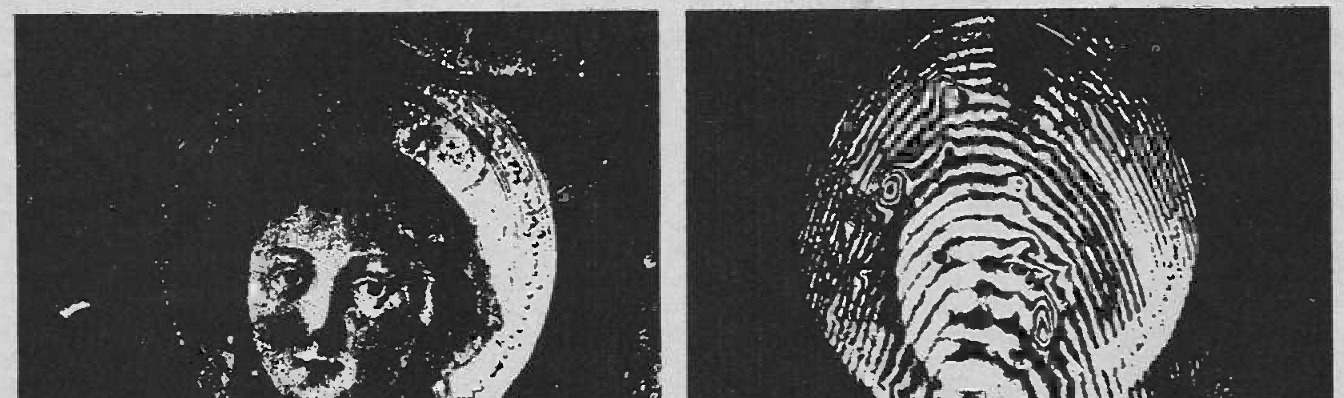
The core substance of gallery work is cleaning, restoring and conserving the pieces as they arrive into safe keeping. Cleaning involves removal of dirt and oxidised varnish. Research findings on solvents and electro-chemical corrosion reduction are applied here. Restoration involves ensuring that the medium is secure on its support; if not, remedying the faults and then the rebuilding of missing areas in as an exactly similar manner as first existed. The golden rule of all antique restoration is that no repair or alteration is carried out in a manner that is not reversible. It must be possible to entirely remove the repair at a later date. The restorer should, ideally, add no permanent interpretation of his own.

Although much research has already been expended on corrosion mechanism, chemical analysis and strength of materials, the conservation/restoration scientist finds that many of the antiquarian problems in these fields have not been researched. Corrosion of metals over short periods is the main emphasis in engineering — not the slow decay of articles such as plaster, paper, wood and fabrics over centuries of time. For this reason alone, more research must be carried out as and when the demand occurs. Most forms of art deterioration occur so slowly that they often cannot be sensed in one man's lifetime. Surprisingly few groups are studying ways to detect deterioration more quickly. For example, only the National Gallery has equipment — and that is still in a prototype form — that can measure in an absolute way the changing colour of a painting. It seems the point that detection is the first stage to proper prevention has still not been taken by many museum trustees.

How science is applied

Just as a compromise must be made between scientific staff and arts staff, then so also must one be made about the amount of on the spot equipment made available for the resident scientists to use.

The National Gallery has quite a range, as we shall see, but their demands often run to requiring the use of other instruments. In such cases the instrument is moved to the art work or the art work to another laboratory, such as the more extensive British Museum Research Laboratory. The instrument range of the National Gallery reflects the proven needs and, to a lesser extent, the special interests



Holographic interferometry can now be used to detect incipient damage in oil paintings. The technique has been devised by Italian scientists S. Amadesi et al and is fully reported in Applied Optics 13, 2009, 1974.

The painting to be checked is warmed slightly. Any detached areas disperse heat less than sound areas — thus their thermal expansion is greater. The damaged areas can easily be seen by comparing two holograms made five minutes apart.

Our example shows the technique used on Piere Francesco Fiorentina's 'Santa Caterina — a 15th century panel painting. The kinks in the second picture are the damaged areas.

of the staff. Garry Thomson, who heads the Scientific Department, has been largely responsible for setting up objective colour fading practices. Joyce Plesters, (whose husband is a restorer at the Victoria and Albert Museum), is the expert on pigment analysis.

In use, measurements and tests are made as needed and all data recorded in a dossier held on each art-piece. These files contain the information built up about the picture — where and when it was found; the history, where known; the work that has been carried out over the ages and the measurements made. Some dossiers are centuries-old. At present it is the dossier information that largely shows if the work is safely conserved — not objective measurements. The more that is known about the picture, both from static and dynamic viewpoints, the better the restoration.

Environmental control

Since the National Gallery was first conceived it has been obvious to those more skilled in science that a constant environment having the right temperature (about 20°C, but not vital) and relative humidity (55 per cent RH held to within 3%) would best preserve the total fabric of the artworks. Probably the greatest single cause of damage is repeated stressing of the art surface by repeated humidity changes. It is also important to control the noxious gases content of the air — especially SO_2 which forms sulphuric acid with condensation. Figure 3 shows the block diagram of the air conditioning system used. By using washed air methods, particulates and many gases are filtered out: it also enables the relative humidity to be controlled. Climate control, because it uses relatively straightforward technology, is left to the Department of Environment's responsibility. In certain cases the painting is given its own specially controlled environment — for example. hermetically sealed packing modules are being researched at present as a way to overcome transport problems.

Another aspect of environmental control is that the lighting intensity and quality must be up to standards laid down by art experts yet not be such that it accelerates colour changes because of harmful ultra-violet content. To this end natural daylight is made available in all rooms, entering via U.V. filter panels. To maintain a constant level many rooms have automatically moving venetian blinds that are controlled by photo electric cells monitoring the light level. For dull days natural light is supplemented by voltage controlled fluorescent lighting, having dimming capability of 6:1. The ideal illumination level is 150 Lux and (between you and I) much of the time the so-called "natural light" is in fact very much artificial!

Fig.6. Infrared and ultraviolet radiation studies are made using these Perkin-Elmer spectrophotometers.

CHEMICAL ANALYSIS

A major part of the work-load of the Scientific Department is chemical analysis of materials of paintings — wood panels, canvases, paint pigments, varnishes. The restorer desires as much information about the work that is in repair as is possible.

Literally pin-head sizes of paint are removed from the repair area. The flake is then moulded into a small plastic block that is then polished across the flake so as to reveal its cross section.

Using a variety of microscope techniques cross-sectional colour photographs are produced that clearly show the various layers used by the artist. Such information does occasionally aid verification and identification of the artist or his school but not often. Study of the layers used mainly assists the restorer to rebuild the paint as the artist built it originally. In this way the same visual effect is repeated — the final appearance depends much on the underpaintings and composition of paints. In some cases, it is also possible to trace the history of a work, the penetration of one colour into cracks is a valuable pointer as to historical sequence of layer application. The microscope work needs little explanation.

Microchemistry is also used to assist identification of pigments but the move is toward analytic instrument usage. The newest tool purchased at the National Gallery is a laser micro-spectrochemical analyser, a new use to which the laser has been put.

In this instrument a small pulsed laser source is focused onto the specimen of material to be analysed. A shot is fired producing a minute crater. This vaporizes the extremely small area of surface (selected by a simultaneous visual viewing magnifier) liberating various chemicals as gases. It is not easy to make a direct analysis of these gases but the task is made much easier if they are produced against a background of an electrical spark. The resultant combined radiation spectrum is recorded using photographic recording of the dispersed wavelengths. The emission production unit is shown in Fig. 4 along with a typical "fingerprint" spectrum. In use a spectrum recorded for a specimen is compared against a library of standard records. The extremely fine pit of the laser shot, about 10-100μm across depending upon what is desired, gives the analyst extreme detail of pigment composition enabling measurements to be made within the thinnest of paint

SCIENCE IN ART

layers. At present the Gallery possesses some three thousand odd plastic-mounted flakes to be analysed this way!

Knowing about the pigment used is but one part of the need, for pigments must be secured with a medium that turns to a firm permanent binder with time. Artists used all manner of mediums and drying oils – egg tempera (yes, literally egg!); walnut, linseed, poppyseed oils. Whereas the pigments remain reasonably inert with time these latter do not and the gallery staff need to know what happens in order to identify the medium originally used. This, they do, using gas chromatography.

In the equipment used (and shown in Fig. 5) a sample is injected into the end of a long tube that is heated and packed with a suitable absorbent powder. The partitioning chemical process in the tube acts to separate the various chemical constituents so that they arrive at the other end at differing times. With the use of appropriate electronic detectors the various arrival times can be recorded. A trace, such as that given in Fig. 5, provides another type of "fingerprint" that tells the composition.

The laboratory also has proprietary spectrophotometers that enable the transmission/reflection characteristics of filters, paint surfaces and the like to be recorded. The two instruments are shown in Fig. 6. The sample is placed in the appropriate machine – one covers the radiation wavelengths in the ultra-violet (190 nm-800 nm wavelength) – where monochromatic light is radiated (or reflected) through the specimen and the intensity recorded This is repeated as a continuous scan with a range of wavelengths to produce an intensity versus wavelength plot. These instruments find use for checking U.V. and I.R. filter materials.

Many calculations are needed with the various analytical instruments. To reduce the effort a programmable desk calculator with coupled tape interfacing is available for use where needed. A one hundred channel data logger system is also used in various kinds of research tests. Many other methods of analysis exist – if the above methods do not suffice the staff make use of instruments in other institutions.

BEFORE CLEANING

AFTER CLEANING

Fig.7. X-radiographic examination of "St. Michael" by Pierò della Francesca revealed an anomolous area under the final painting – bottom right hand corner.

Non-visible imaging

In 1895 Röntgen discovered the existence of X-rays and the principle of X-radiography rocketed into immediate use.

It is common knowledge that X-rays enable photographs to be made where high-mass contrast exists, metals in non-metal bodies, for instance. This makes the technique useful for viewing the hidden shape of massively corroded articles – it was used by the British Museum to restore the Bull Cup from Cyprus. It can also be useful in art-work studies, for the X-ray shot can reveal variations in the underlayers densities that are not visible to the eye, especially before the work is cleaned. The painting "St. Michael" by Piero della Francesca was shown in this way to be one part of a five panel altar piece for the Church of St. Agostino in the mid-1400's. In this case, X-rays provided the clinching evidence by revealing (see Fig. 7) a piece of drapery in one corner. All but one panel have now been located.

Another non-visible imagery technique is to image the picture in the infra-red radiation region. The gallery staff use a television system based on the "Resistron" camera tube which is sensitive around 1.75µm. I.R. methods can penetrate the paint layers to reveal the original artist's sketch made with charcoal or the like before painting was commenced. Such a sketch is a valuable clue to the actual artist, the school and the date. In this time, when remote-sensing is currently of interest for world resource mapping, one might be inclined to suggest that false-colour photography might be useful in art work but this is not so.

COLOUR CHANGE

I have already touched on the need to be able to detect deterioration with utmost speed – a century of subjective observation is not good enough.

Various tests can be made on substitute materials – they can be subjected to accelerated fading conditions of light and pollutants: the real test, however, is what is actually happening to the painting in question. Remarkably, no other gallery appears to have made attempts to find out how to make reliable objective measurements.

Working with Professor W.D. Wright (formerly of Imperial College, London) the National Gallery have

Fig.8. This special spectrophotometer has been developed to monitor changes in colour over long periods.

just completed a specially constructed prototype spectrophotometer. In use the painting is placed in front of its input viewing area, as shown in Fig. 8. The spot on the painting that is to be measured is brought into the correct place using a coincident optical viewer and past photographs. To ease this operation a fibre-optic bundle cord 'connects' the painting to the more massive spectrophotometer. Once set up, a monochromator, built into the unit, provides pure colour illumination that reflects from the picture to be registered in the photo-electric pick up sensor — a photo multiplier.

In this manner the reflection from an area of picture about 2 mm across is recorded for radiation ranging from 380 to 760 nm. Both reflectance and wavelength are automatically recorded thereby providing a 'fingerprint' of the chosen spot.

This equipment has been carefully designed to maintain long-term accuracy. As the components of the spectrophotometer undoubtedly alter with time, the equipment is periodically calibrated using standard colour ceramic tiles that are standardised with respect to national colour Standards. It is hoped that the method will prove to be so satisfactory that art experts in a century from now will be able to rely on today's results.

The spectrophotometer has not been in use long enough yet to provide deterioration data but without doubt it will provide vitally needed data much quicker than the traditional visual methods.

THE FASCINATION OF IDENTIFICATION

As I have said already the museum scientist is occasionally called upon to verify authenticity of a work. In the same vein, but more common, is the occasional chance find that occurs as the work is being studied to aid restoration and cleaning. For example, Prussian blue (based on ferric ferrocyanide) was accidentally discovered in 1704 and the fact was recorded in history. Hence, any use of it on works accredited before that date must be as additional, repainted areas, or the work must be a later copy. By knowing miriads of facts like this, scientists can provide valuable assistance.

To illustrate the remarks given here I shall outline the procedures of a recent instance. The National Gallery has a painting "Portrait of Pope Julius II" that was thought to be one of a few copies made of an original by Raphael (1483-1520). (Such copies would not be fraudulent paintings but merely copies intended for distribution to places where a Papal picture was relevant.) The Deputy Keeper, Cecil Gould, claimed that the Gallery's version was not a copy, but the original. He based his claim on X-radiographs and an ancient inventory number. Figure 9 shows the painting in question.

X-rays of the uncleaned version had revealed a more formal pattern — of cross-keys and papal tiaras — lying under the green background curtain. It appeared that Raphael had changed his mind after its original completion and had overpainted the background to provide less formality.

The painting was subsequently further examined — X-rays could detect differing layers but did not confirm relative dates at which they were laid down, nor the colours of the original background. A minute piece of paint was observed in cross section under the microscope and a 100mm by 120mm colour transparency made of the paint layers.

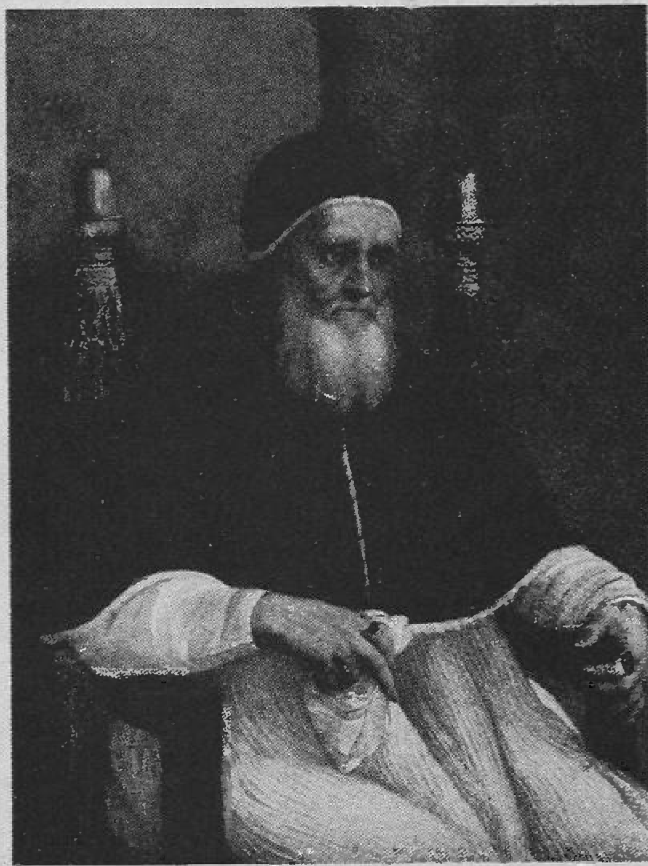


Fig.9. "Pope Julius II", now known to be the original, was painted by Raphael around 1500. The original background — cross keys can be seen now that the work has been cleaned.

SCIENCE IN ART

In total the paint is about 250μm thick with some layers being only 25μm; they are easily seen in the original photograph. The bottom layer is calcium sulphate (commonly called gesso). On this are clearly seen white and yellow layers covered by two green layers. The white and yellow layers are the hidden original background which was over-painted with green. As there is no dirt or varnish layer between the yellow and green, and as the paint filling vertical cracks had dried simultaneously with the bulk of the paint, it is concluded that all layers were put down together indicating a change of heart as it was painted.

Using gas-chromatography, other tests were made to verify that the drying oil medium for the green verdigris pigment was indeed in use in that period. It is now recognised that the National Gallery's painting is, indeed, the original — a fact that can largely be attributed to the use of sophisticated science.

> Just as we close for press, we have been advised of a grant of £14,000 to Prof W.D. Wright, emeritus professor of applied optics, Imperial College of Science and Technology, London, for the construction of a mobile spectrophotometer for use in art conservation (comprising a monochromator with optical link to separate measuring head and associated electronics for spectral reflection measurements to determine the effects of age on the colouring of works of art, and designed for incorporation in suitable transport to form a mobile unit).

THE PART SCIENCE CAN PLAY IN THE FUTURE

Scientific instruments and procedures provide information about a subject so as the cost of measurement methods reduces and their usefulness increases and is better recognised we should see a continual increase in the scientific effort devoted to the discipline. Newly created museums and galleries will have an opportunity given them that their predecessors were denied. Let us hope those making these decisions make the most of their circumstance for their efforts will surely be questioned by later generations.

Electronics Today International is especially grateful to Garry Thompson and Joyce Plesters of the Scientific Department of the National Gallery for providing a most informative visit for the author.

Further Reading:

"The Working of the National Gallery", Trustees of Nat. Gal. London, 1974 (published on occasion of 50th anniversary).
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"Laser micro spectrochemical analysis", M. and L. Moenke, Adam Hilger, 1973, London.

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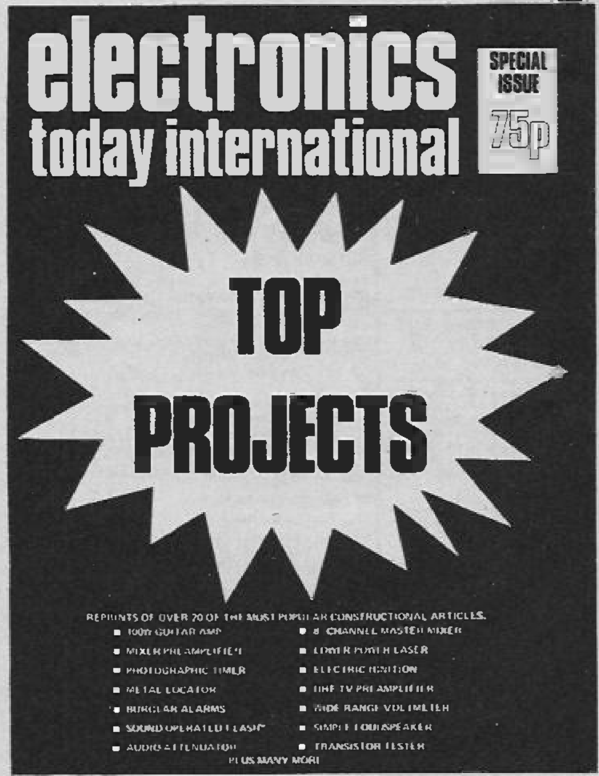

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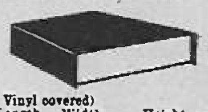

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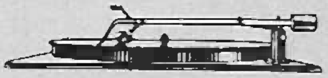

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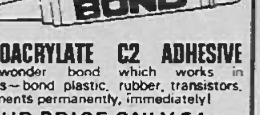

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160	Coil design and Construction Manual	30p
161	Radio T.V. and Electronic Data book	25p
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UK300	4-channel Radio Control Transmitter	£7·80
UK310	Radio Control Receiver	£3·60
UK325	'GCX2' Channel splitting unit 1,000 & 2,000 Hz	£9·75
UK330	'GCX2' Channel splitting unit 1,500 & 2,500 Hz	£9·75
UK345	Superhetrodyne Radio Control Receiver	£7·25
UK525	VHF Tuner 120 to 160 MHz	£12·46
UK555	Radio Control Field Strength Meter	£7·25
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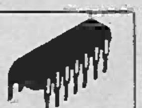
74 Series T.T.L. I.C'S



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Type	1	25	100 +	Type	1	25	100 +	Type	1	25	100 +
7400	0·15	0·14	0·13	7448	£1·10	£1·07	£1·05	74122	0·70	0·68	0·65
7401	0·15	0·14	0·13	7450	0·15	0·14	0·13	74123	0·75	0·73	0·70
7402	0·15	0·14	0·13	7451	0·15	0·14	0·13	74141	0·85	0·82	0·79
7403	0·15	0·14	0·13	7453	0·15	0·14	0·13	74145	£1·30	£1·25	£1·20
7404	0·15	0·14	0·13	7454	0·15	0·14	0·13	74150	£1·50	£1·40	£1·30
7405	0·15	0·14	0·13	7460	0·15	0·14	0·13	74151	£1·10	£1·05	£1·00
7406	0·39	0·34	0·31	7470	0·32	0·29	0·27	74153	£1·00	0·95	0·90
7407	0·39	0·34	0·31	7472	0·32	0·29	0·27	74154	£1·70	£1·65	£1·60
7408	0·25	0·24	0·23	7473	0·41	0·39	0·35	74155	£1·20	£1·15	£1·10
7409	0·25	0·24	0·23	7474	0·41	0·39	0·35	74156	£1·20	£1·15	£1·10
7410	0·15	0·14	0·13	7475	0·60	0·58	0·56	74157	£1·00	0·95	0·90
7411	0·25	0·24	0·23	7476	0·44	0·43	0·42	74160	£1·40	£1·35	£1·30
7412	0·28	0·27	0·26	7480	0·60	0·58	0·55	74161	£1·40	£1·35	£1·30
7413	0·32	0·31	0·30	7481	£1·10	£1·05	£1·00	74162	£1·40	£1·35	£1·30
7416	0·30	0·29	0·28	7482	0·90	0·85	0·80	74163	£1·40	£1·35	£1·30
7417	0·30	0·29	0·28	7483	£1·20	£1·15	£1·05	74164	£1·80	£1·75	£1·70
7420	0·15	0·14	0·13	7484	£1·00	0·97	0·95	74165	£1·80	£1·75	£1·70
7422	0·30	0·29	0·28	7485	£1·60	£1·55	£1·50	74166	£1·60	£1·55	£1·50
7423	0·40	0·39	0·38	7486	0·35	0·34	0·33	74174	£1·60	£1·55	£1·50
7425	0·40	0·39	0·38	7489	£4·00	£3·75	£3·50	74175	£1·10	£1·05	£1·00
7426	0·40	0·38	0·36	7490	0·65	0·63	0·60	74176	£1·25	£1·20	£1·15
7427	0·40	0·38	0·36	7491	£1·10	£1·05	£1·00	74177	£1·25	£1·20	£1·15
7428	0·45	0·42	0·40	7492	0·73	0·71	0·64	74180	£1·25	£1·20	£1·15
7430	0·15	0·14	0·13	7493	0·74	0·71	0·64	74181	£3·95	£3·85	£3·75
7432	0·40	0·38	0·36	7494	0·85	0·82	0·75	74182	£1·25	£1·20	£1·15
7433	0·42	0·40	0·38	7495	0·85	0·82	0·75	74184	£1·80	£1·75	£1·70
7437	0·35	0·32	0·30	7496	0·96	0·93	0·86	74190	£1·95	£1·90	£1·85
7438	0·35	0·32	0·30	74100	£1·50	£1·45	£1·40	74191	£1·95	£1·90	£1·85
7440	0·15	0·14	0·13	74104	0·60	0·58	0·55	74192	£1·95	£1·90	£1·85
7441	0·74	0·71	0·64	74105	0·60	0·58	0·55	74193	£1·95	£1·90	£1·85
7442	0·74	0·71	0·64	74107	0·44	0·42	0·40	74194	£1·30	£1·25	£1·20
7443	£1·20	£1·15	£1·10	74110	0·60	0·55	0·50	74195	£1·10	£1·05	£1·00
7444	£1·20	£1·15	£1·10	74111	0·90	0·88	0·85	74196	£1·20	£1·15	£1·10
7445	£1·60	£1·55	£1·50	74118	£1·00	0·95	0·90	74197	£1·20	£1·15	£1·10
7446	£1·20	£1·15	£1·10	74119	£1·50	£1·40	£1·30	74198	£2·75	£2·70	£2·65
7447	£1·10	£1·07	£1·05	74121	0·50	0·48	0·45	74199	£2·50	£2·40	£2·30

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The NEW AL60 Hi-Fi Audio Amplifier

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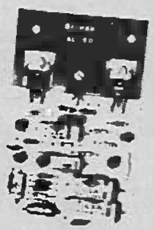
- Distortion better than 0·1% at 1KHz
- Supply voltage 15–50 volts
- Thermal Feedback
- Latest Design Improvements
- Load — 3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm x 105mm x 13mm



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

FULLY BUILT - TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm x 105 mm x 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available. 10p.

TRANSFORMER BMT80 £2·75p. & p.40p

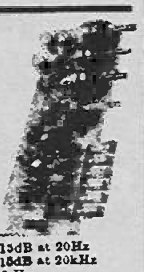
INTEGRATED CIRCUIT PAKS

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

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	12 - 7400	0·54	UIC46	5 - 7446	0·54	UIC90	5 - 7490	0·54
UIC01	12 - 7401	0·54	UIC48	5 - 7448	0·54	UIC91	5 - 7491	0·54
UIC02	12 - 7402	0·54	UIC50	12 - 7450	0·54	UIC92	5 - 7492	0·54
UIC03	12 - 7403	0·54	UIC51	12 - 7401	0·54	UIC93	5 - 7493	0·54
UIC04	12 - 7404	0·54	UIC53	12 - 7453	0·54	UIC94	5 - 7494	0·54
UIC05	12 - 7405	0·54	UIC54	12 - 7454	0·54	UIC95	5 - 7495	0·54
UIC06	8 - 7406	0·54	UIC60	12 - 7460	0·54	UIC96	5 - 7496	0·54
UIC07	8 - 7407	0·54	UIC70	8 - 7470	0·54	UIC100	5 - 74100	0·54
UIC10	12 - 7410	0·54	UIC72	8 - 7472	0·54	UIC121	5 - 74121	0·54
UIC20	12 - 7420	0·54	UIC73	8 - 7473	0·54	UIC141	5 - 74141	0·54
UIC30	12 - 7430	0·54	UIC74	8 - 7474	0·54	UIC151	5 - 74151	0·54
UIC40	12 - 7440	0·54	UIC76	8 - 7476	0·54	UIC154	5 - 74154	0·54
UIC41	5 - 7441	0·54	UIC80	5 - 7480	0·54	UIC193	5 - 74193	0·54
UIC42	5 - 7442	0·54	UIC81	5 - 7481	0·54	UIC199	5 - 74199	0·54
UIC43	5 - 7443	0·54	UIC82	5 - 7482	0·54			
UIC44	5 - 7444	0·54	UIC83	5 - 7483	0·54	UICX1	25 Assorted 74's	£1·65
UIC45	5 - 7445	0·54	UIC86	5 - 7486	0·54			

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

STEREO PRE-AMPLIFIER TYPE PA100



Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292 x 82 x 35 mm

All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

only £14.25

LINEAR I.C's—FULL SPEC.

Type No.	1	25	100 +
72702	0·50	0·48	0·45
72709	0·25	0·23	0·20
72709P	0·20	0·19	0·18
72710	0·35	0·33	0·30
72741	0·30	0·29	0·28
72741C	0·28	0·27	0·26
72741P	0·30	0·29	0·28
72747	0·85	0·80	0·75
72748P	0·38	0·36	0·34
SL201C	0·50	0·45	0·40
SL701C	0·50	0·45	0·40
SL702C	0·50	0·45	0·40
TAA263	0·80	0·70	0·60
TAA293	£1·00	0·95	0·90
TAA350A	£1·85	£1·80	£1·70
μA703C	0·28	0·26	0·24
μA709C	0·20	0·19	0·18
μA711	0·35	0·33	0·30
μA712	0·35	0·33	0·30
TBA800	0·95	0·93	0·90
76003	£1·50	£1·45	£1·40
76023	£1·50	£1·45	£1·40
76660	0·95	0·93	0·90
LM380	£1·00	0·97	0·95
NE555	0·65	0·63	0·60
NE556	0·95	0·93	0·90
ZN414	£1·20	—	—

DTL 930 SERIES LOGIC I.C's

Type	1	25	100 +
BP930	0.15	0.14	0.13
BP932	0.18	0.15	0.14
BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	[illegible]	[illegible]	0.25
BP946	0.15	0.14	0.13
BP948	[illegible]	[illegible]	0.25
BP951	0.70	0.65	0.60
BP962	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
BP9094	0.45	0.43	0.40
BP9097	0.45	0.43	0.40
BP9099	0.45	0.43	0.40

DUAL-IN-LINE SOCKETS.

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100up.
TSO 14 pin type	33p	30p	27p
TSO 16	38p	35p	32p
TO 24	75p	70p	68p
LOW COST No.			
BPS 8 pin type	13p	13p	11p
BPS 14	16p	14p	12p
BPS 16	17p	15p	13p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F.	Muntron 7 Segment Indicator	£1.20
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1.90

VOLTAGE REGULATORS

TO.3 Plastic 1·5 Amps

μA.7805/L129 5V (Equiv. to MVR5V) £1·35

μA.7812/L130 12V (Equiv. to MVR12V) £1·35

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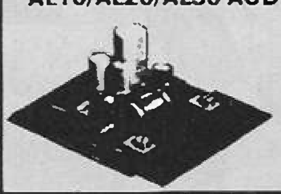
AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



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

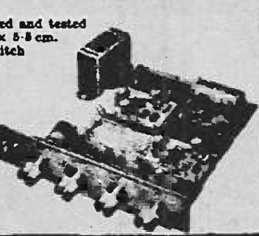
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0·25%
LOAD IMPEDANCE	—	8 – 16 Ω
INPUT IMPEDANCE	f = 1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po = 2 WATTS	50 Hz – 25KHz
SENSITIVITY for RATED O/P.	Vs = 25V. Rl = 8 Ω f = 1KHz	75mV. RMS
DIMENSIONS	—	3" x 2½" x 1"

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

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL = 8 Ω f = 1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·50	£2·85	£3·20

The STEREO 20 £14·45 p & p 45p



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm x 14 cm x 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

TEAK VENEERED CABINETS for:

STEREO, 20
TC 20. £3·95 p&p 45p

TC 100. £6·50 p&p 40p.

E.M.I. LEK 350 Loudspeaker System Enclosure kit in Teak Veneer, including speakers. Rec Retail Price £45·50 per pr. OUR SPECIAL PRICE £35·50 per pair p&p £1. *ONLY WHILE STOCKS LAST!*

FRONT PANEL, 4 knobs, Headphone Socket, on/off switch and neon for PA 100/MK 50. FPK 100 £2·95.

TRANSFORMERS

T461 (Use with AL10)	£1·60 P & P	22p
T538 (Use with AL20 & AL30)	£2·30 P & P	22p
BMT80 (Use with AL60)	£2·15 P & P	37p

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30)	95p
SPM 80. (Use with AL60)	£3·25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm x 84mm x 35mm. PRICE £4·35

Frequency response— 20Hz – 50KHz (– 3dB)
Bass control— ± 12dB at 60Hz
Treble control— ± 14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm Sensitivity 300mV
†Input 2. Impedance 30 K ohms Sensitivity 4mV

FRONT PANEL FP12 with knobs £1·00

Giro No. 388 7006

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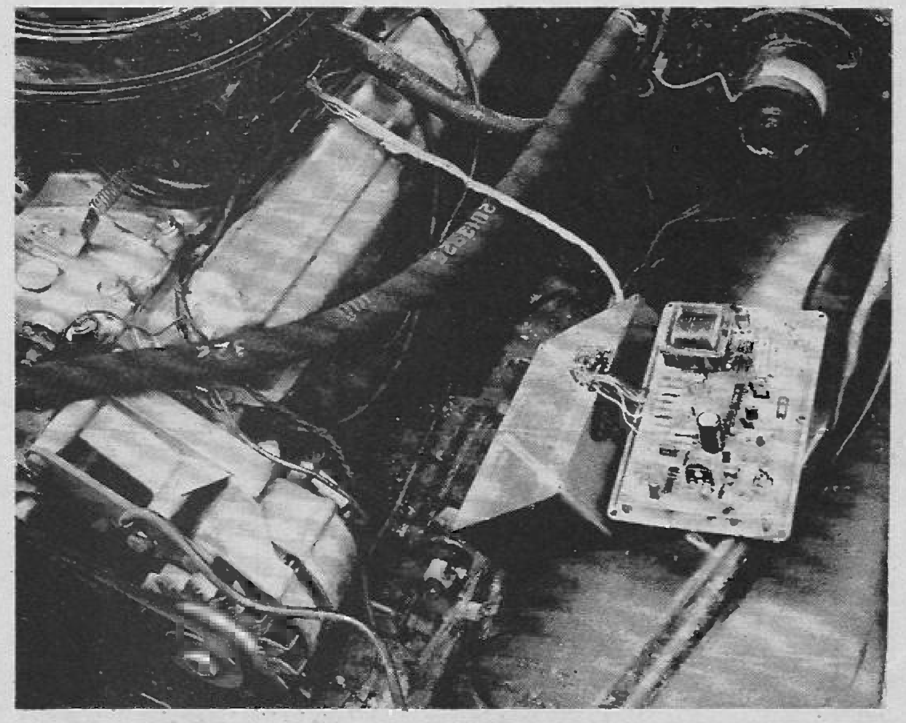
ELECTRONIC IGNITION SYSTEM

PART II

Constructional details of ETI's outstanding CDI/tacho system – designed and developed by Barry Wilkinson.



IN LAST month's issue we traced the historical development of electronic ignition systems, detailed many of the failings common to existing CDI (Capacitor Discharge Ignition) designs, and introduced the ETI system which effectively overcomes these failings.

Here are full constructional details for our ignition system.

CONSTRUCTION

Construction of the unit is considerably simplified by the use of a printed circuit board and this is strongly recommended.

All components should be mounted on the printed circuit board in accordance with the component overlay diagram. Take particular care with the orientation of transistors, diodes, ICs and electrolytic capacitors.

Wiring between the printed circuit board and external components is illustrated in Fig. 5. The switch used in our prototype was mounted internally (it is only used in initial setting up) by soldering it onto the screws which mount the power transistors. If this method of mounting the switch is used, the screws to which it is mounted must be insulated (by insulated mounting washers on both sides of the transistor) from the transistor case. The other two transistor mounting screws should be insulated from the box lid but not from the transistors. When drilling the lid of the box check that the distance

SPECIFICATION

SUPPLY VOLTAGE

Nominal	+ 12 Volts
Maximum	+ 16 Volts

CAPACITOR VOLTAGE

8 to 16 volt input	350 volts (nominal)

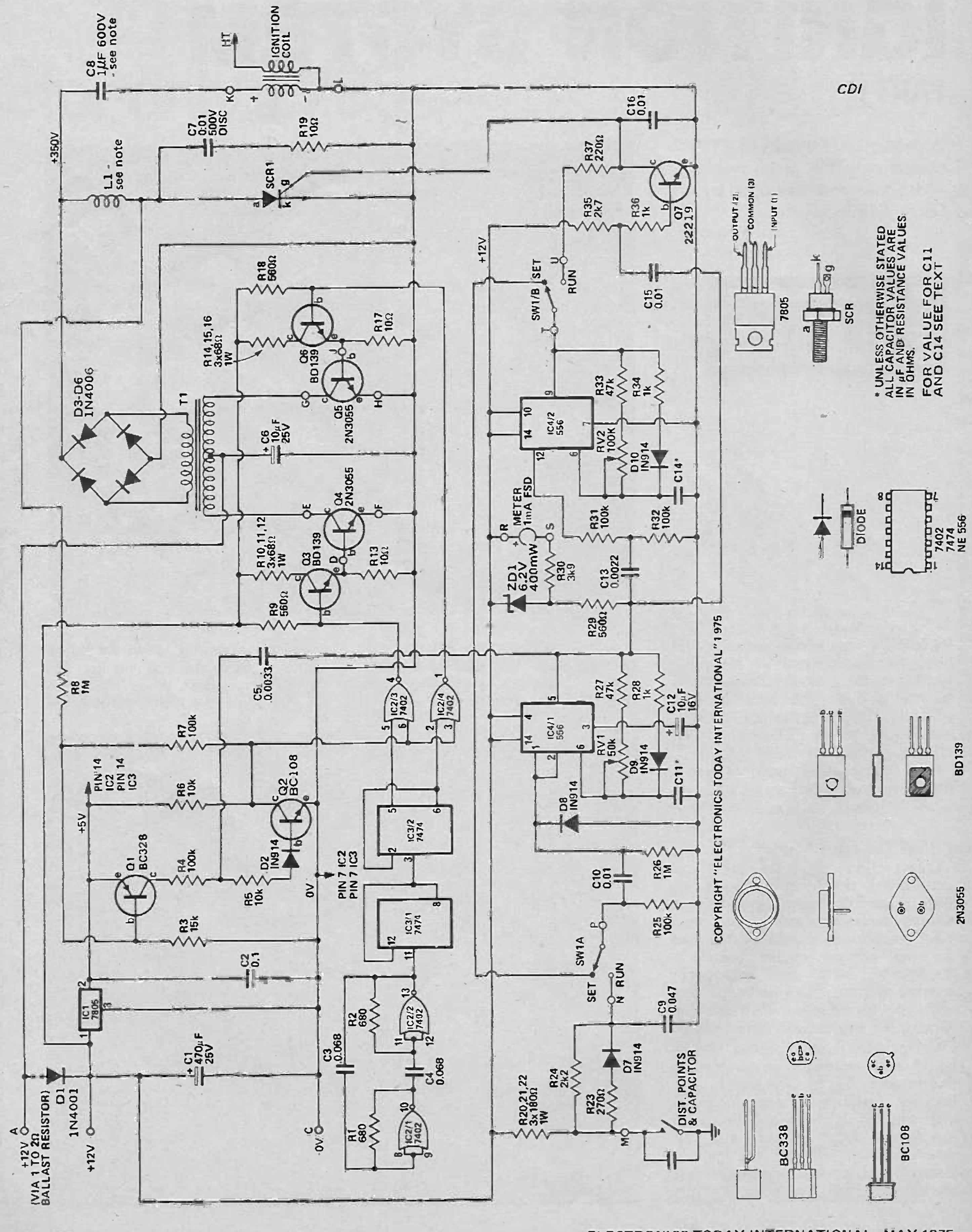
POINTS CURRENT	200 mA (non-inductive)

SUPPLY CURRENT*

RPM			CURRENT
8 cyl	6 cyl	4 cyl	
1500	2000	3000	1A
3000	4000	6000	2A
4500	6000	9000	2.8A
6000	8000	12,000	3.2A
7500	10,000		4A
9000			4.4A

* ballast resistor of one ohm

ELECTRONIC IGNITION SYSTEM



between the two mounting screws is the same as the hole spacing on the switch so that it will fit.

To facilitate easy change over, between standard and CDI ignition, an octal plug and socket is used to connect the unit, and a second socket for the standard system. Whilst our prototype may be seen to have both octal sockets mounted on the box, it is recommended that the second socket be mounted by a separate bracket on the car bulkhead, etc, so that the unit may be removed completely if desired without interfering with normal operation of the car.

CALIBRATION

This may be performed in either of the two ways:–

1. Obtain, or borrow, an accurate tachometer (one which will work with CDI systems). Connect and run the motor at a reasonably high rate and adjust RV1 to obtain the same reading as displayed on the master tacho.

2. Build either of the circuits shown in Fig. 4 and use together with a reference from the 50 Hz mains or a separate oscillator. If 50 Hz is to be used the second circuit is preferable as it gives a higher reading on the meter. To calibrate set RV1 such that the appropriate reading is obtained as detailed in the Table below.

Calibration against 50 Hz

	4 cyl	6 cyl	8 cyl
Circuit A	1500	1000	750
Circuit B	3000	2000	1500

If an oscillator is used the calibration may be performed at a point nearer the top end of the meter scale and the frequency to be used calculated as follows:–

$$\text{Input frequency} = \frac{\text{RPM} \times \text{N}^{\text{o}} \text{ of cyl}}{120}$$

(4 stroke only)

Using this method, the power to the inverter may be removed (detach the wire to pin 2 of the socket) which eliminates the need for connecting the ignition coil. Do not run the unit too long in this condition as resistors R10, 11, 12, 14, 15 and 16 run hot in this mode.

To set the rev limit, simply switch SW1 to SET (power should previously have been applied to the unit) and adjust RV2 to the desired limit as indicated on the meter.

HOW IT WORKS ETI 312

The general block diagram and principle of operation was given last month and we now treat this in greater detail.

Integrated circuits IC2/1 and IC2/2 form a multivibrator which runs at about 26 kHz. The output of the multivibrator clocks the D-type flip-flop IC3/1, the D terminal of this IC is coupled to the $\bar{Q}$ output and the result is that the output is half the frequency of the input. This frequency division is necessary to provide an absolutely symmetric square wave which cannot otherwise be guaranteed from the simple oscillator used. The output of IC3/1 is divided again by 2 by IC3/2 reducing the frequency to about 6.5 kHz. The second division is used because we have two flip-flops available in the 7474 package and this allows us to use a higher frequency oscillator and hence smaller values for capacitors C3 and 4.

The Q and $\bar{Q}$ outputs (these are the same frequency but out of phase, (i.e. when Q is high, $\bar{Q}$ is low) are fed to the gates IC2/3 and IC2/4. If the control input (pin 3 and 6) is low these gates simply pass the 6.5 kHz with just a phase inversion. If however the control is high the output of the two gates will be low irrespective of the other inputs.

The output of these gates control Q3 and Q6 which in turn control Q4 and 5. If the gate output is low all current is shunted away from the base of the appropriate transistor turning it and the transistor it controls off. If the output is high this current will turn the transistor on. With the control voltage low the transistors are switched alternatively on and off at the 6.5 kHz rate. If the control is high then all transistors will turn off.

The transistors Q4 and Q5 control the primary of the transformer whose centre tap goes to +12 volts via a ballast resistor. This resistor is either the one fitted in the wiring-loom of the car, or, if not an additional one ohm resistor will need to be fitted. This ballast resistor allows the transistor to fully saturate by limiting the peak current even when driving into the effective short circuit of the discharged capacitor (C8).

The output of the transformer is rectified by D3-D6 and C8 is charged up via the primary of the ignition coil. This current is small (less than 150 mA) and has no effect on operation of the coil. If allowed, this capacitor would charge to about 450 V using a 12 volt input, however, the output voltage is measured and the inverter is stopped when 350 V is reached. Transistors Q1 and Q2 form a schmitt-trigger circuit where Q2 goes high if the voltage on C8 goes above 350 volts and reverts to a low state if the voltage falls below 325 volts. The reference for this circuit is the 5 volts supplied by the 7805 regulator which also supplies the TTL circuitry. This effectively maintains constant voltage on the capacitor over inputs from 8 to 16 volts.

The SCR1 is what actually controls the output to the ignition coil since if it is triggered on it effectively discharges the energy in C8 into the ignition coil primary. The transformer action of the coil gives the required high voltage for the spark plugs. The inductor L1, along with R19 and C7 protect the SCR from voltage transients which could damage it.

When the distributor points open the voltage at point M rises rapidly to +12 volts, whereas, the voltage at point N rises over a period of about 50 μs. When the points close the voltage at point N requires about 0.5 mS to revert to zero. This helps prevent point bounce. With SW1 in the run mode the rising voltage of the points opening is coupled, via C10, to the input of IC4/1. The output of this IC is normally high (+12 V) and if this voltage at pin 2 goes above two thirds of the supply volts the output will be triggered low. It will remain low until the voltage at pin 6 falls below 1/3 supply voltage when the output will revert to high. When the output goes low C11 will be discharged via RV1 and R27. The IC itself draws virtually no current, therefore, the time to reach 1/3Vs is dependent entirely on the value of C11 and the associated resistors. When the output goes high capacitor C11 is charged rapidly by R28 and D9 ready for the next cycle.

The tacho movement is driven by this IC and, every time the monostable is triggered, a 2 mA pulse is passed through the meter. Since the mono is triggered every time the points are opened the current in the meter will be proportional to the engine speed. When running (if possible) at the maximum tacho reading, the mono on time will be equal to the off time corresponding to 1 mA through the meter.

When the output of IC4/1 reverts to the high state it triggers IC4/2 which is a monostable similar to the first half. The output of this also starts at +12V drops to 0V and reverts to +12V again. The output occurs at the end of the output of IC4/1. The SCR is triggered by a monostable formed by Q7. The transistor derives its power, and that used to trigger the SCR, from the output of IC4/2. The input of the transistor, which is normally held on due to R35/36, is controlled via C15 from the output of IC4/1. The sequence of operation is as follows.

When the points open there is a delay of about 50 μs before IC4/1 is triggered. When the output goes low capacitor C15 couples this fall to Q7 turning it off. If the output of IC4/2 is high the SCR will be triggered activating the coil. If however the points have opened before the expiry of the sum of the delays of IC4/1 and IC4/2 there will be no current available to trigger the SCR, since the output of IC4/2 will be 0 V, and no ignition will result until the engine speed drops. Normally however this would only mean one or two cylinders not firing as the motor will slow down rapidly without ignition.

To calibrate the unit we first adjust RV1 so that the tacho reads the same as some known standard (your local garage will have a tacho) then with the motor stopped, but ignition on, switch SW1 to SET. This will cause the tacho to indicate the preset rev limit. Adjusting RV2 will give the desired limit. The indicated reading may be about 100 RPM lower than the actual limit set but for normal use this should be sufficiently accurate.

Also from IC4/1, we have a capacitor going into the schmitt trigger. Transistor Q2 forms a monostable with this capacitor, which switches off the invertor, or at least holds it off, while the SCR is on and therefore prevents the invertor running into a short circuit. This effectively reduces the power drawn from the battery.

ELECTRONIC IGNITION SYSTEM

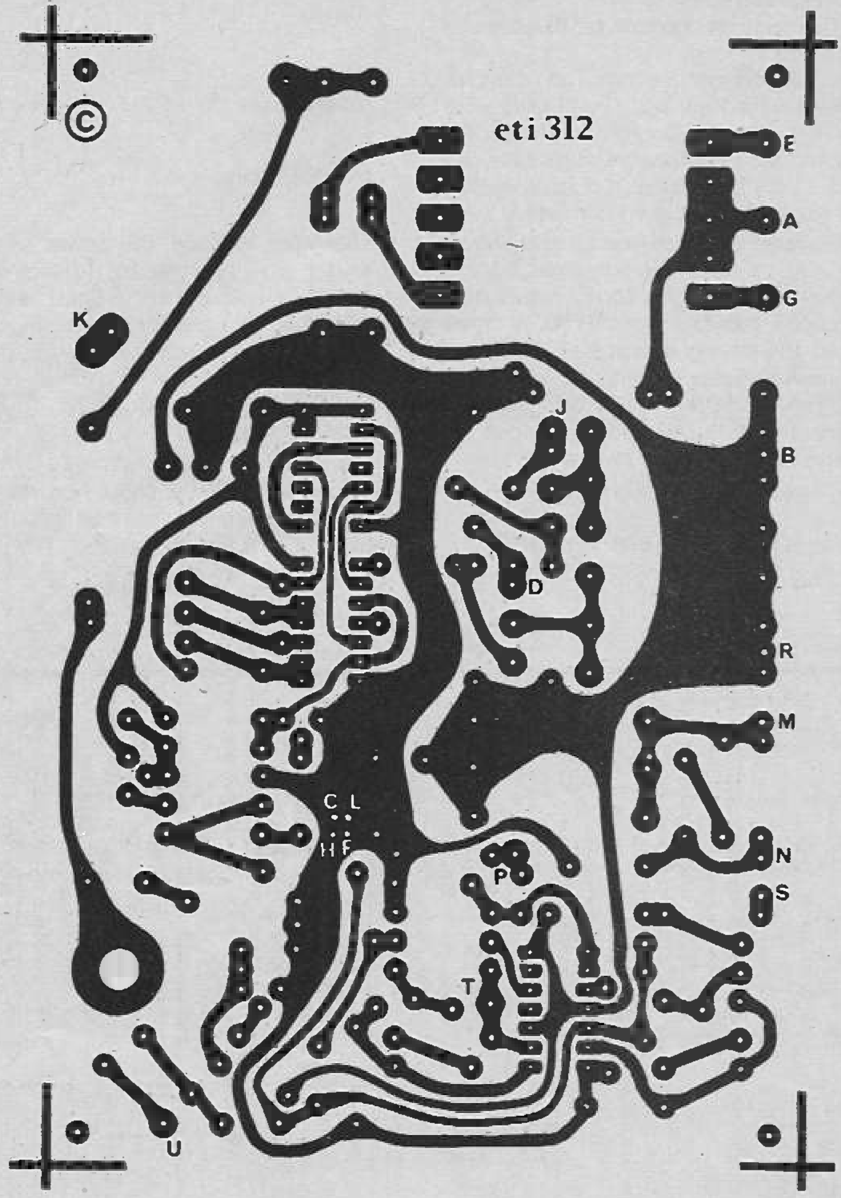


Fig. 2. Printed circuit board layout. Full size 149 x 100 mm.

INSTALLATION

A standard ignition system, illustrated in Fig. 6, usually has a ballast resistor which is either a separate wire-wound resistor, or is built into the wiring loom in the form of a resistive lead. In either case the power for the inverter must be tapped off the *battery* side of this resistor so that a solid +12 volts is obtained. If the resistor is in the wiring loom it may be easier to use another circuit (eg, reversing lights) which is only on when the ignition switch is on.

The connection socket should be wired into the standard circuit as shown in Fig. 7. If the car does not have a ballast resistor, then the power

PARTS LIST ETI

R13,17,19 Resistor	10	½W	5%
R10,11,12 "	68	1W	5%
R14,15,16 "	68	1W	5%
R20,21,22 "	180	1W	5%
R37 "	220	½W	5%
R23 "	270	½W	5%
R9,18,29 "	560	½W	5%
R1,2 "	680	½W	5%
R28,34,36 "	1k	½W	5%
R24 "	2k2	½W	5%
R35 "	2k7	½W	5%
R30 "	3k9	½W	5%
R5,6 "	10k	½W	5%
R3 "	15k	½W	5%
R27,33 "	47k	½W	5%
R4,7,25 "	100k	½W	5%
R31,32 "	100k	½W	5%
R8,26 "	1M	½W	5%

RV1 Potentiometer 50k preset
RV2 " 100k preset

C13 Capacitor 0.0022 μF polyester
C5 " 0.0033 μF polyester
C10,15,16 Capacitor 0.01 μF polyester
C7 Capacitor 0.01 μF 500V disc ceramic
C9 " 0.047 μF Polyester
C3,4 " 0.068 μF Polyester
C2 " 0.1 μF Polyester
C6 " 10 μF 25V electrolytic
C12 " 10 μF 16V pc mounting electrolytic
C1 Capacitor 470 μF 25V pc mounting electrolytic
C8,11,14 See Text.

Q1 Transistor BC328 BC178 etc.
Q2 " BC108 etc.
Q3,6 " BD139, BD135 etc.
Q4,5 " 2N3055
Q7 " 2N2219, BC328 etc.

IC1 Integrated circuit 7805C
IC2 Integrated circuit 7402
IC3 Integrated circuit 7474
IC4 Integrated circuit NE556

D1 Diode 1N4001
D2,7,9,10 Diode 1N914 etc.
D3,4,5,6 Diode 1N4006
D8 Diode 1N914
ZD1 Zener Diode 6.2V, 400mW
SCR1 Thyristor 15A, 400V (C0326, 2N5574 etc)
T1 Transformer — see text
L1 Inductor — see text
PC Board ETI 312
DPDT Slide or toggle switch
Diecast Box, about 7"x5"x2"

2 Octal sockets
1 Octal plug and cover
4 spacers 12mm long plain
8 screws 20mm long screws & nuts
2 insulation kits for 2N3055s
Wire etc.
If the car does not have an internal ballast resistor a 1Ω 20 watt.
M1 1 mA FSD meter scaled to RPM

GETTING HOLD OF THE COMPONENTS

Semiconductors

The transistors are not unusual types and are all listed by more than one mail-order supplier and should present no problem.

The '74' series IC's are of course readily available, and the 556 is listed by a number of companies including Trampus and Marshalls. Both of these companies and Technomatic stock the 7805 regular IC.

The SCR must have a minimum voltage rating of 400V and a current handling capacity of 15A. This is deliberately rated very generously as a failure is more serious in this type of equipment than in some others. A number of companies list SCR's by spec, others use manufacturers codings, however 400V/15A types or better are widely listed.

Diecast boxes are available from Doram (172x121x55mm) and Home Radio (184x114x 51mm).

The printed circuit board is available for £1.30 (inc. VAT and postage) from Ramar, 29 Shelbourne Road, Stratford-on-Avon, Warwickshire.

C8 must be a high quality component. If a 1μF is not available two 0.47μF may be used in parallel. Marshalls and Doram however list 1μF capacitors with working voltages over 600V.

Many readers may not wish to wind their own transformers. Two companies market inverter transformers which have very similar electrical, though not physical, characteristics. Henry's Radio reference is IT3AT and Bi-Pre-Pak of Westcliff-on-Sea will supply the inverter transformer used in the previous ETI ignition System for £2.36 inc. VAT and postage.

is taken to pin 1, and a one ohm, 20 W resistor connected between pins 1 and 2. In addition the standard ignition socket should use pins 1 and 3 rather than 2 and 3.

Mount the unit in the coolest possible place whilst at the same time not making the leads too long. The changeover socket should be mounted on the car in close proximity to the unit.

USE OF REV LIMIT

The rev-limiter is designed to prevent engine revving beyond its safe operating speed. IT IS NOT INTENDED TO ACT AS A SPEED LIMITER. Nor should it be regarded as an infallible watchdog. It is intended solely to limit engine speed if the safe limit is exceeded inadvertently.

Clearly some people *will* use the device as a 'continuous limiter' — racing and rally drivers, motor boat race drivers for instance. In such applications no engine damage should occur, but the silencer (if fitted) may be damaged as *some* fuel will be burnt in the tail pipe.

The device should never be used in this manner on the road. It wastes fuel and it is potentially dangerous as there is no reserve power available to cope with possible emergencies.

TABLE I

TACHO Value of C11

Full scale	8 cyl	6 cyl	4 cyl
5000	0.027 μF	0.039 μF	0.056 μF
6000	0.022 μF	0.033 μF	0.047 μF
7000	0.022 μF	0.027 μF	0.039 μF
8000	0.015 μF	0.022 μF	0.033 μF
10 000	0.012 μF	0.018 μF	0.027 μF

REV LIMIT Value of C14

~	8 cyl	6 cyl	4 cyl
4000	0.039 μF	0.047 μF	0.082 μF
5000	0.027 μF	0.033 μF	0.047 μF
6000	0.022 μF	0.033 μF	0.039 μF
7000	0.022 μF	0.027 μF	0.033 μF
8000	0.015 μF	0.022 μF	0.033 μF

TABLE 2
Transformer Winding Details

WINDING	TURNS	WIRE SIZE	NOTES
Secondary	600	0.315mm (30swg)	layer wind and use 0.05 mm insulation every 150 turns
	interwinding insulation 0.25mm		
Primary 1 Primary 2	15 15	1mm (20swg) 1mm (20swg)	Bifilar wound (i.e. wind both primaries together as a pair)

CORE: E42 Siferrit E cores, B66241-A0000-RO26 or B66244-A0000-RO26, two required.
FORMER: Siemens B66242-A0000-M001, one required.
ASSEMBLY: Insert cores into bobbin after winding. Tape them together and then glue (epoxy) the cores onto the bobbin to hold them into position.

The E cores and former are being stocked by Electrovalue and will be available shortly. Readers not wishing to wait can use the ex-stock 47mmx28mm pot core (Ref B65631) with a single section bobbin (Ref B65632-A0000-M001). The same wire gauge should be used but the primary windings are 10 turns each, the secondary 400 turns. The price of these items is £1.76 inclusive of small order surcharge and VAT (8%). Available from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey.
CHOKE DETAILS: Approx. 30 turns of 0.315mm (30swg) single layer wound onto a 1W resistor with a value over 1kΩ (a resistor is only used as an inexpensive former).

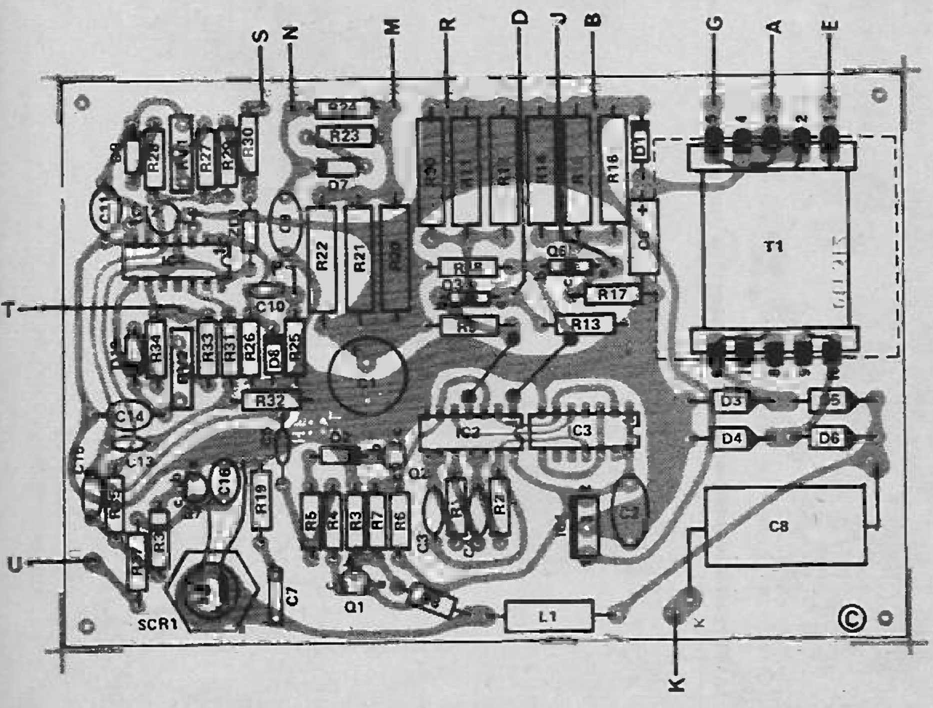


Fig. 3. Component overlay.

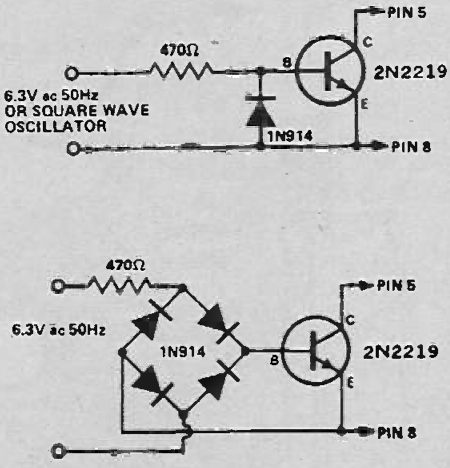
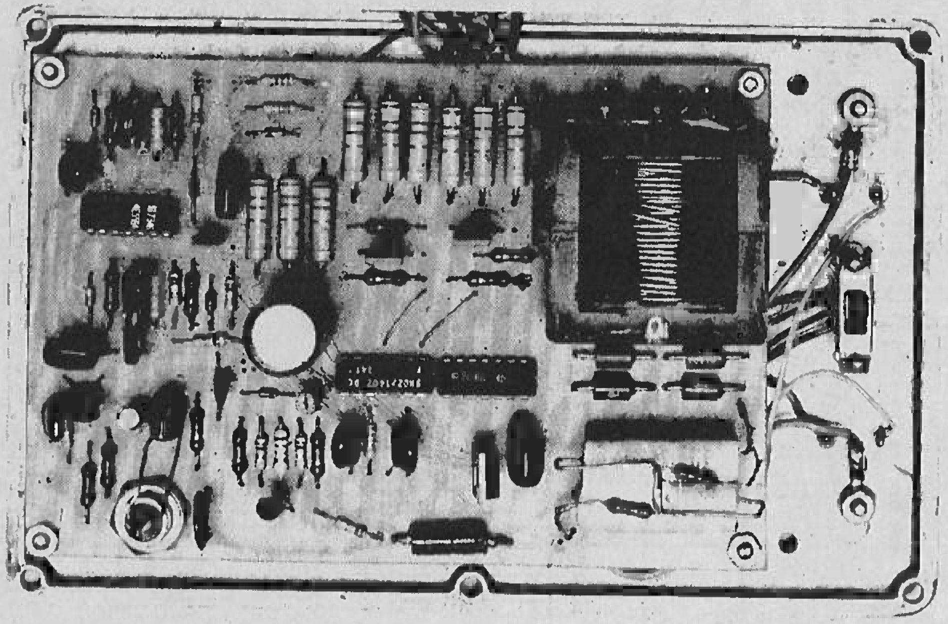
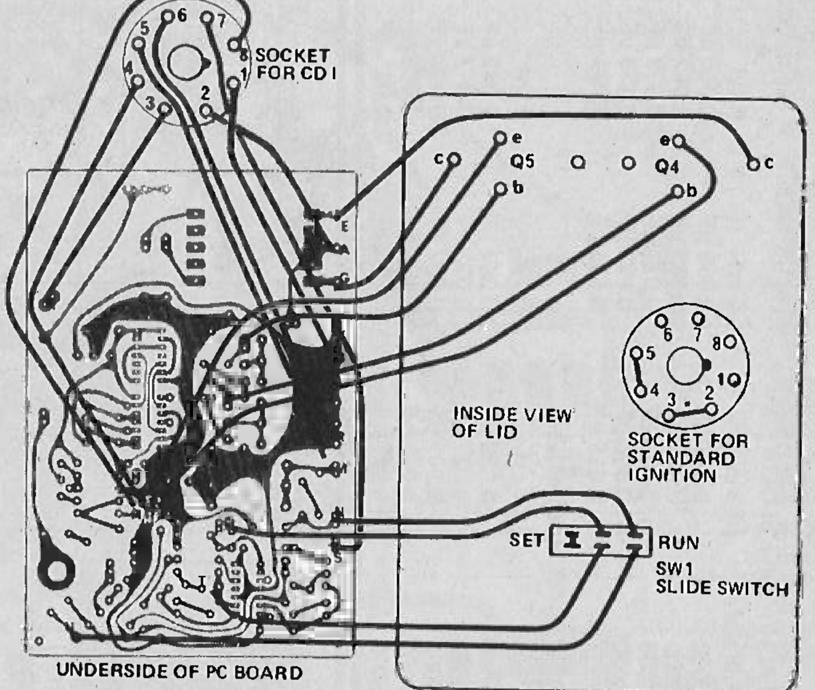


Fig. 4. Two circuits which may be used to calibrate the unit if a reference tacho is not available. The second circuit should be used if a mains transformer is used to supply the 6.3 volts. (See text).





* NOTE IF STANDARD SYSTEM DOES NOT USE A BALLAST RESISTOR LINK PIN 1 AND 3 NOT PIN 2 AND 3.

Fig. 5. Wiring diagram – printed circuit board to front panel components.

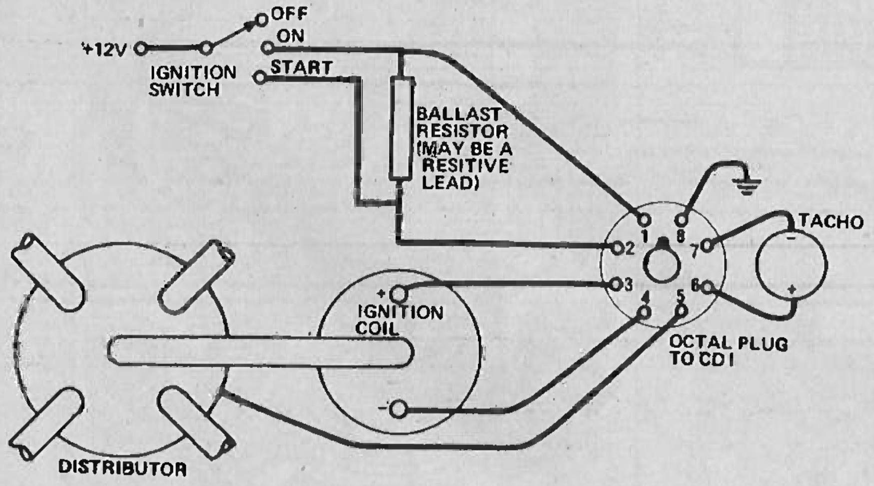


Fig. 7. Method of connecting octal plug into existing ignition system.

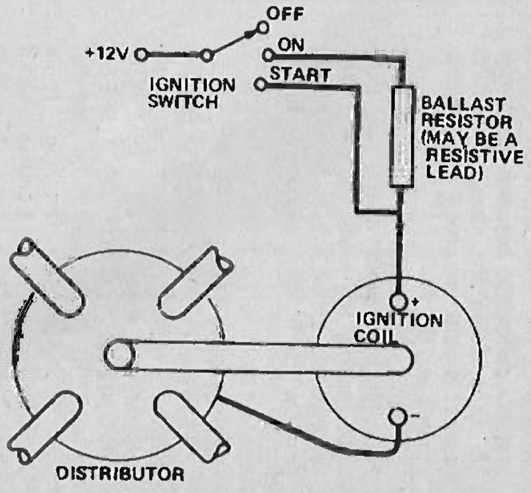
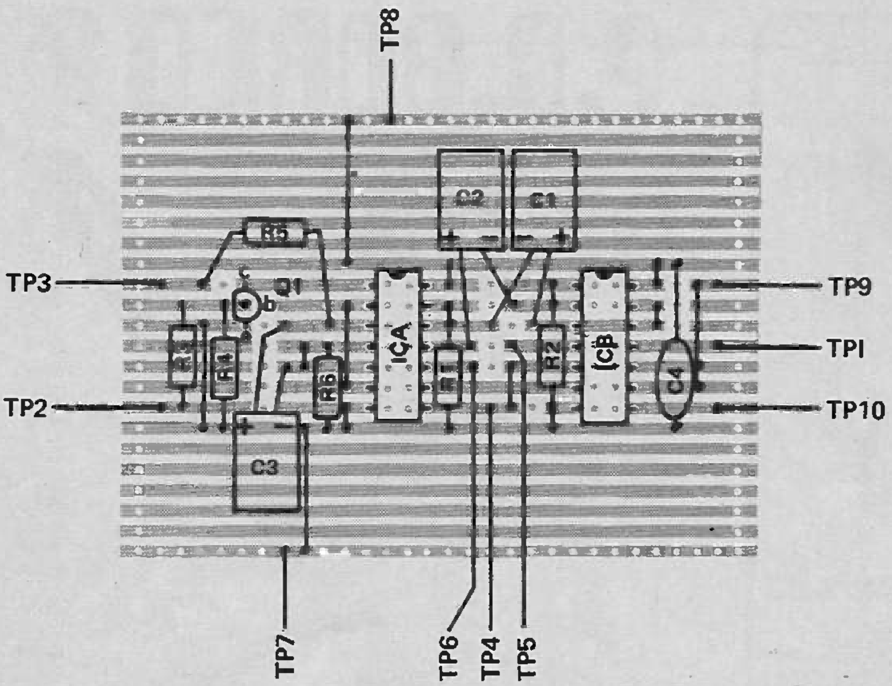


Fig. 6. Standard ignition system.



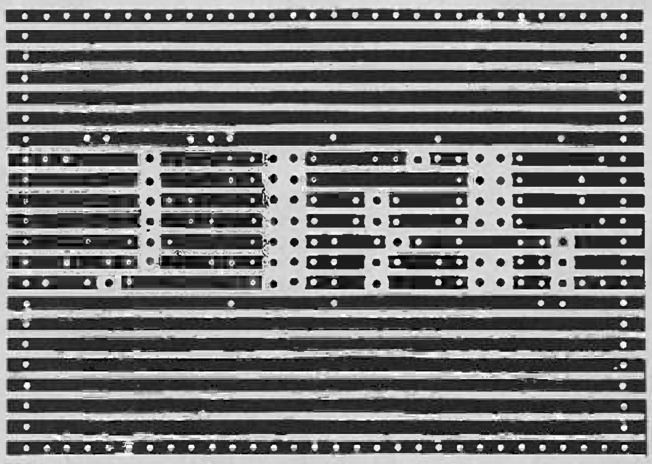
The Australian edition of ETI recently ran a design competition. The prize was to go to the best circuit designed using a limited number of components. This TTL tester/logic trainer/breadboard unit/digital troubleshooter won the first prize. The LED readout is an optional extra because only without this did the circuit qualify for the competition.

TTL super test

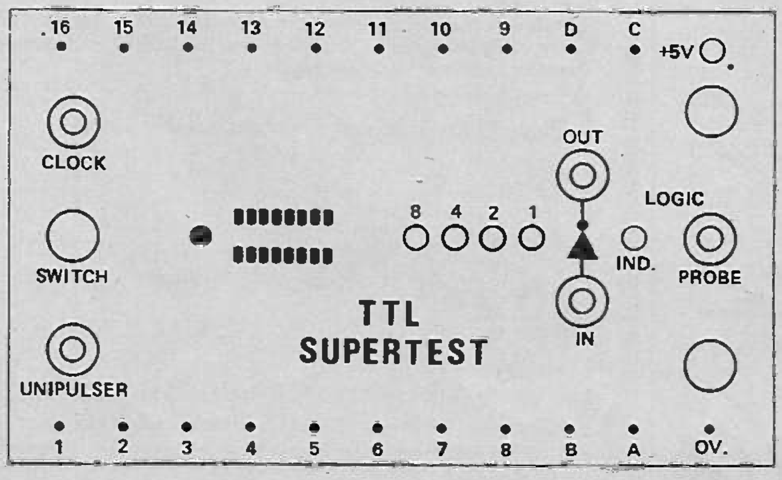
ORIGINALLY conceived as a tester for checking out disposals dual-in-line T.T.L. integrated circuits, this device has also proven effective in the roles of logic trainer, breadboarding unit and digital trouble-shooter.

Two SN7400 quad NAND integrated circuits, together with an NPN bipolar transistor, have been adapted to perform the functions of multivibrator clock-generator, unipulser and pulse lengthener/detector, each function being located on a sub-board and brought out to banana sockets on the front panel.

Continued on page 32.



Veroboard pattern for sub-board. Dimensions are 3.75" x 3.12" x 0.1" pitch. Board is shown here as seen looking down onto copper side. Cut gaps in copper tracks with correct tool or a sharp drill. Ensure that track is completely broken.



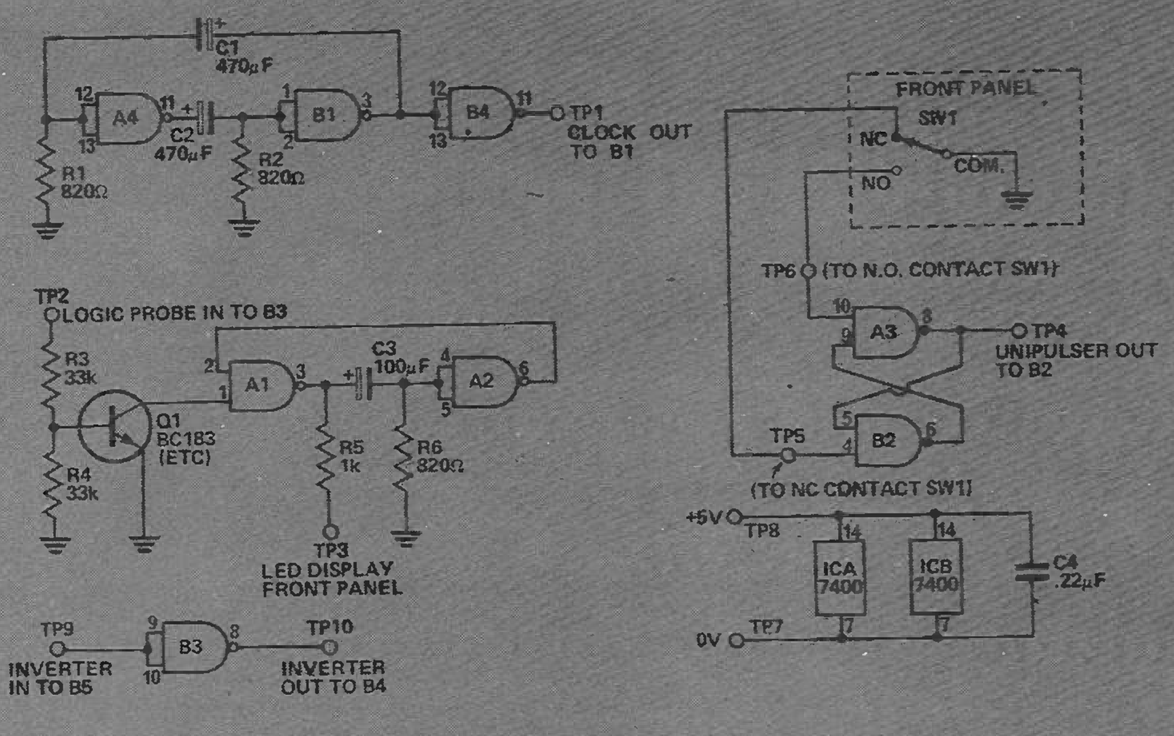
Front panel layout of unit (with optional BCD readout). Use printed circuit board as guide for marking out hole centres etc.

BCD OPTION

A useful addition to the Supertest project is a BCD readout facility consisting of four LEDs brought out through current limiting resistors to binding posts on the front panel.

The LED's, positioned in line and close together for easy interpolation, are fitted in the positions indicated on the layout diagram, using the islands provided on the front panel for mounting the associated resistors and binding posts. The posts should be clearly labelled ABCD and the LED's defined by their binary weightings of 1, 2, 4, 8.

For those enthusiasts who find continuous operation of the clocking multivibrator objectionable, the clock may be inhibited by isolating pin 1 of gate B1 and connecting this point via a toggle switch to ground. When the ground is removed the clock will operate normally. This switch can be located conveniently inboard of the unipulser switch. With the clock inhibited the clock output at TP1 will be a 'low'.



Circuit diagram of complete unit.

HOW IT WORKS

MULTIVIBRATOR CLOCK

The clock consists of a multivibrator formed by gates A4 and B1 and associated RC networks. The period of oscillation is about 0.8 seconds and the output is buffered by gate B4 to reduce loading effects.

The clock rate may be varied, if required, by altering the value of both capacitors. It is inadvisable to increase the value of the resistors beyond 2k as this may result in unstable operation.

UNIPULSER

The purpose of the unipulser is to provide a single, bounce-free pulse, at each depression of SW1, for use in testing counters etc.

The two gates A3 and B2 are interconnected to form a switched bistable (RS flip-flop). Normally pin 4 of B2 is grounded via SW1 and the resulting high at pin 6 is coupled directly to pin 9 of A3. As pin 3 of A3 is not connected, A3 sees both inputs as 'high' and its output will be 'low'.

When S1 is depressed pin 10 is earthed and pin 4 goes high. A3 output goes 'high' and this appears at pin 5 of B2. As both inputs of B2 are now high its output will transfer a 'low' to pin 9 of A3 causing its output to be locked into the high state regardless of any further bouncing of the switch contacts which would otherwise provide spurious input pulses to the counter under test.

Releasing SW1 causes the flip-flop to revert to the state where A3 output is low.

PULSE EXTENDER

This simple circuit stretches very short pulses to about 100 milliseconds duration thus allowing them to be detected easily.

The two NAND gates A1 and A2, together with C3 and R6, form a monostable. Initially both inputs of A2 are held 'low' due to R6, its output is therefore 'high'. All inputs of A1 are thus 'high' and its output is 'low'.

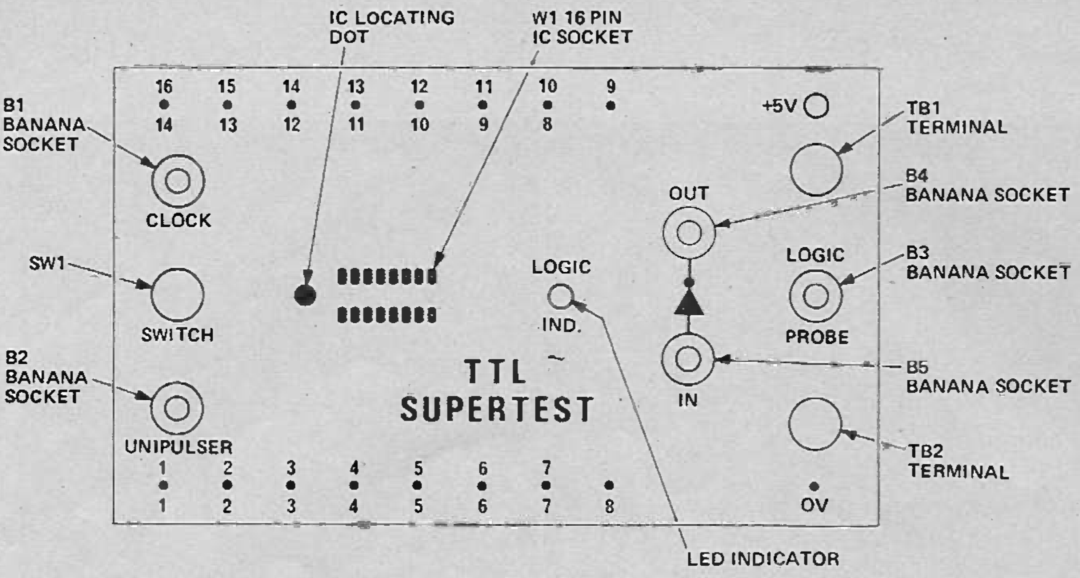
If the input of A1 is driven 'low', by a short duration pulse, the output of A1 will go 'high' transferring a high via C3 to the input gates of A2. Output of A2, and A1 input, will go 'low' holding A1 output 'high'. Hence the LED indicator will be alight.

Capacitor C3 now discharges via R6 and after approximately 100 milliseconds the input to A2 will revert to 'low' and hence A2 output and A1 input will go 'high'. If both inputs of A1 are now 'high' (pulse not present) A1 output will go 'low' and the LED will extinguish. However if a pulse is present A1 output will remain 'high' and the LED lit.

As a 'low' is required to gate A1, an inverter is required for logical '1' detection. This is performed by Q1. Q1 also acts as a current amplifier allowing the logic probe to be of reasonably high impedance. Resistor R3 provides a light load, for the disconnected outputs of operating ICs, thus allowing logic levels to be observed. Resistors R3 and R4 also form a potential divider such that Q1 does not draw excessive current at normal logical '0' levels.

INVERTER

The spare NAND gate, B3, is wired as an inverter. This allows inversion of the clock or unipulser outputs or 'low' logic detection using the logic probe.



Front panel layout of basic unit — the associated printed circuit board is shown page 5. Scale approx 70% — use pc board as guide for marking out hole centres etc.

Three hook probes with banana plug terminations are provided. The use of banana sockets for probe entry frees the probes for use in conjunction with other equipment.

Logical 'I' and 'O' detection is available. Logic indication is by a red LED — alight for TRUE.

A 16 pin dual-in-line socket with base connections fanned to well spaced binding posts (Fig. 3B) is used for the testing of both 14 and 16 pin D.I.L. integrated circuits and also for breadboarding and training purposes.

The front panel is clearly labelled with carefully applied Letraset — lacquered to increase durability — and housed on a small black plastic utility box to give the completed unit a professional appearance.

Thirteen short leads — approximately 230 mm long — twelve terminated with small insulated alligator clips and one with banana plugs, complete the test kit.

The unit is intended to operate from an external power source of 5 V and this is normally provided by the digital equipment under test. But for casual purposes a 6 V lantern battery, connected via two forward biased silicon diodes, is a satisfactory and economical power source. Current drain is about 30 mA.

CONSTRUCTION

Prepare the sub-board from Veroboard by cutting the tracks as shown on page 53 and then commence wiring by fitting the resistors and links. Sleeve any long links with 'spaghetti'. Next mount the ICs taking particular care to orientate the notch (or dot) as shown in the overlay.

Mount the capacitors and Vero-pin terminal posts taking care to insulate the capacitor leads with spaghetti. As C1 and C2 are physically large, they should be laid on their sides and bound to the board with a length of spaghetti-sleeved wire.

After checking the board for errors, poor solder joints etc, it may be tested by temporarily wiring the LED between TP3 and TP7 — the lead closest to the flat on the LED being connected to the grounded terminal, TP7. The unit is then powered by applying +5 volts to TP8 (zero volts to TP7). The LED should flash briefly on application of power and then extinguish.

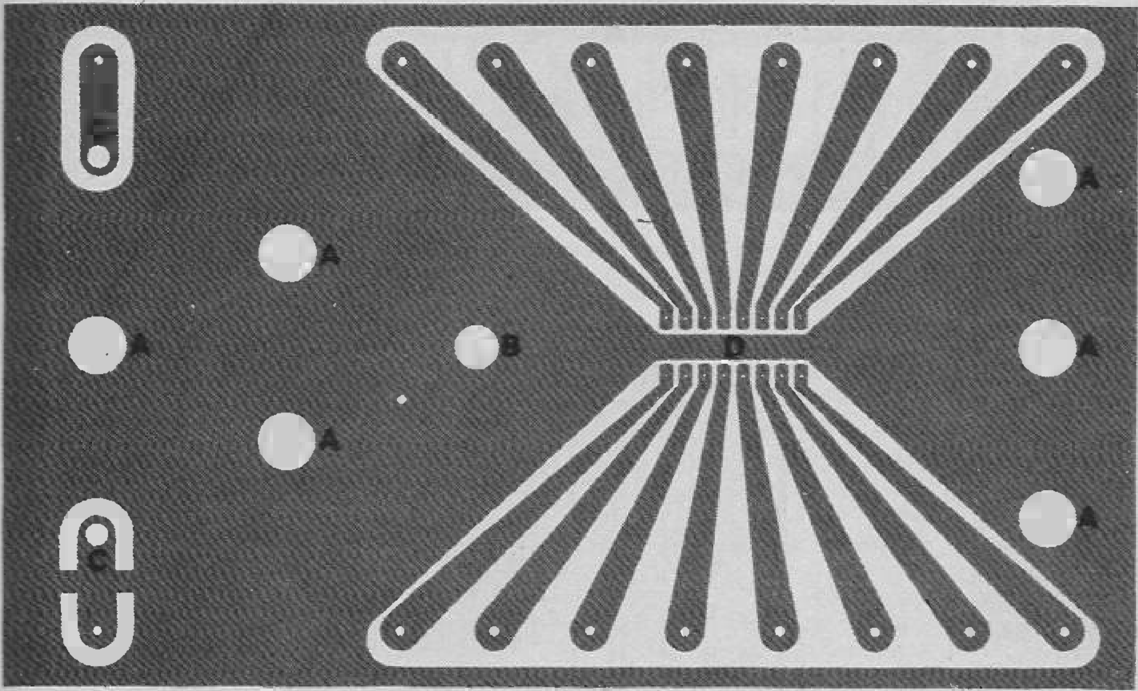
Connect TP2 to TP8 — the LED should light and then extinguish when the connection is broken. Observe that there is a pulse stretching action by flicking TP2 against TP8.

Connect TP2 to TP1. The LED should flash regularly at approximately 1 Hz. Now connect TP5 to TP7 and TP2 to TP4 in that order — the LED will be extinguished. Disconnect TP5 and connect TP6 to TP7 — the LED will light. Note that repeated disconnections of TP6 will have no effect on LED indication.

Disconnect TP6 and reconnect TP5

PARTS LIST

ICA, ICB Integrated circuit SN7400
Q1, BC108 or similar
C1, C2 Capacitor electrolytic 470μF 16V
C3 Capacitor electrolytic RB 100μF 16V
C4 Capacitor 0.22μF 100V tantalum
R1, R2, R6 resistor 820 ohm ¼W 10%
R5 resistor 1k ¼W 10%
R3, R4 resistor 33k ¼W 10%
TB1, TB2 terminals
W1 DIL IC socket 16 pin
Veroboard .1" matrix, 3¾" x 3 1/8"
PCB, 6" x 3"
Veropins (.1"), 30
SW1 switch DPDT pushbutton, momentary action
LED TIL209
Probes (3 off), self gripping *(Doram)*
Banana sockets
Banana plugs
Crocodile clips, miniature, plastic covered, (24 off)
Solder, hook-up wire, sleeving, epoxy and insulating posts.
Box, 190 x 90 x 50mm, or similar.



Printed circuit layout for basic unit. (shown full-size)

DRILL 'A' HOLES 8.0 mm DIA DRILL 'B' HOLES 6.4 mm DIA DRILL 'C' HOLES 3.2 mm DIA DRILL 'D' HOLES FOR IC SOCKET ALL UNMARKED HOLES DRILL PRESSFIT FOR BINDING POSTS

to TP7 – the LED will extinguish. Note that repeated interuptions of TP5 connection will have no effect on LED indication.

Connect TP9 to TP7 and TP2 to TP10 – the LED will be lit. Disconnect TP9 from TP7 – the LED will go out. Now connect TP9 to TP8 – the LED should still be out.

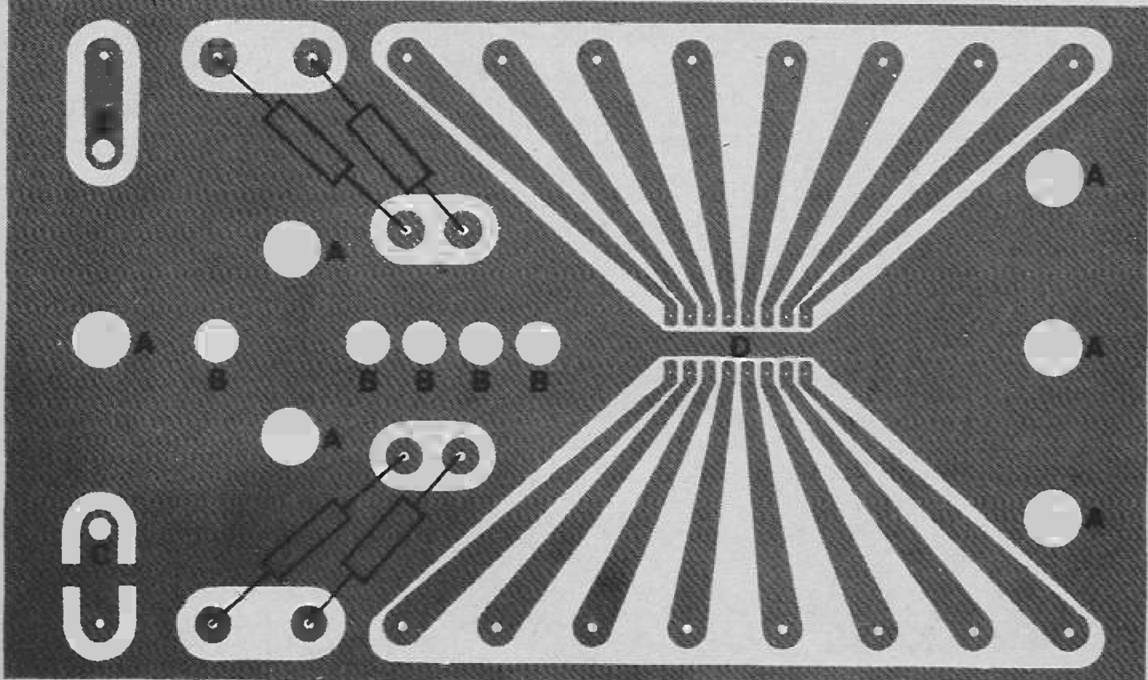
That completes testing of the sub-board. The banana sockets, IC socket, power terminals and unipulser switch should now be fitted to the front panel. Note that the common lead on SW1 is earthed to the panel ground-plane adjacent to the switch body.

Mount the LED using the plastic mounting clip provided, and solder the lead near the flat side of the LED to the ground plane. Take care, when bending the leads from the LED, to hold the wire near the base of LED with long nose pliers. Unless the strain is relieved as above, the leads are prone to break off at the base.

Mount four, half-inch insulated posts to the sub-board with screws and then, using 5 minute epoxy, cement the other end of the pillars to the front panel. When the glue is set unscrew the sub-board so that final wiring may be performed as follows.

Connect TP1 to B1; TP2 to B3; TP3 to LED; TP4 to B2; TP5 to NC SW1; TP6 to NO SW1; TP7 to GND; TP8 to +5 V; TP9 to B5; TP10 to B4.

When all these connections have been made, the sub-board may be reinstalled on the front panel and the whole assembly mounted in the utility box. ●



DRILL 'A' HOLES 8.0 mm DIA DRILL 'B' HOLES 6.4 mm DIA DRILL 'C' HOLES 3.2 mm DIA DRIL 'D' HOLES FOR IC SOCKET ALL UNMARKED HOLES DRILL PRESSFIT FOR BINDING POST POSTS

Printed circuit layout for modified (BCD) unit (shown full-size). Note resistors. These should be about 470 ohms (330 – 1k will do) and connect the LED's to the appropriate binding eti product test

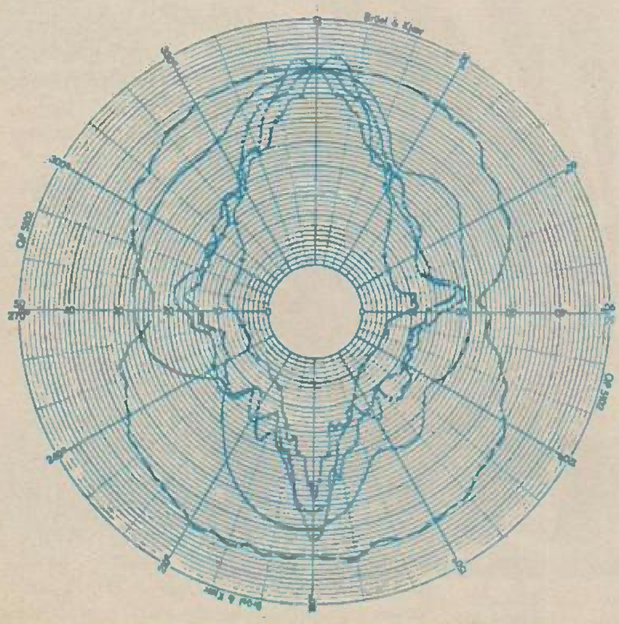
QUAD ELECTROSTATIC LOUDSPEAKERS

At the time of their introduction, the Quad speakers were undoubtedly the finest monitor loud speakers produced anywhere in the world. Their major attribute was colouration one or two orders less than virtually any other competing speakers. Added to this they had a transient response which was at that time described as superb.

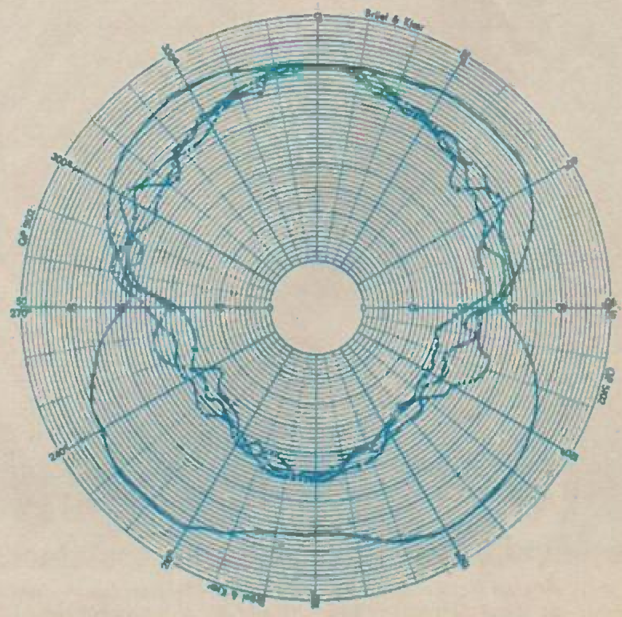
The aim of our investigation was to determine just how well this twenty-year-old system compares with the legion of new breeds of systems and speakers which have been developed since.

Our first series of tests were to place the Quad electrostatic speakers in an anechoic environment above a reflecting plane to plot out the polar patterns of each speaker at frequencies of 125 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz and 16 kHz, in both the horizontal and vertical planes.

The manufacturer's literature includes polar curves, which we presume show the horizontal plane as no commentary or description is provided. We could not reproduce the front to back discrimination that their curves showed at the high frequency end of the spectrum, but did achieve bandwidths between the 3 dB points that were comparable and if anything, superior.

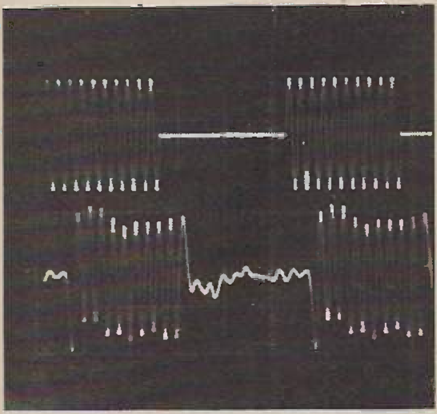


Vertical pattern at two metres (input, one-third octave filtered pink noise). [125 Hz – – – –], [1 kHz ——], [4 kHz – . – , – . –], [8 kHz – . . – . . – . . –], [16 kHz – o – o – o].



Horizontal pattern at two metres (input, one-third octave filtered pink noise). [1 kHz ———], [4 kHz – . – . – .], [8 kHz – . – . – .], [16 kHz – o – o – o].

It is twenty years since the quad ESL Speakers were introduced at the Waldorf Hotel in London. In those days everyone agreed they were ahead of their time. But after 20 years of development in the audio field we are just beginning to appreciate *how far* ahead these speakers were.



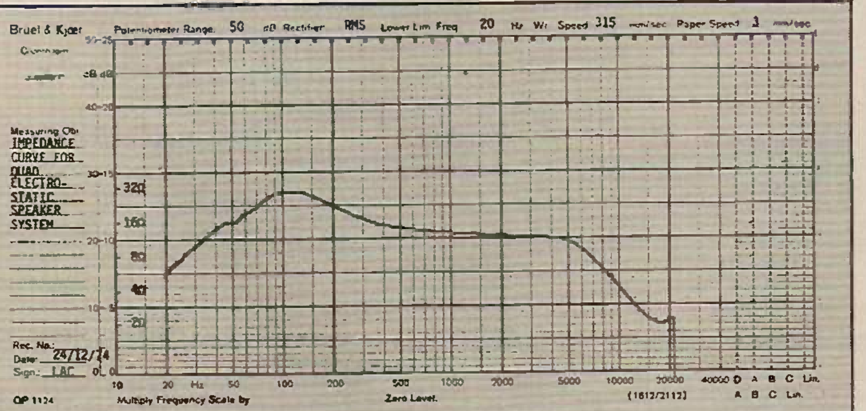
Tone burst 8 kHz – 94 dB peak sound pressure level.

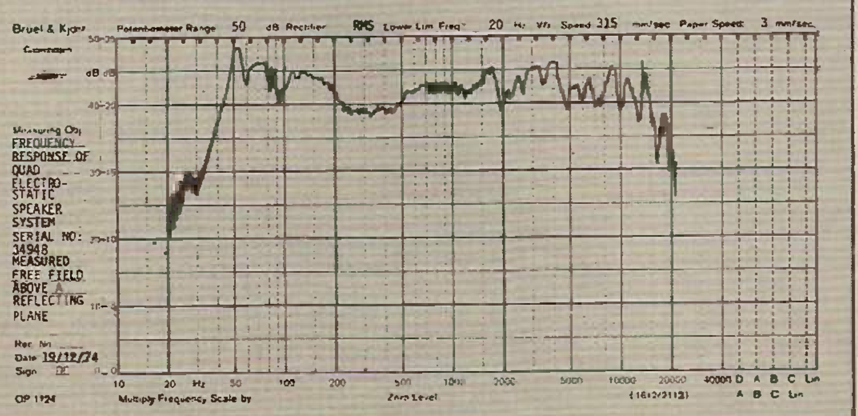
THE QUAD ELECTROSTATIC LOUDSPEAKER SYSTEM

Frequency Response:	±1.5dB 50Hz—18kHz	
Total Harmonic Distortion: (90dB at 2 metres on axis)	100Hz	0.5%
	1kHz	0.4%
	6.3kHz	0.4%
Electro-Acoustic Efficiency: (90dB at 2 metres on axis)	4 watts	
Measured Impedance:	100Hz	28 ohm
	1kHz	12 ohm
	6.3kHz	10 ohm
Dimensions:	Height 790mm, depth 265mm width 880mm.	
Weight:	18kg.	
Price:	£120 + VAT (each)	

Measurements in the vertical plane, however, were far more interesting. In particular they highlighted the problems of vertical dispersion which are a limitation of this system. Thus, at 16 kHz, the response is 10 dB down at ± 10° vertical angle, and is 20 dB down at ± 30° at frequencies of 4 kHz, 8 kHz and 16 kHz. This, we should point out, is still no mean effort but not really what one would expect or desire from a system which is intended for use as a monitor speaker. This limitation should not necessarily deter people from using any of these fine speakers for home listening where the narrow vertical angle is unlikely to be noticed.

The frequency response of the Quads is exceptional and most probably still among the best yet achieved. Right through to 20 kHz it is every bit as good as the manufacturers claim — if anything it is slightly better. We performed this measurement above a single reflecting plane rather than in truly anechoic conditions and found that the frequency response from 50 Hz right through to 17 kHz has a deviation of less than ± 5 dB. It would be regarded as being flat by most purists.





Our next test, which we regard as being of critical importance, was the tone burst response evaluation using the E.T.I. tone burst generator. The performance here, and the results achieved, were to say the least exemplary. The only speaker which has offered a superior performance at higher drive levels is the ESS amt-1 which can produce peak sound pressure levels in excess of 110 dB at two metres on axis. The manufacturer's literature and guarantees for the Quad electrostatic speaker specifically state that the maximum output of the Quad should be limited to 93 dB at two metres on axis, in fact Quad's 303 amplifier provided for the test was unable to produce such high levels.

Notwithstanding, within the manufacturer's rating limits, the response was as clean as we have ever encountered and certainly equal to the best that we have ever measured.

The impedance of the speaker is well controlled over the major portion of the frequency spectrum. This is most probably one of the greatest attributes of the Quad speaker for most other electrostatic speaker systems that we have measured have a response which rises at the top end of the spectrum.

Distortion characteristics are exemplary and certainly every bit as good as the best conventional systems available on the market.

Our final series of tests consisted of a subjective evaluation between the Quad and other state-of-the-art speaker systems, including ESS, Fisher and A-R. At sound pressure levels below 93 dB (at two metres on axis) the Quad still exhibits the cleanest and most uncoloured sound imagineable.

The bass response cannot really cope with modern day rock but it must be remembered that this speaker was designed in another generation, years before "rock" had even been thought of, but for the classical purist we know of no other speaker which is superior in terms of colouration. ●

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160V: 0 01μF. 0 015μF. 0 022μF. 3p. 0 047μF. 0·068μF. 3½p. 0·1μF. 4½p. 0·15μF. 5p. 0 22μF. 5½p. 0·33μF. 6½p. 0·47μF. 8½p. 0·68μF. 12p. 1μF. 14p.

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½	CF	22-1M	1	0 75	0 60	0 55	5 5x16
⅛	MF	10-2M7	2	1 54	1 32	1 1	3x7
¼	MF	10-2M2	2	1 43	1. 21	0 99	4 2x10·8
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4·7μF	63V	6½p	150μF	16V	6½p
6 8μF	63V	6½p	150μF	63V	15p
8·0μF	40V	6½p	220μF	6 4V	6½p
10μF	16V	6½p	220μF	10V	6½p
10μF	25V	6½p	220μF	16V	8p
10μF	63V	6½p	220μF	63V	21p
15μF	16V	6½p	330μF	16V	12p
15μF	63V	6½p	330μF	63V	25p
16μF	40V	6½p	470μF	6·4V	9p
22μF	25V	6½p	470μF	40V	20p
22μF	63V	6½p	680μF	16V	15p
32μF	10V	6½p	680μF	40V	25p
33μF	16V	6½p	1000μF	16V	20p
33μF	40V	6½p	1000μF	25V	25p
32μF	63V	6½p	1500μF	6·4	15p
47μF	10V	6½p	1500μF	16V	25p
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OA5	42p
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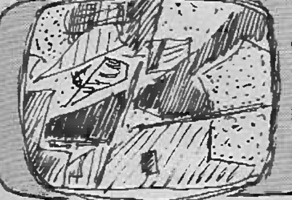

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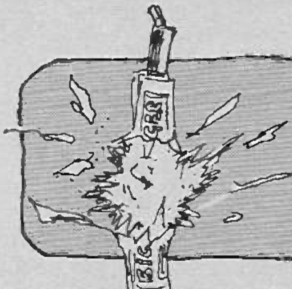

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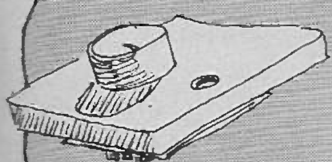

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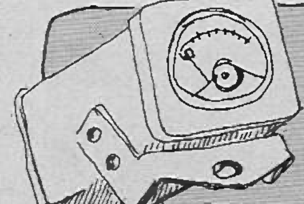

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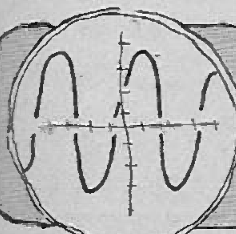

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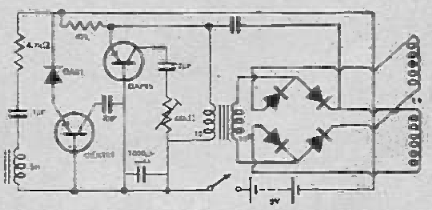
LETTERS FROM OUR READERS

"METER BEATER BEATER"



L1, 30swg, 2 x 200 turns, on 8" former (just large enough to fit over meter).

N.B. The 9V battery is used so that it can also run the policeman's transistor radio.

I designed this device to give the police a chance against readers of your February issue who built the "meter beater". I felt it was my duty (ha! ha!). The principle is that the OAP65 transistor creates a high frequency alternating field in the coil which makes the meter run ten times as fast. So a meter which normally lasts an hour will run out in 6 minutes!

— Anon.

METRIC WIREGAUGES

I note that the wire recommended for the projects in your magazine is quoted in metric units. This can cause a few problems (see April's letters page) as the swg figure is often used in the shops. I do not suggest you print the swg figure because I believe the sooner we are completely metric the better. To use the old-fashioned units would hold up progress and prolong the confusion. However, to help us over the transition could you publish a conversion table. Then I will be able to re-label the old reels in my workshop.

— P. S., Leeds.

The chart on the right shows the metric diameter of common swg values. However we will, for a while, publish the equivalent swg when we recommend wire gauge.

SWG - METRIC CONVERSION

SWG	MM
10	3.240
11	2.940
12	2.642
13	2.336
14	2.030
15	1.828
16	1.625
17	1.422
18	1.219
19	1.016
20	0.914
21	0.812
22	0.711
23	0.610
24	0.558
25	0.508
26	0.457
27	0.406
28	0.376
29	0.345
30	0.304
31	0.290
32	0.274
33	0.254
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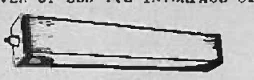

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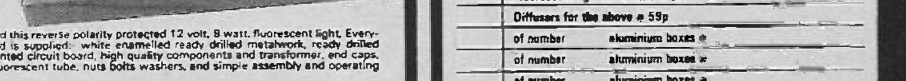

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INTERNATIONAL 3600 SYNTHESIZER

THE International Voltage Controlled Synthesizers have been developed as "state of the art" systems. Extensive use has been made of digital techniques and CMOS has been used as the primary logic family.

This article introduces the construction of the second of our two music synthesizers – the International 3600. The larger International 4600 was described in a series commencing January 1974.

The 3600 is a relatively inexpensive model that is basically designed as a portable, limited capability instrument for stage work. It does however offer a performance superior to most small synthesizers at present on the market.

The larger 4600 is a full scale unit. It uses the same electronics but has more modules, a programming patchboard and many additional features which make it more suitable for studio use.

The flexibility of both units, in particular the larger, allows individual constructors to tailor an instrument to their own requirements.

In the larger 4600 unit no compromises were made that would hinder expansion of the system. Construction could pace the ingenuity or finances of its builder. The unit had a 22 x 22 way patchboard to facilitate the rapid selection of various module configurations.

The 3600 offers the most popular features of our larger 4600 synthesizer but is simpler.

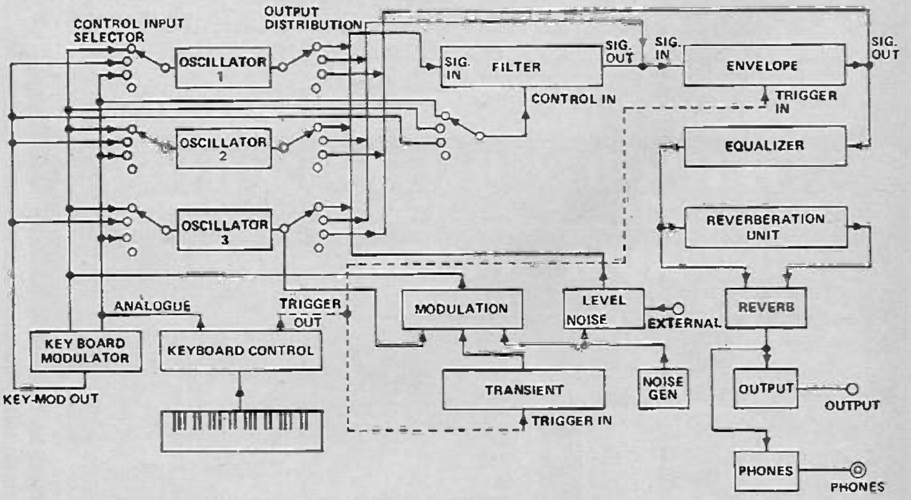
It is faster to operate as it has a switch patching system rather than the matrix patchboard of the larger unit.

The 3600 is particularly suitable for live performance and portable use, being completely enclosed in a rugged carrying case with detachable lid, the lid is large enough to house a monitor loudspeaker which can be driven by the headphone amplifier.

3600 FORMAT

Three Oscillators:

Three indentical Voltage controlled Oscillators give Sine, Triangular, Sawtooth, Inverted Sawtooth (Ramp) and Rectangular waveforms. Each oscillator is switchable over seven (precisely tuned) octaves, plus a



Block schematic of 3600 unit. Note this will be shown larger next month. (Copyright Electronics Today International ©).

Sub-sonic (very low frequency) range for control purposes. The oscillators are insensitive to temperature changes.

Four Octave Keyboard A four-octave monophonic keyboard is provided with variable 'Glide' and 'Sweep' control. Tuning to other instruments is done using the 'Tune' control located on the 'keyboard control' module.

Modulation Mixer A 'Modulation' module provides a control source by mixing the output of Oscillator 3, the Transient generator, and white noise in any combination. The output is also sent to the Keyboard module where it is mixed (technically it is multiplied) with the keyboard voltage and a 'key mod' output is obtained i.e. the modulation modules' output tracks the keyboard.

External Input An external input signal such as guitar or voice can be sent directly to the filter by a continuously variable gain control located in the 'Level' module. A white noise control in the same module sends noise directly to the filter input.

New **Low-Pass Filters** A low-pass Voltage controlled filter selects its' control from the 'Transient', 'Keyboard', 'Modulation', Module or 'Key Mod' outputs. The depth of control is continuously variable by a control next to the selector switch. A 'Tune' control determines the filters' starting point (pitch) and a 'Resonance' control provides variable resonant peak at the (voltage controlled) cut-off point. This filter is *not* the same as the original filters in the 4600 Synthesizer.

Unique Transient Generators A transient generator, intended primarily to control the filter, is triggered whenever a key is pressed on the keyboard and provides a programmed control voltage. It has two slopes, either of which can be rising or falling depending on the 'Start'. 'Hold' and 'Final' level setting.

Initiation of the transient can be delayed until some time (variable) after a key is depressed on the keyboard. The hold level can be sustained until the key is released, or it will hold only for the duration of a preset (variable) period regardless of the key being lifted prior to, or after the set period.

Envelope Generator with 'Hold delay'. The output of the filter goes directly to the Envelope Control (Loudness contour) which has three slopes and an adjustable Hold Level. A hold delay similar to that in the transient generator is also incorporated. This can be overridden for manual hold on the keyboard.

Five Section Tone Equalizer The output of the Envelope control unit goes directly into a five-section equalizer for finer refinement of tonal quality.

Reverberation A Reverberation unit forms the final path for the audio signal. A single control adjusts the amount of reverberation from zero to full.

Super-stable A special feature of the 3600 (and 4600) is that an 'exponential' control voltage is derived directly from the keyboard.

The reason for this is that the basic electronics of a voltage-controlled oscillator requires that a 'linear' voltage change at its input will provide a 'linear' pitch change at its output. However, our twelve-semitone musical scale works exponentially rather than linearly, and so a synthesizer keyboard must ultimately provide an 'exponential' voltage scale if the oscillators are to provide an exponential pitch scale.

It is relatively easy to obtain a 'linear' voltage scale from a keyboard by simply having resistors in a chain, all the same value. Voltages are tapped along the chain as a key is depressed. This 'linear' voltage scale is then converted to an exponential scale electronically, by an 'exponential converter' sometimes called an 'oscillator controller'.

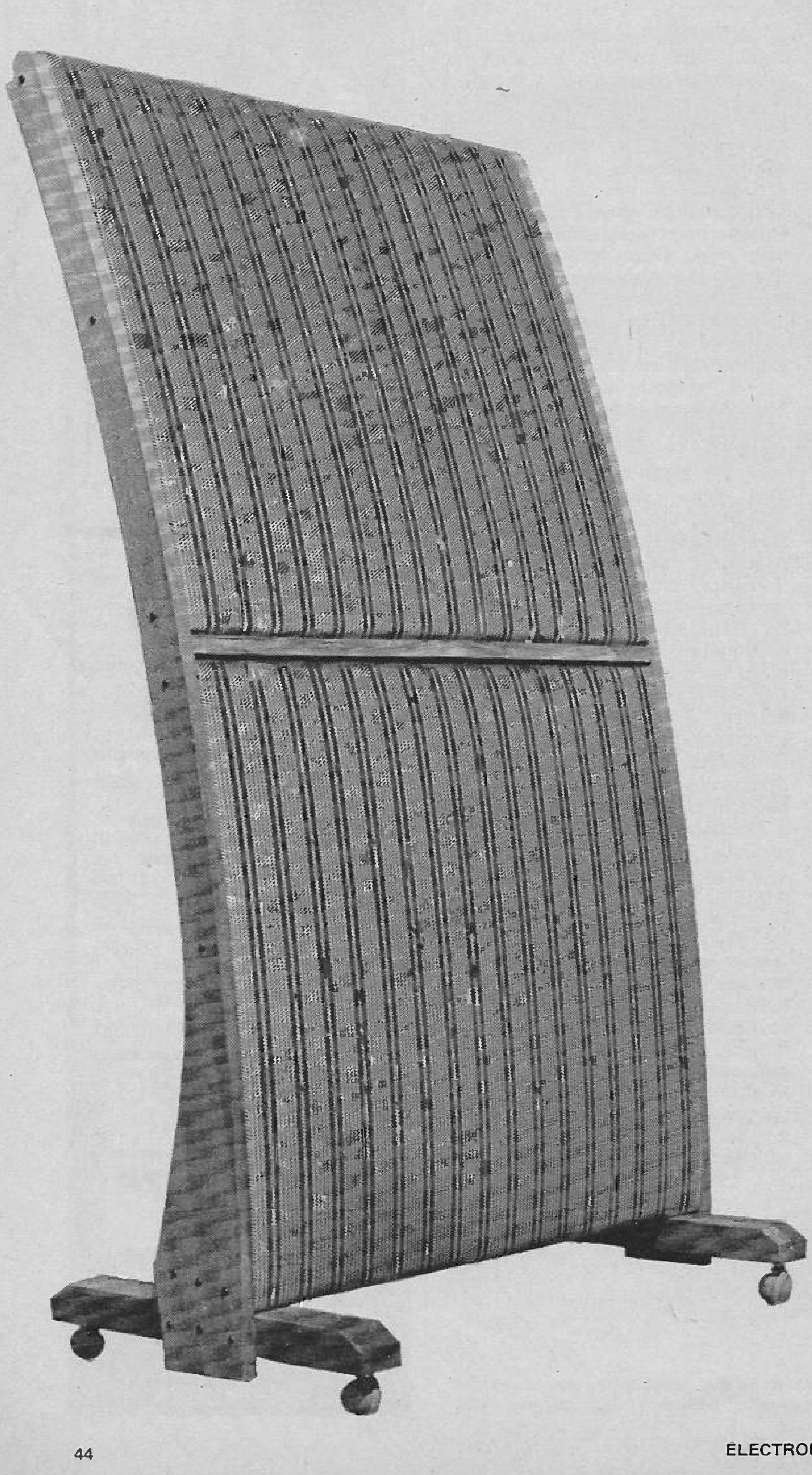
Exponential convertors are particularly susceptible to temperature, and most instruments based on such techniques have to be frequently retuned to overcome the inherent drift in pitch caused by temperature changes. Some synthesizers use only one or two exponential converters to control banks of oscillators, whilst others have a separate converter for each oscillator.

To overcome this very common problem, the 3600 (and 4600) derive an exponential voltage directly from the keyboard by a unique matrixed voltage selection system which is not sensitive to temperature change. This technique also allows more accurate keyboard tuning than the 1% tolerance resistor chain found in most other synthesizers.

Constructional details of the 3600 synthesizer will commence next month. The 3600 uses many modules which are common to the 4600. ●

DOUBLE QUAD

— a step closer to ultimate sound



ONE HAS ONLY to listen to music through a pair of good quality *electrostatic* headphones to realise that the auditory performance of most loudspeakers leaves a lot to be desired. Good quality headphones are, of course, easier to build. Low mass distortion-free units can be built at moderate cost since the physical size of the moving parts is relatively small. The close coupling between the earpiece and ear enables adequate sound-energy to be made available, hence realistic levels of loudness may be achieved without the need for large diaphragm displacements.

Full-range electrostatic loudspeakers are particularly difficult to build — in fact very few are available. The Quad is probably the most familiar example of this type of speaker since it has been in existence for many years, but other brands are now appearing which tackle the problems in different ways and by so doing, generate a new range of subsidiary complications.

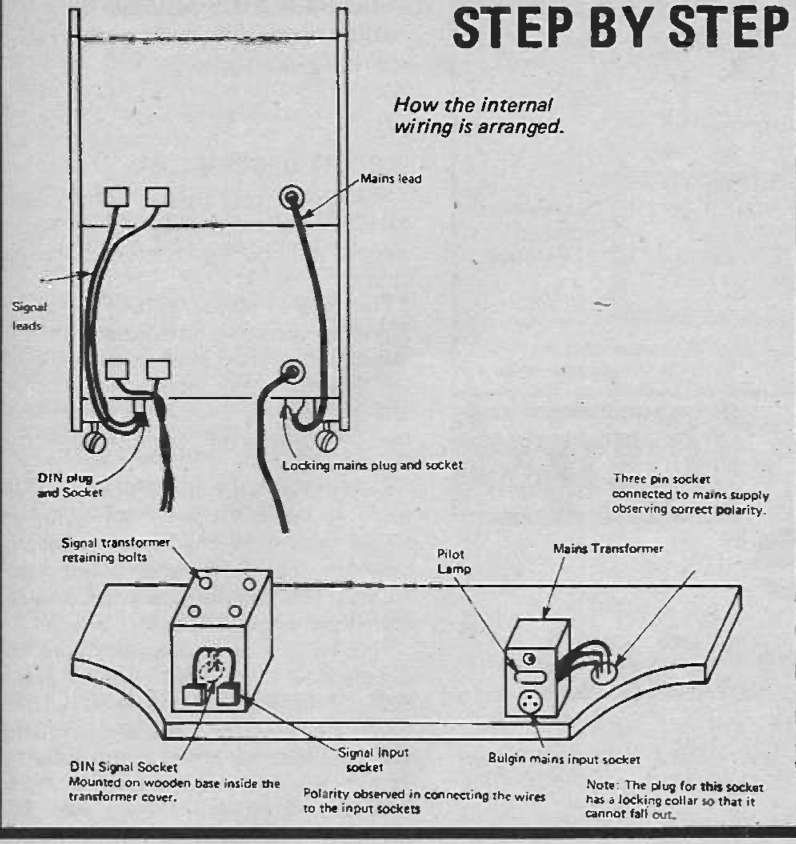
The Quad is a push-pull system in which a lightweight diaphragm is free to move in an air-gap between perforated static plates — so producing sound.

A limitation of such a speaker is that low frequencies (below 50 Hertz) may be restricted, since the large excursions of the diaphragm required for significant acoustic output may not be physically achievable.

In the United States, the Dayton Wright full-range electrostatic loudspeaker uses a system in which the charged plates are sealed in an atmosphere of sulphur hexafluoride. This confers two advantages over an air-spaced system: it gives a higher loading to the moving membrane — because of the density of sulphur hexafluoride relative to air; it also enables the voltages of the static plates to be increased because of the better electrical insulation properties of the gas. This in turn enables the spacing between plates to be increased, so allowing the diaphragm to be driven harder when reproducing low frequencies.

In general, a full-range electrostatic loudspeaker has certain merits relative to the majority of moving coil designs. It has low colouration since it is of doublet design and has no cabinet resonances. It has a lightweight diaphragm which is driven uniformly across the whole of its surface rather

STEP BY STEP INSTRUCTIONS



How the internal wiring is arranged.

SIGNAL INPUT:

(a) Remove rear wire mesh cover of lower speaker.

(b) Loosen the four retaining bolts on the signal input transformer and displace slightly to one side so that the wooden speaker base is exposed.

(c) Cut hole in exposed speaker base to take DIN socket.

(d) Wire DIN socket to shanks of transformer signal input sockets, observing polarity.

(e) Replace transformer.

(f) Staple signal leads carrying a DIN plug to speaker framework to carry signal to uppermost speaker.

MAINS INPUT:

(a) Cut hole in wooden speaker base near the mains input transformer to take three pin socket with locking collar.

(b) Connect three wires between the pins of the socket and the Bulgin socket mounted in the mains transformer corner (or to other appropriate wiring points which may be more easily reached and which preserve the correct polarity).

(c) Replace lower speaker rear mesh.

(d) Staple mains cable to edge of wooden framework.

(e) Terminate mains cable with Bulgin plug to energise uppermost speaker.

than from one small area, which minimises unwanted diaphragm flexing.

SPEAKERS IN PARALLEL

The advantages of driving two moving-coil speakers in parallel has been often stressed, for example by Gilbert Briggs, ('Loudspeakers', Wharfedale Wireless Works Ltd) but little has been written concerning the possible advantages of driving two full-range electrostatic speakers in parallel. One advantage, in the case of the Quad electrostatic, would be to double the amount of air acted upon. Also if the speakers were mounted vertically one above the other, high frequency dispersion would be improved. Because of the shape of the high frequency transducer of the Quad (which is a long narrow vertical element) the horizontal dispersion is approximately 70°. However the vertical dispersion is only 15° and this produces a beaming effect which results in changes in loudness of high frequencies when the listener moves his head. Such effects can be tiring and this is one of the reasons why "reflected sound" loudspeakers are preferred by many audiophiles. The construction of the double Quad system was undertaken with the aim of bringing about these improvements.

HOW THEY WERE MADE

Constructing double Quad speakers is quite straightforward. The wooden side pieces are removed and two extended wooden arcs screwed in their place. The arcs are constructed to continue the line of curvature of the front of the speaker grille. The angle of tilt of the complete assembly is then adjusted so that the uppermost speaker retains the same angle of inclination as a single unit mounted on the floor. The three feet of the Quad speaker are replaced by two parallel wooden extensions projected fore and aft from the speaker assembly. Four castors enable the unit to be moved quite easily and since the centre of gravity is well within the base, it is completely stable.

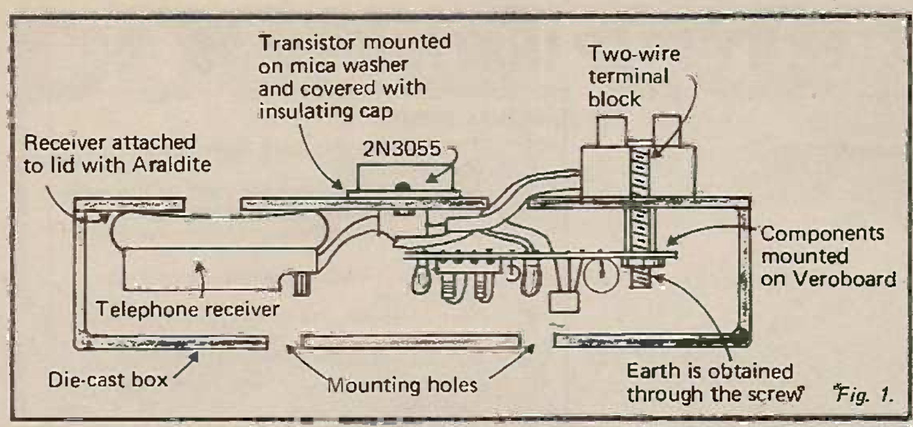
The complete double speaker construction is much more easily moved than the single Quad with its rather unstable tripod leg arrangement. This feature of the standard Quad is something which the manufacturers could well improve since even an obstreperous cat has on occasion tipped ours over!

A danger to be avoided when loudspeakers are run in parallel results from the excessively low impedance which may be created; this may produce undesirable effects upon the amplifier. Modern direct-coupled amplifiers can supply large amounts of subsonic energy and therefore may damage a speaker if its impedance is very low. The Acoustical Quad amplifier has a capacitor output which blocks direct current and low-frequency signals and it is for this reason that the manufacturers of other amplifiers (for example Amcron, who produce the D-60 amplifier), recommended that a capacitor, in parallel with a four ohm resistor, be inserted between the amplifier and an electrostatic loudspeaker load when the direct current resistance of the input transformer of the loudspeaker is less than three ohms, (which it is in the case of the Quad speakers).

When driving Quad electrostatic speakers in parallel, the impedance of the double unit falls to three ohms at frequencies above 8 kHz, but this is not too bad compared with some electrostatic systems in which impedances may fall even lower than this.

It may perhaps be asked why one should go to all this trouble with electrostatic speakers when the problems could be solved by using moving-coil units which in general do not have the limitations of full-range electrostatic speakers. However in lengthy listening sessions involving moving-coil, hybrid and full-range electrostatics, full-range electrostatics seemed the most 'transparent'. Although at the extremes of frequency response some roll-off occurs, the detailed and accurate mid-range reproduction combined with an absence of bass colouration makes them difficult to beat. ●

A full review of the normal Quad speaker is published on page 34 of this issue.



Suggested method of construction.

This inherently reliable flash unit is not affected by voltage or load changes.

Solid-state flasher for cars

FLASHING TURN INDICATOR lamps on cars are invariably controlled by a thermal relay unit. Many of these units are fragile and unreliable. A further disadvantage is that the flashing rate is affected by the load current. Thus, connecting up a trailer or caravan may vary the flash rate beyond the legal limit.

The unit described has the inherent reliability of solid state components and is not affected by load current. Its flashing rate is independent of supply voltage, and should cost little more than a commercial thermal relay unit.

The flash rate and duty cycle can be varied (providing they remain within the legal limit — which is between 60 and 120 flashes per minute). It can be used in either a 6 V or 12 V system.

Details are shown for both +ve and -ve earth systems. A switch can be added to give an "all lamp flashing" mode as a warning signal at the scene of an accident.

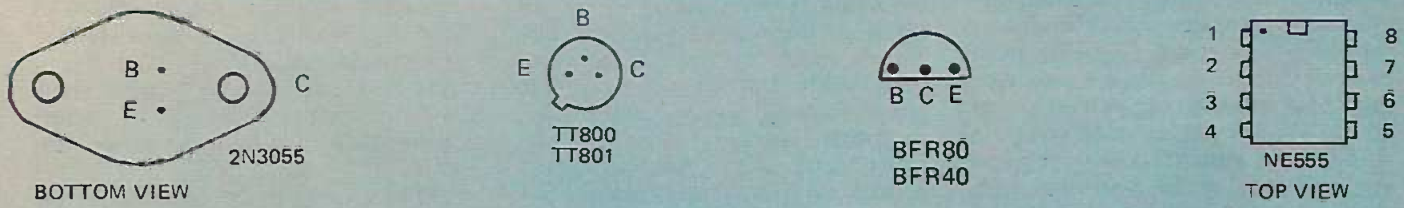
CIRCUIT DESCRIPTION

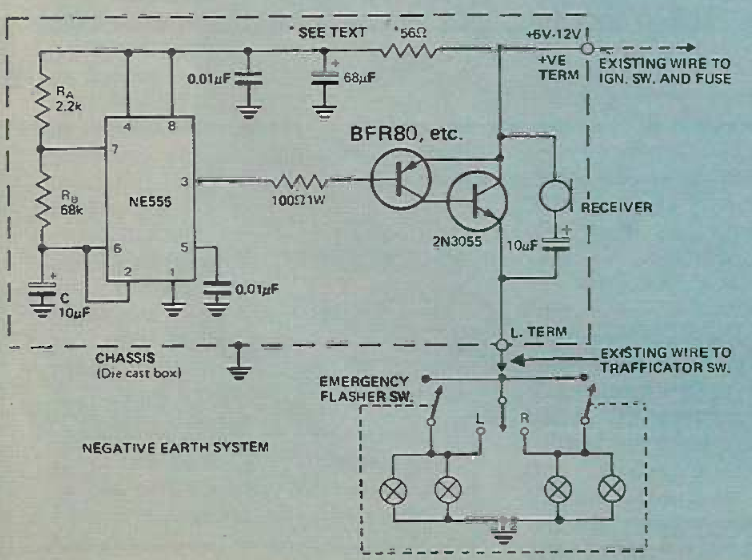
The solid state flasher unit consists of two sections, the adjustable timing circuit and the high current switching circuit.

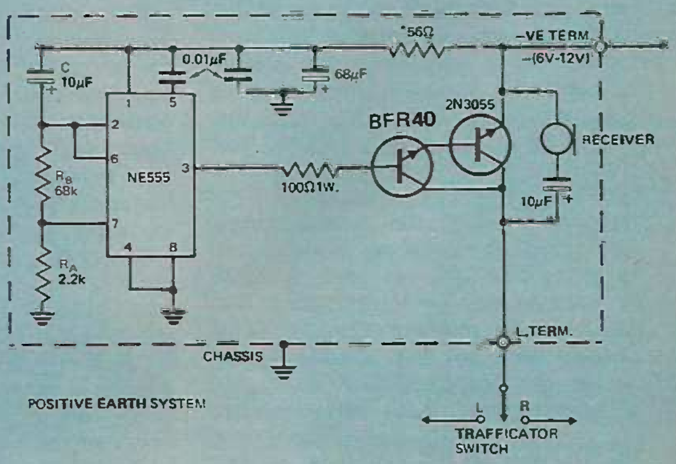
The heart of the timing circuit is Signetics' versatile integrated timer — NE555. It is used here in an "astable" or "free running" mode. Its frequency and pulse duty factor are determined by three external components R_A, R_B, and C.

A flash rate and duty cycle of ½ sec on — ½ sec off is achieved using the values shown in the circuit diagram, however for those who might wish to vary this the necessary calculations are shown elsewhere in this article.

The NE555 is decoupled from the supply rail by a 56Ω resistor and a 0.01μF capacitor in parallel with a 68μF tantalum. For 6 V auto systems, the 56Ω resistor is not really essential as the chip will operate from a Vcc of between 4 V and 16 V and still produce the same accurate timing. Decoupling capacitors are required across the supply to eliminate voltage spikes on the supply rail. The 68μF capacitor smooths out most of these spikes but it is just not quick enough (it has too much inductance) to ground the very sharp, short spikes that may damage the NE555, hence the 0.01μF capacitor which must be







The Telephone Receiver can be obtained from Bi-Pre-Pak.

placed as close to the chip as possible.

The output (pin 3) controls a direct coupled Darlington transistor output stage that switches the current through the lamps, the 100Ω resistor limits the current from the chip. The circuit is energized continuously when the ignition is switched on but the power consumed is negligible. Only when the trafficator control switch is moved right or left, does heavy current flow through the 2N3055. The driver of the 2N3055 is not a critical type but seeing that this unit was designed to switch 10 amps comfortably a medium power transistor with a collector current of 1 amp was chosen.

The law requires that an audible indication be given to indicate that the trafficators are operating. This is achieved by connecting a telephone receiver earpiece across the 2N3055, thus producing the audible clicks.

Most cars have two pilot lamps on the dashboard to indicate right or left hand indicator operation. If, however, there is only one pilot lamp, it can be connected between the two sides of the trafficator lever, providing that the lamp can be completely insulated from the dash. Thus when one set of lamps is energised, the pilot lamp operates in series with the un-energised lamps, which, being of high wattage and with cold filaments, do not light.

It is also a good idea to provide an "emergency flash" mode to warn other drivers of a road accident, etc. A double-pole switch capable of handling the current (shown on the -ve earth circuit) will provide this. The extra load will not affect the flash rate or ratio, but one should check the fuse/s used in conjunction with the flasher unit to see if it will handle twice the normal current.

VARYING THE FLASH RATE AND DUTY CYCLE

The charge time (the high or + ve output) is given by:–

$$t_1 = 0.685\,(R_A + R_B)\,C$$

and the discharge time (the low or – ve output) by:–

$$t_2 = 0.685\,(R_B)\,C$$

Thus the total period is given by:–

$$T = t_1 + t_2 = 0.685\,(R_A + 2R_B)\,C$$

The frequency of oscillation is then:–

$$f = \frac{1}{T} = \frac{1.46}{(R_A + 2R_B)C}$$

The duty cycle is given by:–

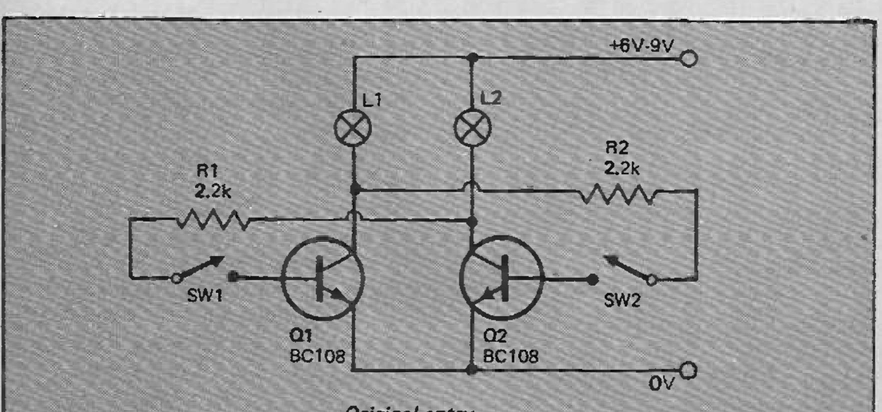
$$D = \frac{R_B}{R_A + 2R_B}$$

CONSTRUCTION DETAILS

The most convenient method of building this flasher unit is to mount the components on to the lid of a die-cast box. The main part of the box should be bolted firmly to the car chassis, thus providing the necessary earth. The receiver can be attached to the lid, using epoxy resin. The 2N3055 can be mounted on the outside of the lid, thus providing the transistor with a ready-made heatsink. This transistor must be completely insulated from the metal lid and a transistor cover must be used. The remaining components can easily be mounted on a small piece of Veroboard which in turn can be secured to the lid via the screw used for the terminal block. ●

Electronic Windicator

Circuit indicates which of two switches is first depressed.



Original entry

The circuit was originally designed for use in a game in which two players on command each try to press their respective switch before the other.

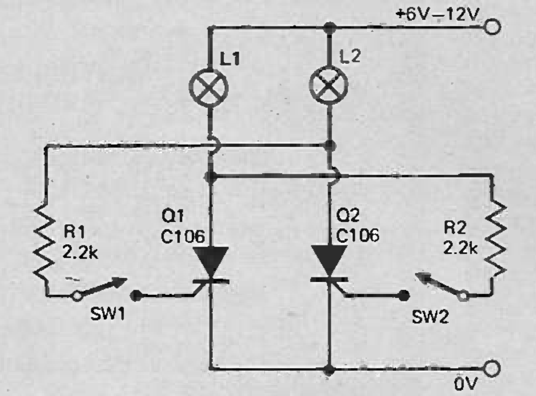
The first to do so causes 'his' bulb to light, and providing he keeps his button depressed his opponent cannot cause his own globe to light until the circuit is reset by momentarily breaking the power input or by the winner releasing his button.

With minor modifications, the circuit may be used in quiz games and/or the lights replaced by buzzers (in the latter case diodes should be wired across the buzzers to protect the transistors from voltage spikes generated by the back emf).

Operating principle is simple. Assume switches SW1 and SW2 are open, both transistors Q1 and Q2 have their bases 'floating' – neither is turned on. Neither bulb is alight.

Now assume SW1 is closed. The voltage at the collector of Q2 (which is high) will flow via R1 to Q1's base. Transistor Q1 will now be switched on thus lighting L1. Although SW2 may now be depressed the voltage at Q1's collector is too low to bias on Q2. So L2 cannot be energized.

One disadvantage of the circuit is that it is not self-latching. The winner must keep his button depressed until his opponent has conceded defeat.



The circuit is self-latching if the transistors are replaced by SCR's.

SELF-LATCHING

The modification shown here overcomes this disadvantage – at the cost of a slight increase in price.

Basically all that is required is to replace the two BC 108 transistors by two small SCR's. Almost any low current devices will do – C106's for instance. SCR's are self-latching devices so the first bulb to be illuminated will stay that way – even though the winner's button is released – until the main power is momentarily broken. ●

Low-battery warning

Flashing light indicator warns of low battery voltage

The prototype of this device will be used in a hospital operating theatre in conjunction with battery operated medical equipment (powered by four 'pen-light' cells).

A moving coil voltmeter was not appropriate as, in the designers' experience, medical staff have difficulty in interpreting a voltmeter – and sometimes find themselves half way through an operation with exhausted batteries. Therefore, the requirements for the indicator were that:

1) the display be eye catching, easily understandable and provide a sense of urgency as the battery approaches exhaustion;

2) provide adequate warning of battery failure (at least 1 hour);

3) current consumption of the indicator be low in relation to the main equipment;

4) preferably, be more rugged and cheaper than a moving coil meter.

The design was based on a programmable unijunction transistor (PUT), because its threshold characteristics can be well defined, arranged to flash a light emitting diode (L.E.D.) indicator.

The circuit is shown in Fig. 1. The PUT (Q1) is used in a relaxation oscillator circuit. As the voltage being monitored (V_{mon}) falls, the voltage on the gate (V_g) falls whilst the anode voltage (V_a) remains essentially constant. Oscillation commences when V_g falls below V_a by 0.6 volts.

As V_{mon} falls further, V_g falls and the PUT triggers at lower values of V_a. Thus the cycle time shortens and the frequency of flashing increases giving a sense of urgency as the battery approached exhaustion. Transistor Q2 and C2 act as a pulse stretcher and amplifier to drive the L.E.D. display.

In the prototype the trigger point can be adjusted from 4.5-5.5 volts and the current drain when V_{mon} is 6 volts is 1 mA (controlled primarily by R1). This is considered acceptable as the device being monitored draws 17 mA. All the requirements have been met. The components are mounted on the printed circuit board of the main device. ●

PARTS LIST

R1	2.2k	¼W
R2	100k	"
R3	18k	"
R4	18k	"
R5	330Ω	"
RV1	10k	Lin pot.
C1	2.2μF	
ZD1	4.3V 400mW	
Q1	2N6027 PUT or similar	
Q2	BC107	

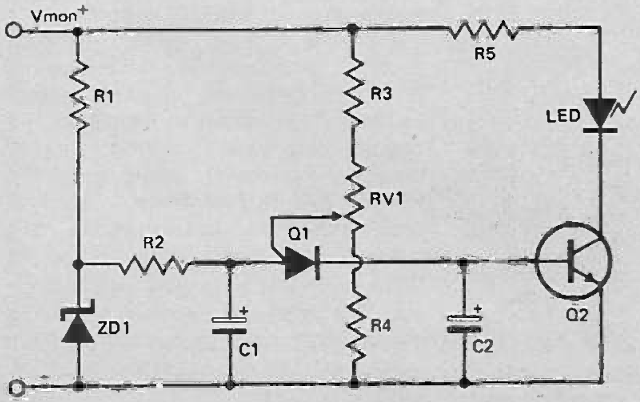


Fig. 1.

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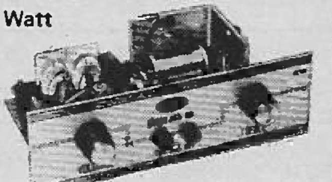

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UNDERSTANDING COLOUR TV

PART FOUR

by Caleb Bradley B.Sc.

This month – the PAL colour signal.

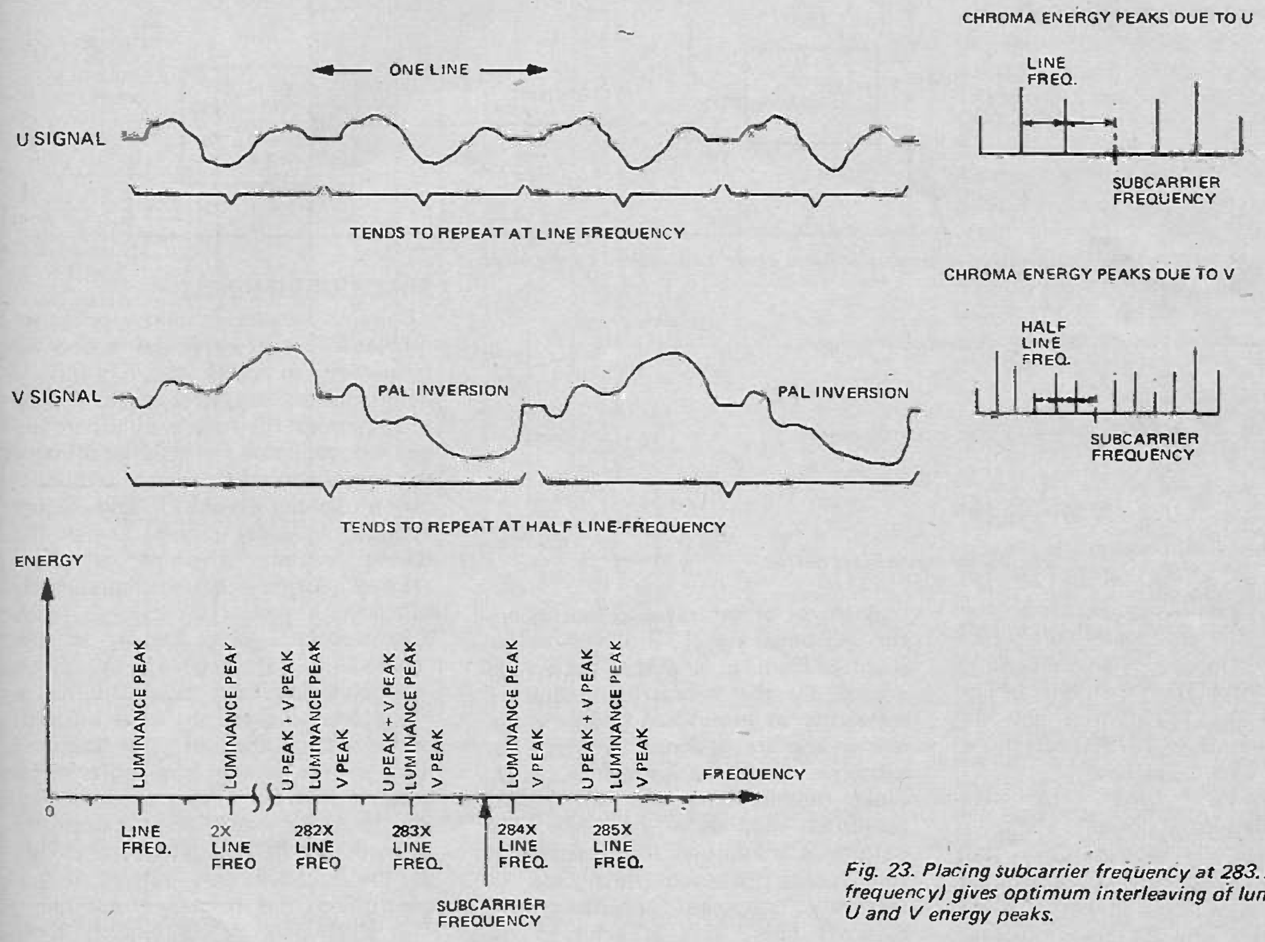


Fig. 23. Placing subcarrier frequency at 283.75 (line frequency) gives optimum interleaving of luminance, U and V energy peaks.

A PAL COLOUR television signal is similar to a monochrome signal except that it includes a high frequency subcarrier on which the colour-difference signals are modulated in quadrature. This subcarrier is known as the chroma signal. The frequency of the subcarrier is chosen with absolute precision to minimise the interfering effect of chroma on luminance. This involves the following factors:

1. The subcarrier frequency should be as high as possible so that any interference it causes on a monochrome picture is invisible from a reasonable viewing distance.

2. Since the colour-difference signals are allowed a bandwidth of about 1 MHz, the sideband energy of the chroma signal extends 1 MHz above and below the subcarrier frequency. The bandwidth of the composite television signal is limited to 5.5 MHz so the subcarrier frequency must be below 4.5 MHz to avoid excessive attenuation of the upper chroma sideband.

3. In Part 2 it was shown that interference between luminance and chroma can be minimised by placing the subcarrier frequency between any two harmonics of line frequency (15 625 Hz). This causes the predominantly line-harmonic energy

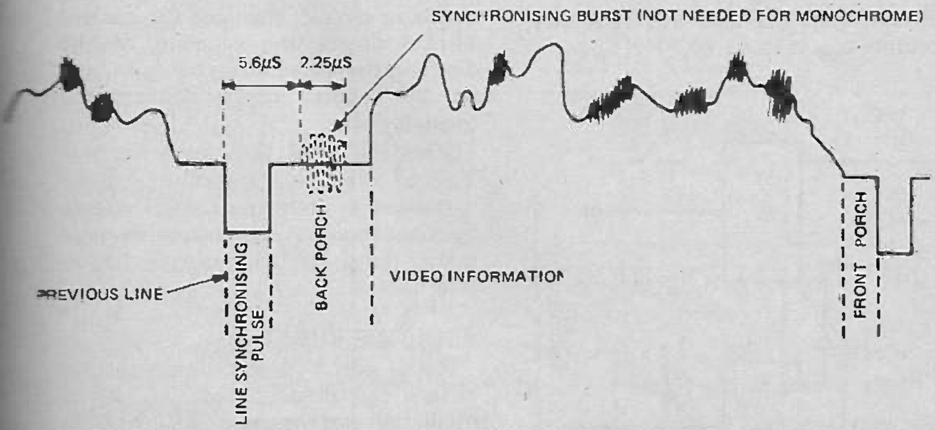


Fig. 24. Waveform of one line of a colour picture. A short 'burst' of unmodulated 4.43 MHz subcarrier is transmitted in the back porch period for reference oscillator synchronisation.

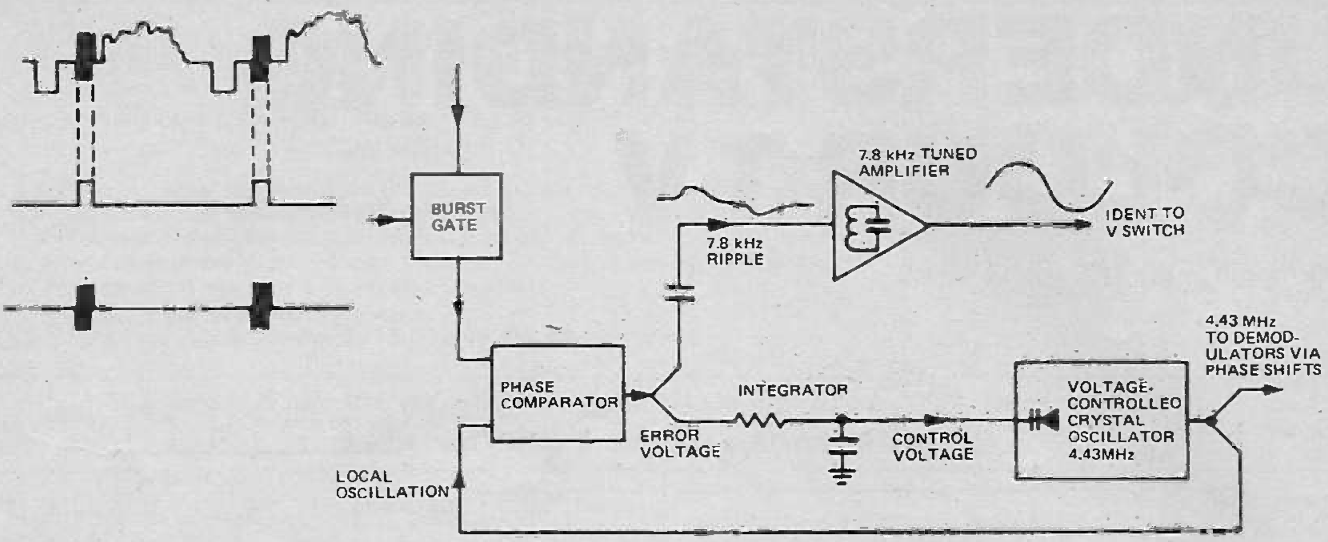


Fig. 25. The phase lock loop by which the reference oscillator phase is controlled by the burst.

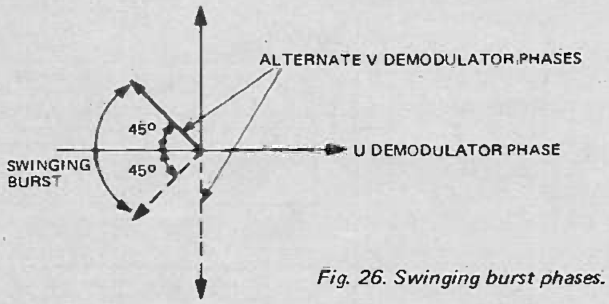


Fig. 26. Swinging burst phases.

contents of luminance and chroma to 'interleave'. So far, a reasonable choice of subcarrier frequency would seem to lie between the 283rd harmonic of line frequency (4.421875 MHz) and the 284th harmonic (4.437500 MHz), i.e. at 283.5 x (line frequency).

4. Since one of the colour-difference signals ('V') is reversed (or 'modulated' by) half line-frequency in the PAL system, the chroma energy peaks due to V alone are at steps of only half line-frequency either side of subcarrier frequency — see Fig. 23. To separate these peaks from the luminance peaks a better choice of subcarrier is 283.75 x (line frequency).

5. Areas of saturated colour where the chroma signal is large suffer slightly from a fine dot patterning caused by the subcarrier frequency appearing as luminance detail. While colour sets are designed to reject the subcarrier from the luminance signal, older monochrome sets with good resolution may show the effect. The pattern is minimised if the dots and the spaces between them are in relatively staggered positions on adjacent lines. This is achieved by offsetting the subcarrier frequency by an amount equal to the rate at which each line of the picture is refreshed (frame frequency) i.e. 25 Hz.

Thus the final choice of subcarrier frequency for the PAL signal is:
(283.75 x 15,625) + 25 Hz
= 4.43361875 MHz

Broadcasters maintain this frequency accurate to a fraction of 1 Hz!

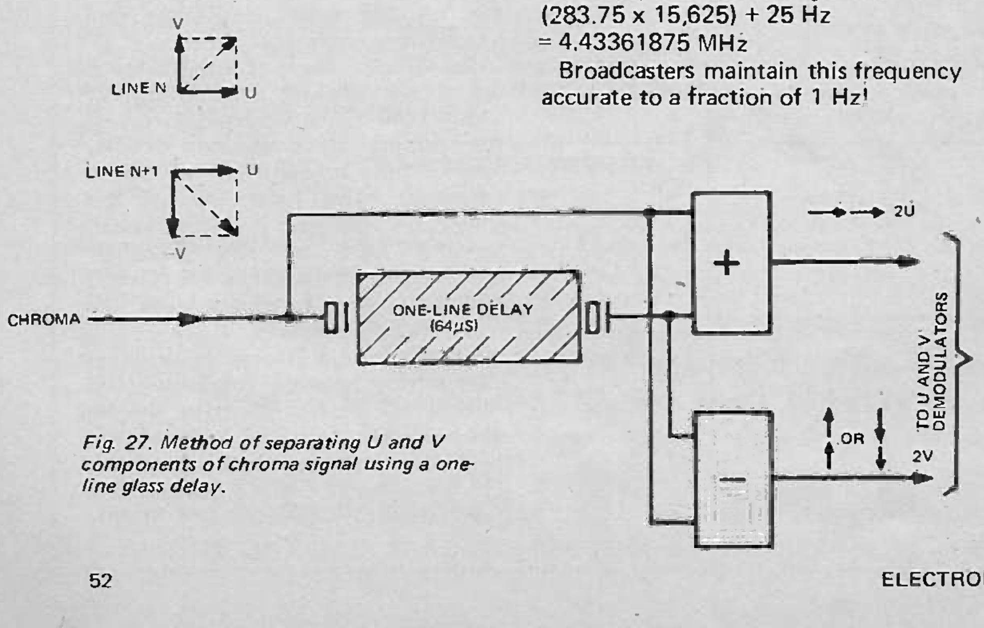


Fig. 27. Method of separating U and V components of chroma signal using a one-line glass delay.

SUBCARRIER BURST

Colour receivers contain a reference oscillator which generates subcarrier frequency to drive the U and V demodulators. A quartz crystal is used to determine the frequency accurately but the oscillator can only be brought to exactly correct frequency and phase by a special synchronising signal included in every picture line of the colour signal. This is a short transmission of unmodulated subcarrier, just 10 cycles (2.25 microseconds) long, known as the 'burst'. Fortunately for monochrome/colour compatibility a monochrome signal contains a 'dead' period at the start of each scanning line, known as the back porch. The burst is inserted in this space — Fig. 24. Its position on the line is carefully defined so that a simple gating circuit in the receiver can extract it for controlling the reference oscillator. This is achieved by applying the local oscillation and the burst to a phase comparator which detects any error in the local oscillator phase and corrects it by means of a control voltage applied to the oscillator. The phase-lock loop so formed is shown in Fig. 25. The control voltage is usually applied to a varicap diode in the oscillator circuit; changing the control voltage causes the capacity of the diode to change and the change in load on the quartz crystal affects the oscillator phase.

Since the burst is present for only 3½% of a line, an integrating capacitor is needed to store the control voltage between bursts. The integrator also makes the phase lock more resistant to interference.

SWINGING BURST

The U and V demodulators require different phases of reference oscillation and these are obtained from the reference oscillator by simple phase shift networks. While the U

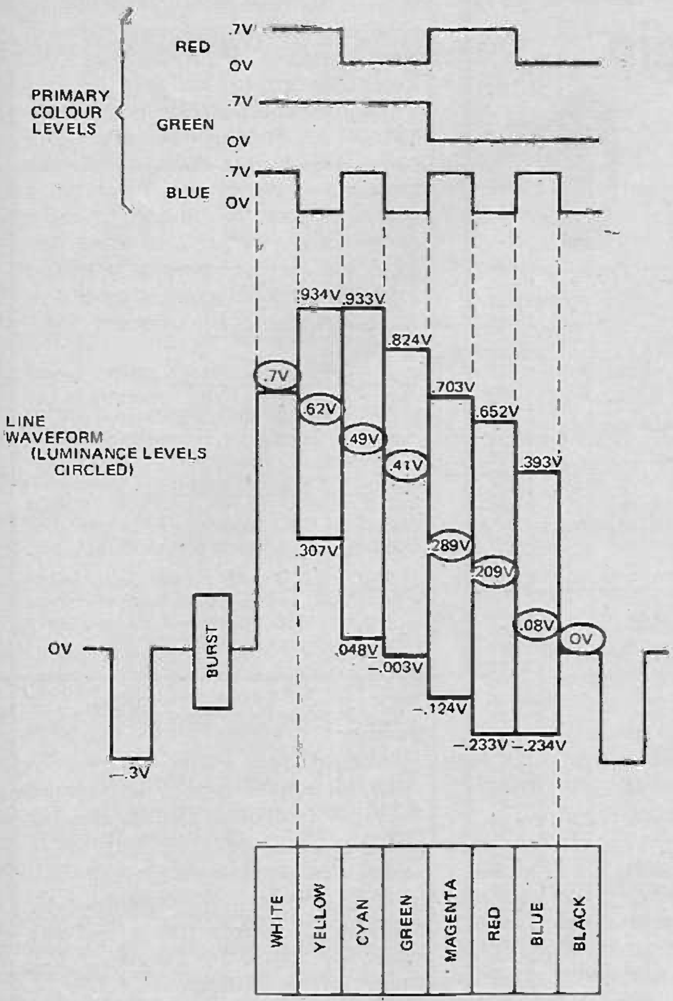


Fig. 28. 100% amplitude, 100% saturation colour bar pattern and waveform. Levels are shown relative to OV = black level.

demodulator needs a fixed phase, the V demodulator needs different phase (± 90°) on successive lines to match the PAL switching at the transmitter — see Fig. 26. Some receivers switch the V signal itself instead of the demodulation phase; this achieves the same thing and in either case an electronic reversing switch working at half line-frequency (7.8 kHz) is

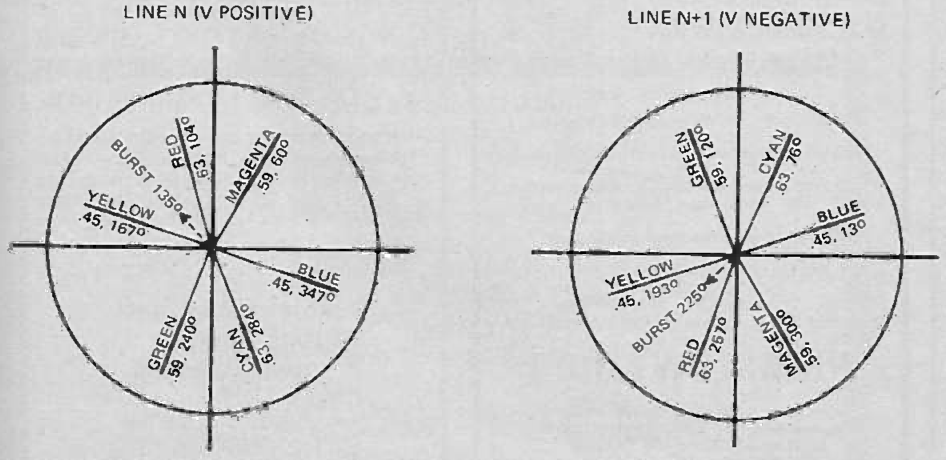


Fig. 29. Chroma and burst vectors on successive lines for colour bar pattern.

needed. The switch phasing must match the transmitter for correct V demodulation. The burst is used to synchronise the V switch as follows.

The bursts do not have uniform phase, instead they alternate ± 45° on successive lines. These swings are not intended to be followed by the reference oscillator and to prevent this the integrator in Fig. 25 has a time constant much longer than one line. Therefore the reference oscillator settles at the *average* phase of the bursts which is the —U axis. The purpose of the swinging burst is to produce a small 7.8 kHz ripple in the error voltage from the phase comparator. This ripple is picked off by a tuned amplifier to give a 7.8 kHz signal known as the *ident*. The ident conveys the phase information needed by the V switch. Without it the V switch would only have a 50% chance of starting in the right phase every time the set is switched on.

PAL-D (Delay)

Although under ideal conditions U and V can be separated from the chroma signal by correctly phased demodulation, the phase errors which occur in real situations cause Hanover blind colour errors. Although these are less objectionable than the corresponding hue errors in the simpler NTSC system (since the eye tends to integrate the errors to see near-correct colours) most PAL receivers use the PAL-D refinement by which Hanover blinds are entirely eliminated. This involves passing the chroma through a one-line delay unit. The delay consists of a ceramic transducer which converts the chroma into ultrasonic (4.43 MHz) vibrations which travel a carefully measured path through a glass block to a second transducer which converts the vibrations back to an electrical signal. The block is ground to give a 64 microsecond delay. In Fig.27 the direct and one-line-delayed chroma signals are both fed to two stages: an adder where the alternate line phased V components cancel out leaving U alone, and a differencer where the U components, being similar on successive lines, cancel out instead leaving alternating V. Thus U and V are separated *before* the demodulators. This is not essential but gives the advantage that phase errors (Fig. 22 last month) are averaged out between adjacent lines electronically without Hanover blinds appearing. A minor consequence of PAL-D is that vertical colour resolution is slightly reduced but this is far preferable to Hanover blinds. The delay line in Fig. 27 must be trimmed to one-line period to within a fraction of a subcarrier cycle or the circuit will cause permanent Hanover blinds!

When PAL was introduced it was expected that slightly cheaper PAL-S (simple) receivers without a chroma delay line would be made. In practice the cost of the mass-produced glass delay line is so low that virtually all PAL receivers are PAL-D type.

COLOUR BARS

A standard pattern of colours is enormously useful for checking receiver performance — the colour bars pattern is shown in Fig.28. The sequence of colours is chosen to give descending luminance levels from left to right so that a monochrome receiver displays steps of grey from white to black. The separate red, green and blue signals which make up the bar pattern are shown in Fig. 28; they are generated electronically for accuracy. If the receiver decoder is working correctly the red, green and blue beams of the display tube will be controlled by these signals. This is readily checked by switching on each beam in turn and counting the number of bars of colour displayed.

The peak excursions of the composite luminance chroma waveform are given in Fig. 28. The luminance levels are found from:

$$E_Y = .3E_R + .59E_G + .11E_B$$

The peak-to-peak chroma amplitudes are found by summing vectorially the U and V values for each colour found from the equations given in Part 3 i.e.

$U = .493\ (E_B - E_Y)$ where $E_B - E_Y = .7E_R - .59E_G - .11E_B$ and $V = .877\ (E_R - E_Y)$ where $E_R - E_Y = .3E_R - .59E_G + .89E_B$

The amplitudes of the resultants are the same for +V and −V lines, only the chroma phases change. The chroma phase for each colour is shown in Fig. 29. Note that black and white have no chroma signal.

The colour bar pattern in Fig. 29 is the most basic but the 100% amplitude, 100% saturation colours do not often occur in real pictures. Therefore other versions of the pattern where amplitude or saturation is reduced are often used. This does not affect the vector angles in Fig. 29, only the luminance or chroma amplitude respectively.

COMPLETE RECEIVER

The delay line in Fig. 27 and the phase lock loop in Fig. 25 are the heart of a receiver colour decoder which will be described next month. ●

AUTO-AMP

Boost portable radio output in your car.

eti project

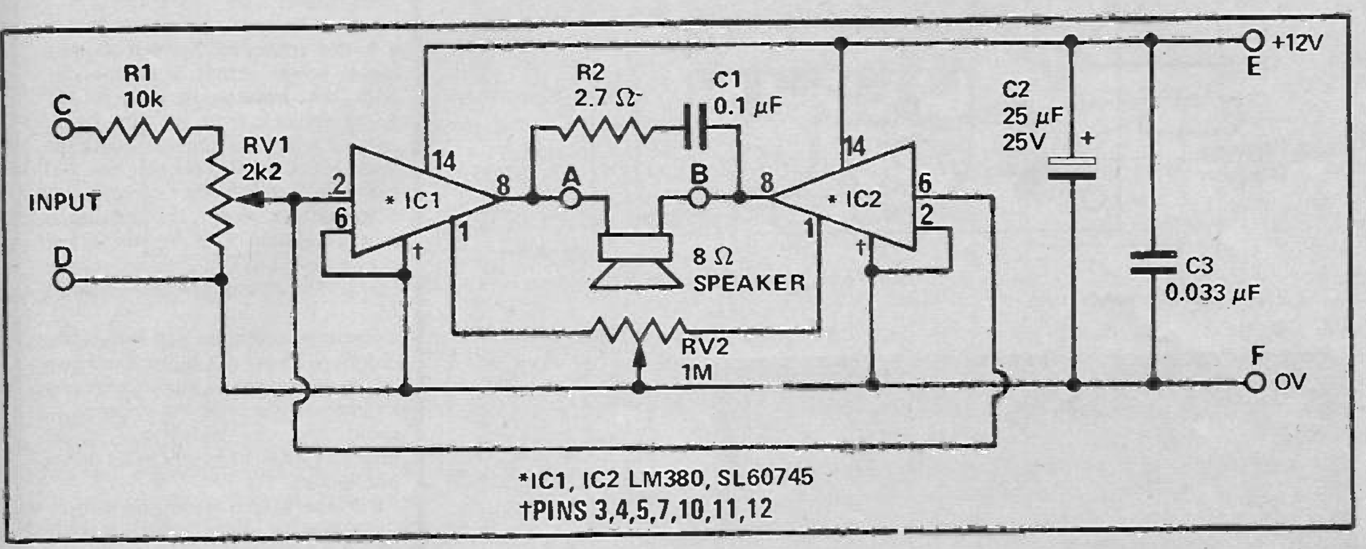


Fig. 1. Circuit diagram of the booster amplifier.

MOST portable radios and cassette players have a power output which seldom exceeds 100 milliwatts. Whilst this is entirely adequate for normal listening, many people find that it is entirely inadequate when such equipment is used in a car. There the extremely high noise level effectively drowns out such radios and one is left with the choice of buying a proper (and quite expensive) car radio, or, of forgetting about the whole deal.

However this problem can be overcome by using a small booster-amplifier to provide the additional power required. Such an amplifier should be powered from the 12 volt car supply and should accept an input from the earphone, or external speaker socket of the radio or cassette player.

The ETI booster amplifier has been designed to suit such applications and uses the inexpensive LM380 (or SL60745) ICs. Two ICs are connected in a bridge arrangement which provides an output of around five watts RMS (12 volt supply and 8 ohm speaker). The amplifier may be used to drive an eight-ohm speaker permanently mounted in a suitable position in the car.

CONSTRUCTION

The components should all be mounted on a small printed circuit board (or Veroboard etc) as shown in the component overlay diagram. If Veroboard construction is used it is preferable to mount the ICs, in line, such that a common heatsink may be attached to both ICs on each side. Each heatsink should be at least 25x50mm and be constructed from copper or tin plate.

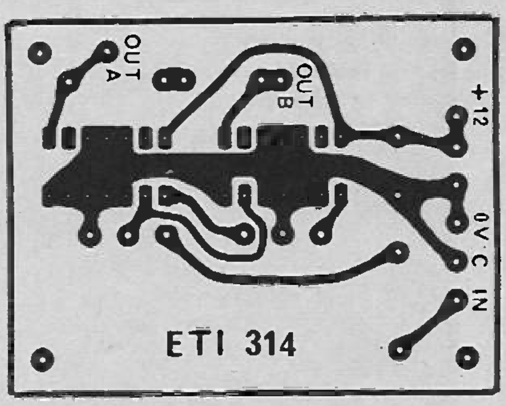


Fig. 2. Printed circuit board. Full size 50 x 65 mm.

Two preset potentiometers are provided for setting up the amplifier. The preset-volume potentiometer, RV1 should be adjusted to suit the output voltage available from the radio or cassette. Sensitivity of the booster is such that 5 watts output will be obtained (with RV1 at maximum sensitivity) with an input of 50 mV. This should be entirely adequate as most radios will provide in excess of 200 millivolts.

The balance potentiometer should be set for minimum dc through the speaker as detailed in the 'How It Works' section.

The compactness and simplicity of the amplifier enable it to be mounted in any convenient position, eg, even on the rear of the speaker itself! However, care should be taken to position it such that mechanical damage is unlikely to occur, and that adequate ventilation of the heatsink is obtained.

PARTS LIST ETI 314

* R1	Resistor	10k ½W 5%
R2	"	2.7 ohm ½W 5%
* RV1	Potentiometer	2k2 Trim
RV2	"	1M Trim
C1	Capacitor	0.1μF polyester
C2	"	25μF 25V electrolytic
C3	"	0.033μF polyester
IC1, IC2	Integrated Circuit	LM380, SL60745
PC Board		

* The value of these components may vary for different input requirements.

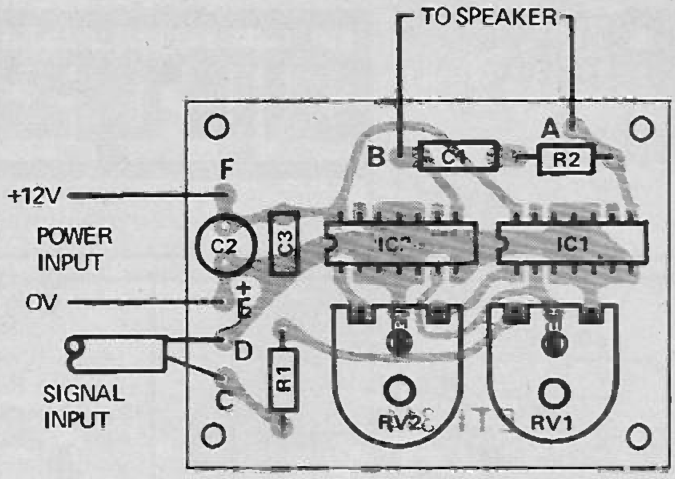


Fig. 3. Component overlay.

SPECIFICATION

POWER OUTPUT		
12.6 volt supply 8 ohm load		5 watts
DISTORTION		
12.6 volt, 8 ohm, 1 kHz		
at 5 watts		3%
at 3 watts		0.5%
SUPPLY VOLTAGE		
Nominal		12 volts
MAX SUPPLY VOLTS		
	Speaker load	
LM380	8	15 volts
	16	22 volts
SL60745	8	18 volts
	16	22 volts
SPEAKER IMPEDANCE		> 7 ohms
FREQUENCY RESPONSE		
10 Hz – 100 kHz		$\pm^{0}_{3}$ dB
SENSITIVITY		
Maximum (no input attenuator) into 75 k ohm		50 mV

HOW IT WORKS – ETI 314

The LM380 (SL60745) is an integrated audio amplifier which, has a fixed gain of 50 (34 dB) and, can be connected in either inverting or non-inverting mode (ie output 'out of phase' or 'in phase' with the input respectively).

Two of these ICs have been used in a bridge arrangement which allows a higher power output to be obtained with the low supply voltage (12 volts) available from the car. To do this we drive both amplifiers with the same signal, but connect one for inverting, and the other for non-inverting mode. The speaker is now connected between them and thus receives twice the output voltage that would be available from a single IC.

The input required for full power output is about 50 millivolts. Hence we have provided an input attenuator to increase the input requirement to about one volt which will enable preset adjustment to suit most radios or cassettes.

We used a trim potentiometer on the board to adjust sensitivity such that full volume is obtained with the volume control of the source about half way up. If desired, a separate potentiometer may be used in place of the preset as a volume control.

Output voltage of the ICs is about half of the supply. However since the speaker is direct coupled, any slight difference in amplifier outputs will result in a dc current flow through the speaker. Potentiometer RV2 should be adjusted, with the aid of a multimeter, for zero volts across the speaker (or minimum current from the supply). Alternatively, if a multimeter is not available, make and break one speaker connection and adjust RV2 for minimum 'clicking' sound from the speaker.

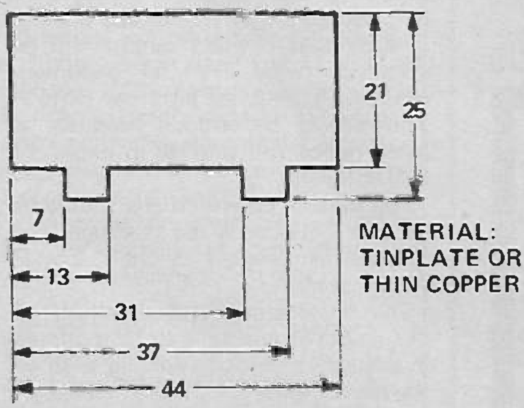
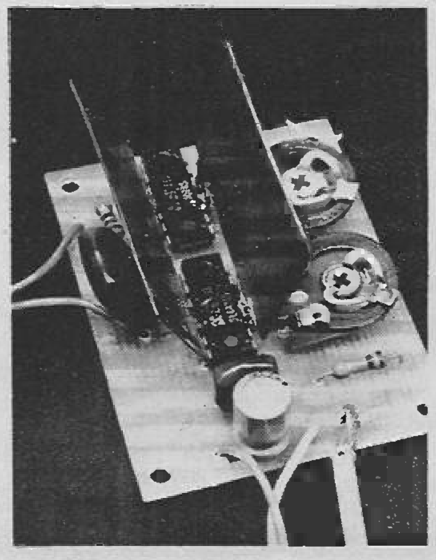


Fig. 4. Heatsink (two required) to be attached to either side of both IC's as shown in main picture.



ELECTRONICS -it's easy! PART 15

Simple power supplies.

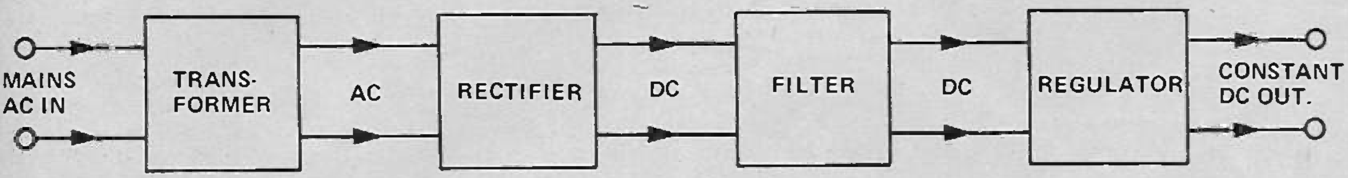


Fig. 1. The various sections required in the process of converting the ac mains supply into a source of dc power.

AN AC SUPPLY provides a sinewave current that changes direction at the supply frequency. Firstly, the ac voltage has to be transformed to the appropriate voltage level. To obtain dc a switch (the rectifier) is needed to reverse polarity of alternative half cycles. This done, all that remains to be added is a method of smoothing out (filtering) the half-sinusoids to obtain a steady current. We will look at each of these steps in turn.

TRANSFORMERS

The principles of inductance were briefly introduced in Part 6 of this course. We suggest that the section be read again.

If two inductors A & B are placed such that the axis of their coils align (as in Fig. 2), and coil A is energised with an ac source a voltage will be generated across coil B.

As we move the coils closer to each other the voltage developed, across coil B, approaches a value which is proportional to that across coil A. The proportion will be equal to the ratio of the number of turns on B, to the number of turns on A.

ie $\frac{E_B}{E_A} = \frac{N_B}{N_A}$

Where E_B = voltage across coil B
E_A = voltage across coil A
N_B = turns in coil B
N_A = turns in coil A

The effect is due to the field of one coil cutting the turns of the other and is known as mutual inductance. If the coils are wound on top of each other, and an iron core is used, the coupling is improved to almost unity and we have a device capable of changing ac voltage from one level to another. Such a device is known as a transformer.

There are losses in the transformer due to the resistance of the wire in the coils — these are known as copper losses, and in the iron of the magnetic core — these are known as iron losses.

A transformer can never *create* power — it can only transfer it and change voltage levels. Small transformers have power efficiencies from 60-90%; 85% is typical.

To reduce the iron losses as much as possible the core material (at frequencies below 20 kHz) is usually a special silicon steel called "transformer iron". The core is built up of thin laminations of this iron individually insulated by a thin coating of lacquer. By this means eddy current (circulating currents within the core) losses are reduced to a minimum.

Note particularly that the transformer is an ac device. It will *only* produce voltage in the secondary winding when there is a current change in the primary. A dc current flowing in the primary will not produce a secondary output.

The iron laminations retain the magnetic field ensuring virtually total magnetic linkage between coils. For high frequencies, up to several megahertz, ferrite powder mouldings are often used. In many high-frequency applications, the ferrous magnetic circuit is omitted altogether. Figure 3 shows a range of transformers for use at various frequencies.

In mains-operated power supplies the relatively low frequency of the mains leads to efficient coupling. Hence the ratio of input/output voltage is as the ratio of input turns/output turns. A transformer is, therefore, selected to provide the correct voltage (stepped down or up) and must be designed with wire in each winding heavy enough to carry the currents needed without overheating. Usually selection of a transformer is made from manufacturers' product lists using the nearest listed, with any difference being on the conservative side — higher voltage or higher current capability when the exact requirement is not available. The power capacity of transformers is stated as the volt-amp

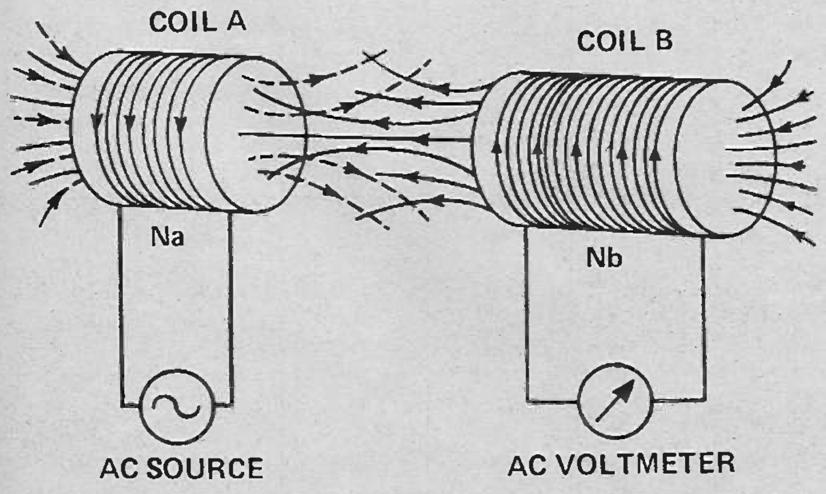
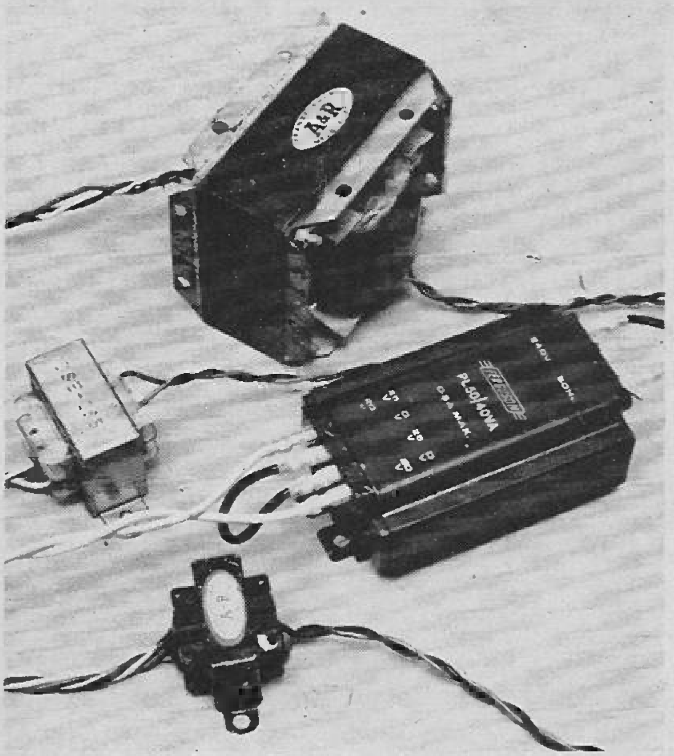
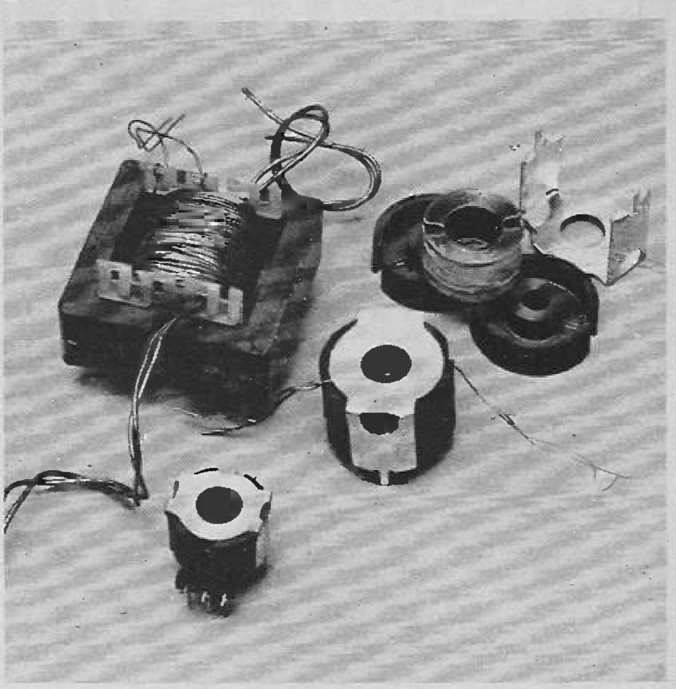


Fig. 2. Transformer relies on the principle that when lines of magnetic force move through a coil, a voltage is induced in the coil which is proportional to the number of turns in the coil.

ELECTRONICS -it's easy!





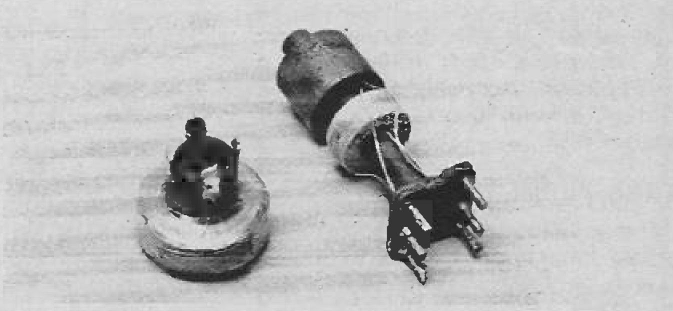
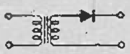
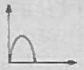
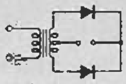
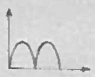
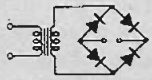
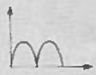
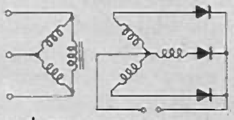
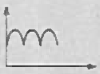
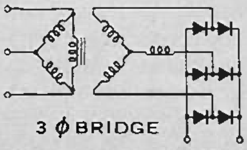
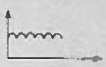


Fig. 3. The design of a transformer depends greatly on the frequency of operation and the amount of power to be handled.
At low frequencies (eg 50 Hz mains) a laminated silicon-steel core is required, (TOP LEFT).
At medium frequencies a ferrite core or slug may well be used to adjust as well as increase inductance (50 kHz to several MHz).
At high frequencies (eg 50 MHz and above) air spaced coils may be all that is necessary, (RIGHT).

Fig. 4. These characteristics of common rectifier arrangements will help you select a transformer to obtain a particular dc output.

COMMON RECTIFIER ARRANGEMENTS

	1 Cycle Output Waveform	Average dc Volts Output	RMS Volts at Output	Peak Volts Output	Peak Reverse Rectifier Voltage	Percent Ripple RMS/dc out
 (A) 1 φ HALF WAVE		1	1.57	3.14	3.14	121%
 (B) 1 φ FULL WAVE CCT		1	1.11	1.57	3.14	48%
 (C) 1 φ FULL WAVE BRIDGE		1	1.11	1.57	1.57	48%
 (D) 3 φ STAR (WYE)		1	1.02	1.21	2.09	18.3%
 (E) 3 φ BRIDGE		1	1.00	1.05	1.05	4.2%

product of the total output or input. This can be found as the product of volts times amps of all of the secondary output circuits plus about 10% for losses.

All transformers have rms rated outputs. In practice this voltage is the *unloaded* output voltage and may vary from transformer to transformer. Additionally, because of the finite winding impedance, the transformer output will drop when loaded. This effect, known as transformer 'regulation', is quoted as the percentage voltage between load and no-load. In prototype designs it is therefore advisable to use a transformer with a number of tappings so that the correct rms output may be selected on test.

RECTIFIER STAGES

Many different rectifier systems may be used, Fig. 4 shows the most commonly encountered, together with their schematic diagrams and relevant conversion factors. Note that the dc output *is not* the same as the ac input. A mistake commonly made by beginners is to assume that the dc output from the rectifier will be the same or less than the rms output from the transformer.

A single rectifier , as in A, gives half wave operation only and clearly, whilst saving a rectifier element, only allows half the sine-wave through with a resultant drop in average dc output. The gain in saving rectifier elements is offset by the need to provide a higher output voltage from the transformer and a more powerful filter to smooth out the pulsating dc current (121% ripple!).

Clearly, fullwave rectification (that is, use of both half cycles) is better but it requires more rectifiers. There are two main methods. One uses four rectifiers to create a 'reversing' switch — the so-called bridge circuit. Output current from the transformer of one polarity passes through to the filter stage using two of the rectifiers; the next direction of current is then allowed through by the second pair which are connected to accept reverse current polarities. An alternative full-wave method uses only two diodes instead of four. It works as two half-wave systems that alternately connect to the common filter terminals with the same polarity. It uses less rectifier elements than in a bridge circuit but requires a centre-tapped transformer. Rectifier diodes for bridge circuits are available ready-packaged as a full 4-element bridge in a common encapsulated unit.

Where a three-phase (the normal industrial high-power mains) supply is available, other rectifier arrangements are possible — as shown. As the number of phase half-cycles used is increased the dc produced becomes smoother, relaxing the degree of filtering needed. Other more sophisticated six-phase systems (using special transformers) are used industrially.

Originally, rectifier elements were either vacuum-tube diodes (two-element tubes) or specially made contacting surfaces of copper oxide or selenium. Although both of these are still in service, they have been more or less superseded by modern solid-state, two-layer semiconductor diodes (in the simplest form) and by the family of multiple-layer semiconductor devices in which the current can be controlled as well as being rectified. (These devices, SCRs and TRIACs, will be covered later.)

Virtually all diodes designed for power rectification are now silicon devices — although germanium still finds some use for low-power, signal-detection diodes. The power handling capability of a diode depends upon the voltage drop across it and the current flowing through it. These determine the heat to be dissipated at the diode junction. Provided the *junction* itself is maintained below its maximum safe value, all is well. Heat sinks are usually used to help liberate this waste heat, thereby raising the current capacity of the rectifier units. When selecting diodes for power use it is necessary to ensure that they can safely withstand the peak reverse voltage of the waveform — this can be as much as three times the quoted ac value (which is usually the rms value). In the manufacturer's data this is shown as the peak inverse voltage (PIV). In a half-wave circuit supplying, say, a 100 Vdc output, the peak inverse voltage rises to 314 V!

Diodes come in all shapes and sizes as Fig. 5 shows. Large power diodes are intended to be mounted on heat sinks and the manufacturers have built them accordingly to ensure good thermal contact. Special heat-sink extrusion is made for this purpose.

Individual diodes in a bridge circuit must be insulated from one another — nevertheless it is often convenient to mount them on a common heat-sink. Mica washers are often used for this purpose as they provide good electrical

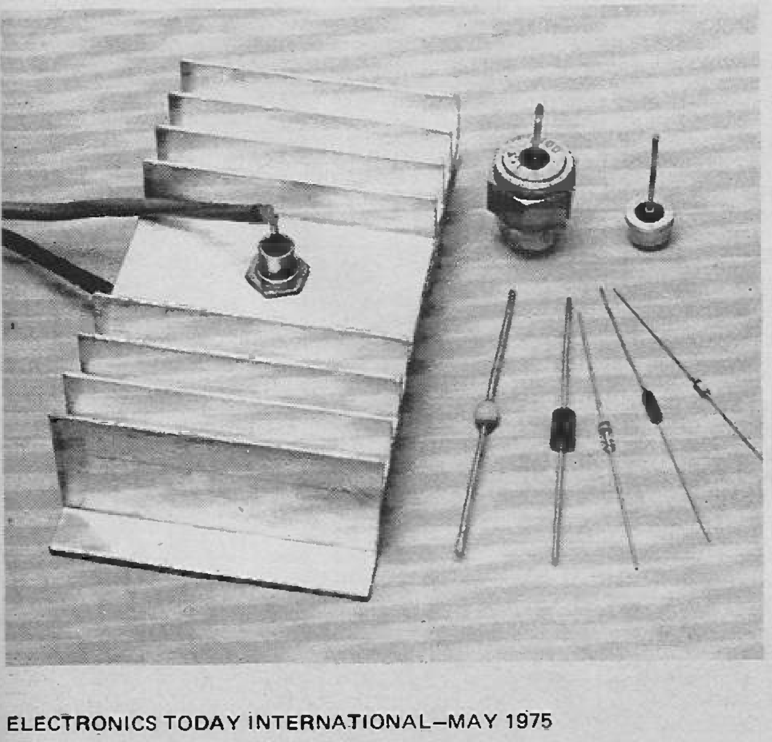


Fig.5a, A selection of commonly used solid state rectifiers. High-power diodes are sometimes mounted on a heatsink to help radiate the heat generated due to internal losses.

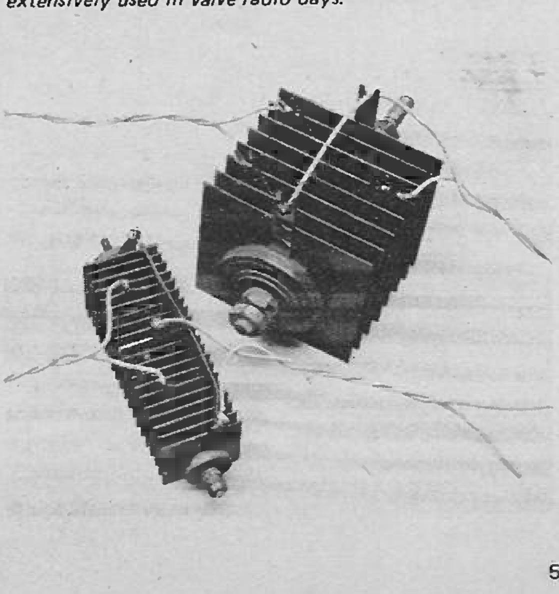


Fig.5b, Selenium rectifiers were quite bulky but were extensively used in valve radio days.

insulation whilst allowing heat to be passed through.

The current rating needed for the diodes depends upon the rectifier circuit. If half-wave it must be able to handle the full current expected. For full-wave bridge or centre-tapped single-phase arrangements, the diodes only switch on alternate half cycles and, therefore, can be rated for half the output load current. Special care must be used when silicon diodes are used. The initial onrush of current to the uncharged filter capacitors can exceed the safe maximum of the diodes unless adequate limiting resistance exists in the transformer winding or input leads. Typically, the peak current may be as much as 10 times the average dc current.

FILTERING

The output of any rectifier system consists of a train of half-sinusoid waveshapes. We know that all waveshapes can be constructed by adding a number of pure sinusoidal signals. Thus the rectifier output is a complex waveshape containing a basic dc level plus many other frequencies. To smooth the signal, therefore, a low pass filter is needed that rejects all frequencies above dc (frequency of zero).

Several alternative methods of filtering are available. The commonest, shown in Fig. 6, is to use a large value shunt capacitor across the output terminals. At each new half-cycle the diodes pass a burst of current into the capacitor to recharge it, making up for charge drawn by the circuit load on the supply. By appropriate choice of capacitor size for a given load and adequately low bridge resistance (this decides how quickly the charge will enter the capacitor), the supply can be made to hold a voltage up near the peak value of the waveform. However care must be taken to ensure that the

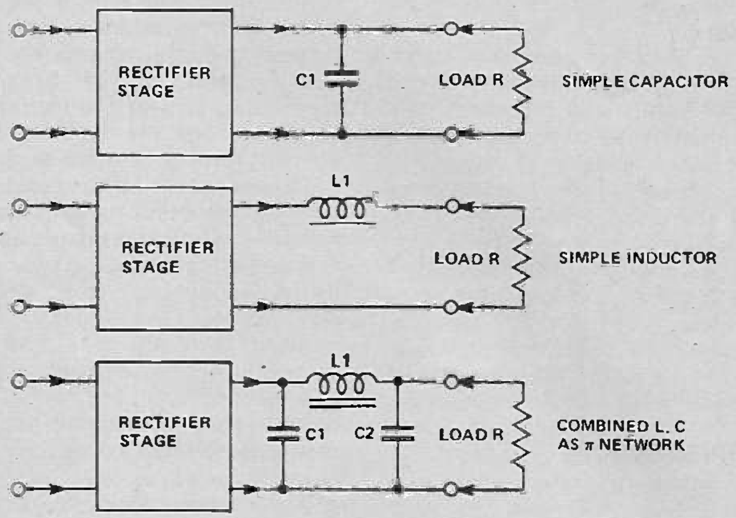


Fig.6. Various types of filter may be used to smooth the pulsating dc from the rectifier. (a) a simple capacitor (b) a simple inductor. (c) a combination of capacitance and inductance (pye filter).

peak current rating of the diodes is not exceeded.

In applications where a relatively large power level is involved it may be more economical to use another method. The shunt capacitor method, above, provides a short-circuit path to high frequency signals (capacitive reactance falls with increasing frequency) thereby shunting them away. Only dc is unattenuated. The same effect may be achieved if an inductor is used, as shown in Fig. 6 – but this time in series with load. The inductor provides lowest impedance to lowest frequency so dc passes virtually without loss (provided the dc resistance of the winding is low – hence the high cost of effective filter inductors) but provides increasing impedance as the signal frequency rises.

These two basic methods can be taken further again using both together to increase the frequency rejection. We will not pursue the design of sophisticated power supply filters for they tend to be rather specialised. Note, however, that the filtering effect depends largely upon the magnitude of the load current drawn. This can be seen by regarding the filter component reactance and the load impedance as a series or parallel network (see Fig. 7) in which the supply voltage is the output produced across the load impedance.

An increasing load current occurs due to a reduction in load impedance (usually regarded as a resistive load). The series inductive method provides less ripple (the name given to the ac component-present) as the load increases. On the other hand, with the capacitive shunt method the ripple increases as load increases. Hence the

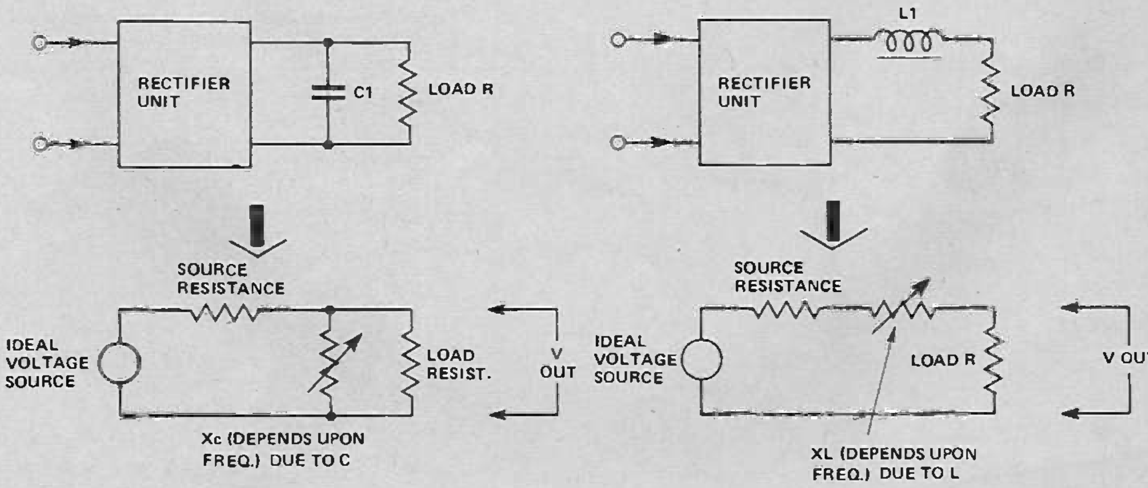


Fig. 7. The performance of a simple filter may be evaluated by replacing the capacitor (etc) by its equivalent resistance at the ripple frequency. Thus we have a voltage divider due to this and the source impedance. We may also from such equivalent circuits calculate the degree of regulation for any given load.

two methods complement each other and (as neither is ideal) the two are combined in more advanced filtering methods.

It should now be clear that the rectifier stage design will largely determine the specification of the transformer and that the filter method must also be considered in the overall design.

Power supply design is not as straightforward as might at first be thought. Each stage determines the requirements of the other stages so a certain degree of skill and experience is needed to reach a satisfactory design. Furthermore, as we will see later, the design must also make allowances for the way the supply is to be used and for the method of stabilisation employed.

POWER SUPPLY TERMS

The two forms of power supply — voltage or current — as we have seen earlier, can be represented as black boxes which consist simply of a source (voltage or current) and an equivalent resistance value. A voltage source ideally maintains the required voltage regardless of load current. A current source, the reverse situation, provides the required current regardless of output voltage. Practical supplies have a finite resistance value (the ideal of zero output impedance is unobtainable) but it is possible to produce a circuit that is close enough to the ideal for practical purposes.

Let us now see what happens to a voltage supply as the load current increases. We see from Fig. 7 that the voltage appearing across the load is that produced by a perfect generator driving a divider chain. Hence, provided the source resistance is much smaller (at least ten times smaller) than the minimum load resistance, the change in voltage across the load as the load current varies will be negligible. The aim, therefore, in good voltage supply design is to produce a unit with low internal resistance. Factors of one thousandth are typically obtained.

Constant voltage supply is by far the most common requirement, but there are also many applications for constant current supplies. In addition there are other supplies available with special characteristics.

Because of finite internal power-supply resistance the voltage output of basic supplies (caused in reality by the resistance of the diodes, transformer losses and filter resistances) drops as the load current increases. All these effects produce voltage drops that subtract from the original voltage source. The ratio of, no load voltage (less full load voltage) to the no load voltage is called the regulation of the supply. This is expressed as a percentage.

IMPROVING REGULATION

In some instances, battery supplies for example, the internal resistance is adequately low and the output remains reasonably constant with time and changing load. A lead-acid storage battery for example will provide voltage constant to about 0.1% for quite a long time as long as the load is fairly low.

Mains derived supplies, however, exhibit poor regulation, unless (costly) stabilising circuits are added. Apart from this their output is also proportional to changes in mains voltage — which can fluctuate by as much as ±10%.

In many electronic systems the voltage must remain constant regardless of changes of mains input and load and changes in component values with time. Consequently, basic sources of dc power are often followed by a unit known as a regulator. Its role is to maintain the output constant to a chosen degree (0.1% changes in output due to load or input changes is typical). The degree of stability obtained relates to cost. Techniques cover a wide range — from a single special diode and a resistor, to multiple transistor circuits and special purpose IC's.

Power systems such as these will be covered in the next part of this series.

ELECTRONICS — in practice

THIS month we will continue our discussion of operational amplifiers by looking at some of the design considerations for one of our most popular projects. The circuit uses two op-amps, illustrates a number of new points and provides a very useful piece of equipment.

A MIXER-PREAMPLIFIER CIRCUIT USING OP-AMPS

The signal provided by a sensor operating at audio frequencies, eg a microphone, a guitar-string vibration sensor, a record-player cartridge — needs boosting before the signal is used to drive a main amplifier or recording unit. The preamplifier shown here accepts signals of around 2 mV level, has an input impedance of

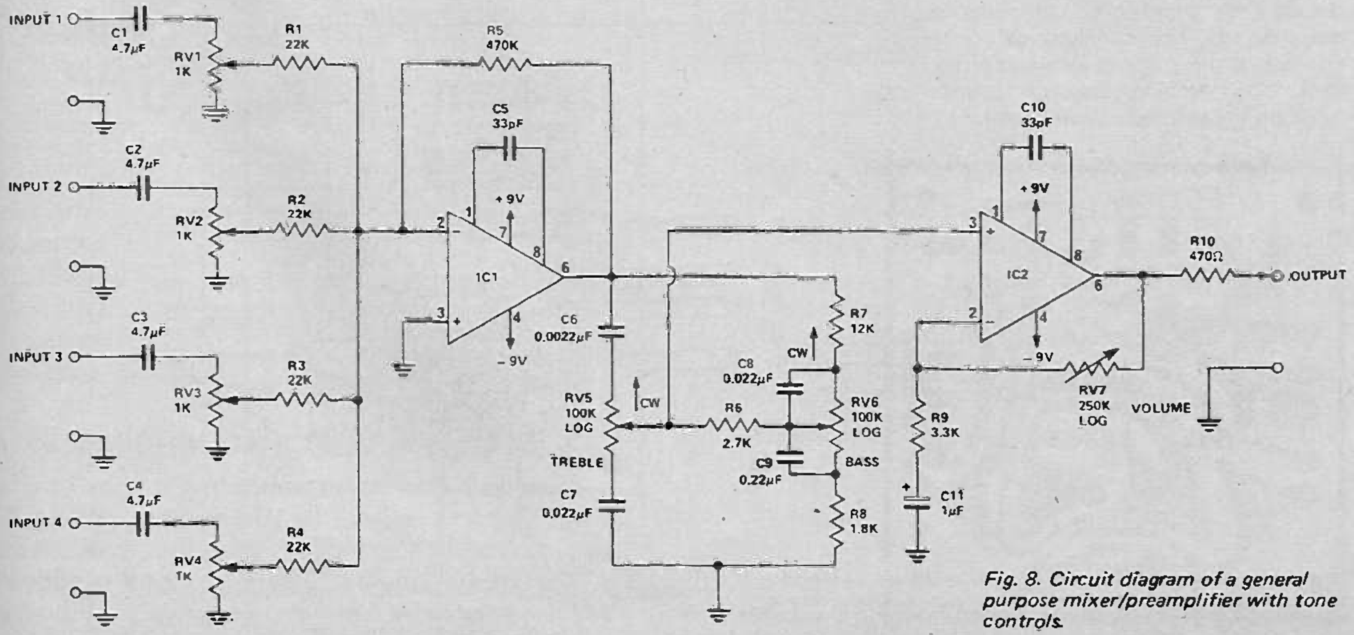


Fig. 8. Circuit diagram of a general purpose mixer/preamplifier with tone controls.

1 k, provides a gain of approx. 1600, and has an output swing of up to 3.2 V for 2 mV input. It introduces comparatively little distortion and is designed to accept four inputs, each having a level control. A special tone control network is incorporated that enables bass and treble signal frequencies to be varied over ±10 dB (at 100 Hz and 10 kHz respectively). Although primarily intended for mixing audio signals in entertainment applications, the circuit can also be used as a single-input, variable-gain unit in any application where gain and frequency adjustment are needed.

OPERATION OF THE MIXER-PREAMPLIFIER

Each input of the circuit given in Fig. 8 is ac coupled and has an attenuating potentiometer that allows the gain of each input channel to be independently adjusted as required. Four such inputs are summed by an inexpensive IC op-amp, connected as a summation circuit, having a maximum stage voltage gain of around 20 (25 dB).

The output of this stage feeds the next stage via a conventional tone control network which either attenuates or boosts bass and treble frequencies according to the settings of each potentiometer. Note that the second stage op-amp is connected as a non-inverting (the output signal has the same polarity as the input) single-input amplifier stage having a maximum gain of about 80 (37 dB). The feedback resistor, in this case, is a potentiometer allowing the overall gain of the unit to be varied. Thus this potentiometer acts as a master gain control.

In the circuit diagram (Fig. 8) the power supply connections are not shown. This is usual in op-amp circuitry to avoid over complicating the diagram. The connections are — positive to pin 7 and negative to pin 4. These connections are, of course, made on the printed circuit board.

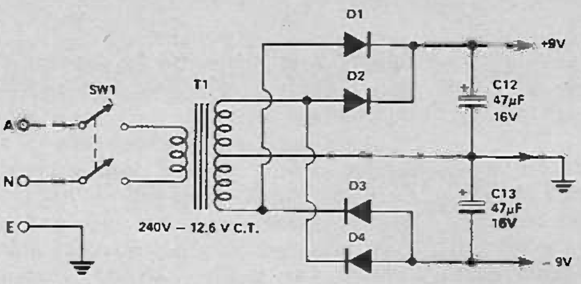


Fig. 9. Circuit diagram of an unregulated power supply suitable for use with the preamplifier of Fig. 8.

A simple power supply (Fig. 9) may be used if batteries are unsuitable. This provides the positive and negative supplies necessary for the op-amp. At first glance the circuit appears to be that of a full-wave bridge. In reality it is two separate supplies, driven from different sides of a centre tapped transformer, each being connected in the opposite way to provide opposite polarities.

Note that the transformer supplies a total of 12.6 volts rms, that is 6.3 volts on either side of the centre tap. This, when rectified and filtered, provides 9 volts dc (capacitor charges to peak of waveforms that is $\sqrt{2} \times 6.3 = 8.9$ volts). Hence the capacitors must be rated for at least 9 volts — a little more is usual, say 12 volts, but not too much higher as the rated capacity of some capacitors falls if not worked at near full design voltage.

The diodes must have a peak-inverse rating of *twice* the peak voltage, 18 volts in this case, because at the time when the diode is non-conducting it has the charged capacitor voltage on one side and the full peak reverse voltage from the transformer on the other. In practice modern silicon power diodes have voltage ratings starting from about 50 volts and the 1N4001 specified is rated at 100 volts — much more than is required.

BUILDING THE UNIT

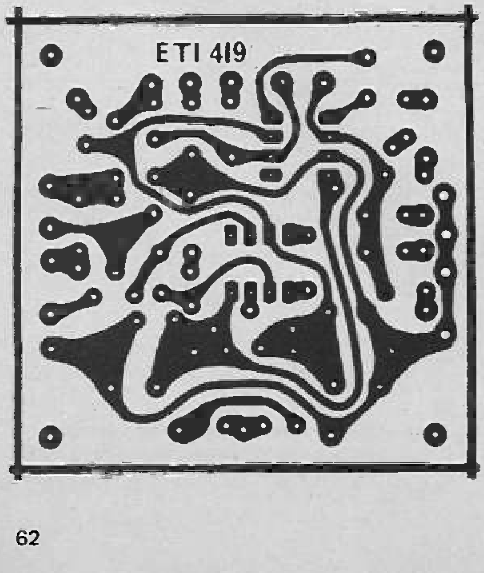
A printed circuit-board layout for the pre-amplifier is given in Fig. 10 along with the component overlay that shows where each component is placed. Take particular note of the polarities of the diodes, the ICs and the electrolytic capacitors when fitting them to the board.

The power supply components (watch the mains connections — they must be made safe) and the board may be conveniently housed in a diecast box or one of the plastic boxes made for electrical use. Mark each control clearly for ease of operation. ●

Parts List for mixer/preamplifier

R1	22 k	½ watt	5%
R2	22 k	½ watt	5%
R3	22 k	½ watt	5%
R4	22 k	½ watt	5%
R5	470 k	½ watt	5%
R6	2.7 k	½ watt	5%
R7	12 k	½ watt	5%
R8	1.8 k	½ watt	5%
R9	3.3 k	½ watt	5%
R10	470 k	½ watt	5%
RV1	potentiometer		1 k log.
RV2	"		1 k "
RV3	"		1 k "
RV4	"		1 k "
RV5	"		100 k "
RV6	"		100 k "
RV7	"		250 k "
C1	4.7µF	10V	
C2	4.7µF	10V	

C3	4.7µF 10V
C4	4.7µF 10V
C5	33 pF ceramic
C6	0.0022µF polyester
C7	0.022µF "
C8	0.022µF "
C9	0.22µF "
C10	33 pF ceramic
C11	1µF 25 V tag tantalum
C12	47µF 16 V electro. P.C. mount
C13	47µF 16 V electro. P.C. mount
IC1	LM301A
IC2	LM301A
PC Board	
SI DPDT toggle switch, 400 V, 1 AMP	
T1 transformer 240V—12.6V C.T. 50mA minimum.	
D1 4 1N4001 or similar	



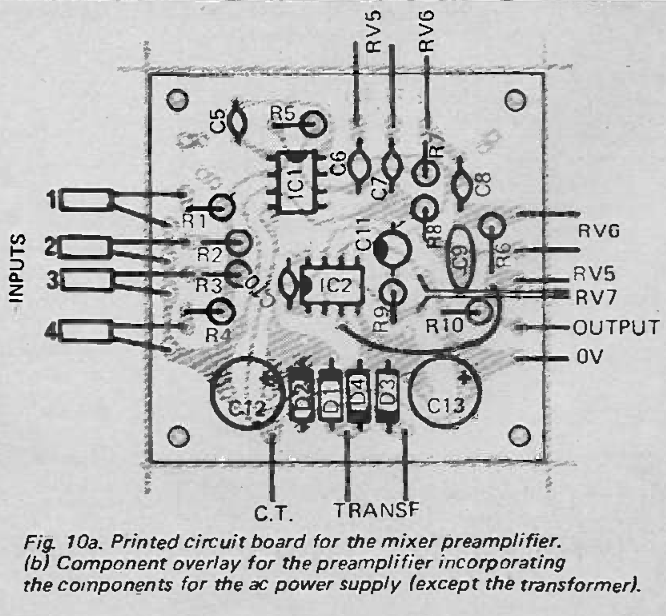


Fig. 10a. Printed circuit board for the mixer preamplifier. (b) Component overlay for the preamplifier incorporating the components for the ac power supply (except the transformer).

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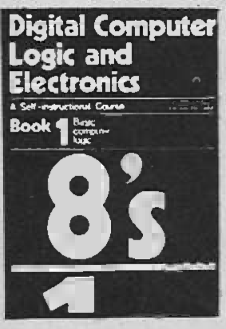

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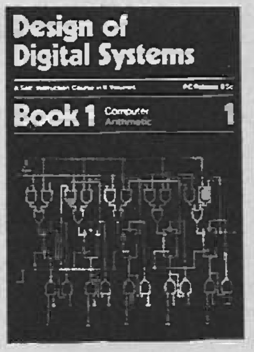

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Electronics Tomorrow

by John Miller-Kirkpatrick

FIRST OF ALL I must apologise in advance for mentioning two of my favourite subjects again - calculators and television sets. I am not about to launch into a praise or criticism of anybody's new pocket calculator or a new television set but the modifications thereto.

Let me introduce you to three new products from the Mostek stable, all based on calculator chips in one way or another. Two of these chips are in fact reprogrammed calculator chips, reprogrammed internally that is. The MK50206 was a standard four function calculator chip until some genius designer came up with the idea of changing some of the internal count registers to divide by 6's instead of 10's. This unit is then fed with 1Hz pulses which (I assume) are ADDed into the count register, presented to the display register, and end up on a four digit display. In case you haven't already guessed, the chip is now a digital clock, but a clock chip with a few very important differences. For a start the time setting is done via a standard calculator keyboard thus making the setting up procedure very simple and very fast, and it could be done via logic gates instead of the keyboard. One of the other main features of a calculator which has been inherited by the MK50206 is the ability to compare two numbers or to be able to test for zero. The MK50206 has several comparison systems; two alarm times may be set as an accessory start time and an accessory stop time, a minutes and seconds timer can be set up to count down to zero and then switch off an accessory.

When power is initially applied to the MK50206 it lights up with the display flashing to indicate a power failure. This condition is reset by pressing the CLEAR key. The correct time is then set by pressing the SET TIME key and then entering the desired time in hours and minutes from the keyboard including the AM/PM key, pressing the DISPLAY CLOCK key will start the clock running normally. If an illegal entry is made (such as 11.65) the display will flash and the alarm will beep three times as soon as the DISPLAY CLOCK key is pressed. The countdown timer works by pressing the COUNTDOWN TIME key and entering the desired run time in minutes and seconds. The timer is allowed to run by closing the TIMER ENABLE switch and pressing START TIMER, it can be stopped by opening the TIMER ENABLE switch. When the counter reaches zero the timer output will switch off, the display will switch to time of day and the alarm will beep once. The accessory timer is used by pressing RUN TIME and entering the desired run time in hours and minutes and then pressing STOP TIME and entering the desired accessory stop time in hours and minutes, the chip then calculates the required accessory start time. The accessory will then be turned on and off at the appropriate times each day. Applications for such a chip include tape recorder controls, cooking ranges, central heating, street lights, and many other forms of time switching applications.

The second chip is from the same family as the first and is identified by the code MK50204. This IC is still a calculator chip and can be used in a standard four function calculator - but it has additional advantages. The MK50204 acts as a standard 50200 series calculator with the added features of hours/minutes/seconds to seconds and seconds to hours/minutes /seconds conversion functions and stopwatch timing. Conversion is made by simply entering hours/minutes/seconds or seconds and pressing the appropriate conversion key. The stopwatch is used by connecting digit 9 output to the KQ input line via a simple toggle switch. The stopwatch will count up if the plus key is pressed or down if the minus key is pressed. The count will stop if the equal key is pressed and then resume if the plus or minus key is pressed. The count can be initiallised by entering a time in seconds before switching into stopwatch mode, this time is then converted into the hours/minutes/seconds/1/10th seconds format used for counting. The information sheet from Mostek did not say what the timing frequency source was, but I presume that a standard CR network is used, in which case it could be replaced with a crystal source to give a very accurate stopwatch which, if necessary, could be started and stopped with logic gates in parallel with the keyboard.

So much for modified calculator chips which still look like calculator chips and use keyboard type inputs. The MK50395 is a six decade synchronous up/down counter/display driver with compare register and storage latches. The counter and the compare register can both be loaded digit by digit with BCD data, and the counter also has asynchronous clear and count inhibit functions. Figure 1 shows a possible application of the chip together with TTL inputs, BCD switch inputs and a six digit display. The counter can be loaded from the TTL data by multiplexing the data and entering it digit by digit, the load is controlled by the 7410 which gives the multiplexer a BCD form of which digit is being presented by the MPX SCANNER on the 50395. Once the data has been stored in the count register it is latched into the display register and displayed, if the latch control is now removed then the display will continue to hold the loaded number regardless of any changes in the count register. Let us assume that the number that has been loaded from the TTL is the required number of production units to be despatched from a conveyor belt for a specific order. As each unit passes a photo-cell counter it causes the count to be reduced by one each time. When the counter reaches the number that has been set up on the BCD switches, the compare equal output will change state and sound an alarm which also stops the conveyor belt. An operator then manually restarts the belt at a slower speed and supervises the packing of the final units. When the count reaches zero the belt will stop again to allow the operator to remove the packing box, mark on it the number of units loaded from the display and then press a button to inform the system to get the next quantity ordered from the TTL control.

This simple example shows most of the functions of the 50395 chip but we have not used the clear counter function, the count up function or the load comparator function. The display can show the actual count and does not have to be latched and either of the BCD inputs can be from switches or TTL or indeed any other form of BCD input. A very versatile little chip which can perform various count and control functions, it could replace the unit which was described in Electronics Tomorrow last year using an Advance calculator.

I mentioned television sets at the beginning of this article for two reasons. Firstly to remind you that CEEFAX/ORACLE is now being transmitted and that the IBA are now doing test transmissions as well as the BBC. If you already have a receiver then the two organisations would like to hear your comments on the system, if you haven't built a receiver yet then do so at the earliest opportunity - it's a British development which could do with your support. If you want further information on CEEFAX/ORACLE then either the BBC or IBA can supply you with a booklet with technical information for the modest sum of 50p plus P & P.

The second reason for mentioning television sets was to hopefully pre-release some information about a set of clock chips which will display the time on your TV screen. The data and permission to release it has not yet arrived on my desk and so it will have to be held over until next month.

Will the data arrive in time?

Can Captain Marvel escape the clutches of the evil monster and rescue the fair damsel in distress?

Will the 'copy' reach ETI offices this month? Do not miss next month's thrilling installment ●

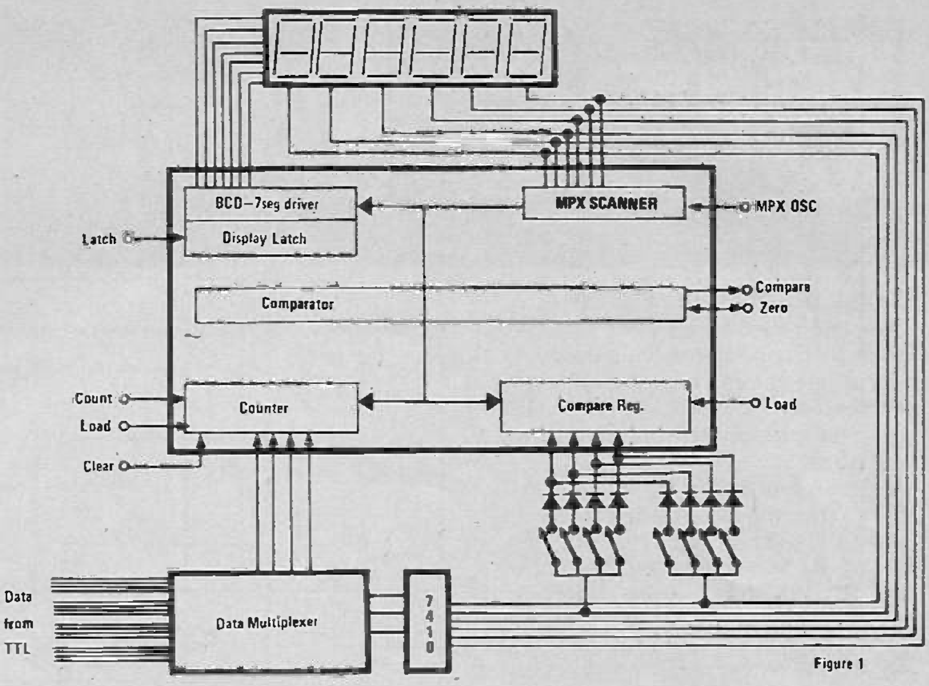
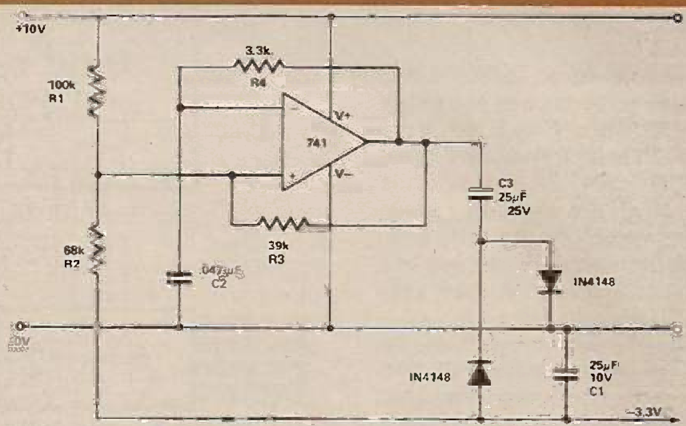


Figure 1

tech-tips

SIMPLE DC–DC CONVERTER



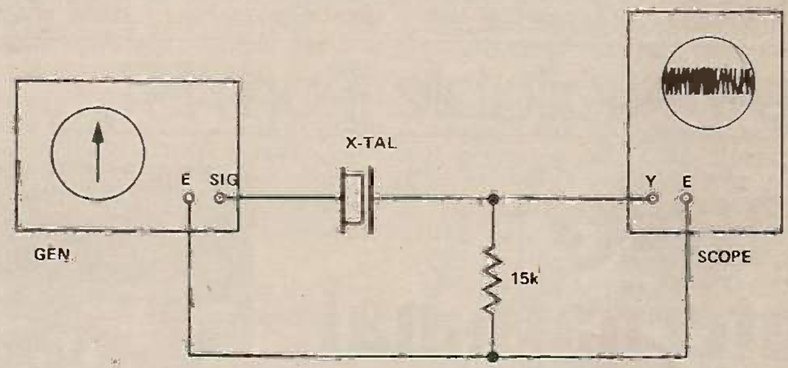
Often in circuit design it is handy to have a low-current negative rail available to bias FETs etc. This circuit generates a supply rail 2 to 5V below its 0V line.

If the lower end of R2 is connected to 0V, then the circuit is seen to be an op-amp relaxation oscillator driving a pair of diodes that charge C1 negatively. R3 provides positive feedback, changing the switching point of the op-amp, according to whether C2 is charging or discharging through R4. When the voltage on C2 reaches the switching point, the circuit changes state, and the C2 voltage sets out for the other switching point.

When the lower end of R2 is attached to the negative output, then as the negative charge on C1 increases, the operating range of the oscillator is pulled down until it is outside the operational range of the 741, and the charging ceases. This provides a form of switching regulation of the output voltage, roughly halving the output impedance. The output voltage can be set to the desired value by altering R2. For 3.3V output the prototype showed about 10mV ripple on full design load of 1mA.

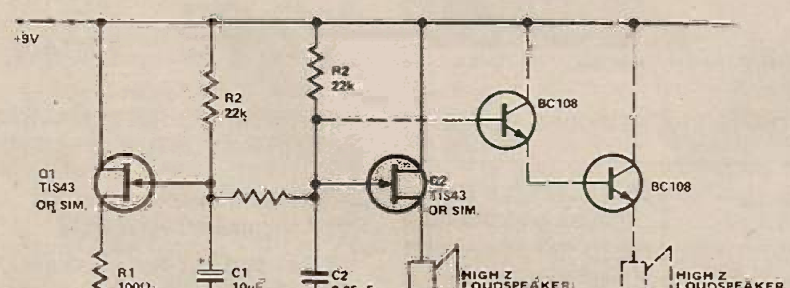
The output is inherently short-circuit protected by the current-limiting action of the 741.

CRYSTAL CHECK-UP



If one has access to a signal generator and oscilloscope, the hook-up shown will check both the generator and crystal. As the frequency is increased, the low impedance series vibration of the Xtal can be observed by a sharp increase in Y amplitude. This is followed by a dip as the Xtal goes into the high impedance parallel mode. The harmonic activity can be checked by comparison with the fundamental.

SIMPLE SIREN



The circuit consists of two unijunction relaxation oscillators, Q1 for low frequency and Q2 for audio frequency. R3 couples the slow rising voltage across C1, determined by the time constant C1 and R2, to the audio frequency across C2, determined by the time constant of C2 and R4. The effect is that the audio frequency generated by Q2 rises in pitch as the slow rising voltage across C1 is applied, via R3 to the time constant C2/R4.

This type of sound carries much further than a continuous note from a single oscillator. Extra amplification can be achieved, by adding two transistors in a super-alpha arrangement as shown dotted. R5 should be replaced by a 100 ohm ¼W resistor.

Connected to a pressure mat (from across C2), this unit would make an excellent baby snatch alarm for prams.

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

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

VARIABLE FREQUENCY MULTIPLE WAVEFORM GENERATOR

Signetics 566 IC chip lends itself ideally as a test generator by utilising its internal voltage controlled oscillator (VCO).

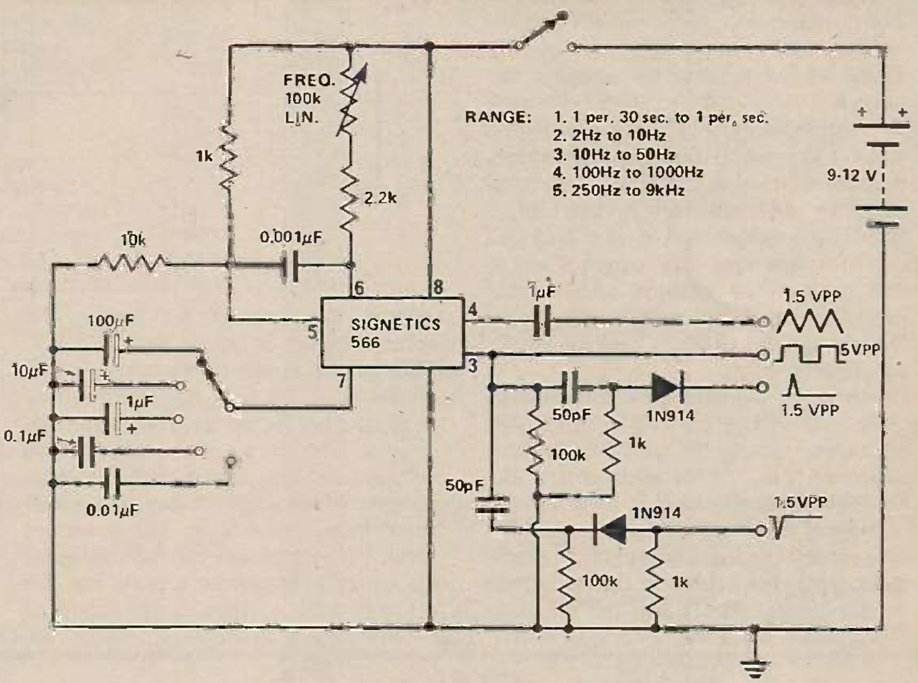
The circuit will deliver separate outputs giving triangular and square waves and both positive and negative going spikes.

The square wave amplitude is 5 V pk-pk, all other waveforms are 1.5 V pk-pk.

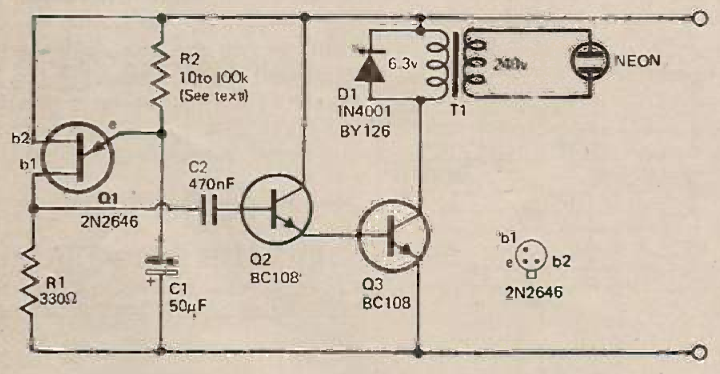
Frequency is determined by the value of the capacitor connected to pin 7.

It is preferable to use tantalum capacitors rather than electrolytics.

The outputs are designed to operate into high impedance loads. A transistor buffer stage is needed to match to low input impedance devices.



NEON TUBE FLASHER



Flashing neon globes have use in many applications, however their relatively high working voltage precludes their general use where a mains supply is not available.

This circuit enables neon tubes or bulbs to be operated from a low voltage dc supply.

The voltage required to ignite the neon tube is obtained by using an ordinary filament transformer (240-6.3V) in reverse.

Battery drain is quite low – being in the region of 1 to 2 milliamps for a nine volt battery.

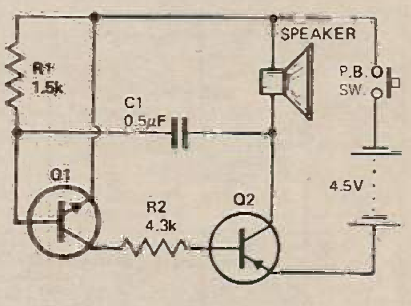
Q1 is a unijunction transistor and operates as a relaxation oscillator. Its frequency of operation is determined by R2-C1.

The pulses from Q1 are directed to Q2 which in turn drives Q3 into saturation.

The sharp rise in current through the 6.3V winding of the transformer as Q3 goes into saturation induces a high voltage in the secondary winding causing the neon to flash.

The diode D1 protects the transistor from high voltage spikes generated when switching currents in the transformer.

TRANSISTORISED BEEPER

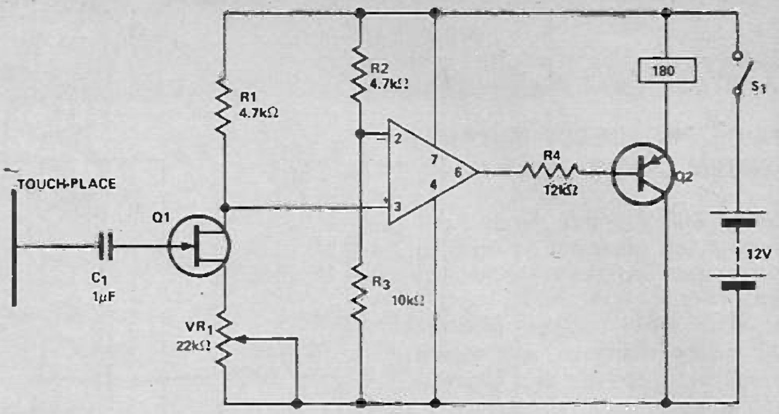


This circuit consists of an assymetric multivibrator activated by a pushbutton. The loudspeaker is a transistor radio type with a voice coil impedance of about 25 to 40 ohms. Earpieces up to 500 ohms can be used for lower power output. R1 varies frequency over the audio range.

Transistor Q1 can be any LF small signal type (NPN), either germanium or silicon. (AC127, BC107, BC108 etc). Q2 is a small signal germanium type of up to 1A collector current. (AC128, AC132, AC188 etc). The battery size should be determined by the drain current of Q2.

tech-tips

TOUCH-SENSITIVE SWITCH



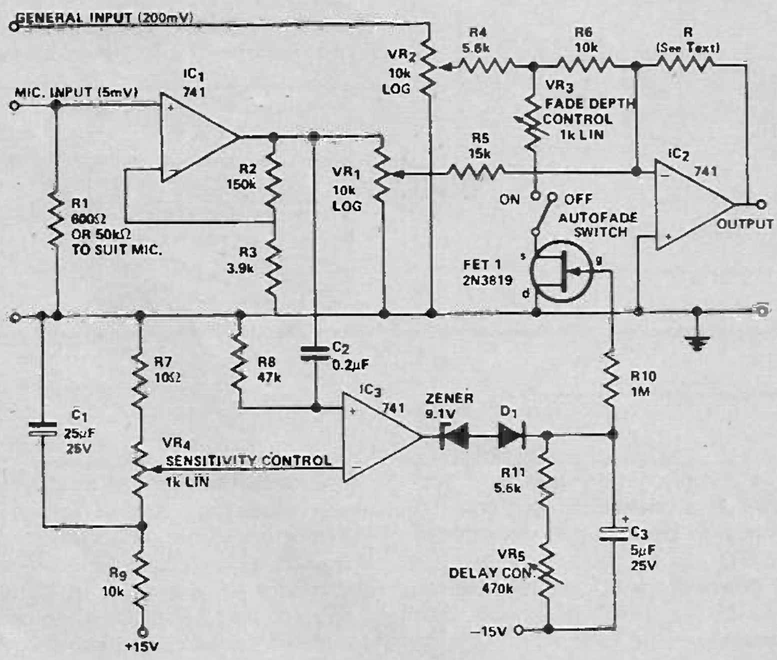
The circuit illustrated can be set to energise the relay when the plate is lightly touched. Under certain circumstances the proximity only of the body is sufficient to operate the switch.

A high impedance input is provided by Q1, a general purpose field effect transistor such as 2N3819. A general purpose 741 op-amp is used as a sensitive voltage level switch and this in turn operates the current buffer Q2, a medium current pnp bipolar transistor, thereby energising the relay which can be used to control equipment, alarms etc.

In the quiescent state, the voltage at pin 3 of the op-amp is set higher than the voltage at pin 2 by adjustment of VR1. This ensures that the voltage at pin 6 is high and Q2 and the relay are off. Upon lightly touching the touch-plate, a decreasing reverse bias V_{GS} increases the drain current flowing through Q1 and the resultant voltage drop across R1 lowers the voltage at pin 3 below that at pin 2. The voltage at pin 6 falls and switches on the relay via Q2. Resistor R4 may need to be selected to ensure that the relay is held off since a small positive voltage at the output remains even though the voltage at pin 3 is lower than that at pin 2 in the quiescent state. This problem can be overcome by using dual power supply for the op-amp in the more usual mode of operation of this device. Component values are not critical and there is considerable scope for experimentation.

The sensitivity of the circuit to the proximity of the body depends upon the nature and strength of the surrounding electromagnetic fields produced by mains wiring and equipment in the vicinity, for it is the pick-up of this energy which the body couples to the circuit.

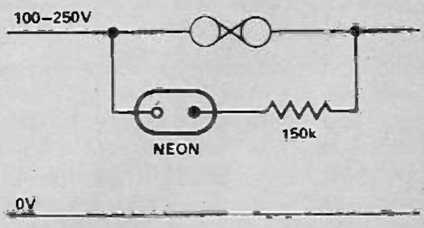
DISCO AUTOFADE



This is an autofade circuit for use in discotheques and the like. This autofade unit has advantages over VCG ICs which introduce distortion and noise (the 741s may be substituted by low noise op-amps) by using a FET to switch the signal gain characteristic. The principle may be easily adapted into existing mixers.

The microphone is amplified by IC1 and fed to the input mixer (IC2 the gain of which is set by R) and to the comparator IC3. If the input is large enough (larger than the voltage on the wiper of VR4) the output swings positive and charges C3 (in about 4mS). When the voltage across C3 is sufficient the FET is turned fully on and the fade depth control is grounded hence attenuating the signal. The FET turn off time is determined by R11, VRs and C3 and may hence be varied between 25mS and 2.5S.

BLOWN FUSE INDICATOR



Here is a very simple method of identifying a blown fuse. This is of course more advantageous on systems employing several fuses.

Across the fuse holder is wired a neon in series with a resistor. When the short circuit, or whatever, blows the fuse, the neon will light indicating immediately the area of the fault. Neons with built-in resistors need not of course have an extra 150k as shown.

 Continued from page 8.

TEXAS SR-51

Texas Instruments have a new scientific calculator, the SR-51. It combines scientific functions and statistical analysis and includes the features of the SR-50. Algebraic logic is used and for statistical analysis there is automatic computation of the mean, variance, standard deviation, least squares, linear regression, factorials, permutations and a random number generator is included.

The random number generator function, which gives a two digit readout, is believed to be unique. The least squares linear regression provides for a minimum of two and a maximum of 99 data points. This feature is particularly useful in business applications such as projecting future earnings and in scientific applications such as the correlation of experimental data. The basic mathematical functions include trig functions and their inverse, hyperbolic functions and their inverse powers and roots, common and natural logs and anti-logs. Others include percent, delta percent, constant mode for group calculations and a fixed or floating decimal point option. The constant key allows the user to perform group calculations using the four basic functions, plus y^x, $\sqrt[x]{y}$, and delta percent.

Three separate accessible memories greatly extend the usefulness of the SR-51. These memories are accessed either as direct storage, summation in to memory or product of memory and displayed quantity entered in to memory. Twenty common engineering conversions and their inverses, including 13 metric conversions can be performed.

The SR-51 display is a 14-digit red LED display made up of a 10-digit mantissa, a 2-digit exponent and two sign digits. Three major MOS/LSI ICs provide all the computational power required for the SR-51. Two ICs are ROMs, storing a total of 26,624 bits and the third is a complex data processor chip.

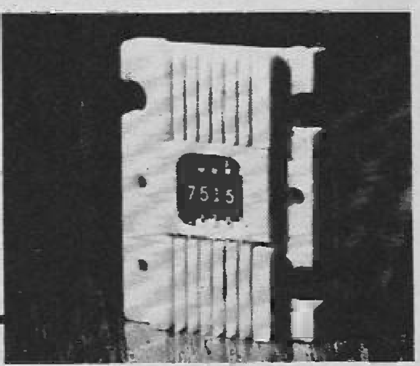
The SR-51 comes complete with carrying case, rechargeable batteries, adapter/charger, operator's handbook and 12 months' guarantee. It costs £129.95 (inc. VAT).

TEA CO_2 LASER

A new TEA CO_2 laser operating at 10.6μm is available from Rofin Limited. The model DDL2SH gives a peak power output of more than one megawatt of infrared radiation. The price of the system is £2651. From Rofin, 13 Alston Works, Alston Road, Barnet, Herts.

'SLIDING BIAS' MINI AF AMP

Bowmar have a new 75dB class A monolithic integrated circuit audio amplifier. The circuit of the BL1100 incorporates a 'sliding bias' class A output stage providing 0.75mW output power with low distortion. The sliding class A circuit adjusts its bias current in response to input signal resulting in power consumption being less than that normally associated with this class of amplifier.



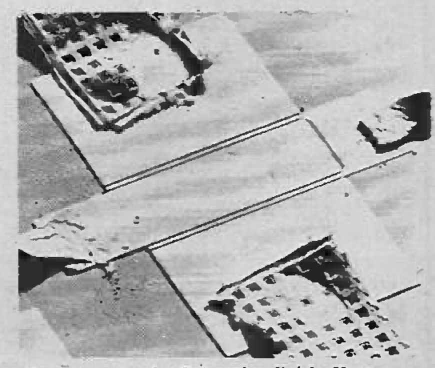
A separate telecoil (for telephone pick-up) and on-chip voltage regulator (for powering electret microphones) make the amplifier ideally suited for hearing aid and low level audio applications. Bowmar are at 41 High Street, Weybridge, Surrey, KT13 8BB.

The Dokorder 1140 is one of several ranges of hi-fi products which are now available in the UK from Acoustico Enterprises Ltd, Unit 7, Space Waye, North Feltham Trading Estate, Feltham, Middlesex, TW14 0TZ. The Dokorder 1140 is a 2/4 channel machine selling at £470 plus VAT. Other Dokorder tape and cassette decks are available, as well as Jensen loudspeakers, Fuji tapes and Jecklin Floats (electrostatic headphones).

HIGHLY CONDUCTIVE ORGANIC COMPOUND

A new type of organic crystal, whose ability to conduct electricity approaches that of some metals, has been fabricated by IBM scientists in the USA. The high conductivity was achieved by replacing sulphur atoms with selenium atoms in a crystal of tetrathiofulvalenium tetracyano-p-quinodimethanide (commonly called TTF TCNQ).

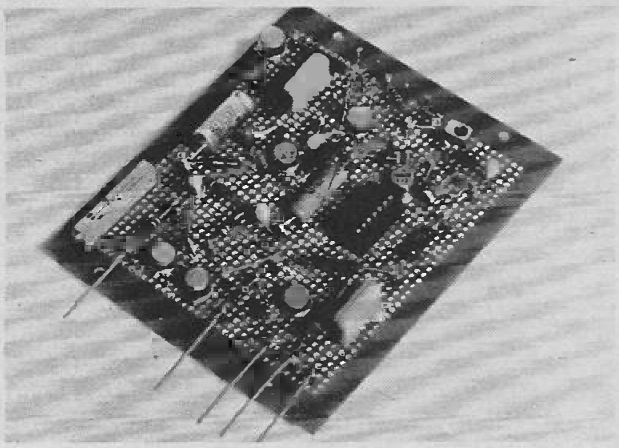
The new organic crystal (called TSeF TCNQ) consists of separate columns of positively and negatively charged organic molecules, allowing for the movement of electrical charges along the columns. It is being studied to see if it can be used in any novel electronic device. At room temperature, the conductivity of organic "metals" lies between that of a metal and a semiconductor, and the conductivity increases many times as the crystals are cooled to cryogenic temperatures. However, when cooled further - below a transition temperature - they are converted from "metals" into semiconductors.



Photograph of a Schottky field-effect transistor made of gallium arsenide. The gate and drain electrodes (right and left) are situated between the source contacts (top and bottom). Specimens have been produced with a cut-off frequency of 40 GHz at a Seimens research lab.

This is the control centre of the London Fire Brigade in Croydon where a new VDU system handles emergency calls for the entire Greater London area South of the Thames. About 100 emergency calls are handled each day and passed to the 45 stations in that 420 square mile area. Control centres in Wembley and Stratford also have the new system, which is said to reduce call handling time by 25 seconds (or 25%) and give clearer call details.

CIRCUIT ASSEMBLY KIT



A re-usable Circuit Assembly Kit (No. 13) is available from Letrokit. It comprises five plain circuit boards and 500 pre-tinned brass solder pins.

The SRBP circuitboards measure 4¾ x 4in. and are perforated on a 0.1in. matrix. The kit costs £4.32 from Letrokit Limited, 3 Trafford Road, Reading, RG1 8JR, Berkshire.

BOWMAR CHEAPIES

Bowmar are launcing two new inexpensive battery calculators, the Mathmate 1 and the Mathmate 11.

The Mathmate 1 is an 8-digit, 5 function machine with floating decimal automatic constant and % for a price of £16.95 (including VAT).

The Mathmate 11 offers the same features as the Mathmate 1, plus a memory facility and is priced at £19.95 (including VAT). Both calculators are covered by Bowmar's one year warranty.

The new BIC 980 turntable available through Belmont A/V Limited - cost will be approximately £99.36 (including VAT). Note the 'Program' control which allows auto play of up to six records. From Belmont A/V Ltd., Fircroft Way, Edenbridge, Kent.

SKYLARK GUIDANCE

The Inertial Systems Department of Ferranti Limited in Edinburgh, whom we mentioned in our March "Space Craft Guidance" article, has been awarded a contract by the Science Research Council to supply two inertial attitude reference units for the Skylark sounding rocket. The contract also covers ground control equipment.

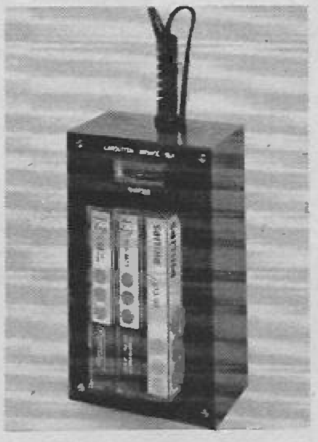
In previous Skylark rockets, attitude control has been achieved using sun or lunar sensors together with an associated gyro stabilisation system. This type of attitude control constrains the rocket launch times to the availability of the optical reference.

The Ferranti system for Skylark is designed to provide a high-precision attitude reference so that the rocket can be pointed accurately in a desired direction in space during the stage of flight when scientific observations and experiments are made. The forthcoming programme of SRC scientific experiments will be concerned primarily with measurement of x-ray emission from space sources and an x-ray survey of the southern skies.

CASSETTE SERVICE SET

Combined Electronic Services Limited are marketing a new Philips Cassette Service Set.

It incorporates a meter measuring



device to indicate any deviation in a 50Hz tone when played back via the recorder under test, compared to a mains frequency signal derived from the test unit. By means of adjustment controls available in the motor control circuit of the cassette recorder, the correct speed is indicated by minimum deflection on the meter.

The record/play back head of the cassette recorder can be adjusted for correct alignment by using a 8kHz recorded tone which comes on a test cassette. There is also a cassette cleaning tape and an unrecorded C60 cassette in the pack. It is priced at £18.00 + VAT from Combined Electronic Services Limited, 604 Purley Way, Waddon, Croydon CR9 4DR. •

MINI-ADS

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BC157/8/9	11p	MPF102	40p	IN4001	5p
BC169B	11p	2N3819	25p	IN4002	6p
BC169C	12p	2N3823	30p	IN4004	7p
BC177/8/9	17p	ZENERS BZY88 2·7V–33V	9p	IN4148	4p
BC182/3/4 L	11p	Bridge Rectifiers		OA47	6p
BC212/3/4 L	12p	50V 2A:30p		OA81	7p
BCY70	15p	100V 2A:36p		OA91	5p
BCY71	22p	200V 2A	41p	OA95	5p
BCY72	12p	400V 2A:46p		OA200	6p
BFY50 51	16p			OA202	7p
BFX29	30p				
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2N2904A	18p				
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0.47μF	(1 3/8"x¾")	71p	4.7μF	£1.30	£1.05	85p
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0.68μF	(2"x¾")	80p	10.0μF	£2.00	£1.60	£1.40
1.0μF	(2"x¾")	91p	15.0μF	£2.75	£2.15	£1.90
2.0μF	(2"x1")	£1.22p	22.0μF	£3.50	£2.90	£2.55

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TRANSISTORS:

BC107/8/9	9p	BC212/212L	14p	BFY50	20p
BC147/8/9	10p	BC547	12p	BFY51	20p
BC157/8	12p	BC558A	12p	BFY52	20p
BC182/182L	11p	BF194	12p	OC71	12p
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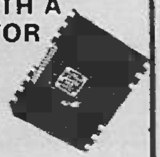

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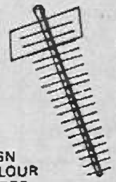

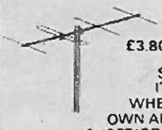

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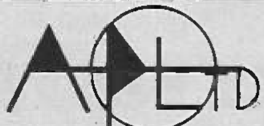

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Ambit . . . 54
Amtron . . . 49
Arbour Electronics . . . 29
B. H. Components . . . 36
B.I.E.T. . . . 75
Bi-Pak . . . 20&21
Bi-Pre-Pak . . . 9
Bywood . . . 18&36
Cambridge Learning Enterprise . . . 63
Chiltmead . . . 50
Davian Instruments Ltd . . . 73
Decon . . . 29
Electronic Design Associates . . . 41
Elvins . . . 74
Fibre Optic Supplies . . . 72
Henry's Radio . . . 2
J.E.T. . . . 69
Maplin . . . 76
Marshall's . . . 49
Marco Trading . . . 72
Minikits . . . 43
Ramar Constructor Services . . . 72
Sinclair (Project 80) . . . 4&5
Sinclair (IC20) . . . 22
Sintel . . . 69
Tamar Electronics . . . 72
Technomatic . . . 72
Trampus . . . 41
Wilmslow . . . 54