electronics today international

FEBRUARY 1975

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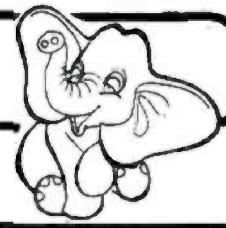

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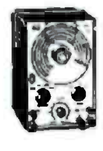

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BC147	0.10	OC28	0.66	2N3442	1.39
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FEBRUARY 1975 Vol.4 No. 2

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Now-two fascinating ways to enjoy saving money!

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£19.95
(INC. VAT)

Britain's most original calculator now in kit form
The Sinclair Scientific is an altogether remarkable calculator.

It offers logs, trig, and true scientific notation over a 200-decade range – features normally found only on calculators costing around £100 or more.

Yet even ready-built, the Sinclair Scientific costs a mere £32.35 (including VAT).

And as a kit it costs under £20!

Forget slide rules and four-figure tables!
With the functions available on the Scientific keyboard, you can handle *directly*

- sin and arcsin,
- cos and arccos,
- tan and arctan,
- automatic squaring and doubling,
- log $_{10}$, antilog$_{10}$, giving quick access to x^y (including square and other roots),
- plus, of course, addition, subtraction, multiplication, division, and any calculations based on them.

In fact, virtually all complex scientific or mathematical calculations can be handled with ease.

So is the Scientific difficult to assemble?
No. Powerful though it is, the Sinclair Scientific is a model of tidy engineering.

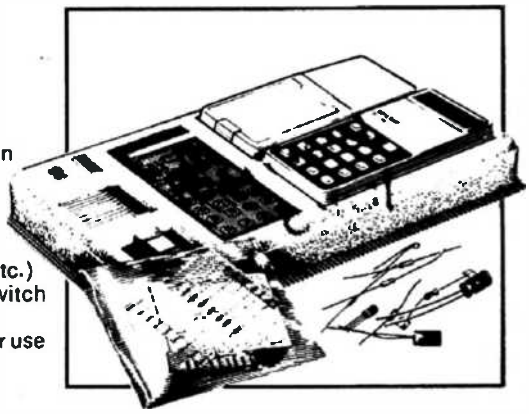
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our Service Department will back you throughout if you've any queries or problems.

Of course, we'll happily supply the Scientific or the Cambridge already built, if you prefer – they're still exceptional value.

Components for Scientific kit
(illustrated)

1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc.)
8. Battery assembly and on/off switch
9. Soft carrying wallet
10. Comprehensive instructions for use

Assembly time is about 3 hours.



Features of the Sinclair Scientific

- **12 functions on simple keyboard**
Basic logs and trig functions (and their inverses), all from a keyboard as simple as a normal arithmetic calculator's. 'Upper and lower case' operation means basic arithmetic keys each have two extra functions.

- **Scientific notation**
Display shows 5-digit mantissa, 2-digit exponent, both signable.

- **200-decade range**
10^{-99} to 10^{+99}

- **Reverse Polish logic**
Post-fixed operators allow chain calculations of unlimited length – eliminate need for an = button.

- **25-hour battery life**
4 AAA manganese alkaline batteries (e.g. MN 2400) give 25 hours continuous use. Complete independence from external power.

- **Genuinely pocketable**
4 1/3" x 2" x 11/16". Weight 4 oz. Attractively styled in grey, blue and white.

Sinclair Cambridge kit

Now only £14.95 (INC. VAT)

At its new low price, the original Sinclair Cambridge kit remains unbeatable value

In less than a year, the Cambridge has become Britain's most popular pocket calculator.

It's not surprising. Check the features below – then ask yourself what other pocket calculator offers such a powerful package at such a reasonable price.

Components for Cambridge kit

1. Coil
2. LSI chip
3. Interface chip
4. Thick film resistor pack
5. Case mouldings, with buttons, window and light-up display in position
6. Printed circuit board
7. Keyboard panel
8. Electronic components pack (diodes, resistors, capacitors, transistor)
9. Battery clips and on/off switch
10. Soft wallet

Assembly time is about 3 hours.

Take advantage of this money-back, no-risk offer today

The Sinclair Cambridge and Scientific kits are fully guaranteed. Return either kit within 10 days, and we'll refund your money without question.

All parts are tested and checked before despatch – and we guarantee any correctly-assembled calculator for one year. (This guarantee also applies to calculators supplied in built form.)

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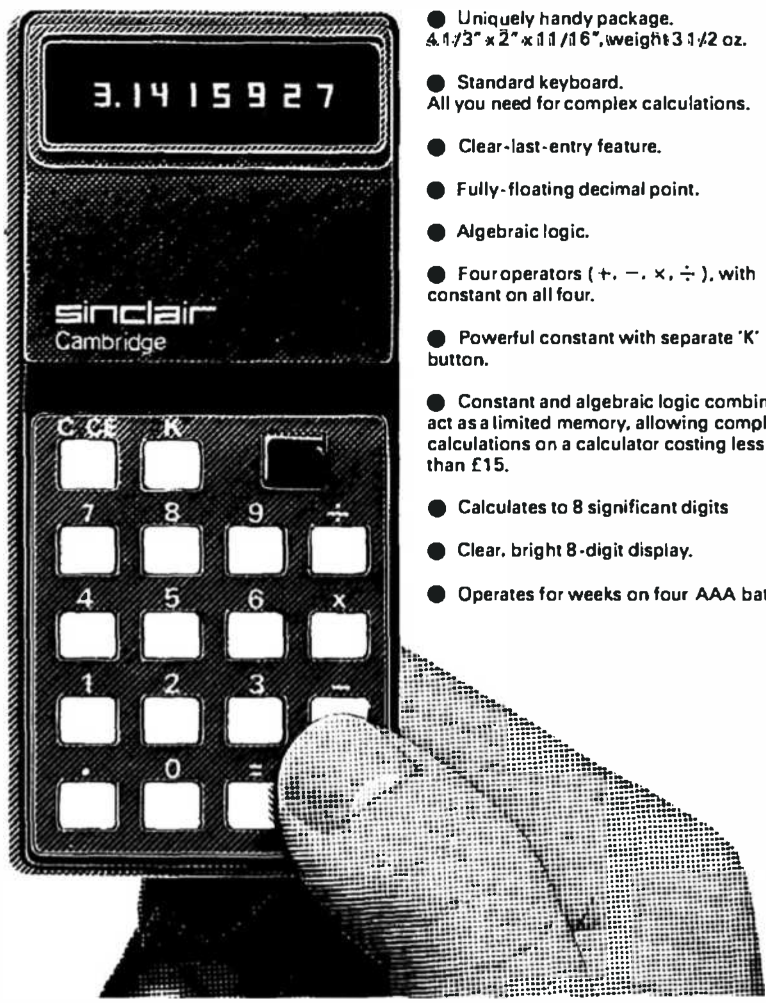
Features of the Sinclair Cambridge



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☐ Sinclair Cambridge built at £21.55

All prices include 8% VAT.

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*Please debit my *Barclaycard/ Access account. Account number

*Delete as required.

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sinclair

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NEWS DIGEST

TALKING CONTROLS COMPUTERS

A series of general-purpose computer systems which are controlled solely by the human voice has been introduced by the EMI group. These revolutionary systems, the first of their type commercially available in the world, can recognise words spoken in any language, irrespective of vocabulary, accent or dialect, and even against the background sounds of an operational environment.

The ability to identify spoken words and convert them into digital signals overcomes the limitations of conventional methods of computer communication, eliminating the intermediate paperwork associated with data preparation. It is particularly suitable for increasing job efficiency in situations where manually operated computer communication techniques cannot be applied because an operator's hands, and perhaps eyes, are already fully occupied.

The desktop equipment will be marketed by EMI Threshold, of Hayes, Middlesex, a company formed jointly on a 60-40 basis by Britain's EMI limited and Threshold Technology Inc., USA.

Apart from wide business usage, EMI Threshold systems can broaden the horizons of the physically handicapped. They can provide the means to be independent: controlling by voice many day-to-day functions such as room lighting, heating, telephone, radio and television, typing letters or making simple calculations.

The first system to be announced is the Voice Information Processor (VIP) 100, capable of accepting a vocabulary of up to 150 words or short phrases including digits. The equipment comprises a speech pre-processor unit, mini-computer, alpha-numeric display, microphone headset and standard teletypewriter. The system is quickly programmed to accept instructions from up to 16 operators in sequence. The voice data of each person can be stored either in the system's memory, on orthodox punched paper tape or magnetic disc.

Programming the system is easily done. Initially, the selected vocabulary of up to 150 words or phrases is inserted by teletypewriter into a mini-computer together with any program of operations which the system will be carrying out later, from spoken instructions. Users of the system then 'train' the equipment to understand their individual pronunciation of the vocabulary by repeating each word either 5 or 10 times into a noise-canceling microphone. The repetition of each word enables the VIP 100 system to obtain an average voice pattern from the slight variations which occur each time the speaker pronounces the word.

The speaker's pattern for each word is then stored in the memory against the relevant vocabulary data inserted by teletype-writer. The system is now prepared for operation.

To use the system, each operator calls up his own voice pattern, identified by reference number set on a control unit for speaker selection and word training. Each vocabulary word also has a reference number enabling the operator to call up any given word, at any time during use, from the computer for retraining should the operator's speech be affected by a cold or other causes since initially training the system.

As each word is spoken, it appears on a VDU providing the user to verify, at a glance, that the computer has correctly understood the communication.

If, when checking the data on the visual display unit, the operator discovers he has made an error, this can be deleted simply by using control word such as 'erase' or 'mistake'.

The offending words are then cancelled allowing correct data to be inserted.

The VIP 100 costs around £12,500 in its basic form. An interesting optional extra is an audio response unit which will verify spoken information it has accepted by repeating it in electronically-generated speech.

In the United States two leading international airlines are now using these systems in conjunction with automatic handling equipment to improve the efficiency of passenger baggage sorting at airport terminals.

Soon a major UK bank will use the system in daily counter transactions involving international exchange rates.

Future additions to the EMI Threshold range will include a system for the security field. It will have the facility to identify each voice by its individual aural characteristics (in the same way that sets of fingerprints are unique) offering many applications including the automatic control of access to restricted buildings.

NUCLEAR LASER

Nuclear energy has been successfully converted directly Into laser light by the US Atomic Energy Commission.

The technique uses a neutron pulse from a nuclear reactor to excite a helium-neon gas laser in what the AEC describes as 'fission fragment excitation'.

Commenting on the achievement, NASA say that the new technique may lead to major advances in long range communications, energy conversion and long distance power transmission.

It will of course open the door to the long-sought high power laser military weapon.

BROADCASTING BREAKTHROUGH

A prototype AM broadcasting transmitter with a kilowatt range solid state output has been developed by Westinghouse Electric Corporation (Baltimore Md. USA).

Few specific details are available, however our US office understand that apart from two existing units (of 1 kW and 5kW output respectively) for AM use, the Westinghouse is believed to have developed other devices for VHF FM use.

The initial transmitters are currently being tested at the Federal Communications Commission's Chicago radio station.

If these trials are satisfactory we believe that Westinghouse will demonstrate the new solid-state transmitters at the April 1975 convention of National Association of Broadcasters.

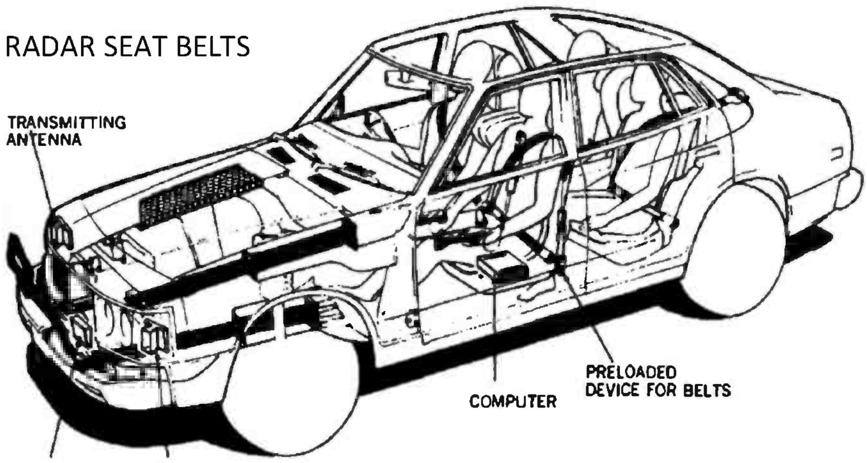
BSI APPROVAL FOR SMALLEST MOULDED RESISTOR

BSI have granted Erg Components approved (to BS9111-F014) for their resistor EE0-05. This is the smallest moulded precision metal film resistor to be approved by BSI and these resistors are already used in defence, avionics, and computer application.

The dimensions are a mere 4.1 mm x 1.8mm and the range covered is 10R to 360K, with tolerances from ±0.05% to 1% and temperature coefficients of 15, 25, 50 and 100 ppM/OC.

Erg, Luton Road, Dunstable, Beds. LU5 4LJ.

RADAR SEAT BELTS



Car seat belts must be tight to be truly effective in an accident - tighter than in fact than is really comfortable.

The Nissan Motor Company have joined forces with Mitsubishi to produce what they feel may be an effective method of automatically tightening the belts just prior to collisions.

Their system uses a pulsed-Doppler radar in conjunction with a series of logic circuits. The radar and logic circuits sense the distance between the vehicle to which they are fitted and any object that the vehicle approaches. If the circuitry decides that a collision is unavoidable, the system is triggered and the belts automatically tighten and lock a few milliseconds prior to the accident.

SATELLITE CONTACT WITH NORTH SEA PLATFORMS

Norway's Telecommunications Directorate is arranging for satellite communication for offshore platforms in the Norwegian sector of the North Sea. Receiving stations are being established at Moi, S.W. Norway, and on board platforms operated by Phillips, Elf, and Mobil. The service will operate from 1st November 1975, and will be the first communication system per satellite for offshore platforms in the world. The receiving equipment is being supplied by C. Itoh of Japan. The Moi station will have a capacity of about 120 speech channels, 60 data channels, 360 telex channels, and a number of system control channels. It is claimed that quality will be as good as the best telephone channels.

COMPONENT DISTRIBUTOR ENTERS THE AMATEUR MARKET

Semicomps Ltd., of Northfield Industrial Estate, Wembley, Middlesex, have recently entered the amateur market and have introduced two new catalogues for their new customers.

Semicomps have, of course, been major semiconductor distributors for some time but until recently they have not been going after the amateur market deliberately. This policy is now changed.

Albert Shipton, Marketing Manager, at a recent Press Conference said this move had been planned for some time and the reason for breaking the new ground had nothing to do with the present depressed state of the semiconductor market in the U.K. He hoped that this new venture would enable the amateur enthusiast to obtain specialised semiconductors at a reasonable price, together with detailed manufacturers data sheets which, Mr. Shipton said, were not usually available to the amateur.

The company have introduced two new catalogues, Prices List 1 and Price List 2, one of which is aimed specifically at the radio and TV repair business, the other at the constructor market. Mr. Shipton went on to say that Semicomps hope to give a very rapid service, better than that usually provided, to the amateur market. The number of semiconductors, transistors and I Cs available from Semicomps should be about 4,000 but data on another 4,000 devices is also available.

ETI wish this new venture well if they are able to give the sort of service and scope to the constructor that the company are promising. The catalogue is available, free of charge from SCS Components, 5c Northfield Industrial Estate, Beresford Avenue, Wembley, Middlesex HAO 1SD.

CTV ON LPs

Philips video long play recorder has suddenly become a reality. The VLP which uses "records" to play colour television programs was first demonstrated by Philips two years ago. But then they had no adequate source of programs available.

Now MCA Inc. of Los Angeles, has reached a long term agreement with Philips for the sale of the VLP and compatible discs in the consumer market. The VLP will be manufactured and marketed by Philips through its worldwide marketing and distributing network. Concurrently, MCA will manufacture and market VLP video disc programs.

The VLP looks like a record player, but when plugged into a normal colour TV receiver it "plays" colour television programs. It uses discs which resemble LP records. Each disc contains a colour television program which runs for up to 45 minutes. A laser beam is used to pick up the signal, so there is no contact between the record and the playback unit. This means that neither the recording nor the playback system can wear out.

Philips and MCA will establish a licensing organisation to negotiate with others for patents. The licensing policy will be liberal, enabling the entire industry to participate in the video player technologies of Philips and allows them to be expanded by up to five times. and MCA.

This liberal policy is in line with Philips offers to industry regarding two earlier inventions their audio "Compact" cassette and the videotape cassette recording (VCR) systems.

Philips make these systems freely available to other manufacturers in order to promote worldwide standardization.

The Philips VLP will not replace the videotape cassette but will supplement it.

The VLP system is extremely flexible in use. It can, for instance, provide stills, slow-motion or even reverse motion pictures from recorded scenes.

HEATHKIT'S NEW PRODUCTS

Fourteen new kits have been announced by Heath (Gloucester) Ltd., Bristol Road, Gloucester GL2 6EE.

The digital electronic car clock/timer uses orange 7 -segment Beckman planar gas discharge tubes which dim in dull lighting and brighten in sunlight. A quartz crystal keeps the accuracy to within one minute per month. The memory counts at all times and the display is lit when the ignition is switched on or by a push button.

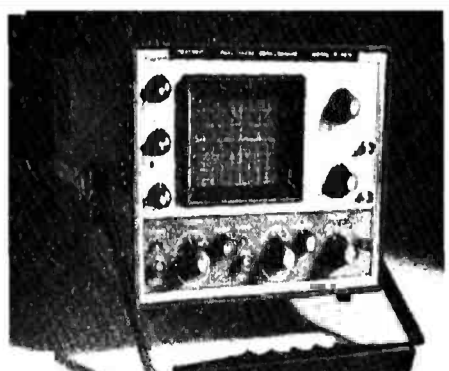
A timer is also provided for elapsed time in minutes and seconds up to ten minutes and in hours and minutes up to twenty hours. During timing the clock readout can be recalled without interfering with the timer.

The clock timer is coded GC-1093 and in kit form (with assembled display) costs £39.90 inc. VAT.

Another new kit, coded 10-4510, is a triggered, dual trace oscilloscope offering 1mV sensitivity from DC to 15MHz. Twelve ranges of attenuation cover 1mV/cm to 5V/cm. An internal delay live allows display of the pre-triggered waveform (at least 20nS). The trigger select switch and level control enable choosing a trigger point on any part of the positive or negative slope of the trigger signal, or at zero· crossing.

The time base offers 22 calibrated time bases from 0.2S/cm to 0.1µS/cm (in a 1·2-5 sequence).

The speed control provides continuous variation of these time bases:



A 1 V square wave signal is provided for calibration checks. Five PCBs carry the main circuitry and these use push-on connectors for easy removal and trouble-shooting. The kit costs £299.90 inc VAT, but ready-assembled this would be £426.60.

The new range contains other gadgets for the motorist and the workbench/lab. For the motorist who use the digital clock to time his journey to work and would like to increase his speed the new tune-up meter would come in handy. In any case it could make your car more economical. This easy to build kit costs £21.40 (inc VAT) and it will operate as a voltmeter up to 20V DC, as a two-range tachometer (0-1500rpm and 2500rpm) and as a dwell meter it has three scales: 10-45 degrees (8 cylinder), 20-90 degrees (4 cylinder) and 25-60 degrees (6 cylinder).

If economy is important enough to you, you could build the exhaust gas analyzer (CI-1080). A 4 1/2 inch meter shows the air-fuel ratio, combustion efficiency (%), and carbon monoxide percentage. A stainless steel tube samples the exhaust gases and a sensor measures the thermal conductivity for analysis. The instrument costs £34.60 in kit form.

Back to the lab to look at the new function generator (IG-1271). Waveform can be sine, square or triangular, from 0-1Hz to 1MHz, and with attenuation of up to 50d8 (10V P·P to 30Mv p - p. The kit costs £61.80 inc VAT.

The IC-2100 is a desktop scientific calculator allowing trig functions, algebraic entry, degrees or radians entry for trig, ex, lnx, log X, AX, 1/x,vx, and a *1r* key. Results can be accumulated in the memory or displayed on the eight 1/2" Beckman displays (with decimal point fully floating). Overflow negative sign and error can be displayed.

The calculator measures 2 1/4" x 7" x 9 5/8" and comes in a kit for £79.90 inc VAT.

The alarm clock-radio is coded GR-1075 and features automatic dimming, 7 minute snooze cycle, and an AM-FM radio. It comes as a kit with cabinet for £83.90 inc VAT.

The rest of the new range comprises a complete amateur radio station. The transceiver (SB-104) is claimed to have the most advanced design in its field. To operate one just chooses the band, dials the frequency and selects the mode. It is claimed one can QSY from CW on 80 to SSB on 10 in seconds - with no need for tuning up! All the latest features are incorporated including digital frequency readout and call sign on the display panel! The kit costs £425.00 (inc VAT and delivery) and ready for 12V operation. The mains PSU is £59 more.

Another £199.80 and you can build up the SB230 linear which will give up to 1200W PEP. The SB664 is a remote VFO for the SB104 and the kit will be another £53.90. For £21.00 you can build a matching speaker with enough space to hold the PSU.

An interesting package of five station accessories is the SB634 Station Console. A 24 hour digital clock, a ten minute timer (for ID) an RF watt meter, an SWR Bridge and a phone patch (for where this is permitted) for £109 inc VAT. The last item in the new range is the SB614 Station Monitor, with a 1W' x 2" CRT, costing £91.80 (inc VAT and UK delivery) as a kit.

TRAFFIC ELECTRONICS

We, have news of two electronic systems concerned with vehicle movement and control currently under development.

The first, from Japan's Toyota car company is a multi-purpose system. Four sub-systems are used. Two of these transmit data concerning major traffic congestion, accidents, weather conditions and information of an essentially 'emergency' nature. One channel is used as a radio-telephone link, and the fourth one enables the driver to choose the most traffic-free route to his destination.

All emergency-type data are transmitted from a central office to so-called 'leaky' cables laid alongside all major roads. Special receiving equipment in each vehicle continually monitors the cable and feeds any relevant data automatically into the vehicle's normal car radio.

Also within the car is a visual data panel. This displays all information that is currently indicated by roadside signs - stop signs, speed limits, no entry signs, pedestrian crossing warnings etc. Input data for this service is transmitted via inductive loops buried beneath the road surface.

Optimum route selection is performed by a computer control centre that collects data from many different points. By using a keyboard panel, the driver can check the state of traffic congestion at any road intersection alongside his route. Thus he can plot the quickest, least congested route to his destination.

The second electronic system is the brainchild of Fred Sterzer, Director of RCA's Microwave Technology Division in Princeton, New Jersey, USA.

Dr. Sterzer's proposal is for an active number plate which if interrogated by a microwave transponder, would transmit a coded signal unique to that vehicle.

The electronic number plate would consist of a printed circuit antenna on which be printed the normal license number (for visual identification) together with an RF detector, frequency doubler and modulator, and an IC digital generating coder.

The main use of the system, says Dr. Sterzer, is for improving the scheduling and dispatching of vehicles, nevertheless RCA see innumerable other applications in what they rather euphemistically call 'traffic safety'.

These include the identification of stolen and speeding cars, toll collection by a central billing system, automatic entry or restriction to parking areas, tracking down vehicles whose owners have ignored traffic fines etc.

DIGITAL TELEVISION

Engineers from the BBC Research Department demonstrated their experimental machine for recording colour television signals in digital form at the International Broadcasting Convention recently. The experimental machine is based on a TD10 tape transport incorporating Spin Physics headstacks by SL Labs. Information relating to the 8 bit digital signal is divided amongst 42 tracks recorded on one inch tape. Signal processing is carried out by 42 identical printed circuit boards contained within the recorder cabinet.

The recorder is basically intended for use as a research tool in the development of error detection and correction and to investigate the effects of applying television bit rate several times in succession during the history of the signal.

BUBBLE MEMORIES

Bubble memories will replace tape recorders and computer disc and drum memories in aircraft and spacecraft within a few years, predicts the US Air Force Avionics Laboratory. Such memories utilize the magnetic domains of very thin magnetic garnet material that contract into stubby cylinders a few microns in size under the influence of an external magnetic field. The laboratory currently is testing and evaluating a 10,000-bit module.

NEW MULLARD RADAR UNIT COULD ACT AS GUIDE DOG

A cheap, tough Doppler radar circuit, which could be used to guide blind people, has been produced by Mullard Research Laboratories (UK) - one of Philip's research centres.

The radar shows the dire tion and speed of objects, and because of its small size, it could be used in a number of applications including traffic light control and conveyor belt monitoring, as well as in an electronic guide dog system for the blind .

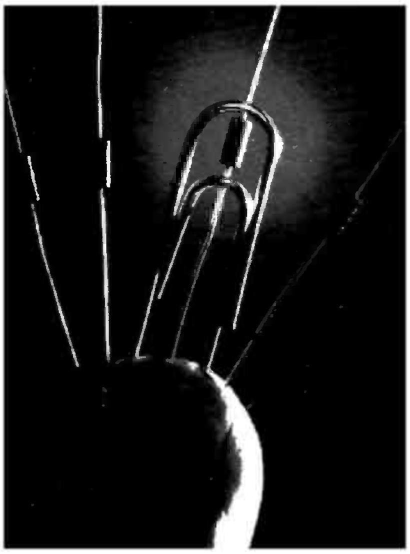
In a Doppler radar, use is made of the fact that the observed frequency of signals originating in an object increases as the object approaches the observer and decreases as it moves further away from him.

In the new device all microwave circuit functions, with the exception of the Gunn source, are carried on a single slice of alumina substrate, 18 x 16 x 0.5mm.

This radar can be operated without need for adjustment or modification, within the frequency band 9.3 to 10.6GHz. The tangential signal sensitivity for an i.f. bandwidth of 4.5MHz is -70dBm.

The information given above relates to a laboratory model; development and production will be undertaken by Mullard Ltd.

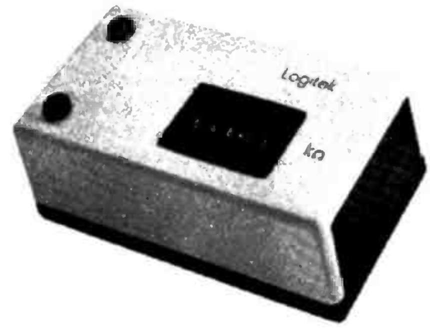
SUBMINIATURE METAL FILM RESISTOR



ERG Components have a new metal film resistor to be added to their range. Series NR50 is a sub-miniature semi-precision resistor offering the inherent advantages of metal film with a range of 100-150K, low temperature co-efficients, 50 ppm maximum, and high stability.

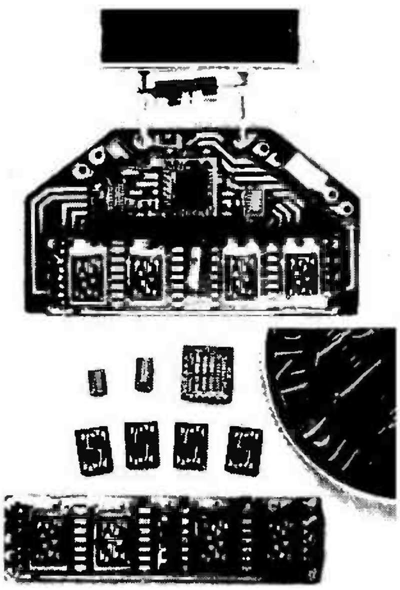
From ERG, Luton Road, Dunstable, Beds, LU5 4LJ.

Logitek of 13 Carron Place, Kelvin Industrial Estate, East Kilbride, produce this new Decade Resistance Box. The D85R is just one of a range of neatly designed equipment at the low cost end of the professional equipment market. This fingertip operated device covers 10 ohms to 1 Megohms. The ergonomic design approach payed off when this device was chosen for the Design Centre by the Design Council.



DIGITAL WATCH KIT

A series of LEO digital watch kits has been announced by Litronix, the California-based optoelectronic and semiconductor manufacturer.



Designated the Litronix L WS6120 Series, the kits are all based on the LMC6120 low power CMOS time-keeping chip (an IC which counts hours, minutes and seconds). Also included are two monolithic NPN bipolar arrays, the LBC1060 digit driver and the LBC1070 segment driver. All three circuits are provided in chip form intended for hybrid assembly methods. Eight different display options are available. These displays may be supplied either as monolithic LED chips or prepackaged and aligned for flow solder mounting to the watch module. The LED kits are priced from £16.62 in quantities of 100.

LEDs allow multiplex drive capability and simplify the design of electronic circuitry, for more information contact Litronix, Bevan House, Bancroft Court, Hitchin, Herts SG5 1LW.

SEMICONDUCTOR NEWS

The bad times have arrived for some semiconductor manufacturers, especially those in North America. The growth in this market for the coming year has been predicted at zero, indeed many informed sources are suggesting that a real decline can be expected.

This has not dissuaded certain companies trying even harder to maintain or even increase their share of the same sized market and price cuts have already started with a vengeance. National Semiconductors have announced dramatic dramatic price reductions across their entire CMOS range: Motorola have announced their third price cut in a year on all CMOS logic devices, making them a third of their price of January 1974.

Buyers may like what is turning into a price war but the benefits may be short lived. A healthy electronics market does not necessarily mean tiny profit margins, indeed the opposite is true. We have no confirmation but manufacturers often look to their R & D sections for the first area to make economies.

From Reticon (available from Walmore Electronics, 11-15 Betterton Street, London WC2) comes an entirely new IC comprising a circular array of photo-diodes complete with scanning, addressing and storage circuitry on a single chip. The 64 photo-diodes are arranged in a circle 2.08mm in diameter with an aperture of 0.1mm. They are operated in the charge storage mode for maximum sensitivity and are addressed sequentially in a clockwise direction. The charge in each photo-diode is dumped onto a common output line under the control of a ring-counter. At one point in each circular scan, an output pulse is generated by the ring counter to synchronise external circuitry.

The new device will find applications in such diverse fields as target acquisition, tracking, alignment, automatic pattern and line followers, pattern recognition, inspection and automatic focusing.

Motorola have recently turned out 40 new products including additions to their ECL, CMOS, Opto and Linear families. Also they announce 2 new 16k ROMs and a double-matched input gold metalization 60W UHF transistor. And National Semiconductor have bought out some new CMOS for their 74C line.

EVENTS

In the ETI office we receive news, from time to time, of lectures, exhibitions, courses etc. Here's a few we got in recently.

First the Faraday Lectures. The "Social Computer" (the title of the 1974/75 talk) is now on the road and the 1975 dates are as follows - Southampton City Hall 21st January, Swansea Brangwyn Hall 23rd January, Bristol Colston Hall 27th and 28th January, Leicester De Montford Hall, 6th February, Sheffield City Hall 11th February London Central Hall 20th and 21st February. (More details from the I EE; address below).

Also in February is a 3 day course in microprocessors and microcomputers (5-7th February) in London organised by Integrated Computer Systems Inc, 12561 Appleton Way, Los Angeles, CA 90066 USA.

The Institution of Electrical Engineers give notice of an International Conference to be held from the 7th to 10th April on "Satellite Communication Systems Technology". In June (from 3rd to 5th) they will hold another conference - "Antennas for Aircraft and Spacecraft". Contact the IEE, Savoy Place, London WC2R OBL.

Plans are underway for the 1976 IEA Exhibition and the Electrex Exhibition to be held next year in Birmingham. Details will soon be available from Industrial and Trade Fairs Limited, Radcliffe House, Blenheim Court, Solihull, 891 28G.

OLD McDONALD
The BBC in London have an Engineering Information External Inquiries Officer.

This character is rapidly gaining world-wide fame by answering his telephone with a short sharp 'EIEIO'.

ERRATA

Graphic Equaliser, January issue pages 24 and 29.

C16 should be 0.001µF as in the parts list and R20 should be 18k as in the diagram.

Rumble Filter, January issue page 53.
C2 and C3 are 0. 039µF as in the circuit diagram (not as indicated in the parts list).

COLOUR ORGAN

ETI PROJECT

Produce all the colours of the rainbow in synchronism with your music!

THE SUBJECTIVE appreciation of music may be considerably enhanced by adding a coloured light display. If the three primary colours, red, green and blue are projected onto a translucent screen, or some other diffuse material, and selectively modulated by the instantaneous amplitude and frequency content of the music you are listening to, the three colours mix to produce all the colours of the rainbow (as well as white) in synchronism with the content of the music.

A difficulty arises when you try to determine what frequency a 'blue' note should be, or for that matter red, green or any other colour. Bass instruments predominate the frequency range below 220 hertz. Vocals cover the midrange to about 1200 hertz. The higher fundamental notes of wind and string instruments complete the treble register to about 4000 hertz. Harmonics of- course extend well beyond this.

It is generally agreed that red should represent low notes, green mid range, and blue the high notes. After much critical listening to tone oscillators and recorded music, in conjunction with light displays our panel of discriminating 'muso's' agreed that 'red' notes should extend to A - an octave below middle C. Green over the next three octaves and then followed by 'blue'. This is accomplished ·by dividing the frequency spectrum into three bands by means of filter networks. The ·amplitude content of each band is averaged and used to modulate the brilliance of the associated lamps.

For best effect, the direct light from the lamps should not be seen. It is not very stimulating, and in fact can be disturbing, to watch bulbs flashing on and off. However, the lights can quite readily be arranged to shine behind a· translucent panel or be reflected off a wall. Alternately large diameter spheres made from crushed glass or plastic are available as standard lighting fixtures. We tried one that had been converted to accommodate three 100 watt coloured bulbs. Another simple effective arrangement we tried consisted of a cone which we made from a large sheet of translucent draft-ing film. This was positioned over our 250 watt floodlights mounted inside a five-gallon drum. Incandescent blue lamps are generally inefficient so we added an extra blue lamp in order to achieve colour balance. A lot of creative fun can be had trying different arrangements!

To keep this project as economical as possible we used only one control to vary the input sensitivity. Individual controls however can easily be added if desired. This involves substituting a log potentiometer with an appropriate series resistor in place of each of the resistors R23, R24 & R25.

CONSTRUCTION

We wound the line filter chokes, L1, L2 & L3, on three pieces of ferrite rod 30 mm long. These were cut from a 9 mm diameter aerial rod. To cut the rod, first file a V groove around the circumference of the rod at the point where it is to be cut. The groove need only be about 0.5 mm deep and can be cut with the sharp edge of a small triangular file.

Grip the rod in a vice, at the notch, being careful not to screw up the vice too tightly' as the material is also very brittle and shatters easily. Now give the rod a gentle tap and the rod will part cleanly. Wind the chokes as detailed in Table 1.

The trigger transformers are wound on pot cores having split bobbins, again as detailed in Table 1.

The heat sink should be constructed from a piece of aluminium as shown in Fig. 4. Carefully follow the component overlay, when assembling the board checking that all diodes, transistors and electrolytic capacitors are inserted the right way around.

The line chokes are secured to the PC board by tinned copper wire looped

COLOUR ORGAN

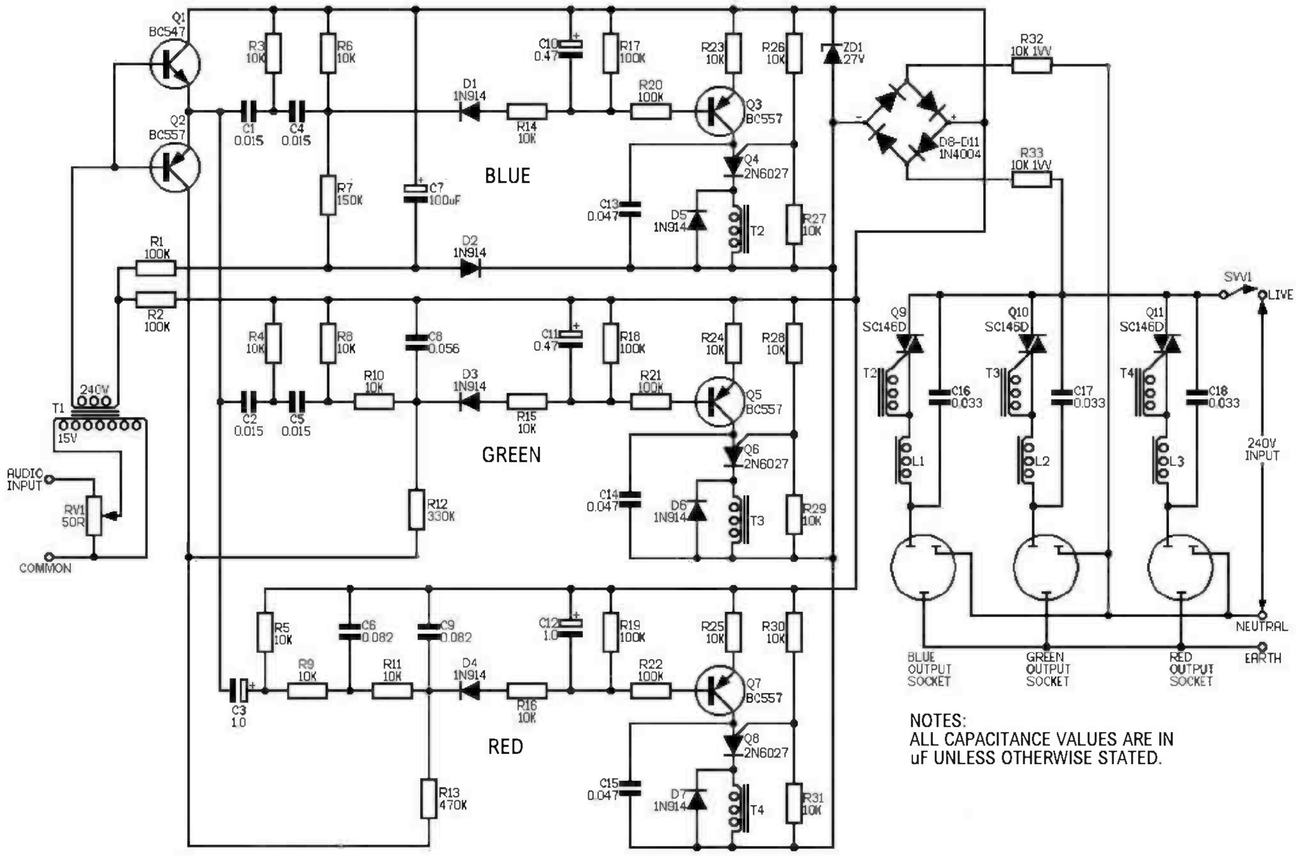


Fig. 1. Circuit diagram of the colour organ.

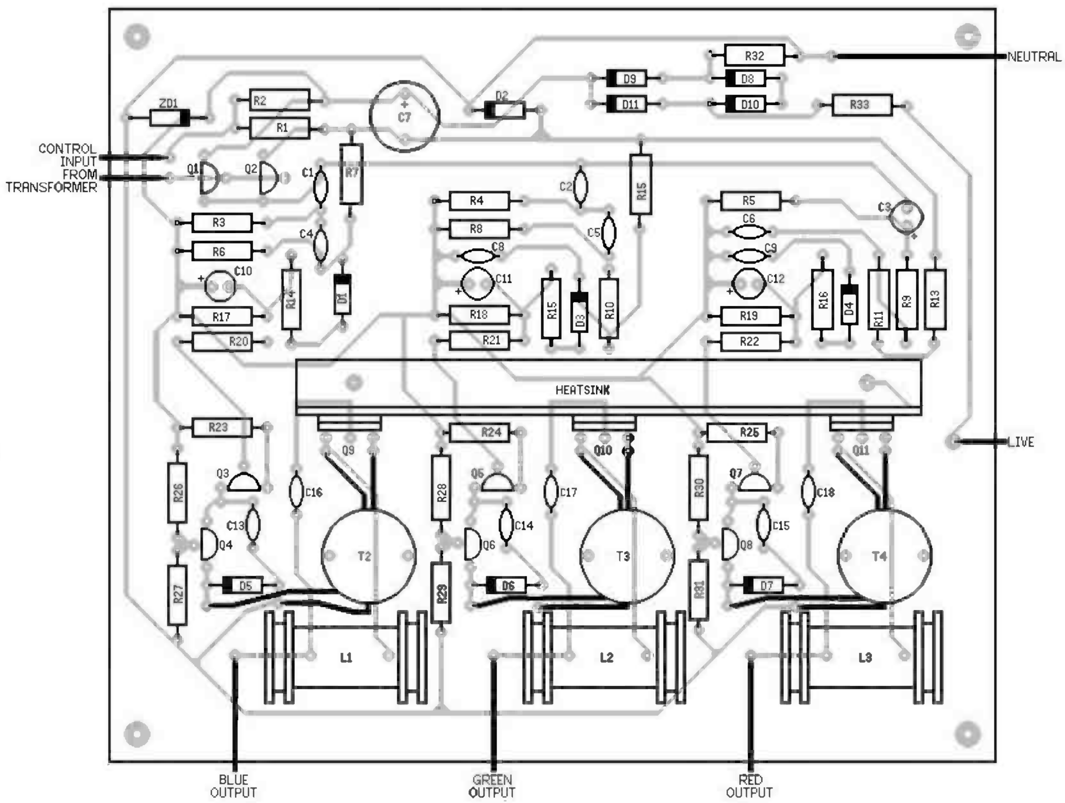
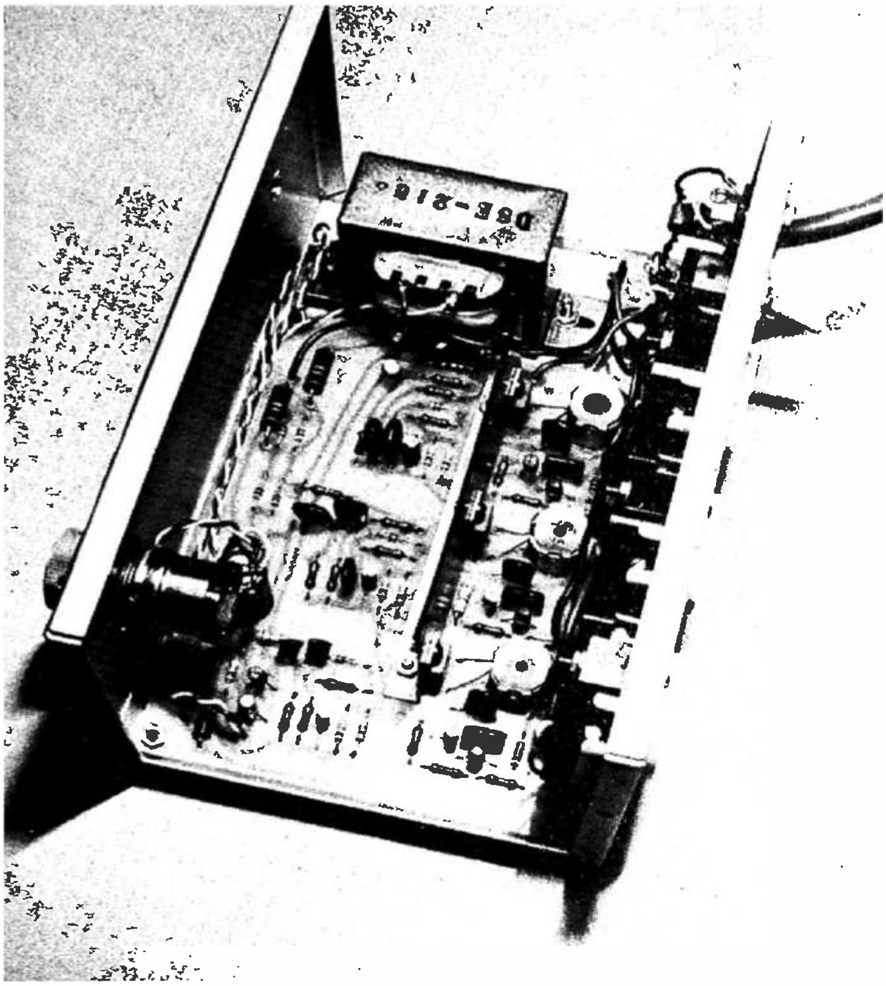


Fig. 2. Component overlay for the colour organ.



◀ How the unit is constructed

PARTS LIST

RESISTORS (all 1/2W except where stated)

R24		3k9
R3,4,5,6		10k
R8,9,10,11		10k
R14,15,16,23,25		10k
R26,27,28,29,30,31		10k
R32,33		10k 1W
R1,2,17,18		100k
R19,20,21,22		100k
R7		150k
R12		330k
R13		470k
RV1	potentiometer	50R 2W

CAPACITORS

C1,4	0.015uF polyester
C16,17,18	0.033uF 630V
C13,14,15	0.047uF polyester
C8	0.056uF polyester
C2,5,6,9	0.082uF polyester
C10,11	0.47uF 35V electrolytic
C3,12	1.0uF 35V electrolytic
C7	100uF 35V electrolytic

SEMICONDUCTORS

Q1	BC547, BC107 or similar.
Q2,3,5,7	BC557, BC177 or similar.
Q4,6,8	2N6027 or similar
Q9,10,11	Triac SC146D or similar
D1-D7	Diode 1N914 or similar
D8-D11	Diode 1N4004 or similar
2D1	Zener Diode BZY88 C27 or similar (27V 400mW)
T1	Transformer 240V /15V
T2,3,4	Pulse Transformer see table 2.
L1,2,3	Chokes see table 1.
SW1	Switch 240V AC 10A

PC board
Heat-sink to fig. 4.
Three 3 pin outlets
Metal box to suit about 210 x 100 x 140 mm
3 core flex and plug
7 rubber grommets
1 cable clamp
1 knob
terminal strip for mains connection

HOW IT WORKS

Audio is fed to the input from the loudspeaker terminals of the amplifier. RV1 controls the input sensitivity and transformer T1 steps up the input voltage as well as providing safety isolation from the 240 volt mains on the remainder of the circuit. Transistors Q1 and Q2 provide a low impedance drive for the three filters and present a constant load to the transformer thereby keeping the level independent ofvarying frequency.

The 'red' channel is driven via a two stage 12 dB/octave low pass filter. The principal frequency determining components are R9, R11 & C6, C9. Diode D4 rectifies the signal which is converted to an average DC level by R16, R19, R22, C12. This varies the bias on transistor Q7 which operates as a constant current source.

The instantaneous current is set by the applied bias, and by the value of Q7 emitter resistor R25. The resulting constant current charges C15 and when the voltage across C15 equals the reference voltage set at the anode gate terminal (ag) of the programmable unijunction transistor (P.U.T.) Q8, the P.U.T. fires discharging C15 through the primary winding of trigger transformer T4.

The resultant pulse, from the secondary of T4 fires triac Q11 thus switching power to the red lamp. The 'firing cycle of the. P.U.T. is synchronised to the 50 Hz mains by the unfiltered supply derived from Zener diode ZD1. Diode D7 bypasses the reverse fly back pulse from the triac and ensures the pedestal voltage of CI5 remains constant.

The operation of the green and blue channels is similar with the exception of the filters. Components C2, C5, C8, R4, R8 & R10 form a bandpass filter for the green channel, whilst C1, C4, R3 & R6 make a high pass filter for the blue channel. Chokes LI, L2 & L3 in combination with capacitors C16, C17 & C18 are incorporated in order to reduce radio frequency interference.

round the grommets and then soldered to the board. As the triacs used are rated at 10 amps, the main limitation on the maximum load is the associated domestic wiring which would limit the total load to 2400 watts. We have designed the heat sinks with this in mind. If it is required to c!rive heavier loads the area of the heat sink should be increased and possibly triacs rated to carry higher current substituted. Of course then ordinary domestic power outlets should not be used.

A 300 millivolt input is sufficient to drive the lamps to full brilliance. At one hundred hertz the input impedance is approximately 12.5 ohms, accordingly any amplifier capable of delivering a watt or more would suitably drive the unit.

Set the amplifier volume control to the normal listening level, then adjust the input sensitivity control such that the lamps only light up to maximum brilliance on musical peaks. If this control is not set correctly the input level will be too high with the result that the lamps will all light up together regardless of the frequency content of the program. If everything is working at this stage, you can now watch the changing moods and drift into happy ecstasy!

COLOUR ORGAN

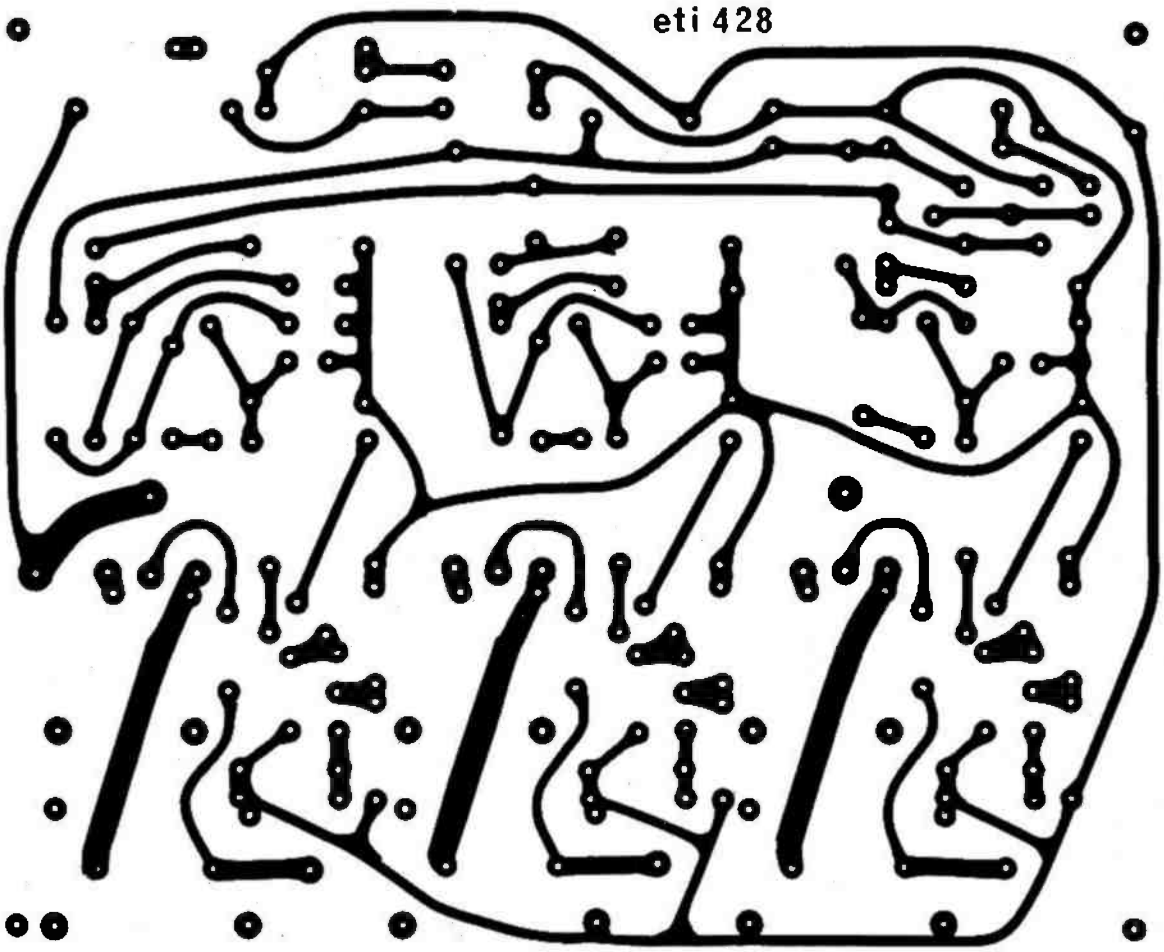


Fig. 3. Printed circuit board layout for the colour organ. Full size 127 mm x 158 mm.

TABLE 1 CHOKE WINDING DATA L1,L2 & L3

Core: 30mm length of 3/8" diameter ferrite rod
Winding: 40 turns 0.63mm (26swg) wound in two layers, each 20 turns, close wound using the centre 16mm only of the core.
Insulation: two layers of plastic insulation tape over complete winding.
Mounting: use rubber grommet (3/8" ID) over each end and join to PCB by looping turned copper wire around grommets and secured into holes provided.
Made from an aerial rod - file a groove around it at the desired cutting point then snap off.

TABLE 2 PULSE TRANSFORMER - WINDING DATA T2, T3, T4

Winding a double section bobbin
Primary - 30 turns 0.40mm (30swg) one section
Secondary - 30 turns 0.40mm (30swg) second section.
Bring leads out at opposite ends of coil.
Winding a single section bobbin
Primary - two complete levers 0.40mm (30swg) close wound insulation - two layers of plastic insulation tape
Secondary - two complete layers 0.40mm (30swg) wire close wound
Bring leads out at opposite ends of coils.

For details on the core see box on the right.

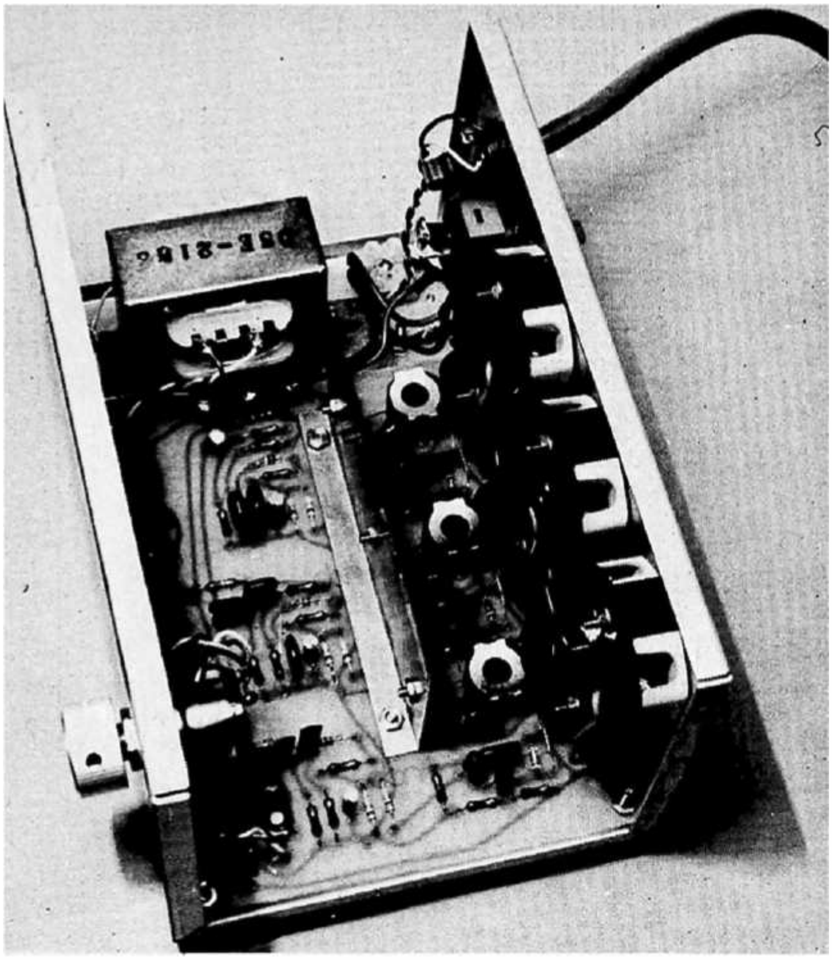
GETTING HOLD OF THE COMPONENTS

SEMICONDUCTORS
Supplies of the 2N6027 PUTs have been laid on specially by Marshall's. Marshall's will be able to supply ail the semiconductors for this project (1xBC647, 4xBC557, 3x2N6027, 3xSC1460, 7x1N914, 4x1N4004, 1xBZY88) for a special price £6, inc VAT and p&p.

POWER OUTLETS
Any mains sockets will do, provided they can take the current. Marshall's have stocks of the Bulgin three-pin recessed power sockets in 2 sizes: the 1" version socket and plug sell for 40p and the heavy duty P437 sells for 70p.

INPUT TRANSFORMER
This is used to step up the audio impedance and the current rating is not important. Any convenient 240V: 16V transformer will do.

PULSE TRANSFORMER POT CORES
Problems may arise with these cores. The requirement is for a pot core with an AL value of 520 and uE of something like 250. This can be achieved using the following Mullard components - core: LA 1225; adjuster: LA 1502; 2-section former: DT2281; ring: DT2366; tagboard: DT2369; clips (4 required): DT2357. We have asked Marshall's to stock these to help readers who have problems getting hold of suitable parts.



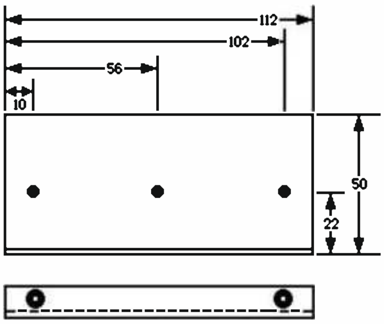


Fig. 4. Dimensions and drilling details for the heat sink bracket. 5 holes 3.2 mm diameter and material is 1.0 mm aluminium.

WARNING. All components on the board and the heat sink, upon which the triacs are mounted, are at mains potential. Use extreme care as you would with any exposed wiring carrying 240V. Avoid working on the unit whilst it is connected to 240 volt mains, make sure any test equipment you are using is isolated from earth, and that you yourself are well insulated from the floor by a rubber mat etc.

The largest selection

BRAND NEW FULLY GUARANTEED DEVICES

AC107	0·22
AC113	0·20
AC115	0·22
AC117K	0·32
AC122	0·13
AC125	0·19
AC126	0·19
AC127	0·20
AC128	0·20
AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·20
AC141K	0·32
AC142	0·20
AC142K	0·28
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·22
AC180K	0·32
AC181	0·22
AC181K	0·32
AC187	0·24
AC187K	0·25
AC188	0·24
AC188K	0·25
ACY17	0·29
ACY18	0·22
ACY19	0·22
ACY20	0·22
ACY21	0·22
ACY22	0·18
ACY27	0·20
ACY28	0·21
ACY29	0·39
ACY30	0·31
ACY31	0·31
ACY34	0·23
ACY35	0·23
ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·63
AD142	0·63
AD143	0·42
AD149	0·56
AD161	0·39
AD162	0·39

AD161 & AD162 (MP)	0·75
ADT140	0·55
AF114	0·27
AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·33
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·55
AF179	0·55
AF180	0·55
AF181	0·55
AF186	0·55
AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
ASY27	0·33
ASY28	0·28
ASY29	0·28
ASY50	0·28
ASY51	0·28
ASY52	0·28
ASY54	0·28
ASY55	0·28
ASY56	0·28
ASY57	0·28
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ASY73	0·29
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BC107	0·14
BC108	0·14
BC109	0·16
BC113	0·11
BC114	0·17
BC115	0·17
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BC117	0·20
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BC119	0·33
BC120	0·88
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BC126	0·20
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BC134	0·20
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BC136	0·17
BC137	0·17
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BC147	0·11
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BC149	0·13

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BC180	0·27
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BC186	0·31
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BC213L	0·14
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BC220	0·30
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BC303	0·35
BC304	0·40
BC440	0·34
BC460	0·40
BCY30	0·27
BCY31	0·29
BCY32	0·33
BCY33	0·24
BCY34	0·28
BCY70	0·16
BCY71	0·22
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCZ12	0·26
BD115	0·63
BD116	0·88
BD121	0·68
BD123	0·72
BD124	0·76

BD131	0·55
BD132	0·66
BD133	0·72
BD135	0·44
BD136	0·44
BD137	0·50
BD138	0·55
BD139	0·61
BD140	0·66
BD155	0·88
BD175	0·66
BD176	0·66
BD177	0·72
BD178	0·72
BD179	0·77
BD180	0·77
BD185	0·72
BD186	0·72
BD187	0·77
BD188	0·77
BD189	0·83
BD190	0·83
BD195	0·94
BD196	0·94
BD197	0·99
BD198	0·99
BD199	1·06
BD200	1·05
BD205	0·88
BD206	0·88
BD207	1·05
BD208	1·05
BDY20	1·10
BF115	0·27
BF117	0·50
BF118	0·77
BF119	0·77
BF121	0·30
BF123	0·55
BF125	0·50
BF127	0·55
BF152	0·61
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BF274	0·39
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BSX20	0·17
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C450	0·24
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2N2925	0·16
2N2926(G)	0·14
2N2926(Y)	0·12
2N2926(O)	0·11
2N2926(R)	0·11
2N2926(B)	0·11
2N3010	0·77
2N3011	0·16

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2S304	0·77
2S305	0·86
2S306	0·86
2S307	0·86
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2S323	0·62
2S324	0·77
2S325	0·77
2S326	0·77
2S327	0·77
2S701	0·46
40361	0·44
40362	0·50

DIODES

AA119	0·09
AA120	0·09
AA129	0·09
AAY30	0·10
AAZ13	0·11
BA100	0·11
BA116	0·22
BA126	0·24
BA148	0·16
BA154	0·13
BA155	0·16
BA156	0·15
BA173	0·16
BY100	0·17
BY101	0·13
BY106	0·19
BY114	0·13
BY124	0·13
BY126	0·16
BY127	0·17
BY128	0·17

BY130	0·18
BY133	0·22
BY164	0·55
BYX38/30	0·46
BYZ10	0·39
BYZ11	0·33
BYZ12	0·33
BYZ13	0·28
BYZ16	0·44
BYZ17	0·39
BYZ18	0·39
BYZ19	0·31
CG62 (OA91 Eq.)	0·08
CG651 (OA70-OA79)	0·07
OA5	0·39
OA55L	0·23

OA10	0·15
OA47	0·08
OA70	0·08
OA79	0·08
OA81	0·08
OA85	0·10
OA90	0·07
OA91	0·07
OA95	0·08
OA200	0·07
OA202	0·08
SD10	0·06
SD19	0·06
1N34	0·08
1N34A	0·08
1N914	0·06
1N916	0·06
1N4148	0·06
1S021	0·11
1S951	0·07

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mW (DO-7 Case) 12p ea. 1¼W (Top-Hat) 18p ea. 10W (SO-10 Stud) 32p ea. All fully tested 5% tol. and marked. State voltage required.

10 amp POTTED BRIDGE RECTIFIER on heat sink. 100PIV. 99p each

NEW LINE
Plastic Encapsulated
2 Amp. BRIDGE RECTS.

50v RMS	35p each
100v RMS	40p ..
200v RMS	45p ..
400v RMS	50p ..
1,000v RMS	55p ..

Size 15 mm × 6 mm.

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UT46. Eqvt. 2N2646. Eqvt. T1843 BEN3000 30p each, 25-99 28p 100 UP 22p.

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GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY-27/28/95A. ALL usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

		£p
20	For	0·55
50	For	1·10
100	For	1·92
500	For	8·25
1000	For	14·30

SIL. G.P. DIODES £p

300mW	30..0·55
40PIV(Min.)	100..1·65
Sub-Min.	500..5·50
Full Tested	1,000..9·90

Ideal for Organ Builders.

TRIACS

VBOM	2A TO-5	6A TO-66	10A TO-48
	£p	£p	£p
100	33	55	83
200	55	66	99
400	77	83	1·21

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SUPER PAKS NEW BI-PAK UNTESTED SEMICONDUCTORS

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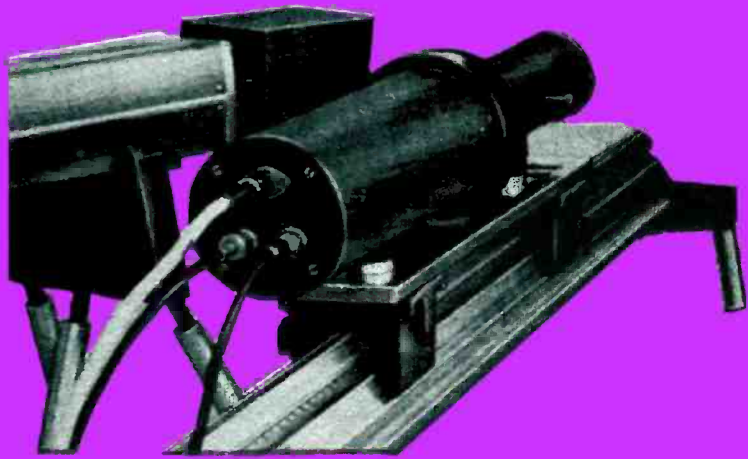
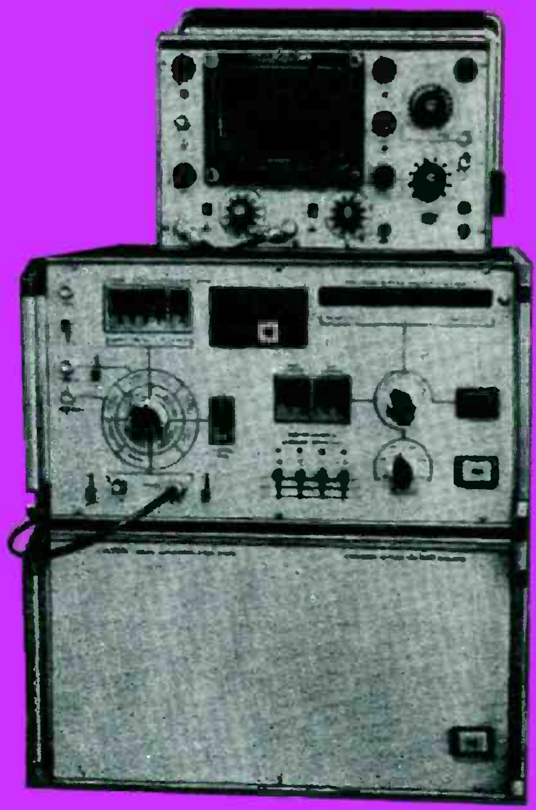
COUNTING PHOTONS





How to extract ultra-low level signals from a high noise environment.

OUR ABILITY to detect signals from any area of interest is largely limited by the extent to which noise signals (those that look like the desired signal but which come from unwanted sources) are present in the total output energy from the system being studied.

All practical signals contain noise: signal/noise ratio expresses the relative proportion of each.

When the ratio is much larger than unity little difficulty in detecting the signal is experienced. It is when it falls close to, or below, unity that special techniques must be brought to bear if the signal is to be extracted.

The uninitiated might feel that a signal containing as much noise as signal is close to useless. But it is possible, provided the noise is different in character to the signal in some way, to separate the two. By the use of certain very powerful methods it is possible to recover signals that are only 1/100,000th of the noise level.

An incredible amount of knowledge gained from research studies has been obtained under conditions where the signal/noise (S/N) ratio is extremely poor. Many experiments can be designed to work with large SIN ratios: this is fine if it can be achieved. However, many effects are not under the control of the experimenter, so when natural background swamps the signal there is no option but to employ advanced detection techniques. Examples include studies of atomic absorption, various forms of spectroscopy, audiometry, bio-medical stimuli response measurement, cochlea micro-phonics, Doppler measurements, electro-luminescence, electron spin resonance, nuclear magnetic resonance, Zeeman effect, laser frequency controllers, Hall-effect probes, probes, photometry, strain gauges, micro-wave studies and many more where signal enhancement is needed if anything useful is to be learned.

A large proportion of these examples are concerned with the measurement of optical radiation levels ... those in the radiation band from infrared to ultraviolet. The usually applied methods for detecting the minute radiation signal energies involve looking at analogue properties of the light - the detector produces a continuous form of signal that has an amplitude proportional to the signal.

The most used method is the lock-in technique (also known under numerous other names, such as, phase-sensitive-detection, synchronous detection, coherent detection). In th is method the photons collected in the detector (photomultiplier's are the most usual form employed in high sensitivity work) are used to produce a voltage or current that is amplified and processed as an analogue signal entity. A good lock-in· amplifier can detect signals as small as 100 pV or, in terms of current, 0.01 pA (10^{-14}A) which is certainly good but it is not the maximum attainable.

Our dual concepts of light tell us that it can be of a continuous nature or that it comes in discrete pulses of energy, called photons. Photons are fundamental quanta of electromagnetic energy occurring in the visible region of the electromagnetic spectrum. In the shorter wavelength region we have the nuclear particles that are handled as pulses for this range, pulse counting methods are used instead of analogue procedures.

It is not so surprising, therefore, to see the same approach to the problem has also been applied to light, considering it as photons. It is a relatively new concept in practice having its commercial origins about seven years ago when the methods were developed for chemical analyses.

Today several manufacturers offer equipment for detecting extremely low-light-levels that are buried in noise by the use of the digital photon counting method.

DIGITAL BETTER THAN ANALOGUE

The analogue lock-in methods of signal recovery, although good, are not as powerful as a well designed photon counter arrangement. Firstly, practical lock ins cannot achieve the same digress of improvement in S/N ratio at very low light levels with a subsequent reduction in overall sensitivity. Secondly, analogue systems are prone to gain changes as the components drift in value with time. Digital counting is far less affected by gain changes, for signal amplitudes are not critical in digital circuitry. Thirdly, detector characteristics are time-dependent because of such things as leakage current variation, applied voltage variations, dimensional and chemical changes which, being analogue in nature, produce drift. If the detector can be used to detect signals that are digital at their source, these drift effects are greatly reduced.

Another important factor is that sophisticated signal processing systems nearly always incorporate digital computing machines, so signals already in a digital form are to be preferred as the need for an analogue to digital converter is avoided.

PRACTICAL CONSIDERATIONS OF DIGITAL LIGHT INTENSITY DETECTION

The energy of a photon is given by hc where h (Planck's constant) and c (the velocity of light) are constant. This means that the pulse height of photons formed by visible radiation (and near to it) will have energy levels that are much the same. This fact is used to effect in noise reduction as we will soon see.

Each quantum of light landing on the detector should ideally produce a well-shaped pulse ready for counting. Furthermore the ideal detector should not generate pulses of its own, for these would appear as signal resulting in misleading answers. Photomultiplier's are usually used; they come closest to the ideal, and have internal gain of around 1 000 000with very little addition of noise.

In practice, as the system is made more sensitive, the signal will. be found to contain stray noise generated in the signal background. It has been established that only some 6.15% of photons are detected in the photomultiplier and that it too generates noise pulses internally. These pulses arise from secondary emission on the dynodes, electron emission from the photo-cathode, and from emissions caused by external radiations fluxing through the photomultiplier. On top of these noise problems there is an unpredictable surface leakage current. A photomultiplier typically generates a background noise count of 10-100 per second from these sources:

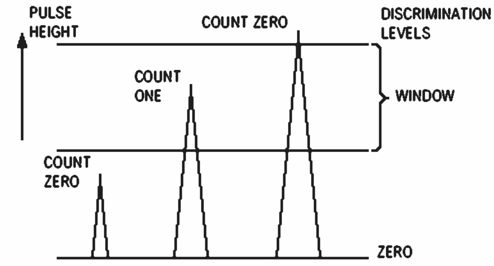
SEPARATING NOISE PULSES FROM SIGNAL PULSES

The analogue lock-in method derives its signal extraction capability by limiting the bandwidth of the signal to very narrow limits, thus reducing the noise energy which is usually wide-band white noise. As the signal energy is all contained in the same narrow bandwidth the signal power remains unaltered but the noise power is reduced. The net result is a dramatic improvement in the S/N ratio. As the improvement is proportional to bandwidth, the longer the response time allowed, the better the signal enhancement.

In pulse counting a somewhat similar procedure is used by distinguishing between pulses of different height. It has been established that the signal pulses have amplitudes lying within well defined limits (the energy equation tells us this) and that the noise pulses (discussed above) have heights ranging from small to large with a uniform distribution of amplitude.

The principle used, therefore, to reduce the noise level of a pulse count is to accept only those pulses that lie within two defined levels of amplitude. Those that lie· above the level are not counted and neither are those that fie below the lower level. The amplitude range wherein pulses are accepted is called the window; see Fig.1. By this means some, but not all, noise pulses are ignored, thus raising the signal to noise ratio. Noise pulses in the window are. of course, accepted as signal.

Another advantage of the window scheme is that the system is more tolerant of detector gain changes - for the following. reason. A gain change effectively raises or lowers the position of the discrimination"window but does not alter its width by much. Signals now accepted in the new area at the top of a raised window are balanced out by roughly equal losses in the area lost below. Provided the window



Fig, 1. Pulses with height lying inside the two discrimination levels are accepted for counting, The central area is known as the window.

width and mean height is chosen intelligently to suit the energy of the signals to be detected, this method is not affected much by gain changes. A similar argument applies for drift in the DC level of the detector output. In sharp contrast, the equivalent analogue method suffers directly from gain changes and drift.

THE BASIC PHOTON COUNTER SYSTEM

The block diagram of the basic photon counting arrangement is shown in Fig.2.

The detector is coupled to the experiment with the known stray influencing effects screened out as well as possible. As the pulses from the photomultiplier are still very small in amplitude (maybe only microvolts), a low noise, very fast (1 ns rise time is used) preamplifier is needed to raise the signal to a reasonable level ready for acceptance by the discriminator. This stage has adjustable discriminator levels that form the window needed for the particular experiment concerned. After discrimination the remaining pulses are fed to the counter unit. The output of the counter can be displayed, fed to data storage, used to control a process or sent for further processing to provide information such as photon rate.

Typical count rates provided in commercial equipments, such as that shown in Fig.3, range from less than 1 per second to 108 per second using interval times from 1μ to 1000s.

As the signals are digital rather than analogue, the DC drift of the detector

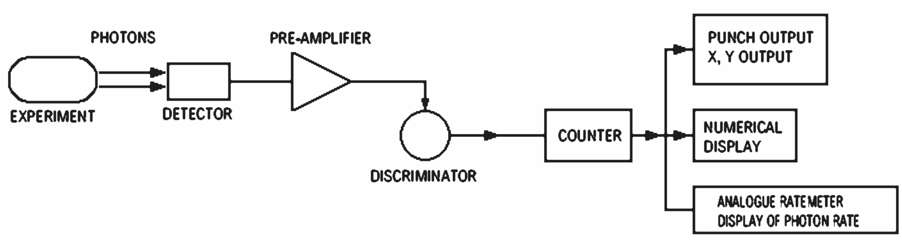


Fig.2. Basic block diagram of a photon counting system.

COUNTING PHOTONS

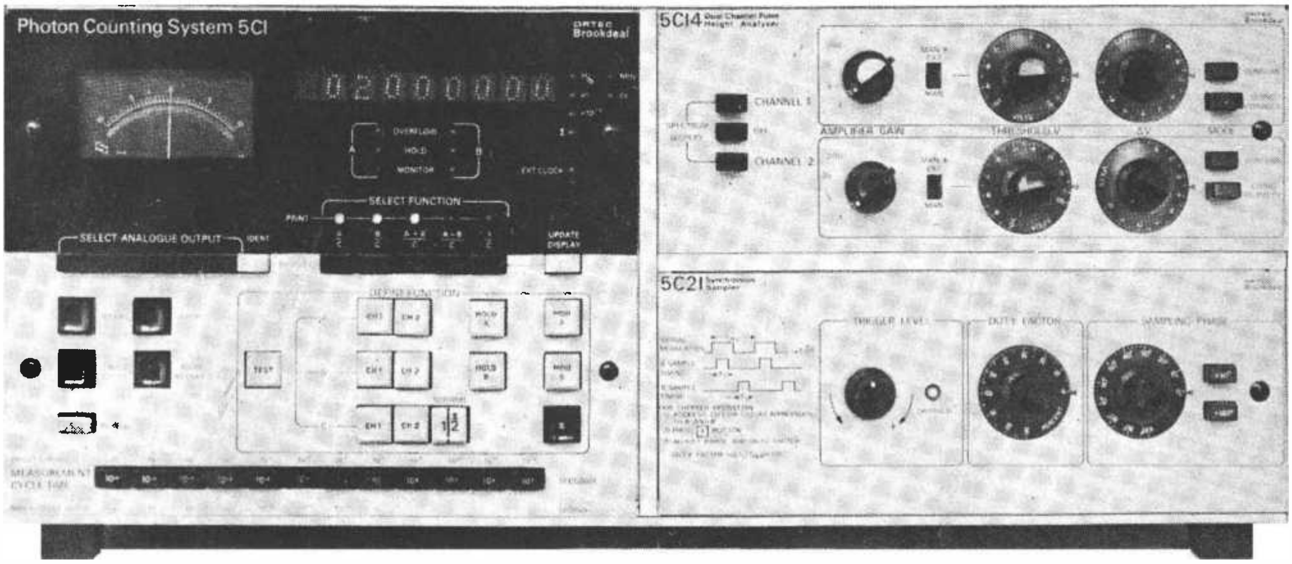


Fig.3. Front panel of Photon Counting System.

with time does not impose a duration limit on the counting period. Very large intervals of counting can be used to improve the accuracy of the data by taking more counts.

IMPROVEMENTS TO THE BASIC SYSTEM

Several interesting improvements can be incorporated to improve the signal detection sensitivity. Let us look at these.

Compensating for light source variations - The number of photon pulses produced at the detector output is proportional to the intensity of the source illuminating the experimental area. Fluctuations in intensity will, therefore, alter the output, introducing error. As this source of error is systematic (we know where it is produced and how) it is feasible to monitor it and make corrections.

Figure 4 shows how this is achieved in the commercial photon counter. A second photo-detector is set up to see the same source as is used to illuminate the experiment. This monitoring detector needs to have the same type of cathode but its gain does not have to be matched with that of the main detector. The Brookdeal system uses a second monitoring counter that is arranged as a preset count-level indicator. Both counters are cleared together, and counting begins. When the monitor count reaches its preset level it is used to inhibit counting in the main store. As the monitor counter fills each time for a given number of photon pulses, the value in the other counter must be the signal counts compensated for variation in the illuminating intensity.

Digital lock-in. The window concept can eliminate noise pulses that are unlike signal pulses on the criteria of amplitude, but it is unable to discriminate against those that look like signal.

If the light signal is chopped just before it enters the detector (a rotating blade is used) the detector firstly sees signal-plus-nois photons and then only noise photons, for the signal is screened from it. The signal still contains some noise that from the strays in the experiment background but the method does reduce the noise contributed by the detector and strays entering its target.

Two counters are used to store the pulses produced, firstly with the chopper obscuring the beam, and then with the chopper open, the two being synchronised. The difference between the two count totals at any time is the signal count. Care has to be exercised with the starting and stopping times as these affect the accuracy of the procedure.

As the noise is random in nature it can be shown statistically that the effect of noise is reduced as the square-root of the number of counts taken. Hence, the longer- the integration time the better the result and with photon counting this is not restricted by drift in the detector.

APPLICATIONS OF PHOTON COUNTING TO ANEMOMETRY

The flow of fluids can be studied at the microscopic level with laser

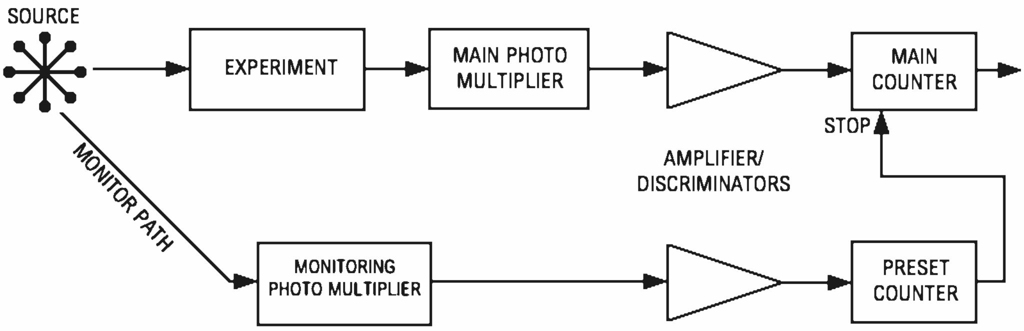


Fig.4. A second photo-multiplier is used to monitor the intensity.

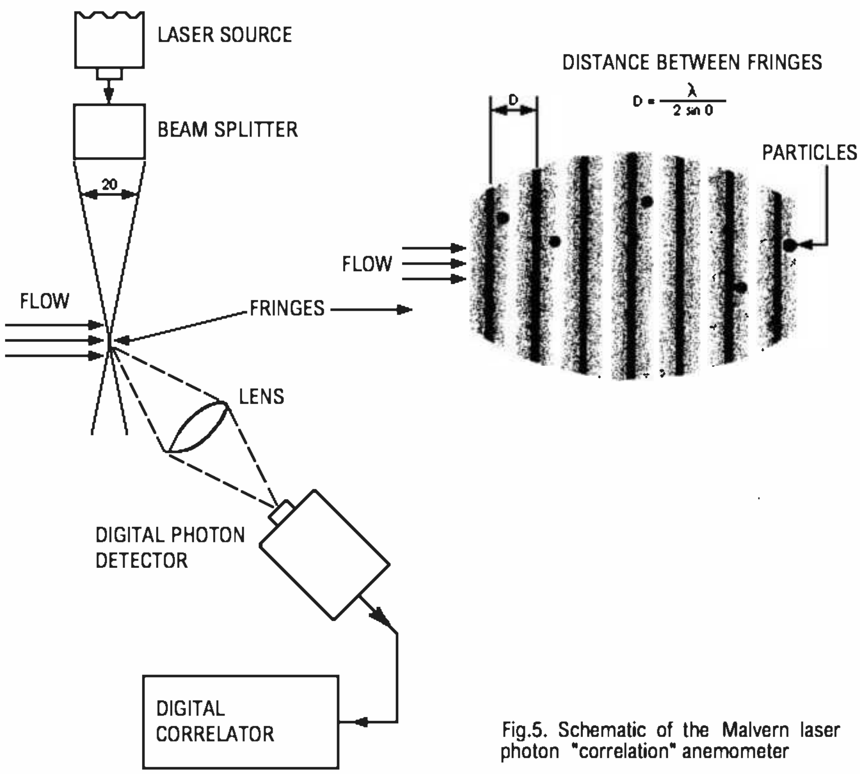


Fig.5. Schematic of the Malvern laser photon "correlation" anemometer

Doppler velocimeter (see E.T.I. Aug. 1972). These use a laser source to produce brief bursts of signal of only a few cycles long from the scattering particles moving with the fluid flow. The frequency of these bursts is related' to the flow rate by virtue of the Doppler effect.

A limitation to this method is that there is often need to add artificial scattering particles in order to gain a reasonable signal level for processing. Seeding is done with aluminium oxide, smoke particles or diesel fuel, but in many instances this is not feasible.

Since the E.T.I. article was published there have been many improvements and a number of alternative equipments operating on this principle are now marketed. The need to seed still exists however.

One method now available can measure velocity without seeding. It, uses laser radiation but processes the signals by correlation rather than with the period measurements adopted in the earlier types.

Referring to Fig.5. the two laser beams converge to produce a fringe pattern in the flow under study. This pattern is viewed by a photon detector like those described above. Particles passing through the fringe-field scatter light to the detector with a signal strength that is greatest when the particles are passing the bright part of the fringe and lowest when in the dark part. In effect it appears as though the particles are bunched info the bright parts of the fringes.

The signal coming from the detector contains these scattered signals, but it is swamped by the general background level, so the whole must be processed in some way to extract the wanted information. This system does not need seeded particles for it can obtain a sufficient return from the microscopic structure of the fluid by virtue of the greatly enhanced sensitivity of the photon detector stage.

The key to enhancement is to use correlation methods to extract the time taken for a particle to traverse a cycle of the fringe. Flashes of light caused by the scattering particles in the flow result in pulse train bursts that have a periodicity related to flow rate. Figure 6 shows what these pulses would look like if the noise could be removed. With the noise added, the plot becomes a mass of pulses. If a section of this plot is recorded and multiplied with many different time-delayed versions of the same train, the plot of this correlated output looks like that shown in Fig.7. The period of the cosine wave produced by the correlate is the time taken for a particle to pass across a fringe pitch. Knowing the geometry of the fringe it is then possible to produce an output that is the velocity of the fluid.

In condition of turbulence, the correlogram takes the form shown in Fig. 8, looking like a damped oscillation. The envelope of the decay is a measure of the intensity of turbulence as is shown by the equation given in Fig.8. The complete system is shown in Fig.3.

This system is, however, unable to yield information about the direction of flow as the correlation procedure takes no account of which way the particles are going. If bi-di ectional flow exists the answer produced will be in error. This disadvantage can be overcome by addition of some more elements into the design.

The fringes, that are normally stationary, are modulated with electro-optic crystals, as shown in Fig. 9. This causes the fringe pattern to move from side to side with a small amplitude about the mean position. If the fringes are moving in the same direction as the flow the correlogram period is lengthened as shown in Fig.10; the opposite effect occurs if the fringe is made to move against the flow.

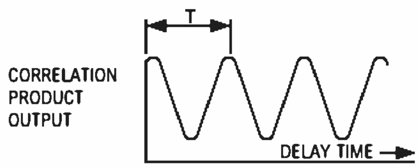


Fig. 7. Correlate output for laminar uni-directional flow.

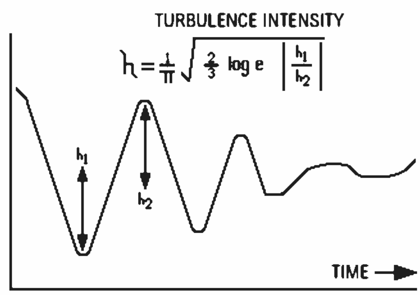


Fig.8. Turbulence produces correlate signals that enable the degree of turbulence to be estimated from the damping.

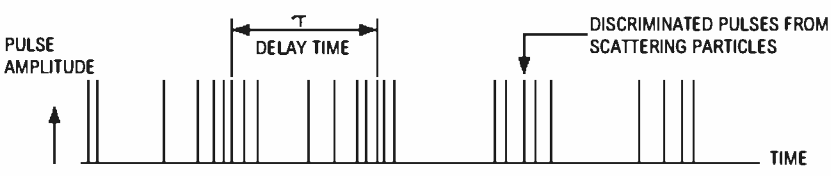


Fig.6. Pulse-time graph of light flashes if the noise could be removed.

COUNTING PHOTONS

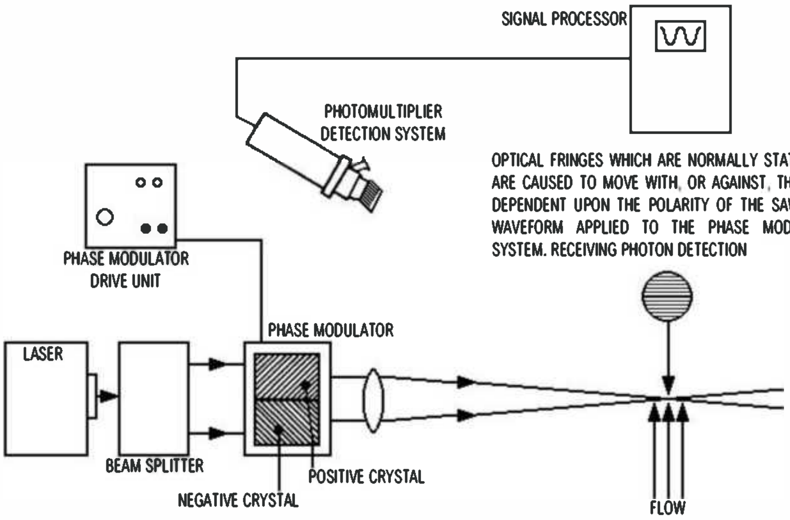


Fig.9. Addition of fringe modulation enables the direction of flow to be ascertained.

a measure of flow direction and being continuous· in nature can be used to close the loop in a servo that controls the fluid flow rate, as is illustrated in the scheme shown in Fig. 11.

It is interesting to see how correlate units have become accepted instruments that are added to systems as dedicated units.

It was not so long ago that they were regarded as highly sophisticated research tools that took many a long day to build. No doubt we will soon see correlates produced on large-scale integrated chips that are wired into circuits in the same casual way that we use integrated amplifiers today.

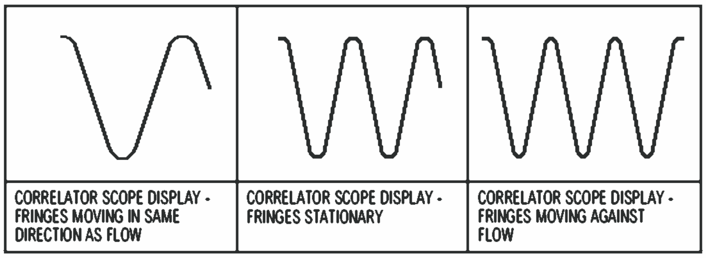


Fig.10. Effect of fringe movement on the correllogram.

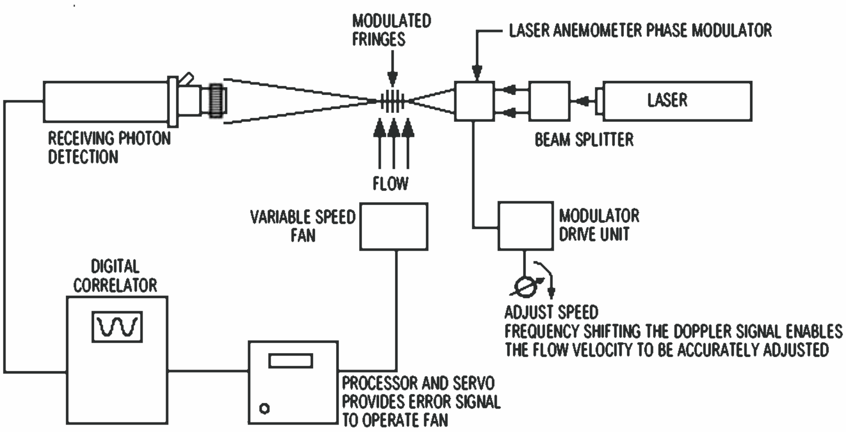


Fig.11. Use of the collelation anemometer to gain cortrol of fluid flow rate.

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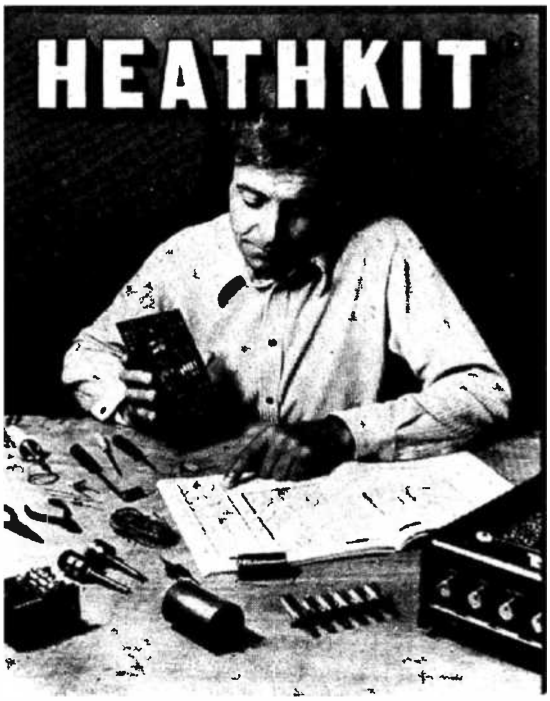

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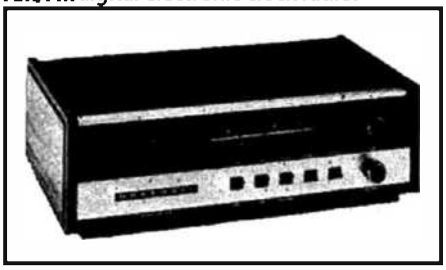

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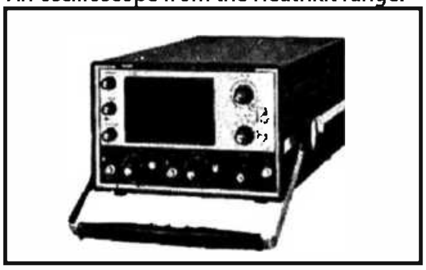
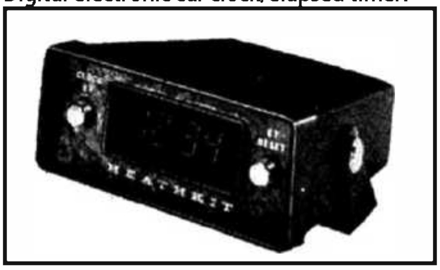


Digital electronic car clock/elapsed timer.



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HEATH Schlumberger

THE 555 TIMER

How to use this versatile IC.

TIME DELAY circuits are easily built if the time delay required is between a few microseconds and a few seconds.

But until recently it was usually simpler to use mechanical devices if longer repeatable delays were required.

Then in 1972 the US Signetics Corporation introduced their type 555 integrated circuit which was designed primarily for timing applications but has subsequently found a thousand and one other uses. It can for example operate in an astable mode switching continually from one state to the other.

The cheapest 555 IC is available for a little over 50P. It is an ideal device for use by both amateur enthusiasts and professional circuit designers.

Various makes and types of the basic 555 design are now available. One of the simplest and most versatile is the Signetics NE 665V, (other similar devices are also available from other manufacturers see below).

The NE 566V is an 8-pin dual-in-line package which is very convenient for the experimenter. Signetics NE555T has a circular metal case with eight leads (known as the T0-99 encapsulation). The electrical characteristics of the two types are identical.

A close tolerance version of the 555 is available from Signetics as type SE555T (in the circular T0-99 package). Although the SE555T can operate over a much wider temperature range than the NE types, it is several times the price.

Electrically equivalent devices are available from Motorola under the types numbers MC1465 and MC1566 (the latter being the close tolerance version). National Semiconductor manufacture an equivalent device, the LM555.

Signetics also offer a 556 device. This contains two 555 units in a single encapsulation.

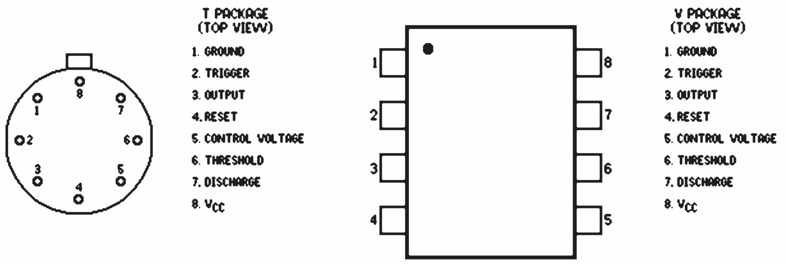


Fig. 1

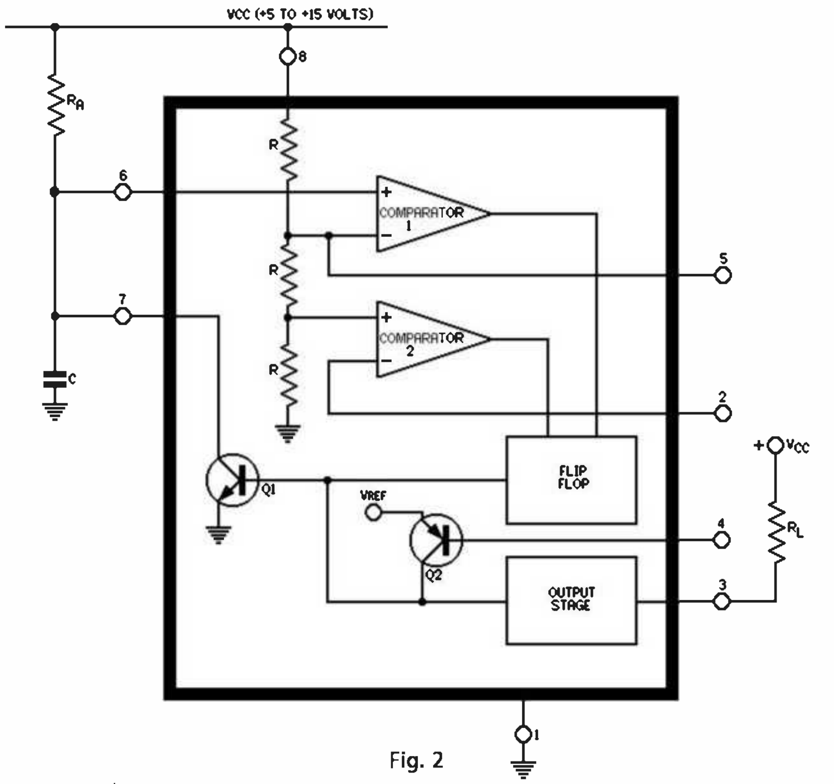


Fig. 2

CONNECTIONS

The eight connections of the 555 for both the dual-in-line and T0-99 devices are shown in Fig.1. Either of these devices may be employed in any of the circuits to be discussed.

SIMPLE TIMING

The operation of the 555 as a simple timer is described using the circuit of Fig.2.

A negative going trigger pulse fed to pin 2 starts the timing operation. The potential at the + input of comparator 2 inside the 555 is one third of the supply voltage, since the values of the three resistors marked R are equal. The trigger pulse must therefore fall below one third of the supply voltage to start the timing operation.

Before the trigger pulse is received, the internal transistor Q1 is conducting. All the current which passes through the resistor A passes through the transistor; the external capacitor C remains uncharged. When a trigger pulse is received by pin 2 of the 555, however, comparator 2 switches the flip-flop and the latter cuts off Q1. In addition, the switching of the flip-flop switches the output stage.

The current flowing from the positive supply line through RA is now used to charge the capacitor C. When the potential across this capacitor reaches a value of two thirds of the supply line voltage, comparator 1 switches the flip-flop back to its initial state. We shall later see that the voltage which must be present across C for this switching to occur can be varied by the application of a control voltage to pin 5 of the device.

The switching of the flip-flop returns the output circuit to its quiescent state. In addition, it switches Q1 to conduction and this transistor discharges the capacitor C ready for the next timing operation. The time delay provided by this circuit is equal to approximately 1.1 RAC when no connection is made to pin 5. This is

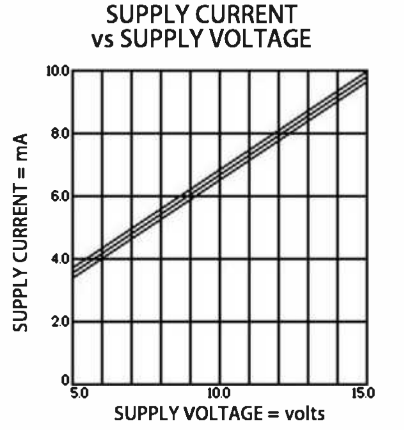


Fig. 3

THE 555 TIMER

the time taken for the capacitor C to charge to a value equal to two thirds of the supply line potential.

THE OUTPUT

In the circuit of Fig.2, the 555's output stage provides a change in the output voltage at the beginning and at the end of the delay period. The output voltage at pin 3 has two values; the 'high' value is only a little less than that of the positive supply line, whereas the 'low' value is only a little above ground potential.

Before the trigger pulse is applied to pin 2, the voltage at the output is in its 'low' state. It rises to the 'high' state at the moment of triggering and remains in this state until the end of the delay period, when it returns to the 'low state'.

If the circuit is connected as in Fig.2, current will flow through the load resistor when the output is in the 'low' voltage state, but only a small current will flow in the 'high' state. If, however, the load resistor is connected from pin 3 to ground, the large current will flow when the output is in the 'high' state. The maximum current which should be allowed to flow to or from pin 3 is 200 mA.

The output pulses from the 555 rise and fall very rapidly; the rise and fall times are typically about 100 ns.

SUPPLY VOLTAGE

The supply voltage to a 555 device may have any value between 4.5 V and 16 V, but it is wise to place an upper limit of about 15V on the supply voltage to allow for possible variations.

The current required to drive the 555 is only a few milliamps, as shown in Fig.3. However, the current taken by the output must be added to this current to find the total power supply current required.

If the supply voltage is increased, the current flowing through RA to the capacitor will be increased in proportion. However, the voltage across each of the resistors marked R in Fig.2 will also be increased in proportion to the supply voltage before comparator 1 is switched. Thus any change of supply voltage will produce a minimal effect on the value of the time delay, provided that the timing period is short compared with the rate of the supply voltage variation.

If the period of the power supply variations is much shorter than the delay period, a capacitor may be connected from pin 5 to ground. This holds the potential at pin 5 constant so that comparator 1 receives th is constant reference potential. The timing period is short compared with the rate of the supply voltage variation.

If the period of the power supply variations is much shorter than the delay period, a capacitor may be connected from pin 5 to ground. Thi holds the potential at pin 5 constant so that comparator 1 receives this constant reference potential. The timing period is then almost independent of the supply voltage even if rapid variations of the latter take place.

TIME DELAYS

As has already been stated the time delay is equal to 1.1 RAC. Thus one may use 100k for RA and 10µF for C to obtain a delay of 1.1 second. If one reduces G to 10nF and keeps RA at 100k, the time delay will be 1.1 millisecond. If RA is 10 megohms and C is 100µF, the delay will be 1100 seconds.

The maximum value of RA which should be employed is about 20 megohms. A current of 0.1µA (in a typical 555) passes to pin 6 of the device, the maximum value of this current in any 555 is 0.25µA. If the value of RA is 20 megohms, the current to pin 5 can produce an appreciable voltage drop across RA.

When electrolytic capacitors are used, the leakage current may produce an appreciable voltage drop across RA if the value of the latter is high. A typical upper limit for the value of the timing capacitor is 100µf to 1000µF. It may be necessary to select such capacitors for low leakage.

If you do use electrolytic capacitors don't expect the timing interval to be accurately related to the nominal value of the capacitor, since such components have tolerance which are typically -50% to +100%. Similarly, high-K ceramic capacitors can have very wide tolerances.

CONTROL VOLTAGE

The potential of pin 5 should not be within 0.75V of the positive supply line voltage. It should be at least 1.5V above the ground potential. This enables the transistors inside the device to operate correctly. If the supply voltage is 15V, the full range of values of the control voltage shown in the table can be employed, namely from 0.1 to 0.95 times the supply voltage. If a smaller supply voltage is employed, however, the range of the control voltage which may be employed is smaller. For example, at the normal minimum supply voltage of 5V, the value of the control voltage should not be smaller than 0.3 nor greater than 0.85 times the supply voltage.

The resistors marked R in Fig.2 each have a value of about 5k. Thus one can vary the potential at pin 5 of the device by merely connecting a resistor

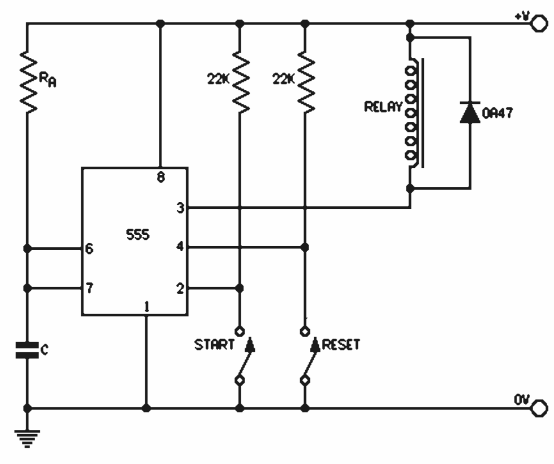


Fig. 4

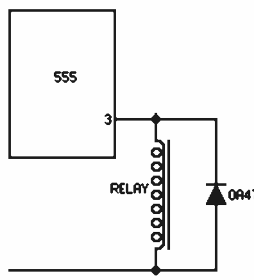


Fig. 5

THE 555 TIMER

from pin 5 to ground to reduce this potential or from 5 to the positive supply line to increase this potential. Generally a resistor of a few thousand ohms or more will be suitable.

RELAY OUTPUT

The 555 device can be used to drive a relay directly, provided that the delay period exceeds about 0.1 second. The relay used must not draw an operating current of more than 200 mA. It should operate with a coil voltage of about the same value as the power supply voltage used to drive the 555 (maximum 15V).

A typical circuit for using the 555 to drive a relay is shown in Fig.4. The closing of the switch marked 'Start' commences the timing operation. The trigger pin 2 is returned via a 22k resistor to the positive supply line to prevent false triggering.

If the 'Reset' switch is closed momentarily during the timing period, the circuit is immediately reset to its quiescent state and the timing ceases. A new timing operation will commence when another trigger pulse is applied to pin 2.

When the current passing through the relay pin 3 of the device is suddenly cut off at the end of the timing period, a high back emf is generated across the inductive relay coil.

This back emf could damage the integrated circuit and must be suppressed by connecting a diode across the relay as shown in Fig.4. A gold bonded germanium diode has been found to be especially suitable for this application.

In the circuit of Fig. 4, the relay is normally closed, but opens during the delay period. If the relay is connected between pin 3 and ground (as in Fig.5}, it will be energised only during the delay period. Thus one can choose whether one wishes to have the relay energised only during the timed periods or only at all other times.

Relay circuits of the types shown can be used to construct a photographic enlarger timer provided that RA is made variable and C is switched. If the relay is connected as in Fig. 5, the closing of the relay can be used to switch on the enlarger lamp when the circuit is triggered; the lamp is automatically switched off at the end of the delay period.

TRIGGERING

The trigger input of the 555 is extremely sensitive, since the current required by pin 2 to trigger the circuit is only about 0.5µA for 0.1uS.

Triggering can be effected merely by touching pin 2 with a finger. You can even trigger the circuit by moving your hand near to a wire connected to pin 2. This causes the potential of pin 2 to fall (by a capacitive effect).

It is possible for re-triggering to occur at the end ·of the delay period when an inductive load (such as the coil of a relay) is connected in the pin 3 circuit if an unsuitable diode (or no diode} is connected across the relay. This occurs only in the circuit of Fig.5. When the current passing through the relay at the end of the timing period commences to fall, the voltage transient produced across the coil is picked up at pin 2 and the circuit is re-triggered before the relay can commence to open. The only outward sign that this is happening is the failure of the relay to open at the end of the timing period. Gold bonded germanium diodes, such as the OA47, appear to prevent this effect, but silicon diodes (such as the IN914) are not satisfactory.

OUTPUT VOLTAGE

The output voltage varies· somewhat with the pin 3 current. This variation is shown in Fig.6 for the case when the output voltage is 'high'. It can be seen that the pin 3 voltage is roughly 1V to 2V below the positive supply line potential.

Figure 7 shows how the 'low' output potential varies with the current to pin 3 when a 10 V supply is used.

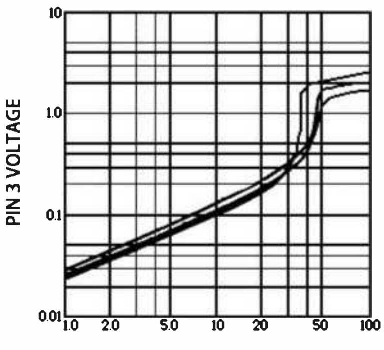


Fig. 6

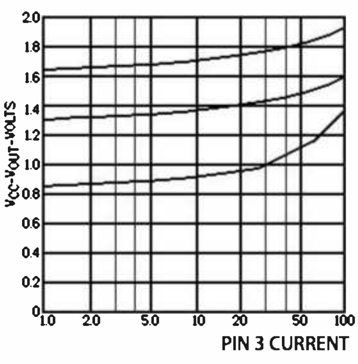


Fig. 7

ASTABLE OPERATION

The versatility of the 555 device is greatly increased by its ability to 'free-run' or operate as an astable oscillator. A circuit of this type which continually produces output voltage changes at preset-intervals is shown in Fig. 8. If desired, the load may be replaced with a diode in parallel with a relay (as shown in Figs. 4 and 5) and the relay will then close and open alternately.

In the circuit of Fig.8, the capacitor C charges through RA and Ra in series, but when the internal transistor Q1 in Fig.2 is switched to conduction, C discharges through Ra only. Thus the charging time is longer than the discharging time.

The capacitor C continually charges from a potential of one third of the supply voltage up to a potential of two thirds of the supply and then discharges again to one third of the supply. The charging time is 0.693 (RA + RB)C and the discharging time 0.693 RB C. For most practical purposes, one may use the factor 0.7 instead of 0.693. The frequency of operation is approximately 1.44/(RA + 2 RB)C.

In the astable circuit of Fig. 8, pin 6 is connected to pin 2. Thus when the voltage across C falls to one third of the positive supply line potential, the circuit is re-triggered and a new cycle commences automatically.

Operation of the 555 in the astable mode can be used to provide square wave output pulses for audio amplifier testing, etc. If the output is used to control a relay, the periodic opening and closing of the relay can be used to provide flashing lights on a Christmas tree or in a shop window. If RA is made small and Ra is made large, the time for which the relay is open will not be very different from that for which it is closed.

In the circuit of Fig.8, it has been assumed that pin 5 is not connected. However, the voltage at this pin may be altered as described previously and th is will either increase or decrease both the charging and the discharging times.

SIMPLEST ASTABLE CIRCUIT

An even simpler astable circuit is shown in Fig. 9. Only one resistor, one capacitor and the 555 are required.

When the output at pin 3 is in the 'high' state, C charges through the resistor R. Comparator 1 of Fig.2 switches the flip-flop when the voltage across C becomes equal to two thirds of the supply voltage. The output then falls to its 'low' value and C discharges into pin 3 through R. When the potential at pin 2 reaches one third of the supply voltage, comparator 2 of Fig. 2 is switched and C then commences to change again from the output which is now in its 'high' state.

The charging and discharging times are each approximately 0,7 RC. If desired, a relay may be connected from the output to either ground or the positive supply line

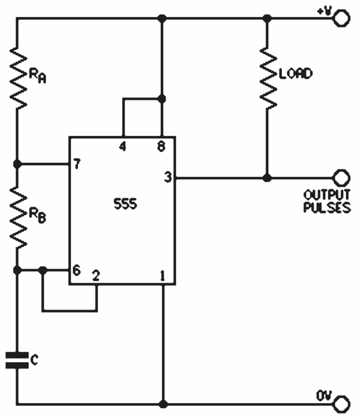


Fig. 8

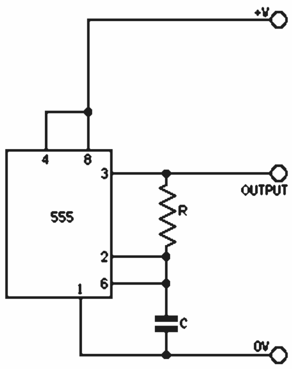


Fig. 9

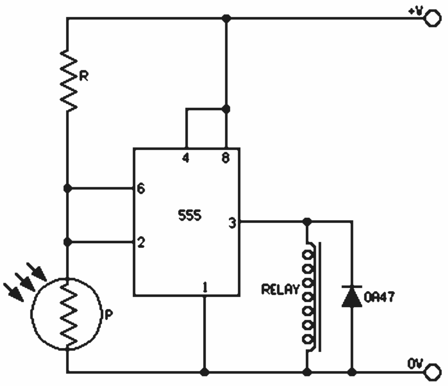


Fig. 10

provided that a diode is connected in parallel with the relay as in Figs. 4 and 5. The relay will then automatically open and close whilst power is applied to the circuit.

PHOTOSENSITIVE CIRCUIT

Although it is intended for use as a timer in both the monostable and astable modes, the 555 is essentially two voltage comparators which switch a flip-flop and the output stage. It can therefore be employed to provide different output levels as the voltage at the inputs to its comparators changes.

The circuit of Fig.10 shows how the 555 can be used as a photosensitive switch. When the intensity of illumination falling on the cadmium sulphide photosensitive cell rises, the resistance of this photo conductive cell falls. The voltage at pin 2 will therefore fall and when this voltage reaches one third of the supply voltage, comparator 2 of Fig.2 will switch the flip-flop stage and the output. The relay then closes.

If the light intensity subsequently falls, the resistance of the cell P rises and so does the voltage across it. When this voltage reaches two thirds of the supply voltage, the comparator 1 of Fig. 2 is switched. This causes the output voltage to fall and the relay opens.

It the relay and diode are connected between the positive line and pin 3, the relay will close when the light intensity falls and will open again when it rises.

The opening and closing of the relay occurs at different levels of illumination. This 'hysteresis' effect is usually advantageous, since it prevents the relay from continually opening and closing (or 'chattering') when there are very small changes in the light intensity.

The type of circuit shown in Fig.10 could be used to switch office lighting or street lights on and off as the level of illumination changes.

The. 555 device is a very versatile integrated circuit. We have considered. a number of its possible applications in this article, but many more can be devised.. For example, if the photo conductive cell P in Fig. 10 is replaced by a thermistor, one could doubtless use the switching of the relay to control temperature. This would be another example of the use of the 555 as a comparator in an application not involving timing.

A variation of the basic 555 design is the 556.

This is in effect two 555 devices within a common package. Each half of the 556 behaves like a separate 555 timer and as such all of the applications described in this article are equally applicable to the 556.

One most useful application of the 556 IC is in obtaining extended time delays.

Both the 555 and 556 ICs use external timing capacitors, but even using low leakage electrolytic capacitors, these limit the normally practical timing range to a maximum of ten minutes.

However by' using a 'divide by N' network between the two halves of a 556, very much longer delays may be obtained.

The 556 timer may also be used as a tone burst generator. In this application, the first half of the device is used as a one shot and the second half as an oscillator.

TABLE 1

Ratio of pin 5 voltage to the supply voltage	Factor by which RAC must be multiplied to obtain the timing period.
0.105	0.1
0.2	0.223
0.3	0.357
0.4	0.511
0.5	0.693
0.6	0.916
0.7	1.203
0.8	1.61
0.9	2.30

Table shows the effect of pin 5 control voltage on the timing period, when pin 5 is not connected, its potential is 0.667 times the supply voltage.

About 3,500 entries were received for this competition in November's ETI - an excellent response. The first three correct entries drawn were received from

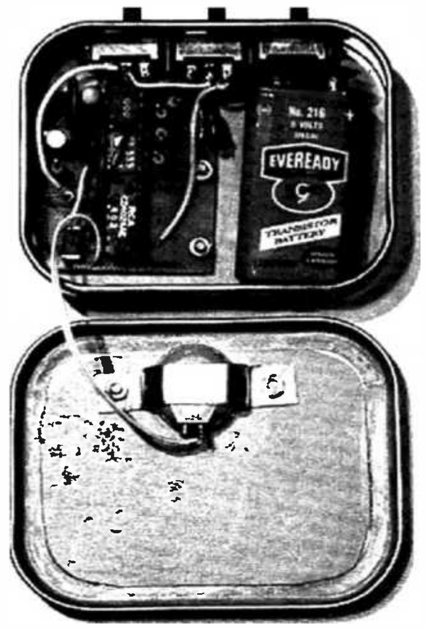
C.J. Pennycuick of Clifton, Bristol. (Gold Prize).
P. Shaw of Plaistow, London E.13. (Silver Prize).
R.W. Harris of Newport, Gwent. (Bronze Prize).

Readers who ask for the Heathkit catalogue should have received it by now.

The answers to the Cross-Number are shown on the right. Surprisingly nearly half the entries got 11 down wrong. (Resistor colour code: white, Brown, Brown). This is 910, not 911 as often entered.

[1] 3	1	[2] 4	1	[3] 6		[4] 1
2		6		[5] 7	[6] 4	7
[7] 1	[8] 9	5	[9] 9		[10] 8	7
	8		3		4	
[11] 9	9		[12] 2	[13] 0	0	[14] 1
[15] 1	2	[16] 1		0		4
0		[17] 2	7	1	8	3

eti PROJECT 229 METER BEATER



Internal view of the completed timer showing how it is assembled into a small tin.

FOR THE PRICE of two or three parking fines you can build the Meter Beater and never get caught again!

The Meter Beater is simply a portable audible alarm which can be set for common parking meter periods 1/2 hour, 1 hour and 2 hours. Several minutes before the expiry of the period it sounds a warning giving you time to get back to your car. It is set by sliding one of the three switches visible in Fig. 1.

CONSTRUCTION

The prototype was constructed on a 47 x 55 mm piece of 0.1 inch pitch Veroboard. This may conveniently be mounted in a small tin such as that shown in the photograph. The Veroboard tracks should be cut in the pattern as shown in Fig. 2. Note that in the component overlay (Fig. 3) the components are drawn as seen from the opposite (component) side of the board.

Take particular care to orientate ICs transistors and electrolytic capacitors as shown in the component overlay. Use a lightweight soldering iron and solder quickly and cleanly. Take particular care with the CMOS IC, IC2, (See ETI November 1974).

As tantalum capacitors have tolerances of +50% to -25% it may be necessary to select values for R1 and R2 to obtain the time required for the 1/2 hour alarm. Once this is set the other times are right.

OUTPUT TRANSDUCER

The output transducer used in the prototype was a hearing-aid ear-piece of about 400 ohms. However these are quite expensive. Alternatively a cheap lapel crystal microphone, mounted on the outside of the tin box, makes a good 'speaker' or a crystal radio ear-piece may be used. If a magnetic ear-piece is available it may be also used provided that it is fed through a small electrolytic capacitor, say 4.7µF. All of these will work quite well but the best of all, if available, is the hearing-aid ear-piece. Whichever device is chosen it is not worn in the ear, but mounted on the lid of the tin box, by means of a small aluminium strap. The complete alarm may then be slipped into a pocket where it is easily heard.

The inside of the tin box and the lid should be insulated with plastic sheeting before fitting the 'works'.

ADJUSTMENTS

The only adjustment provided is the preset pot RV1. This sets the duration of the "1/2 hour" alarm as close to half an hour as desired. However, as pointed out earlier, if the tantalum capacitor is well off the marked value, then a change may be needed to R1 and R2 to obtain the correct adjustment range for RV1.

The switching transistor Q8 should be turned hard on, to obtain the maximum voltage across IC3. This may be checked by measuring the voltage across the transistor when it is on and the alarm is sounding. It should be less than 1 volt. If it exceeds 1 volt then the value of the base resistors R4, R5 and R6 should be reduced to ensure saturation.

USE

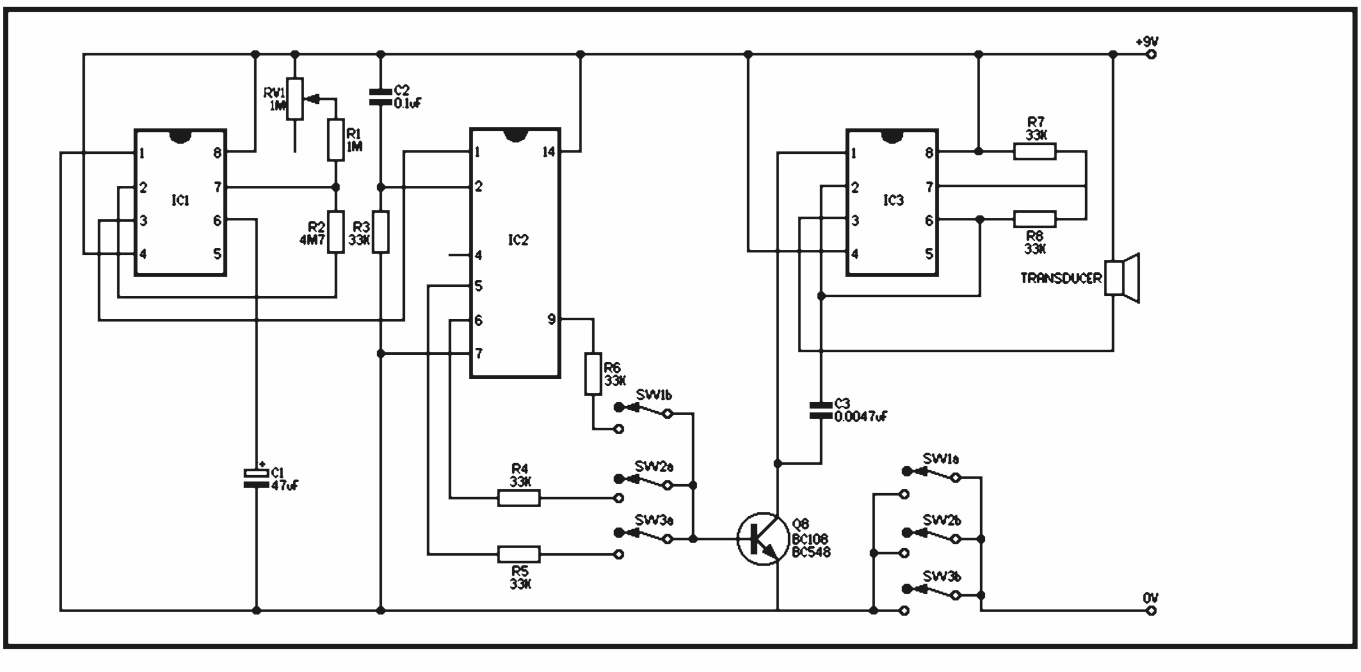
To use the Meter Beater, simply switch it on after putting your money in a parking meter, using the switch appropriate for the time for which you've paid. Put the Meter Beater in a shirt pocket and in due time it will sound off a warning that you must be heading back to your car.

OTHER USES

As will have been noted, only three of the outputs of IC2 have been used. The other -outputs can be used for shorter or longer times if desired up to nearly eight hours. Thus the unit is essentially a long period timer and may be adapted for such purposes as timing hire periods of, say, billiard tables; process timing; a medicine reminder alarm, and any similar long period applications.

BATTERY LIFE

Battery consumption is very low - only about 4mA, hence the 9 volt battery used should have a life of about 100 hours, at two hours use per day.



PARTS LIST ETI 229

RESISTORS (all 1/4w 5% carbon)

R3,4,5	33k
R6,7,8	33k
R1	1M
R2	4M7
RV1 preset potentiometer	1M

CAPACITORS

C3	0.0047uF polyester
C2	0.1uF polyester
C1	47uF 6.4V tantalum

SEMICONDUCTORS

IC1, IC3	NE555
IC2	CD4024AE or MC14024
Q8	BC108
S1, S2, S3	D.P.S.T. slide switch

Transducer - see text, metal box, spacers, nuts & bolts

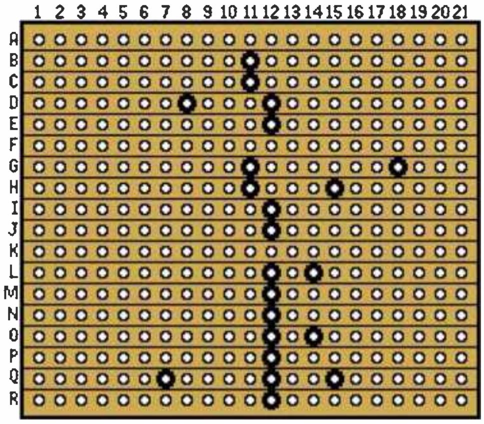


Fig. 2. Veroboard pattern. The tracks should be cut as shown. Full size 47 x 55 mm.

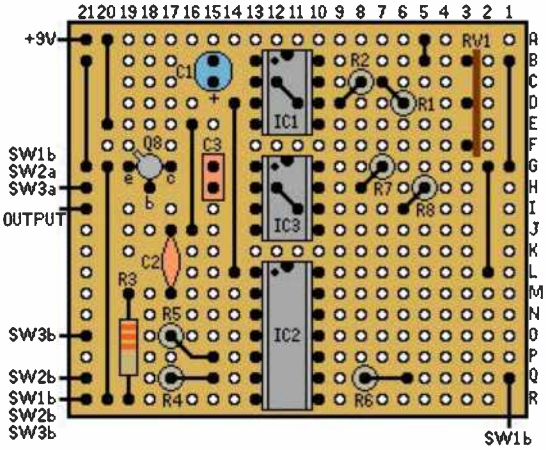


Fig. 3. Component overlay.

HOW IT WORKS

The Meter Beater comprises three elements - a 555 timer connected as a very slow running astable multivibrator, a seven stage ripple counter, and a 555 timer connected as an audio frequency astable multivibrator feeding an output transducer.

Potentiometer RV1, R1, R2 and C1 are the timing elements associated with the first 555 timer IC1. At switch on, the output of IC1, terminal 3, goes high. About 5 1/2 minutes later it goes low, and two minutes later it goes high again. This is shown in the timing diagram. The rust high period is longer than subsequent ones because during the first period the capacitor C1 has to be charged from zero up to 2/3 of battery voltage, whereas in later periods the capacitor is charging only from 1/3 to 2/3 of battery voltage. Hence each full cycle lasts about 6 1/2 minutes.

The output pulses from IC1 are connected to the input of the seven stage ripple counter IC2. For those not familiar with this device - it comprises seven, bistable multivibrators (flip-flops) connected in series. One output terminal of each flip-flop (FF) is brought out to a pin and they are named Q1 to Q7 in the pin assignment diagram Fig.5. Assuming all outputs are first set low, logic 0, then when the first negative going edge of the input pulse reaches the input of FF1, its output Q1 changes and goes high. When the next negative going edge reaches the input of FF1, its output changes again, goes low. See graph of output of Q1 on Fig.4. The negative going edges of the input pulse train are numbered 1 to 16. It can be seen that, at edge 2, the output of FF1 is negative going, and this, being connected to FF2 which is also negative edge sensitive, sends the. output Q2 of FF2 high. It can be seen that the output of FF2 goes high at half the frequency of the input, and similarly, the outputs of the other FF's are at half the frequency of the preceding FF. It can be seen that Q3 goes high after four negative going edges, Q4 goes high after eight, negative going edges and Q5 goes high after 16 negative going edges. It will be noted that only outputs Q3, Q4 and Q5 have been used in this project. Q1, Q2 and Q3 could have been used if IC1 had been made to oscillate much more slowly - but this would have involved higher timing resistors and capacitors - with associated problems of leakage current approaching charging current, and the consequent inaccuracy. Now, reverting to the circuit diagram - it will be seen that each of the three switches is a double pole type and each performs two functions. One pole of each switch S1a, S2a and S3a connects the battery to the circuit, but S1b connects output Q3 to IC2 to Q8 (called Q8 to avoid confusion with the the outputs of IC2) an NPN transistor used as a switch. S2b connects output Q4 to Q8, and S3b connects output Q5 to Q8.

Thus when S1 (the 1/2 hour switch) is closed, the battery is connected and output Q3 is connected to Q8. After about 25 minutes the output Q3 goes high and turns on Q8. This energizes the second 555 timer IC3, for which R7, R8 and C3 are the timing elements. These timing elements set the 555 in the astable mode at audio frequency. The output is connected to the transducer which provides an audible alarm. Similarly when S2 (the one hour switch) is closed, the alarm sounds after about 50 minutes, and when S3 (the hour switch) is closed the alarm sounds after about 1 hour 45 minutes. The amount by which the alarm is ahead of the exact meter period is greater with longer periods, and this allows for the fact that one probably goes further from one's car when it is parked for two hours.

For the device to work it is obvious that all outputs of IC2 must be set low at switch on. The IC has a reset terminal, Pin 2, which must be set high so that all outputs are reset to tow, and must be set low to enable counting to proceed. R3 and C2 provide these functions. At switch on, Pin 2 is 'flicked' high by the pulse through C2, but as C2 charges (which takes very little time) Pin 2 is brought down to negative rail voltage, allowing counting to proceed.

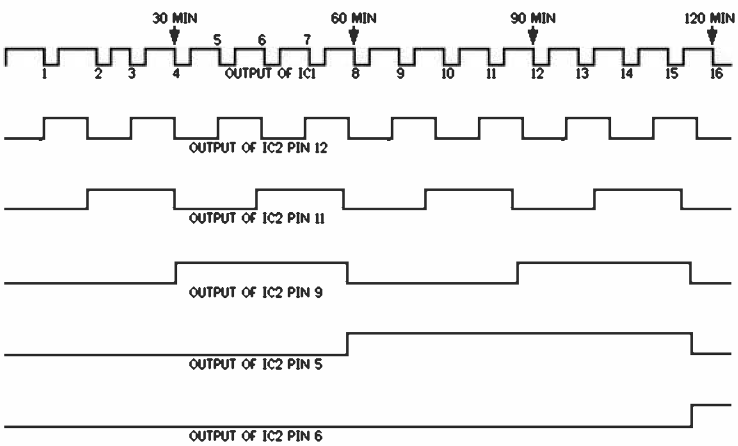


Fig. 4. Timing diagram for the unit.

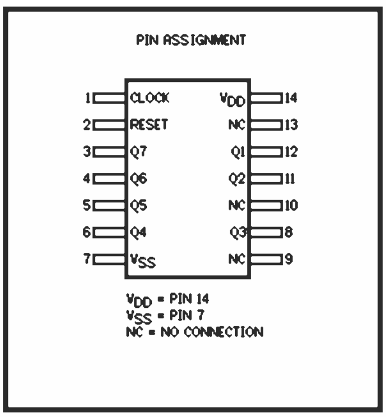
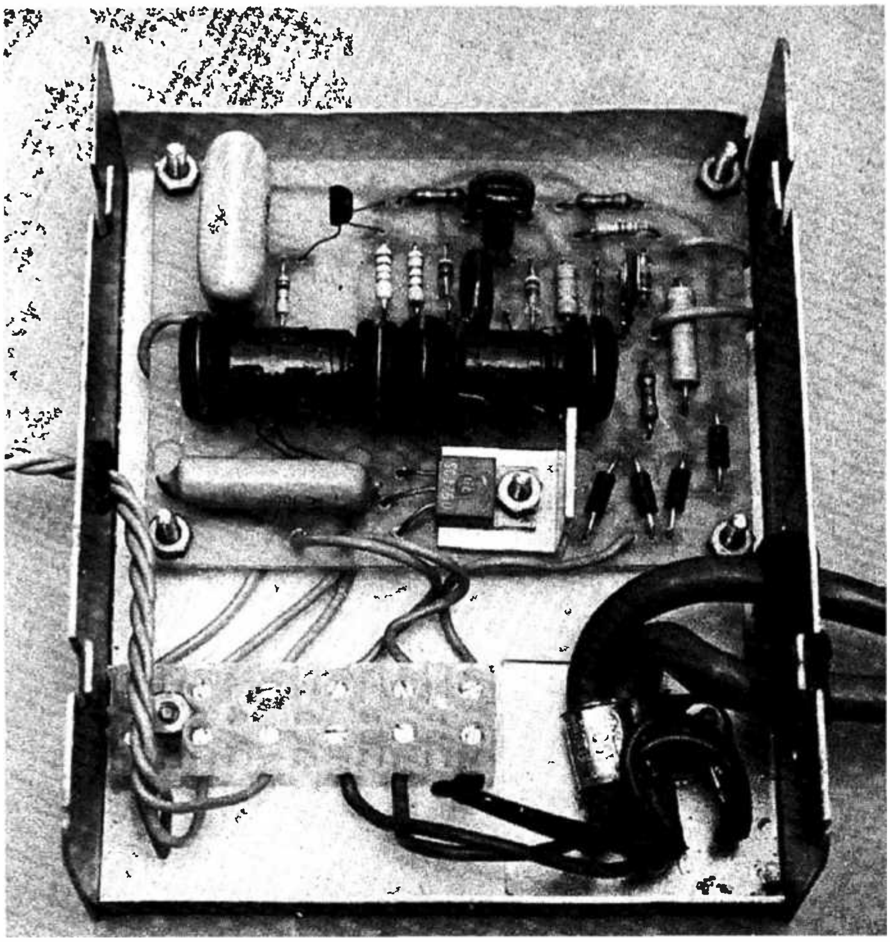


Fig. 5. Pin assignment for the 555 timer IC.



PUSHBUTTON DIMMER

Simple circuit allows light control from a number of locations.

MANY CIRCUITS for light dimmers have been published over the years (including some by us) which are of very simple· construction, and which use a rotary potentiometer. Whilst such circuits are adequate in most respects - especially in terms of cost, there are some strong reasons for a more sophisticated dimming system.

The first objection to simple dimmers is that they usually have an unsightly knob by which light level is adjusted. A second objection is that the light level can only be adjusted from the position where the dimmer is mounted.

The dimmer described in this project can be operated from one or more remote positions - e.g. doors on opposite sides of a room, top and bottom of a long flight of stairs, bedside tables - or even from a control point beside your armchair.

The unit has an on/off switch an two (or more) sets of push buttons, one of which causes the light level to increase, smoothly from minimum to maximum in about three secs, and one which does the reverse. The adjustment may be stopped at any particular level, and that level will be maintained without change for periods up to 24 hours.

The dimmer will handle incandescent or fluorescent lamps up to 500VA with the specified heatsink but, with a larger heatsink, may be used up to 1000VA.

CONSTRUCTION

Wind the choke and transformer in accordance with the details provided in Tables 1 and 2. Be particularly careful to provide adequate insulation between the primary and secondary of the pulse transformers.

If a printed circuit board is used, construction will be considerably simplified. Mount all components on the board with the aid of the component overlay taking particular care with the orientation of diodes and transistors before soldering in position.

A small. piece of aluminium (30 mm x 15 mm) bent at 90 degrees in the centre of the long side, is used under the triac as a heatsink. The pulse transformer and the choke are mounted by means of rubber grommets and secured by tinned copper wire around the grommets and soldered into the holes provided.

After all components are soldered into place, and all external wires attached, the underside of the board should be washed with methylated spirits to remove any flux residue which could cause leakage.

The PC board should be mounted on spacers into an earthed metal box. A piece of' insulation material, about 1 mm thick, should be positioned under the board to prevent any long component leads from touching the chassis.

A six-way terminal block should be used to connect all external wiring.

SETTING UP

All setting up, adjustments should be made using plastic, or well insulated tools. This circuit is live at mains potential and therefore dangerous to handle. **BE EXTREMELY CAREFUL.**

Potentiometer RV2 should be adjusted to obtain the desired minimum light level setting, (with the down button held). Adjust potentiometer RV1 for maximum light level (with the up button held) to just past the point where maximum light level is obtained.

If the lamp load is fluorescent more care must be taken with these adjustments. Additionally the setting up must be redone if the fluorescent loading is changed.

When adjusting the maximum light point on a fluorescent load, slowly increase the light level until the lights just start to flicker. Then turn RV 1 back until there is just a noticeable drop in light level. This increased setting difficulty is due to the inductive nature of fluorescent loads. If the required minimum light level cannot be obtained within the range of RV2, increasing R6 will provide lower light level range, and decreasing R6 will provide a higher level range.

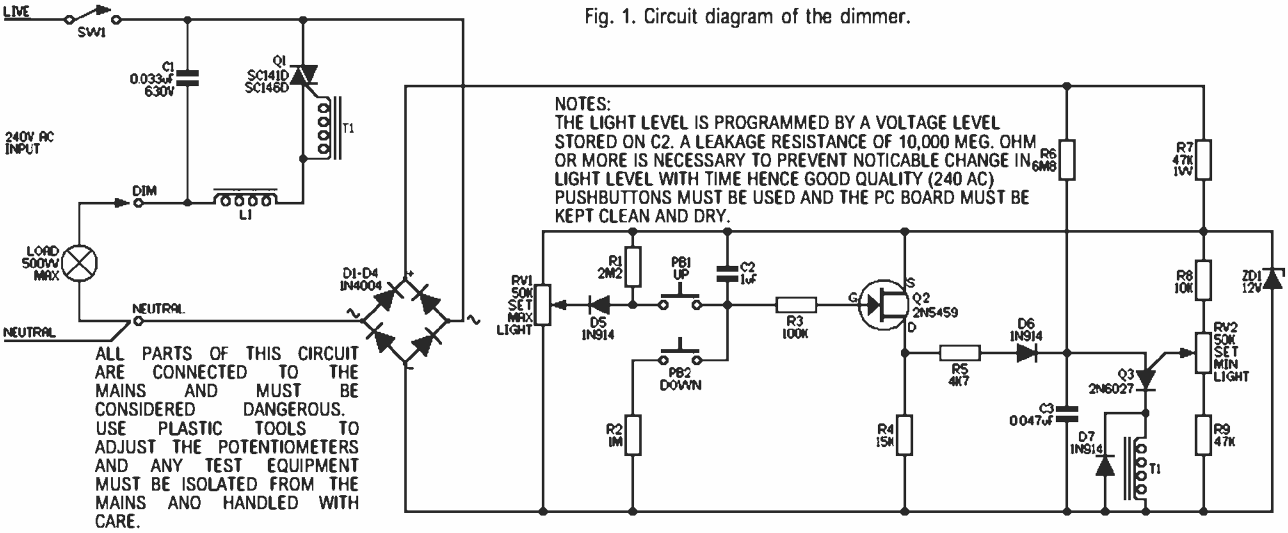
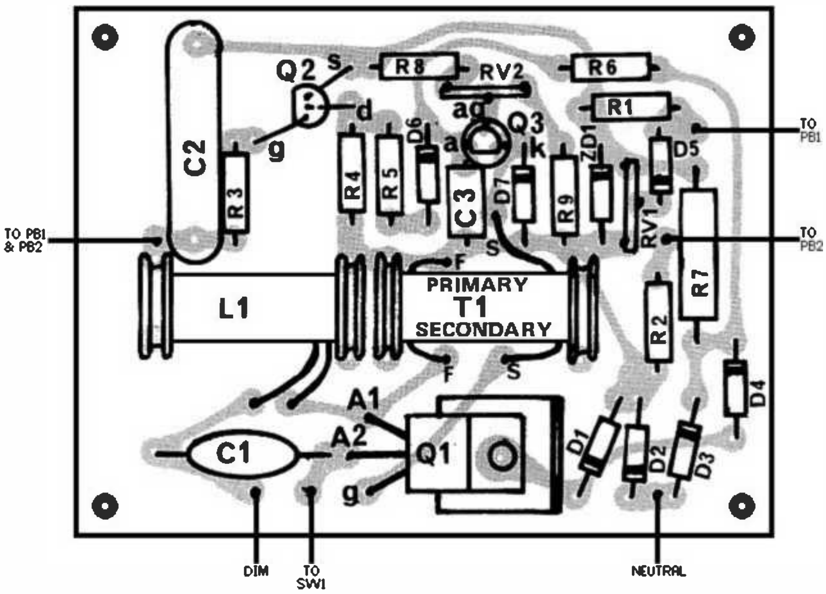
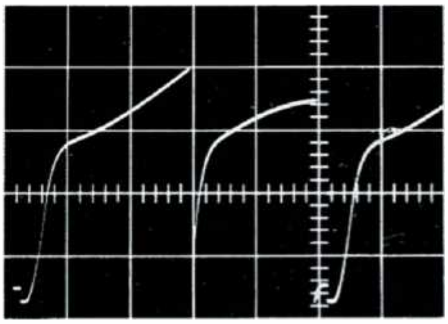


Fig. 1. Circuit diagram of the dimmer.



◀ Fig. 2. Component overlay.



Ramp and pedestal charging (dimmer set to provide about half light output).

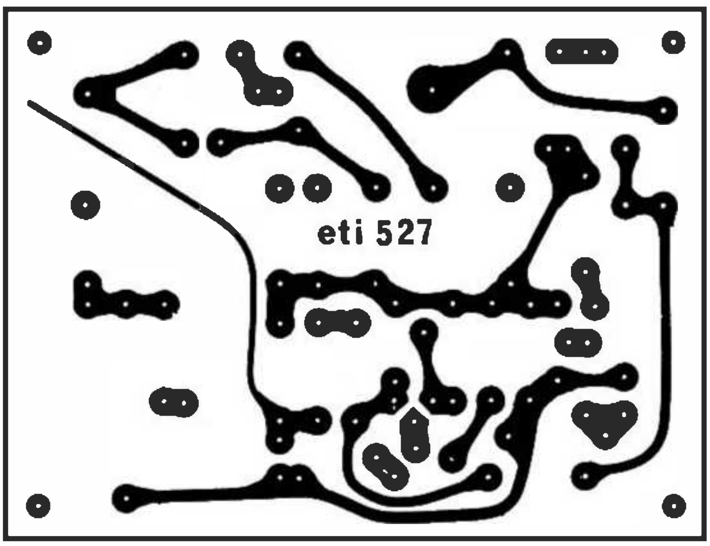


Fig. 3. Printed circuit board layout for the dimmer. Full size.

PARTS LIST

RESISTORS (All 1/2W 5% carbon)	
R5	4k7
R6	10k
R4	15k
R7	47k 1W
R9	47k
R3	100k
R2	1M
R1	2M2
R6	6M8
RV1,RV2	50k trim pot
CAPACITORS	
C1	0.033uF 630V polyester
C2	1uF 200V polyester
C3	0.047uF polyester
SEMICONDUCTORS	
D1 - D4	1N4004
D5,D6,D7	1N914
ZD1	BZX70C12V zener diode
Q1	SC141D, SC146D Triac
Q2	2N5458, 2N5459 FET
Q3	2N6027 PUT
MISCELLANEOUS	
L1	Choke - see table 1
T1	Pulse Transformer - see table 2
6-way terminal block (240V), Metal Box, 2 Pushbutton Switches, Front Plate, Power Switch	

PUSH BUTTON DIMMER

GETTING HOLD OF THE COMPONENTS

SEMICONDUCTORS
The only likely problem is the 2N6027 PUT so we have arranged for this to be stocked by A. Marshall & Son, 42 Cricklewood Broadway, London NW2 3HD. Marshall's will supply all the semiconductors (4xlN4004, 3x1N914, 1xBZX70, 1xSC1460, 1x2N5458, 1x2N6027) for this project for £2. 75 inc. VAT and P&P.
PCB
See the ads of Ramar Constructor Services and WKF Electronics.

TABLE I
CHOKE WINDING DATA

CORE
30mm long piece of (3/8" dia.) ferrite aerial rod. (see main text).
WINDING
40 turns 0.63mm dia (26 swg) wound as two layers, each 20 turns, close wound using the centre 15 mm of the core only.
INSULATION
Use two layers plastic insulation tape over complete winding.
MOUNTING
Use a rubber grommet (3/8" 1.0.) over each end and join to printed circuit board using tinned copper wire in the holes provided.

TABLE II
PULSE TRANSFORMER WINDING DATA

T1
CORE
30mm long piece of (3/8" dia.) ferrite aerial rod.
PRIMARY
30 turns 0.4mm dia (30 swg) close wound on the centre 15 mm of the core.
INSULATION
Use two layers plastic insulation tape over primary winding.
SECONDARY
30 turns 0.4mm dia (30 swg) close wound on the centre 15 mm of the core. Bring wire out on the opposite side of the core to the primary.
INSULATION
Use two layers of plastic insulation tape over complete winding.
MOUNTING
Use a rubber grommet (3/8" dia.) over each end and join to printed circuit board using tinned copper wire in the holes provided.

HOW IT WORKS

As with most modem dimmers, we have used a phase-controlled triac for power control.

The triac, which may be regarded as a switch, is turned on by a pulse at a pre-determined point in each half cycle, and automatically turns off at the end of each half cycle.

Most conventional dimmers use a simple RC and diac system to generate the trigger pulse, but this dimmer is in effect voltage controlled. The 240 volt ac mains is rectified by D l-D4. This full-wave rectified waveform is clipped at 12 volts by R7 and ZD1. As no filtering is used, this voltage will fall to zero over the last half millisecond of each half cycle.

To provide the correct timing, and the energy required to fire the triac, a programmable unijunction transistor (P.U.T.) Q3 is used together with capacitor C3. A PUT also acts like a switch in the following manner. If the anode (a) voltage is higher than the anode-gate voltage (ag), the anode to cathode (k) path becomes effectively a short circuit.

The voltage on the anode-gate, is set by RV2 and, will be between 5 and 10 volts. Capacitor C3 is charged, via R6, and when the voltage across it exceeds that on terminal ag, the P.U.T. fires discharging C3 through the primary of pulse transformer Tl. This induces a pulse in the secondary of Tl which gates on the triac.

As the voltage supply to R6 is not smoothed the rise of voltage on capacitor C3 will follow what is called a cosine modified ramp. This gives a more linear change in light level versus control voltage.

Once C3 is discharged the P.U.T. may either stay on or turn off depending on the individual device. If it turns off it may well fire again if C3 charges quickly enough, but the operation of the dimmer is unaffected by either situation.

If C3 does not charge to the ag voltage before the end of the half cycle, the ag voltage will fall at the end of the cycle and the PUT will fire. This is an essential part of the operation as it ensures synchronization of the timing to the mains. It is for this very reason that the 12 volt supply is not filtered.

To control the charge rate ofC3 (and hence the timing of the turn on of the triac within each half cycle) an auxiliary timing network of RS and D6 is used. As the value of R5 is much less than that of R6, C3 would charge much quicker via this path. If we set the input to RS at; say, 5 volts, the capacitor C3 would charge to about 4.5 volts quickly and then at the slower rate set by R6. This is called a ramp and pedestal type of charging.

As a result of the initial start given by RS, the PUT would fire earlier, and the triac will turn: on earlier, delivering more power to the load. Hence by controlling the voltage at the input of R5 we may control the output power.

Capacitor C2 is used as a memory device. It can be discharged by R1 via PB1 (up) or charged by R2 via PB2 (down). The capacitor C2 is connected from the positive side of the 12 volt supply and hence when the capacitor is discharged the voltage actually goes up with respect to the zero volt line.

Diode D5 is used to prevent the voltage rising above that set by RV1. The capacitor C2 is connected to the input of Q2 by R3. TransistorQ2 is a field effect transistor FET which has a very high input impedance. Hence the input current is virtually zero and the source tracks the gate voltage but at several volts level. (The exact voltage difference depends on the individual FET).

Therefore if the gate voltage is changed, the voltage on C2, the voltage applied to RS will also vary. By pressing either PB1 or PB2 the capacitor voltage and hence the triac firing point and the power delivered to the load may be varied. Upon releasing the push buttons. the capacitor will 'hold' this voltage -EVEN WHEN THE POWER IS SWITCHED OFF -for extended periods of time. The memory time is dependent on a number of factors as listed below.

1. A capacitor with a leakage resistance in excess of 100,000 megohm is required. Use a good quality capacitor, preferably rated at 200 volts. If necessary try different brands.

2.The pushbutton switch should be rated for 240V AC operation. These types have greater separation and hence insulation between the contacts. By physically disconnecting the pushbutton it ls easy to determine whether this is a cause of low memory times.

3. Leakage across the PC board could be a problem. It will be noticed that there is a track running from the source of Q2 which appears to go nowhere. This is a guard line to prevent leakage from high voltage components. If you are using different construction method make the junctions of R3 and Q2 and of R3 and C2 by mid air joints or by good quality ceramic standoffs.

4. The FET itself does have a finite input resistance. We tried many FET's without finding any that would not work. Nevertheless do not overlook this possibility.

The dimmer can be controlled from any number of stations simply by paralleling sets of pushbuttons. No damage will result from pressing both up and down buttons at the same time. However adding many stations increases the likelihood of leakage and consequent loss of memory time. The dimmer should be mounted in a dry dust-free position -as should the pushbutton. Do not try to use the dimmer or push buttons in a bathroom or kitchen as moisture will render the memory virtually useless.

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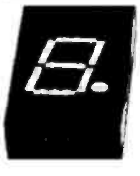

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BC182/3/4*	11p	2N2904/5	20p
BC212/3/4*	12p	2N2926roy8	9p
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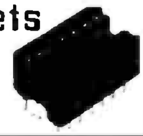

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6·8μF	63V	6½p	150μF	63V	15p
8·0μF	40V	6½p	220μF	6·4V	6½p
10μF	16V	6½p	220μF	10V	6½p
10μF	25V	6½p	220μF	16V	8p
10μF	63V	6½p	220μF	63V	21p
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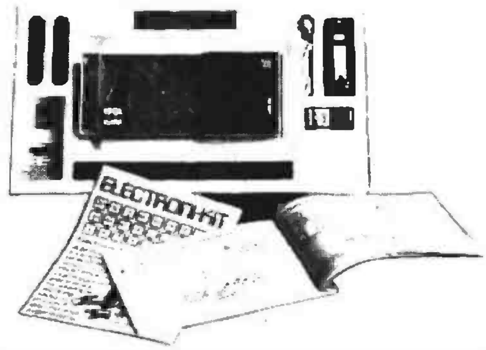
ETI and Electroni-Kit Ltd. together have arranged for ETI Readers to purchase any of three of the Denshi Construction Kits at savings of about 30% off the current retail price. This, like all ETI offers, is genuine and is strictly limited by time and to those who use the coupon below. All prices include VAT and postage.
Denshi Kits are an excellent form of breadboarding, the components are nearly all protected in plastic blocks with the the details engraved on the top. These blocks are then interconnected to build into the circuit. Even the least expensive of the kits offered here will build into 45 different circuits - each described in a voluminous manual which gives additional information to the newcomer to electronics. All parts are available individually and add-on kits are also available to increase the number of circuits possible.



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The ST100 is similar to the ST-45 but there are more components enabling you to construct a 100 circuits. Included are several radio circuits, sleeping aids, sirens, a time buzzer, battery checker, timer, photo electric 'phone, roulette, microphone and a whole lot more.

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MARCH 1975 ISSUE
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AT YOUR NEWSAGENTS

The features mentioned here are, at the time of this issue going to press, in an advanced state of preparation. However, circumstances, including highly topical developments may affect the final contents.

The ETI Guide to Technical Phrases

(OR HOW NOT TO SAY WHAT YOU REALLY MEAN)

This is a glossary of the real meanings of the phrases used in laboratory reports and is alleged to have been compiled in the research department of one of Britain's largest electronic firms.

We must make it clear that this phraseological practice is not used for ETI articles. At present we have no intention of publishing such a guide to the true meanings behind our language.

TECHNICAL PHRASE	TRANSLATION
The apparatus was turned on and the voltage rapidly reduced to zero.	*A fuse blew*
Three sample calculations were made.	*We made others but they were so far out that we conveniently forgot them.*
The apparatus was left to warm up for a suitable period.	*We took 45 minutes off for a tea break.*
The results show that . . .	*The results that we selected show that . . .*
A slight instrumentation error was found.	*Someone had magnetised the meter.*
A straight line graph was plotted.	*The line passed through one point and had one near miss.*
It is generally thought that . . .	*I think that . . .*
It is well known that . . .	*I think that . . .*
A larger current than expected . . .	*We damaged the meter.*
A meter with a higher range was used.	*We still damaged the meter.*
A suitable frequency was chosen.	*The Post Office interference detector van arrived.*
The conclusion is that . . .	*The conclusion is not that . . .*
The answer was found by inspection.	*We looked at someone else's published work.*
The equipment was disassembled.	*The laboratory manager borrowed the Avometers to mend his television.*

In our November issue we asked readers to send in their original problems for 8 digit calculators involving reading the display upside-down. Here are some of these.

THE UPSIDE-DOWN CALCULATORS

Mr. L.E.W. Asher of Nottingham sent this problem in the style of clues to a numbers crossword: *Enter the numbers in succession but don't operate any function keys.*
*Clue 1 — Trombones + 1 = ***
*Clue 2 One Two — — —, once I caught a fish alive = ****
*Clue 3 Famous Squadron (2nd World War film) + 30 = ****

This should be an easy one to crack!

RECIPE

Mr. D. W. Stokes of Launceston, Cornwall, found his larder empty one Sunday tea-time just as he was about to cook his meal: *Remembering upside down calculator magic he selected three resistors from his junk drawer. Carefully he choose a green/black/brown then a red/red/brown and finally a brown/orange/black. He soldered these in one long line and popped it into the pot to boil.*

He found the ohmic value quite nourishing!

A GOOD FIGURE

From J. R. Gray of Moston, Manchester: *Last year (365 days) my overweight wife ate an average of one square pie (π^2) for every hour of the day. When she discovered that each such pie contained 640.52506 calories she found out how to lose weight.* (answer 5537 8 345)

To find the comments she now gets subtract 58535685 (answer −3157340)

THIS ONE SHOULD GET A FEW LAUGHS

Mr. R. G. Fallows of Wirral sent in this story. *Whilst reading a maths book, Father Christmas came across the following problem:*

$$1 \div \frac{[(3.1622777)^4 - 1]}{40}$$

What did he say when he finally solved it? (answer 0.4040404)

NB. With leading zero supression this answer has an altogether different meaning.

CAUTIONARY TALE

Mr. A. Tinsley of Rotherham writes back from the Upside Down Digital World of 2002 with a sad tale warning of the dangers of meddling with the magical powers of the upside down calculator — *"0.7734" (greetings) from #31550.*

Citizen #7718, a man of many credits (15,887 infact), married citizen #31573 and quickly they achieved "55178".

One year later having spent 1553 credits (#7718 + #31573 − 1553) they produced #37738 (leaving them with 14334 credits).

2 years later #31573 leaves #7718 taking 12765 credits with her (leaving 1569 credits).

The sad ending being #37738 − #31573 + 1569 = "7734" "334334"

FROM A DOUBTING READER

Mr. R. P. Fleet of Purley comments on our fuel crisis problem in last Novembers issue:

$$13 \times \frac{((20.22476^2) \times 12)}{12}$$

(answer 5317.5317)

To get his calculator on friendly he feeds it:

$$(\sqrt{1661521}) \times 6 \times 10^{-4}$$

(to which it replies .07734)

POKER POSER

A poker player holds the Ace, King, Queen and Jack of Spades. He knows that there are two full-houses and a flush to the King out against him. What is his probability of winning (given as "X") when

X=the invert of $(2^5 \times 18.43750)^2 + 2677.34$ given that he can only draw one card? (answer 350777.34)

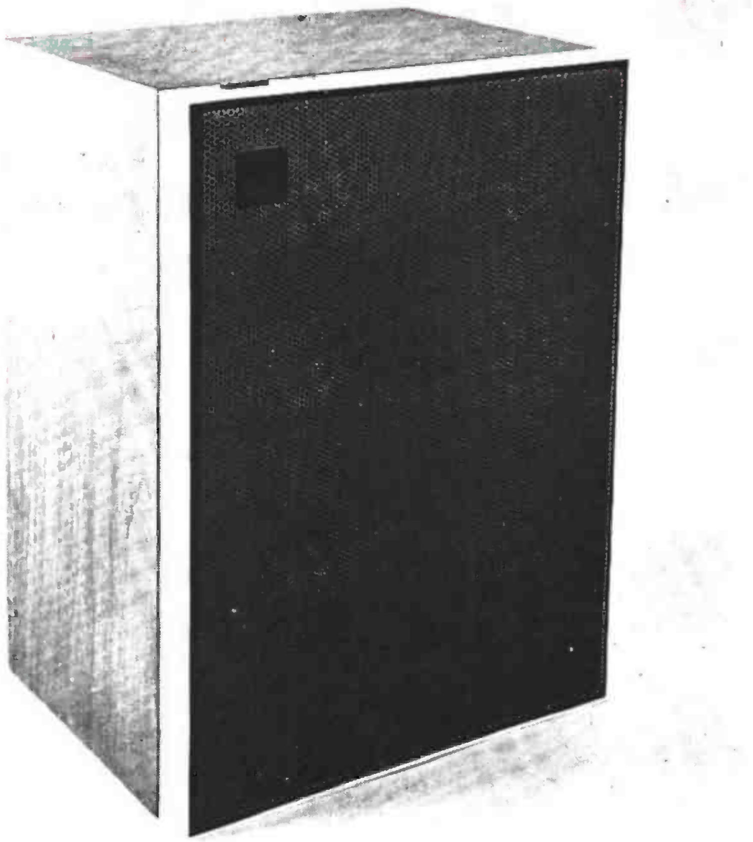
From N. Williams of London NW3.

We found it difficult to judge these entries so we have sent all the above entrants a copy of our "Top Projects Book". This doesn't apply however to the dirty old man who sent in an unprintable application for the Sinclair Scientific.

We ask our readers not to send in any more problems.

eti product test

PHILIPS MOTIONAL FEEDBACK LOUDSPEAKER



EVERYBODY WOULD LIKE to own a loudspeaker that takes up zero space, does not detract from the room's appearance, and provides the sort of performance that one has come to expect from large bass reflex type enclosures, but few small loudspeaker systems have low frequency performance comparable to their big brothers.

The first attempt applied to overcome this limitation was that proposed some ten years ago by Mullard, who introduced the concept of a small loudspeaker system with low frequency response improved through the judicious use of bass boost. But this approach tends to result in a peaky response at the bass end. It also requires a loudspeaker with plenty of low frequency travel, as well as a more powerful amplifier.

Now, more powerful amplifiers are the vogue, so power is not a problem in itself, but even so the bass boost approach does not necessarily result in a substantially better or cleaner sound. Philips' approach is far more complex. They place a small piezoelectric accelerometer at the heart of the low frequency driver and separately connect this up as part of their feedback system. This accelerometer generates a voltage proportional to the acceleration of the cone and this output is compared electronically with the original audio signal. Any difference voltage is returned as a corrective signal to the amplifier, In this way any non linear motion of the cone (with reference to the original electrical signal) is corrected, and the acoustical signal produced becomes a more faithful reproduction of the input signal.

The speaker line up consists of an AD8065/W4 MFB 200mm woofer, an AD 5060/Sq8 120 mm mid-range speaker (both the mid-range and woofer have flexible surrounds to permit the long diaphragm travel required to provide the acoustical output at high levels), and the well proven AD 0160/TS 25 mm diameter dome tweeter.

These are mounted in a vented enclosure a mere 280 mm wide and 380 mm high. Apart from these drive units, the enclosure also houses two amplifiers, one rated at 40 watts {for bass). the other at 20 watts (to drive the mid-range and treble units). When one realizes that the total depth of the enclosure is a mere 210 mm, one begins to appreciate just *how* small the acoustical section really is.

One distinct advantage of such a small size, of course, is that the enclosure is tremendously strong and extremely rigid, and with one minor exception, free of any resonances.

Philips claim that the overall unit has a 60 watt continuous sine wave power rating, but it would be almost impossible {except with pink noise testing) to truly drive both power amplifiers on a continuous basis to their maximum rating.

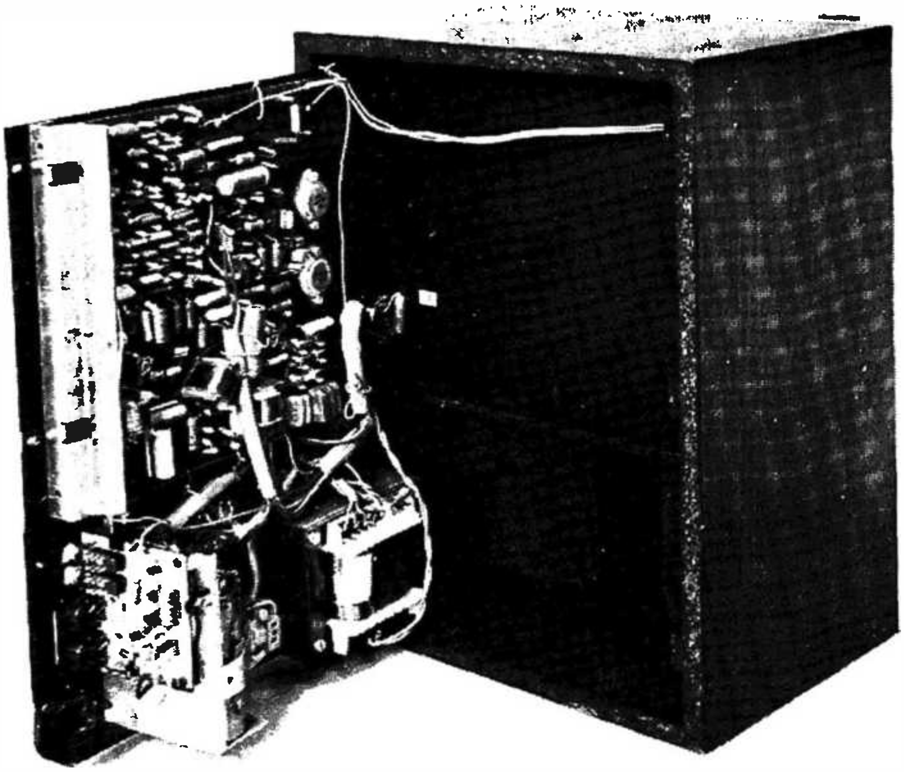
An electronic network is used to crossover (at 500 Hz) from the woofer to the mid-range speakers, and a passive network caters for the crossover between mid-range and dome tweeter -at 3.5 kHz.

Inputs are provided for connecting the Philips units to a preceding pre-amplifier (one volt input) or to a pre-amp/power-amp combination (7 .5 volt input).

Each speaker is provided with a special power lead, using a mains power socket on the rear of the amplifier, and (nominal) eight metre long lead fitted with DIN sockets for connecting to the pre-amplifiers or drive sources.

The power amplifiers are located behind a hinged metal cover which has located toward its base, a red power on-off switch, a mains voltage selection switch, a mains input and mains output supply socket, two buttons for selecting drive sensitivity, and left or right channel respectively,

SUMMARY: Last year we described the principle being used by Philips in these new loudspeakers (Jan. and Sept. 1974). Now we are reviewing the finished product to find that in the lab these speakers come up to the standard previously established in the listening room. Never before have we come across a speaker this size able to deal properly with bass frequencies.



and two DIN sockets for signal in and signal out respectively.

Included in the design is an electronic on-off switch which will only switch the amplifier on when it 'sees' an input signal and switches the amplifier off two minutes after it fails to see any new electronic signal. This is intended to reduce the power dissipation on the power amplifiers if the owner forgets to switch the unit off.

MEASURED PERFORMANCE OF PHILIPS RH532 MOTIONAL FEEDBACK LOUDPSEAKER

Frequency Response	40Hz to 16kHz +5dB -7dB		
Total Harmonic Distortion (for 90dB at 2 metres on axis)	100Hz	1kHz	6.3kHz
	0.7%	0.3%	0.35%
Sensitivity at 1kHz (for 90dB at 2 metres on axis)	low	40mV	
	high	3V	
Cross-over Frequency	500Hz and 3.5kHz		
Measured Impedance	low	3 kilohm	
	high	25 ohms	
Dimensions	238 x 378 x 212 mm		
Price	£ 270.00 (pair)		

The concept is good and is a useful design feature.

The total volume of each enclosure is 15 liters, of which six liters are taken up by the power amplifier. Thus the acoustic section is a mere six litres in volume one of the smallest enclosures we have ever tested.

Our first interest was to determine how the unit sounded, and in particular whether its performance in the range 30 to 100 Hz could live up to the (advance) claims made by the manufacturers.

Our subjective test showed that the bass response is quite good down to 40 Hz, but without running more detailed tests we could not be readily sure how good or stable the unit was at frequencies *lower* than 40 Hz.

Free field tests showed that the frequency linearity in the range 50 Hz to 16 kHz is particularly smooth on .pure sine wave testing, and every bit as good as the one-third octave band plotted figures provided with the manufacturer's data sheet.

Performance under tone burst testing was particularly .interesting. At 1 kHz the tone burst performance is quite good not perfect but more than adequate. At 6.3 kHz, the tone burst performance adds at least an extra two cycles to the original signal as well as a small amount of subsequent ringing. This is a form of colouration which is audible, particularly, so at high signal levels. The speaker does have a definite sound of its own and it is clear that at high drive levels the transient response is not as linear as could be desired.

We found it interesting that the overall system distortion on sine wave testing is particularly low, with the total harmonic distortion being substantially better -than most other speakers that we have tested and very much better than any other small system that we have tested.

Philips do not want this system to be evaluated on the basis of size alone, for they state that its performance is as good as most large conventional speaker systems, and in this respect their claim is basically correct. Nevertheless we believe that the people who will buy this system will do so primarily because of its small physical size.

PHILIPS
Motional Feedback Loudspeakers

HOW THEY SOUNDED

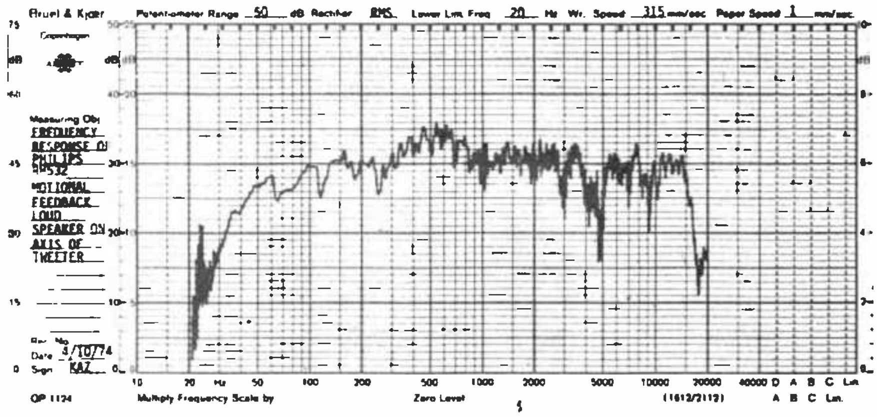
In live testing with high quality program content, such as Sheffield Lab's "Distinguished Mayorga & Distinguished Colleagues Volume III", CBS SBR235514 "Kurt Vonneguts Slaughterhouse-Five", and the Philips special demonstration record Philips 6830 532 "Revolution in High Quality Sound Reproduction", the system demonstrates excellent power handling capacity and a very clean response at levels in excess of 95 dB at 2 metres on axis, but does have noticeable colouration at higher frequencies.

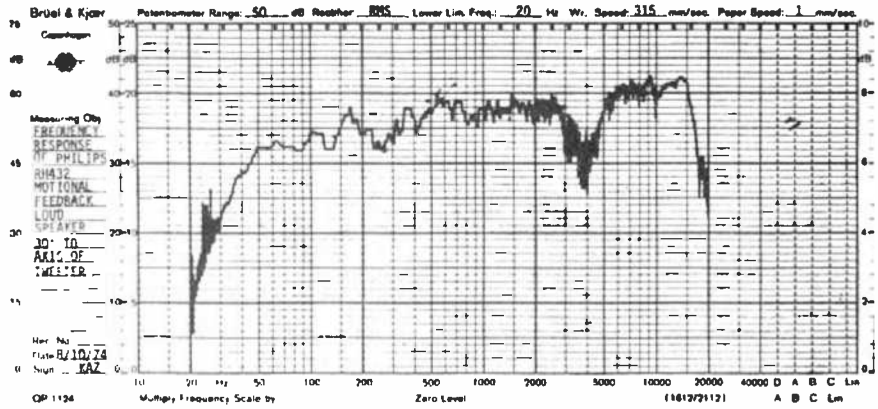
Surprisingly, the performance in the critical region 30 Hz to 150 Hz is far cleaner and substantially better than could have been expected from such a system.

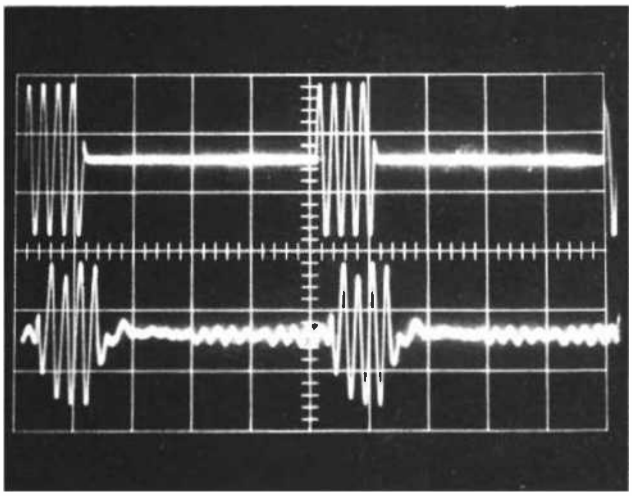
We were really impressed that the majority of the claims made for the speaker were substantiated by our subjective and instrumental testing. We have never before heard a speaker system anywhere near as small which could deliver comparable quality sound. In fact it is hard to imagine any other system which could deliver so much performance whilst utilising so little space.

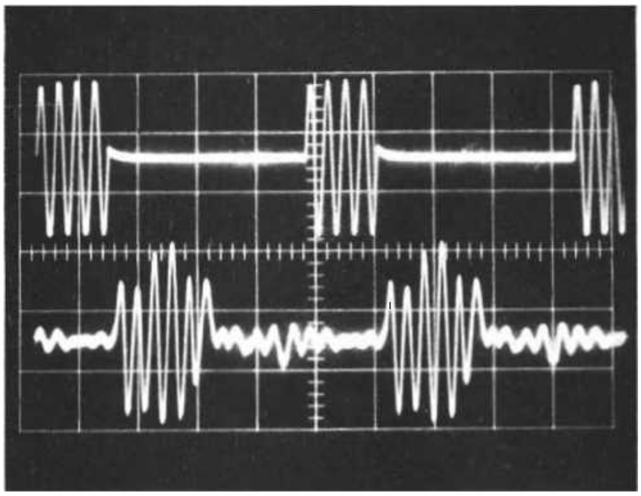
When used in conjunction with one or more of the special Philips record players, tape recorders or preamplifier systems, which are under development, the motional feedback loud speaker system will offer a practical, compact, high fidelity solution to one of the ,biggest problems facing the modern day flat dweller. (The unit can of course also be used in conjunction with almost any existing pre-amp or pre-amp & power-amp combination regardless of the power output.)

At a recommended retail price of £270.00 per pair, and considering the number of power amplifiers and their rating, the cost is far lower then might at first appear.





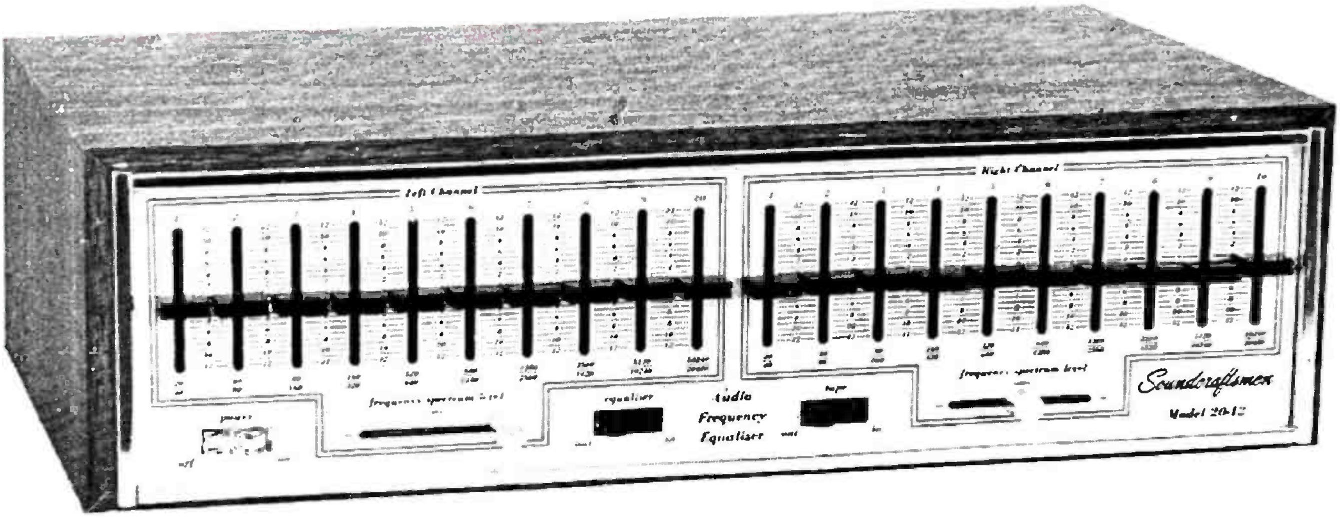




Our two tone-burst oscillographs clearly indicate how some minor colouration is generated in the treble register. LEFT: 1 kHz, RIGHT: 6.3 kHz - both at 4 ms/div. Oscillographs have been recorded using the ETI designed tone-burst generator a feature of which is accurate control over starting and stopping phase angles and total number of cycles in each burst - note how cone movement continues at 6.3 kHz.

eti product test

SOUND CRAFTSMEN GRAPHIC EQUALIZER



Selective filters compensate for room and equipment deficiencies.

LONG before man understood the principles of acoustics he was able to exploit natural phenomena to achieve equalization of sound. Archaeologists have found indications that leaders of prehistoric communes projected their voices (using natural horns) to obtain equal intensity of sound in all areas of a cavern!

Today, graphic equalizers are used to improve room and concert hall acoustics - albeit using more refined techniques.

In principle, graphic equalizers are a series of filters, each filter covering a small segment of the frequency spectrum, and each capable of amplifying or attenuating that segment.

Thus the equalizer 'corrects' for inequalities in a room's acoustics by amplifying or attenuating those segments of the frequency range previously established as deficient.

Professional users prefer octave band centre frequencies for each individual channel control, or ideally one-third octave· band filter spacing.

One-third octave band graphic equalizers are costly devices, and because of this most hi-fi enthusiasts (and not so well-heeled professionals) settle for octave band units.

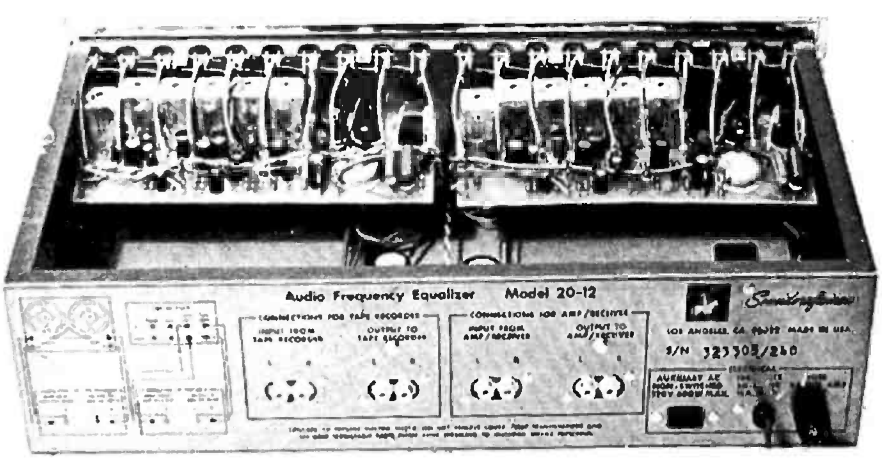
The Sound Craftsmen Stereo 2012 is the first ten channel graphic equalizer that we have seen. It has been designed to provide good performance at a fairly low price. Its major use, as the sales literature states, is to correct for the deficiencies in the standard amplifier treble and bass control circuits - through the use of true spectral equalization.

Whilst some of the previous units offered tended to suffer from asymmetry of equalizer control, particularly between boost and cut, the latest units of which the Sound Craftsmen 2012 is one, provide a well balanced symmetrical control with a minimum colouration or distortion in the pass band of each filter.

What then is the major purpose, and hopefully end result of using such a device?

Firstly, it allows the audiophile to correct deficiencies in the linearity of either his speaker system alone, or the combination of his speaker system plus his living room, for even though the speaker system may be good, it would be most certain that the living room is not. This is easier said than done though, for it is necessary to use spectral analysis equipment, such as a gliding tone record together with a linear sound level meter, or sound level indicator with known characteristics. Alternatively recorded bands of pink noise and a sound level meter for indicating spectral response can be used.

But the average audiophile does not have access to the equipment (of the type that we have discussed above) to



SUMMARY: The circuitry chosen for this unit limits its performance so that it is not suitable for curing all frequency non-linearity problems but it does have a lot to offer in controlling the overall frequency response of a hi-fi system.

optimise the performance of his system.

Sound Craftsmen have foreseen this difficulty and have produced and supplied with the equalizer a special test record that overcomes these problems. The data on the back of the record cover gives clear instructions on the use of the record.

The record presents three distinct methods of use, a simplified equalization, a most accurate equalization, and a professional equalization. These enable the novice or the professional to adjust his system in a given environ-ment to provide a better frequency equalization, and thus a subjective improvement in audible sound.

By using the record supplied in conjunction with whatever record player, amplifier, and speakers we were using, we found it readily possible to equalize the frequency response of a system at a given position to within ± 3 dB for octave band filtered pink noise. We did not attempt to record the frequency response for pure tone under the same circumstances as this would have been an unfair test.

The Sound Craftsmen 2012 graphic equalizer is primarily designed for mounting in a 19" rack and as such the external walnut grained plastic coated chipboard case is purely supplied for shipping convenience, and as the little slip tells, is not warranted against defects. After reading the slip we had to look twice at the case because as it was so well finished we were sure at first that it was true walnut veneer.

The internal circuitry is. very well made and features high quality glass-epoxy printed circuit cards with medium quality consumer electronic components.

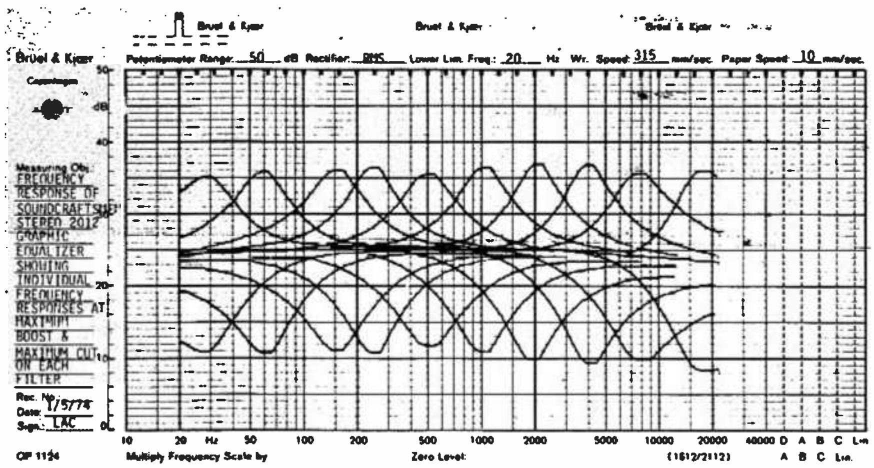
The electronics is remarkably simple using only six transistors per channel output and a regulated power supply which controls hum and ripple to a particularly low level.

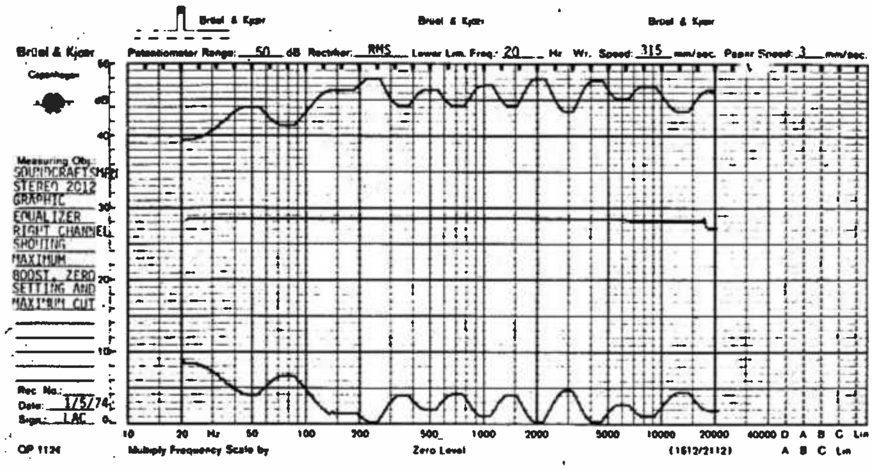
The front panel, too, is very simple. Parallel slider controls featuring flat black knobs, adjust the nominal 12dB boost or cut for each of the octave bands lying between 20Hz and 20kHz.

Centrally mounted below each bank

PERFORMANCE OF SOUND CRAFTSMEN STEREO 2012 AUDIO FREQUENCY EQUALIZER

Maximum Change in Output Level for Equalizer Switch from IN to OUT (with spectrum level at zero setting)	-4dB on right channel
Frequency Response Equalizer out	+0.2dB 20hZ - 20kHz
With equalizer in and all filter settings at zero	+1.5dB
Range Control	+12dB on individual filters with overall maximum +19 - 28dB possible +20dB typical
Maximum Output Signal	8.8 volts before onset of clipping
Maximum Input Voltage	4.5 volts before onset of overload
Harmonic Distortion Level (at 2 volts output)	100HZ 0.15% · 1kHz 0.15% · 6.3kHz 0.1%
Inter-modulation Distortion	Less than 0.2% at 2 volts
Signal to Noise Ratio	Greater than 70dB (Lin) at 2 volts input Greater than 86dB A scale weighted
Price	£165.00 + VAT





SOUND CRAFTSMEN GRAPHIC EQUALISER

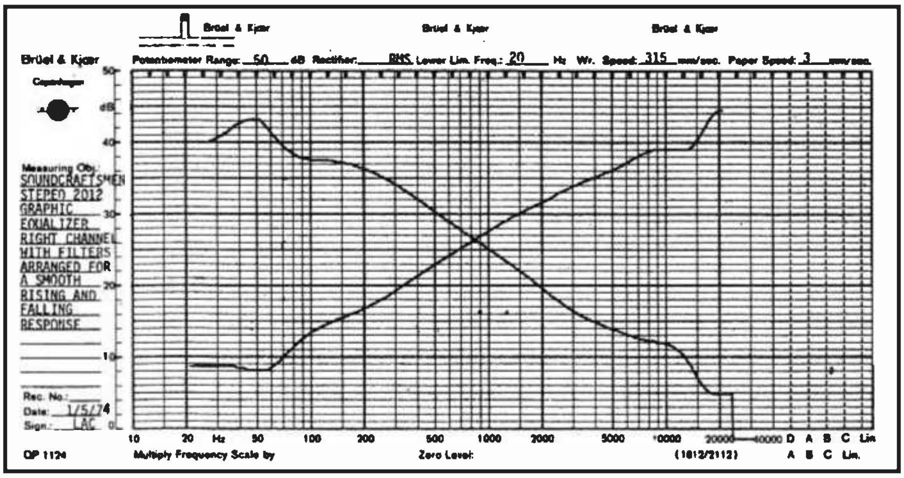
of slider controls are the level control levers providing overall positive and negative amplification. These are flanked on either side by the equalizer out-in switch, and the tape recorder out-in switch. An illuminated power on-off switch is positioned at the lower left hand corner of the panel.

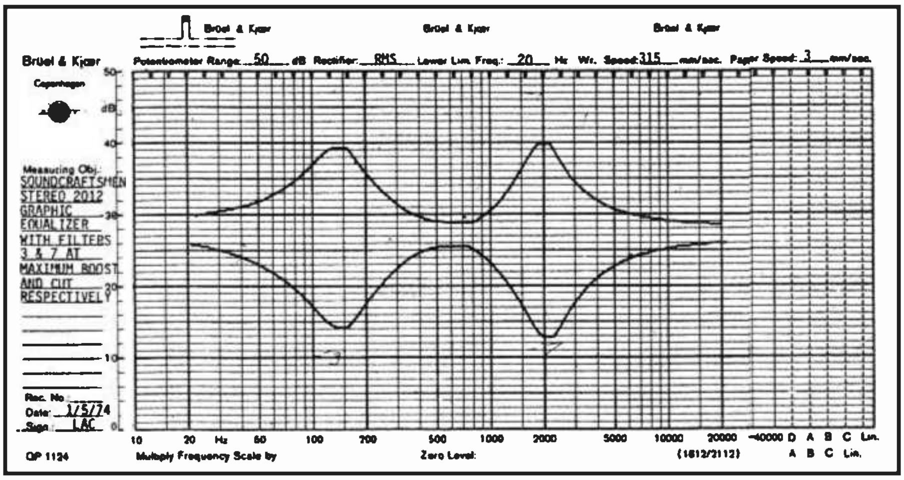
Eight phono plugs are provided on the back of the unit. A diagram shows correct interconnections for tape recorder and power amplifier. Also on the back of the unit are an auxiliary unswitched power outlet, and the mains fuse.

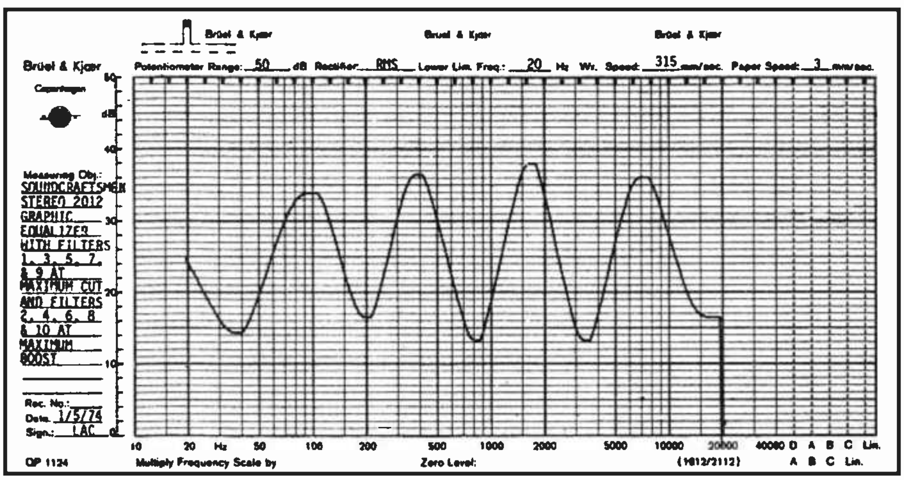
The internal circuitry uses a bank of parallel connected circuits consisting of series connected capacitor, inductor and resistor inductor, and resistor for each separate filter circuit. By connecting these across the main amplifier transistor it is possible to provide symmetrical boost or cut. The circuitry chosen for this graphic equalizer results in significant interaction between the individual filters, so that whilst in theory each one has a significant measure of control over a given frequency, in practice adjacent filters also have a measure of control because of the broad band nature of the circuitry (See level recordings).

For this reason the graphic equalizer is best suited for overall frequency control rather than curing the nastiest types of frequency non-linearity problems which often occur in loudspeaker systems or in rooms. We tried the Sound Craftsmen out in a number of rooms, including a living room with excessive reverberation time; and our office which is fairly acceptable but far from perfect. We found that whilst it does improve and modify a subjective sound it offers little advantage in rooms with excessive reverberation time, except as the brochure points out, for improving the threshold of loop gain where feedback is a problem with a public address system.

We subjected the Sound Craftsmen to exhaustive performance tests and found that the left channel had a small electronic fault in filter number 7 (1280-2560Hz filter) but the right channel was apparently working well. The filters symmetrical offer performance, but the overload characteristics of the individual circuits (with slider controls at the mid-point position) results in asymmetrical wave shaping clipping. This is, however, not normally a problem except on overdrive conditions.





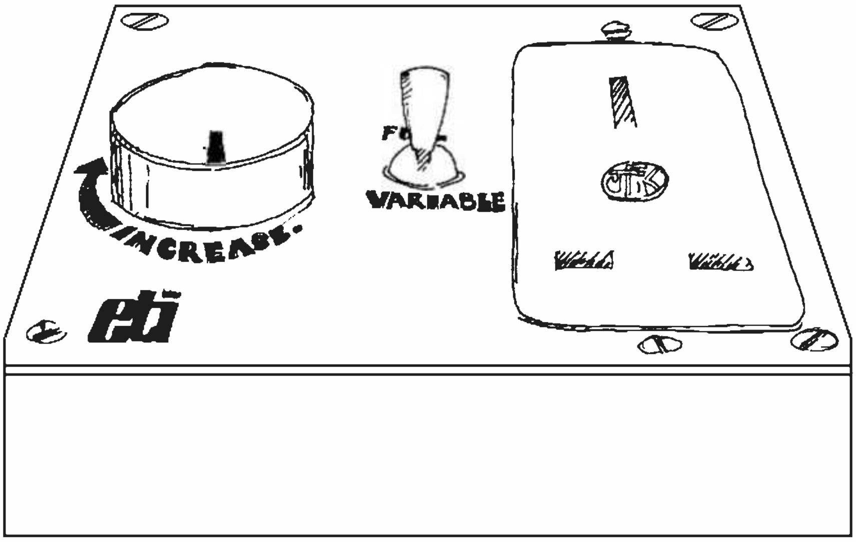


The maximum slope that can be achieved between filters is better than 35dB per octave.

In our opinion there are some excessive claims in the maker's literature, but ignoring the more extreme of these it is true to say that this audio frequency equalizer is a usable and practical piece of equipment.

It is not perfect in that there is interaction between adjacent filters, but the overall performance that it offers is practical, in many situations it is really called for.

At a selling price of £178.20 many serious amateurs and quite a few professionals could more than justify its purchase.



DRILL SPEED CONTROLLER

Variable speed control maintains constant (adjustable) speed regardless of load.

MOST HANDYMEN own a power drill.

There are tens of millions of them in use around the world and they continue to be used for an ever greater variety of tasks. Despite their popularity, many power drills have one major drawback and this is that their speed is often too high for many applications.

This is so even with dual-speed models where even the slow speed, typically 300-750 RPM, is too fast for such jobs as drilling masonry or using fly-cutters on sheet metal etc.

The speed controller described here allows infinite variation of speeds from zero to about 75% of full speed, and is provided with a switch to allow normal full-speed operation without disconnecting the drill from the controller. The controller has built in compensation to maintain substantially constant speed regardless of changes in load.

CONSTRUCTION

It must be emphasized that the controller is connected directly to the mains without the use of an isolating transformer. Care must therefore be taken with the construction to ensure that there is no likelihood of any dangerous conditions arising.

As there are relatively few components used, no supporting tag strip or PC board is necessary. From Fig. 2 it can be seen that only two "mid air" joints need to be made, and these should be carefully insulated to prevent any possibility of short circuits.

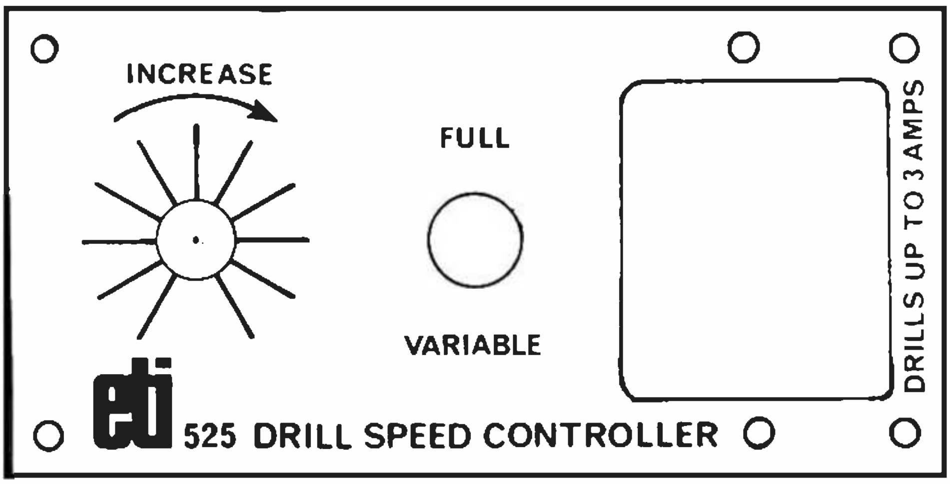
The SCR used is a stud mounting. type and is mounted by using the solder lug, supplied with it, soldered onto the centre lug of the switch. For loads up to 3 amps no other heat-sinking is required. If a plastic-pack SCR is used a hole may be drilled through the switch lug and the SCR bolted directly to it. However in this case it is advisable to insert a piece of aluminium (about 25 mm x 15 mm) between the SCR and switch lug to act as a heatsink.

Remember that, since the unit operates at 240V AC all external parts must be earthed. We used a plastic box with a metal lid. But we also used a cable clamp with a metal screw through the side of the plastic box. This screw must be earthed, along with the lid and the earth terminal of the output socket. The earth wire should be continuous That is, it should go from one earth point through· to the next and not by separate links. Two earth wires may be soldered to one earth lug. But under no circumstances should two wires be secured under a single screw.

The aluminium lid on the (type UB3) box used is not strong enough for this application, especially when the hole for the output socket is cut. A new lid should therefore be made from 18 gauge steel or 16 gauge aluminium.

To further improve safety it is suggested a small amount of glue, lacquer or even nail polish, be used to secure each screw inside the unit .

With some SCR's it may be found that the trigger current supplied by R1 and R2 is insufficient. If this is the case an additional 10k resistor should be placed in parallel with each resistor.



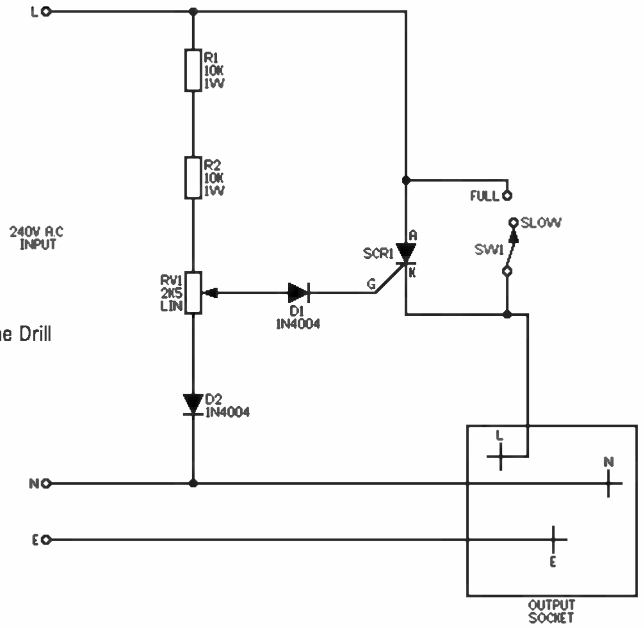


Fig. 1. Circuit diagram of the Drill Speed Controller

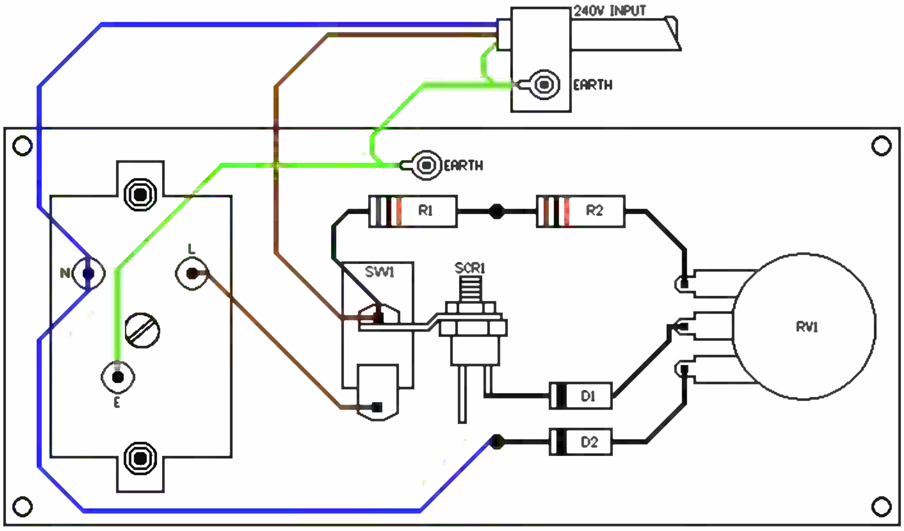


Fig.2. Component layout - compare this drawing with photograph above.

HOW IT WORKS ETI 525

A universal motor, when running, produces a voltage which opposes the supply. This voltage, called the back EMF, is proportional to the speed of the motor. The SCR drill speed controller makes use of this effect to provide a certain amount of speed-versus-load compensation.

This controller uses a SCR (silicon controlled rectifier to gate half-wave power to the drill motor. The SCR will conduct only when a anode (terminal A) is positive with respect to the cathode (terminal K),b/ when the gate (terminal G) is at least 0.6 volts positive with respect to the cathode, and c/ when about 10mA of current is flowing into the gate terminal. By controlling the level of the voltage waveform to the gate we effectively control the time at which the SCR turns on in each forward half cycle. By this means we effectively control the amount of power delivered to the drill.

Resistor R1, R2 and potentiometer RV1 form a voltage divider which provides a half wave voltage of adjustable amplitude to the gate of the SCR. If the motor is stationary the cathode of the SCR will be at zero volts and the SCR will turn on almost fully. As the drill speed increases, a voltage develops across the drill thus reducing the effective gate-cathode voltages. Thus as the motor speeds up, the power delivered decreases until the motor stabilizes at a speed determined by the setting of RV1.

Should a load be placed on the drill, the drill will tend to slow down, but as the voltage across the drill also drops, more power is delivered to the motor since the SCR firing-time is automatically advanced. Hence the speed, once set, is maintained relatively-constant regardless of load.

Diode D2 is used to halve the power dissipated in R1, R2 and RV1 by limiting the current through them to positive half-cycles only. Diode D1 protects the SCR gate against excessive reverse voltage.

In the full speed position the SCR is simply shorted out by SW1. Thus RV1 loses control and full mains supply is applied to the drill.

PARTS LIST

R1,R2	Resistor	10k 1W 5%
RV1	Potentiometer	2.5k Lin
D1,D2	Diodes	1N4004
SCR1	SCR	2N4443 (8A/10A, 400V)
SW1	Switch	
Box		
3-core flex and plug		
Cable clamp		
3-pin power outlet		

* Some SCR's used may have a higher than average trigger current and the unit may not operate. If so parallel the two 10k resistor with additional 10k resistor to increase the available trigger current.

USING THE CONTROLLER

Plug the controller into the mains and the drill into the controller. Select either full speed or variable as required. Note that there is no ON/OFF switch provided on the unit and the normal switch on the drill is used for this purpose. When full speed is selected the drill will run normally and the speed control on the controller will have no effect.

When variable speed is selected, the control will adjust the speed anywhere between zero and about 75% of full speed. There may be a dead zone at both low speed and high speed ends of the control. This is entirely normal and is due to different drill characteristics and component tolerances within the controller.

At very low speeds it may be found that drill runs jerkily under no load. However as load is applied the speed will smooth out.

When using the drill at less than full speed the cooling of the motor will be considerably reduced (as the cooling fan is on the armature shaft and also runs slower). Hence the drill will get hotter when used at low speeds, and extended periods of use in this mode should be avoided.

VARIABLE SPEED SPEECH

In last November's Electronics Tomorrow we first mentioned VSC. Now we look in detail:

THE PACE of modern technology has inevitably caused a demand for faster communications. We are all in a hurry. We need information now, and we cannot afford to spend too much time assimilating it.

In many areas improvements have been made which greatly facilitate the rate of information transfer. For example, in the computer field, getting the information in and out of the computer, rapidly, has been a continuing problem, but this has been alleviated partly by the development of such equipment as high speed printers, tape readers and CRT terminals.

In the audio/visual field special purpose projectors, multi vision techniques and special television effects equipment have vastly improved the rate of visual information transfer.

But - where information must be transferred by spoken word - we have, until recently; made little if any progress.

In the fields of education, staff training, advertising, etc, some method of increasing the playback rate of recorded speech is urgently required. Such a system, known as VSC (Variable Speech Control) is now available.

THE PROBLEM

Average speech rates range from around 110 words per minute for ordinary conversation up to about 175 words per minute for the average news commentator. This is in sharp contrast to the average reading rate of around 300 words per minute rising to 1000 WPM or more for trained speed readers. Obviously the comprehension rate is far higher than practical speech rates.

On the other hand, a secretary endeavoring to type up the tape-recorded minutes of a meeting will find the speech rate about twice that for comfortable typing. Hence it is very desirable to be able to vary the playback rate over a range of half to twice-the normal rate.

If you have ever played a record or tape at an incorrect speed you will be familiar with the effects of speed change. An increase in tape speed by any given factor results in an increase in frequency of all frequency components by the same factor. At best we get the "nutty squirrel" effect, at worst - an unintelligible gabble.

A decrease in speed results in an unintelligible rumble as all frequency components of the speech are lowered proportionately.

Although some special machines have been built · for speech compression, these have been very expensive and hence not been within the reach of the average user. Over 60 million tape recorders are purchased each year for a variety of purposes and quite a large percentage of users would welcome a cheap variable speed device which would allow the playback rate to be varied to suit 'individual requirements. Such a unit should be available at a price which will allow it to be fitted to even the cheapest of cassette recorders.

THE SOLUTION

The pitch change-with-speed phenomena, and a method of eliminating this change, is best illustrated with the aid of Fig. 1.

Speech may be considered to consist of short segments of various tones, called phonemes which make up any particular sound. Assume that we take a 40 millisecond sample of a waveform and find that it is a tone of 150 Hz, as shown in Fig. 1a. If the tape recorder is now replayed at twice normal speed, the tone burst will be compressed into half the time, that is, it will now be at 300 Hz.

We want the time compression but not the frequency change, so, to eliminate" the latter, we must delete half the tone burst and expand the

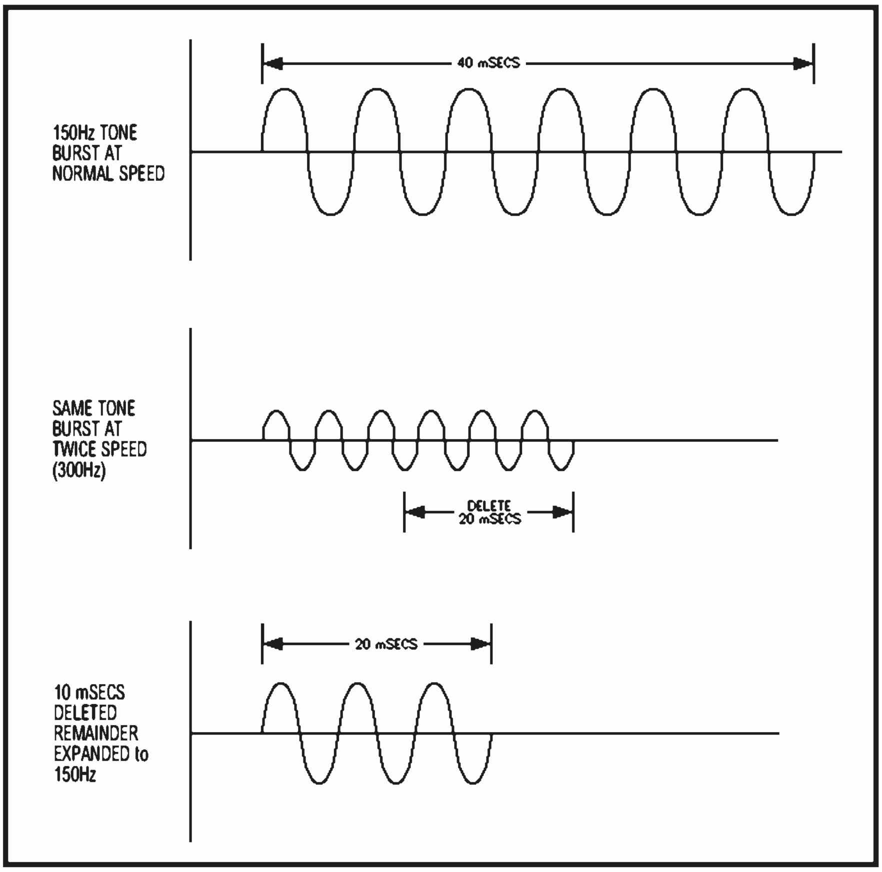


Fig. 1. The method of reproducing sound at normal pitch when replayed at higher than normal speed (in this case at twice speed).

remaining portion again. Thus we finish up with a tone burst of half the duration but at the same frequency, as shown in Fig. 1c.

This is in fact the principle of the new VSC system (Variable Speech Control). In normal speech there is a considerable, amount of redundant information and the basic speech sounds are of around 100 millisecond duration. Hence by sampling the speeded speech and discarding redundant material the remainder may be stretched so that the resulting gaps are filled. Thus speech of normal pitch but at a much faster rate is produced.

The reverse process may also be used by compressing short samples and filling the resulting gaps with redundant material. This allows playback of speech at much slower rate than normal again with normal pitch.

There are two problems in this approach which must be overcome. The first is that the duration· of the portion must vary to suit the change in speed. For example at three times normal speed two thirds of the sample must be discarded. The remaining one third is then expanded three times to produce gap less speech at the correct pitch.

The second problem is in expanding the remaining portion correctly. This problem may best be understood by reference to Fig. 2. Here we see the. signal after speed up compared to the same signal when expanded (X2 speed}. The delay required for each point on the waveform can be seen to increase with time during the sample period and some electronic means of achieving this must be provided.

HOW ITS DONE

The heart of the new system is a new IC developed jointly by Matsushita Electric and Philips. Known as the MN3001, it is an LSI device consisting of 512 dual bucket-brigade stages on a single silicon chip. The two sections may be connected in series to obtain 1024 stages, pr, may be used in parallel to obtain double the output voltage obtainable from a single section.

A bucket brigade device consists of charge storage capacitors separated from one another by MOSFETS. When the FETS are gated by means of a pulse the charge on one capacitor is transferred to the next. Thus by clocking the device with a train of pulses the signal is shifted down the chain. The direction of shift is controlled by using a two phase clock.

Thus the bucket brigade device is a shift register but, it is an analogue shift register because the amplitude of each bit is transferred by the charge transfer process. Thus an analogue signal input

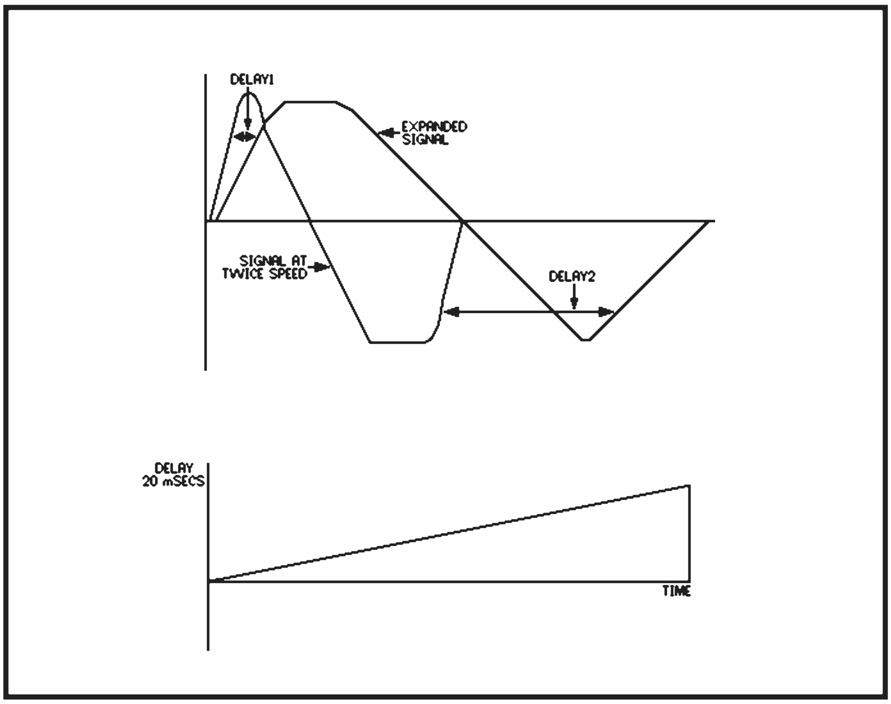


Fig. 2. When expanding a signal sample each segment of the waveform must be delayed, and the delay must increase linearly during the sample time.

This is shown by comparing the delay between pairs of points having the same phase angle, as for delay periods 1 and 2 shown above.

will be delayed by an amount which depends on the clock frequency. The lowest recommended clock frequency is 10 kHz and with a 512 stage device this gives a delay of around 26 mil li seconds.

To return now to our VSC unit (Fig. 3) the audio signal, from the tape recorder head etc, is fed to the bucket brigade device. Instead of using a fixed clock frequency we gradually increase (or decrease) the clock pulse duration during the bit shifting process of each sample. Thus each sample bit of the analogue signal is subjected to a progressively greater (or shorter) delay. The net result is a signal having the correct frequency components but

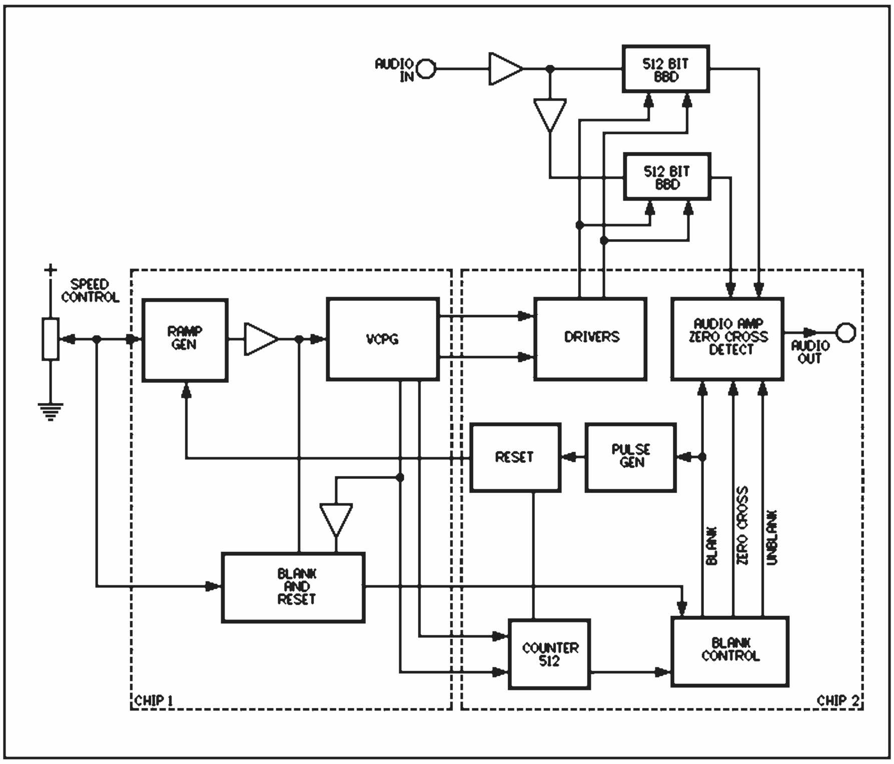


Fig. 3. Functional block diagram of the VSC system. Two chips are used for control and a third chip contains the dual bucket-brigade analogue shift reader.

VARIABLE SPEED SPEECH

being played back at a faster (or slower) rate.

The speed control potentiometer, as well as determining the speed of the recorder, provides a control voltage to a ramp generator. If normal speed is set, a ramp is not generated and the bucket-brigade device merely delays the signal without other change. If the recorder is speeded up, a positive going ramp is generated, and if slowed down a negative going ramp is generated. The ramp is passed to a VCPG (Voltage Controlled Period Generator) and as the ramp sweeps it varies the clock pulse period from the generator such that a progressively greater (or smaller) delay is obtained during the sample.

Before the ramp overdrives the period generator a comparator causes the amplifier to be blanked at the reset zero crossing point of the audio (to avoid annoying switching noise). At the same time the ramp is reset and a staircase counter is started.

During the next - 512 counts the amplifier remains blanked allowing the sample stored in the analogue shift register, to be dumped out. At the end of the count the amplifier is gated on allowing the next sample to be loaded into the shift register.

Thus a discard period of 20 to 40 milliseconds is generated and the amplitude and polarity of the ramp will vary the playback rate from less than one half to three times normal speech rate.

Although only one bucket-brigade shift register is required, the use of two devices feeding a differential amplifier allows twice the output voltage to be obtained. Additionally, the differential amplifier will cancel out common mode noise, due to switching etc, thus improving the signal to noise ratio by 3 dB.

The development of the VSC process was carried out by a small group, specially set up in 1966, known as Cambridge Research and Development Group, (CRDG). The basic design was first implemented with discrete FET storage stages and the advent of the Philips/Matsushita bucket-brigade devices was a fortuitous development which allowed an IC design to be immediately feasible.

The design is now to production stage and three licensing agreements have been conclud with Sony Corp, Matsushita Electric Co and with Magnetic Video Corp of US. Additional licenses are likely to be appointed in the near future. In fact as we close for press we have just heard that Hitachi's new TSC-8800 cassette recorder has the system built-in.

At present the VSL system is constructed on three chips, one for the dual 880 device and two for the control logic. This system will allow low cost tape recorders to be modified for VSC at reasonable consumer price levels.

It is expected that, in the future, the entire system will be integrated onto one chip, using CMOS techniques. Such a low voltage, low power device will make VSC a technique which will probably be incorporated in all low-cost dictation equipment and cassette recorders as a matter of course.

COURTESY LIGHT EXTENDER

ALL MODERN CARS are fitted with door-switch operated courtesy lights. Useful devices; but not quite as useful as they might be because they are so arranged that the light is extinguished as soon as you close the door - just when you need light to find the ignition switch, do up your seat belt etc. How much better if the internal light stayed on for a few seconds after the door is closed.

This little project does just that. It provides a four-second delay (approx) after which the interior light slowly dims being finally extinguished after 10 or 12 seconds.

The unit is very simple to construct and once tested and properly insulated it may be wired across one of the car door switches. In operation, after a short delay the lights will gradually dim until they are completely extinguished. There is no battery drain in the off-state as the unit only operates during the delay period after the door is closed.

HOW IT WORKS

Most car door switches are simply single-pole switches with one side earthed. When the door is opened the switch earths the other line thus completing the light circuit.

In a car where the negative terminal of the battery is connected to the chassis the negative wire of the unit (emitter of Q2) is connected to chassis and the positive wire (case of 2N3055) is connected to the wire going to the switch. In a car having a positive earth system this connection sequence is reversed.

When the switch closes (door open) C1 is discharged via D1 to zero volts and when the switch opens C1 charges up via R1 and R2. Transistors Q1 and Q2 are connected as an emitter follower (Q2 just buffers Q1) therefore the voltage across Q2 increases slowly as C1 charges. Hence Q1 acts like a low resistance in parallel with the switch - keeping the lights on.

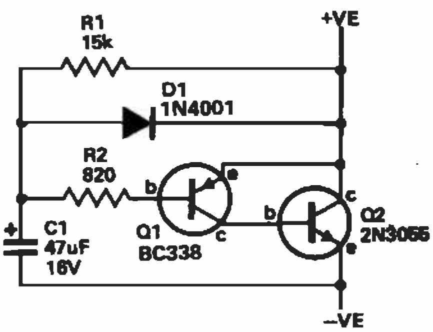
The value of C1 is is chosen such that a useful light level is obtained for about four seconds, thereafter the light decreases until in about 10 seconds it is out completely. With different transistor gains and with variation in current drain due to a particular type of car the timing may vary, but may be simply adjusted by selecting C1.

CONSTRUCTION

In our prototype, as shown in the photograph, all the components are assembled directly onto the 2N3055 transistor. This only requires two "mid-air" joints to be made.

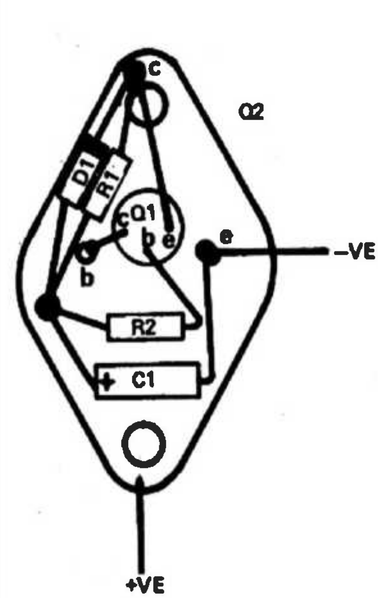
After checking that the unit works correctly the assembly may be placed in a small plastic pill box which is then filled with epoxy. Alternatively merely wrapping the unit in insulation tape will be sufficient.

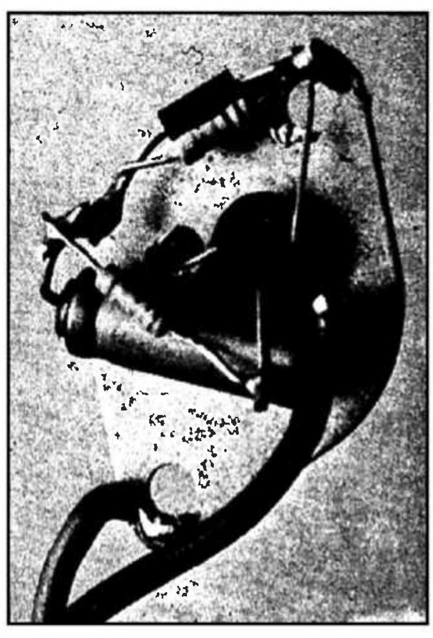
Due to the fact that the 2N3055 only conducts for a few seconds every so often, a heatsink is not required for cars fitted with a single lamp courtesy light. If your car has more than the usual amount of interior lighting operate the unit a number of times in fairly quick succession. Then, if the 2N3055 gets too hot to touch, use a small piece of aluminium as a heatsink. This need should however be rare.

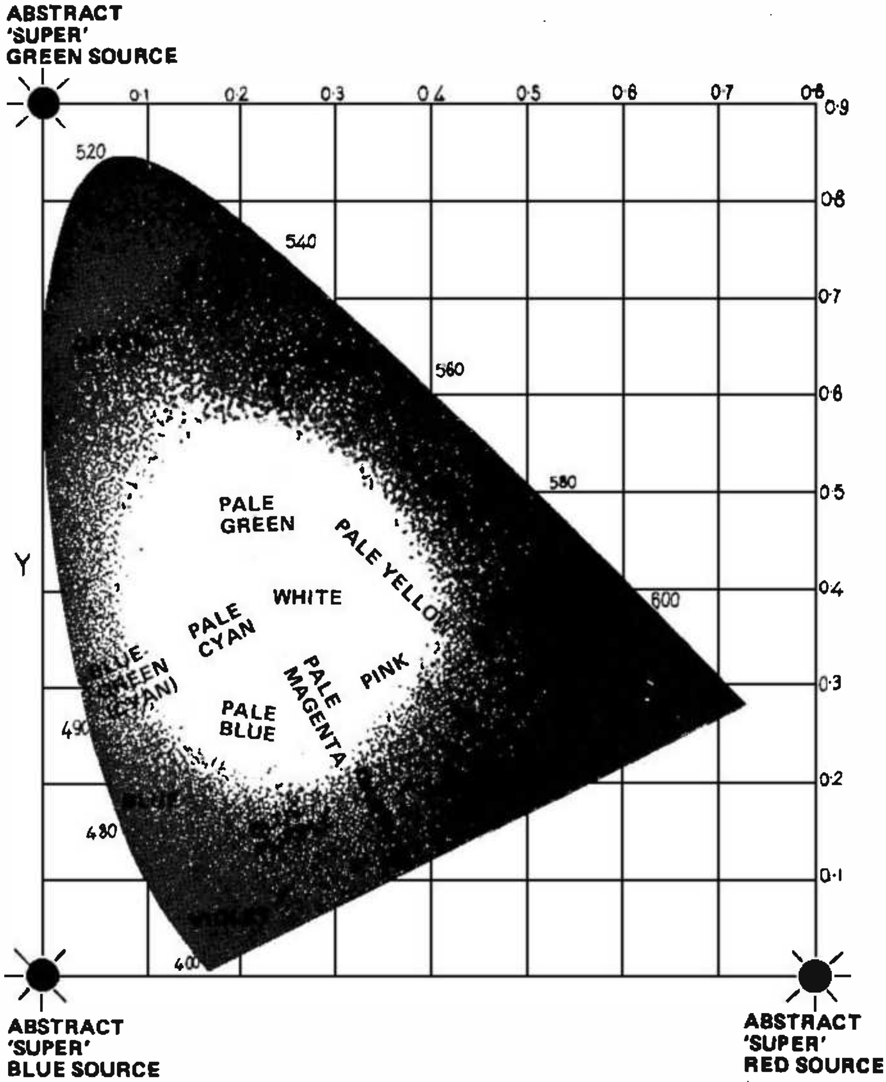


PARTS LIST

R1	resistor	15k 1/2W 5%
R2	resistor	820R 1/2W 5%
C1	capacitor	470uF 16V electrolytic
D1	diode	1N4001
Q1	transistor	BC338
Q2	transistor	2N3055







The aim of this series is to explain the basically simple principles which, when combined, make the near-miracle of colour television possible.

The intention is to avoid intensive explanations of any step in the process (as a specialist may require) since this would cause a general reader to feel adrift.

Instead we shall describe the fundamentals which are essential matter for anybody seeking a broad understanding of colour television.

Fig. B. The C.I.E. chromaticity diagram which shows how all colours, including spectral colours which lie along the heavy line can be achieved by combining three 'super' fictitous primary sources.

UNDERSTANDING COLOUR TV

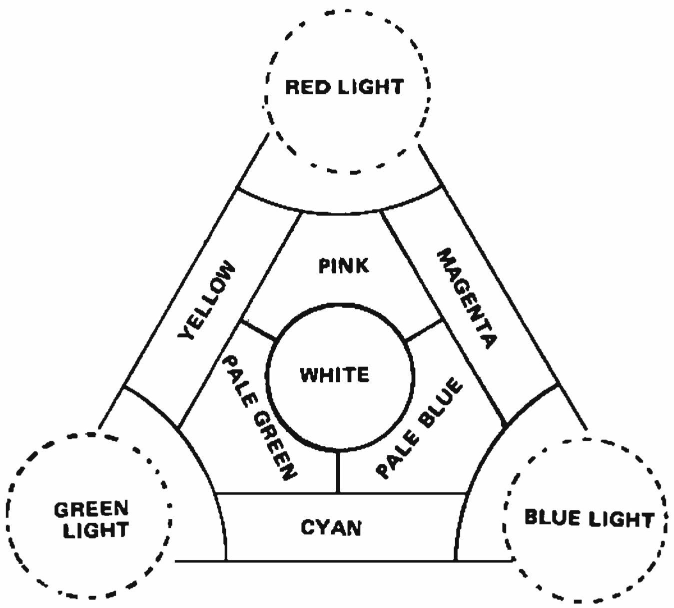


Fig. A. The triangle show the effects of mixing varying proportions of lights coloured red, green and blue, These are the 'additive primaries' used in colour television.

WITHOUT COLOUR awareness we would distinguish between only a few shades of grey. With colour many tens of thousands of different shades can be seen, with virtually infinite possibilities for colour combination's. The physical nature of colour was a complete mystery until 1666. Then, Sir Isaac Newton discovered that a single beam of sunlight passing through a wedge shaped piece (prism) of glass becomes dispersed into a fan-shaped beam or spectrum of many brilliant colours.

Now that light is known to be a form of radiation differing only in wavelength from other radiations such as radio waves or X-rays, we recognise the spectral colours as different wavelengths of light energy which were all present in the sunlight but have become separated by varying degrees of bending in the glass wedge. For example, spectral green is a monochromatic (single wavelength) radiation of about

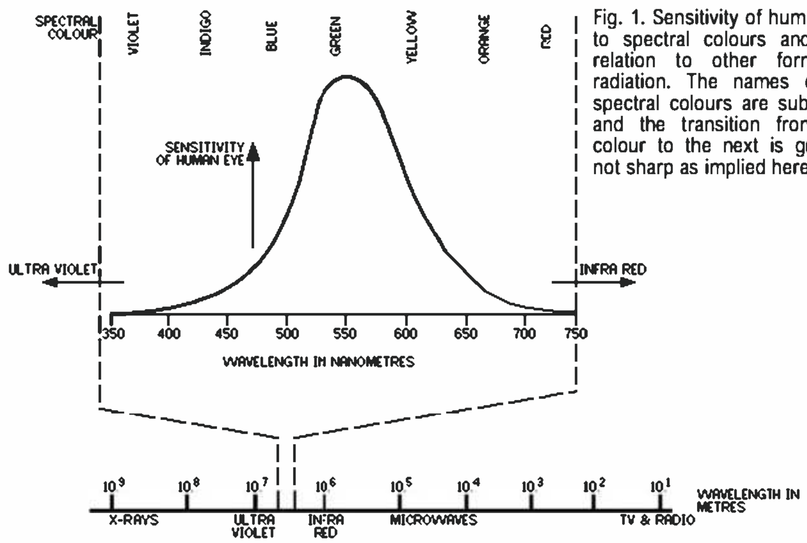


Fig. 1. Sensitivity of human eye to spectral colours and their relation to other forms of radiation. The names of the spectral colours are subjective and the transition from one colour to the next is gradual, not sharp as implied here.

550 nanometers wave-length. Its frequency is nearly 1 000 000 000 megahertz.

Visible light occupies only a tiny part of the full spectrum of radiation shown at the bottom of Fig. 1. The actual range seen is from 380nm (violet) to 780nm (deep red) wavelength (1 nm = 1 nanometer = 10-9 metre = 10). The colours at these extremes appear comparatively dim, this is because the eye has less sensitivity to these wavelengths.

Although there is surprisingly great variation between people, an average response curve for the eye has been measured and is shown in Fig. 2. Those in electronics will notice that this curve resembles the response shape of a tuned-circuit and it is a remarkable result of evolution that the peak is 'tuned' to near the wavelength of maximum emission from the sun.

HUMAN COLOUR VISION

Appreciation of spectral colours does not explain the undeniable existence of colours such as purple or brown which can not be found in the spectrum, nor does it provide a principle for colour television. The answers lie in the discovery that the eye does not recognise colours by wavelength.

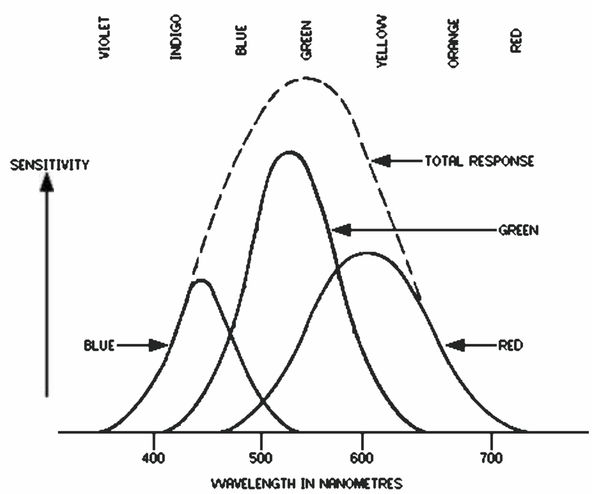
Instead the eye seems to contain three sets of nerves with different wavelength responses, and the sensation of colour seems to be a sensation of the relative proportions in which this triad of nerves is stimulated - see Fig. 2. It must be stressed that this description is merely conjecture. However the theory can be tested because it implies that if we combine three light sources which stimulate each nerve individually (particular shades of red, green and blue light called primaries), any possible colour impression can be simulated by varying the strengths of the sources.

Certainly though it is a reasonable conjecture, for if we combine three light sources (particular shades of red, green and blue light called primaries) and stimulate each nerve individually, any possible colour impression can be simulated by varying the relative strengths of the sources.

Figure A shows the degree of success of this experiment. It is a colour triangle where each primary coloured light is shown alone at a corner and becomes mixed with one of. the other two primaries as one moves towards one of the other two corners, or becomes mixed with both of the other two primaries as one moves towards the centre of the opposite side. At the centre is the colour 'white'. This is produced by near equal strengths of each primary: The precise position of white m the triangle is a matter of choice since, like any other colour, its separation from bordering colours is indistinct. The colour triangle shows only the colours produced by different proportions of the three lights. It does not show the effect of brightening or darkening all three lights by the same factor. Doing this does not change the colour of any position on the triangle, it merely varies the luminosity (brightness) of the colour. Since luminosity information is absent from the triangle, the 'white' area could equally rightly be called light grey, medium grey, dark grey or black since this is the variation caused by varying luminosity. The reason brown was not found in the spectrum is now apparent: brown is merely the colour yellow with low luminosity. (Therefore a brown object brightly lit against an otherwise dark background, so the eye over-estimates its luminosity, appears yellow!) Also the nature of purple, a mixture of red and green which has no single place on the spectrum, becomes clear in Fig. A.

Artists may be questioning our choice of red, green and blue primaries since they have found red, blue and yellow to be the most flexible choice of paints to be mixed to give other colours. However our simulation of colours by additive mixing of lights is quite different from the process of paint. mixing which is a subtractive process, the more coloured pigment is added to the mix, the darker the result because fewer wavelengths of light are reflected. An artist concocts his colours by removing some of the wavelengths present in white light (the colour of his canvas or of the base of his paints) until the right mixture is left. He can therefore start with more than one set of subtractive primaries, using more than three for best results (as is done in printing the cover of this magazine). Although the combination of primary coloured lights to create new colours is fairly successful, some colours, including the spectral colours, cannot be simulated completely by any mixture. For example, spectral blue-green cannot be copied by mixing any other colours, spectral or otherwise. (Of course if we choose spectral blue-green as one of our

Fig. 2. The three hypothetical responses which combine to give the overall eye response in Fig. 1 (based on experimental data). From left to right the peaks are at blue, green and red which suggests fhat these colours could be used to influence each response individually, and In combination cause the eye to see any colour.



UNDERSTANDING COLOUR TV

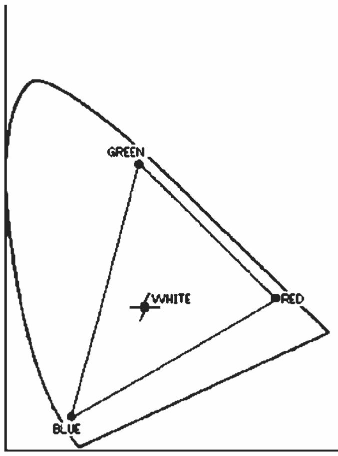


Fig. 3. A feature of the chromaticity diagram is that the colours achievable by combining any three primaries can be found by connecting them on the chart. The three dots above represent to scale the best television screen phosphors available for colour television. Therefore colour television can only reproduce colours lying inside the triangle.

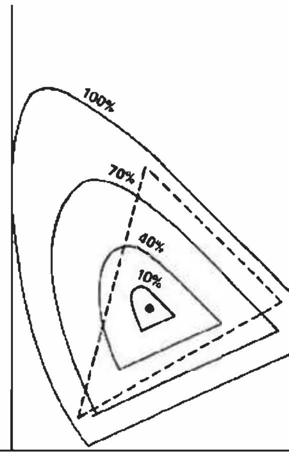


Fig. 4. Contours of four levels of saturation. Dot at centre is white 'zero saturation'

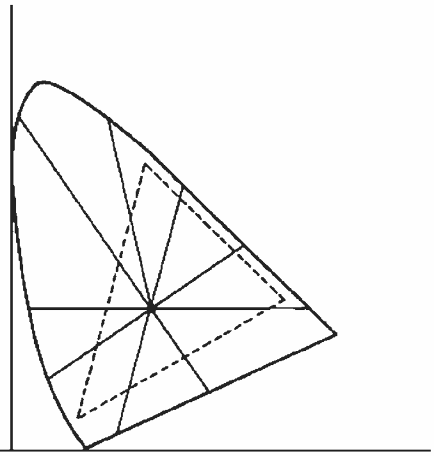


Fig. 5. Each radiating line joins colours of a particular 'hue'. White at the centre has no hue.

primaries this particular problem is solved but all the other spectral colours remain. However, it has been found that any of these inimitable colours, if first modified by adding an amount of one of the primary colours, becomes a colour which can be simulated by combining the remaining two primaries. It is as though each spectral colour contains a negative quantity of one primary; addition of this primary to the pectral colour counteracts the negative quantity to produce colour which lies within Fig. A.

Since we cannot have negative light sources, spectral colours will lie outside any colour triangle drawn with real light sources at the corners. However the C.I.E. (Commission Internationale de L'Eclairage - the International Commission on Illumination) defined in 1931 three abstract primary colours which, if they existed, could be combined in suitable ratios to stimulate any known colour impression, including all the spectral colours. The usual presentation of the colour triangle using these sources is the 'chromaticity diagram' shown in Fig. B. Here the quantities of the primaries are · given in 'tristimulus units' x, y and z, which have the property that units of different primaries can be summed to give an accurate measure of the visual brightness of the resulting colour. Since brightness (luminosity) variation does not affect the triangle, luminosity can be given unity value and the triangle drawn like a conventional graph with only two variables, x and y, since the third z can be found for any colour position from $z = 1 - (x + y)$.

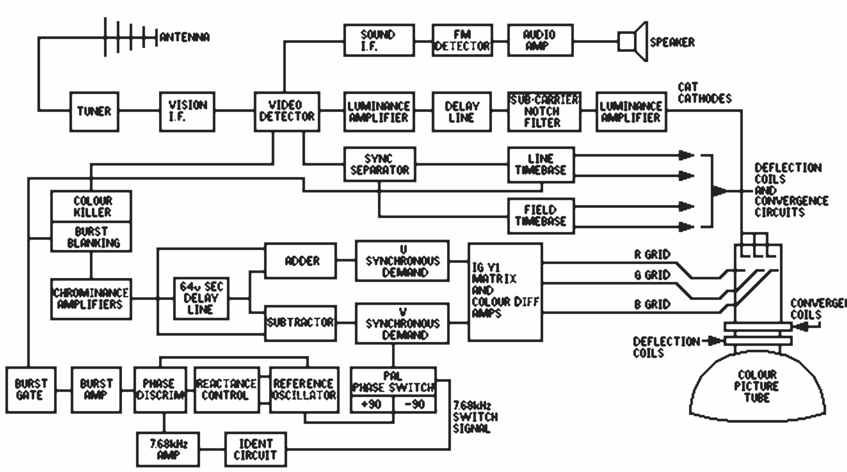
Much can be deduced from this diagram. For example it shows that any real colour triangle must have as its corner primaries three colours on the diagram - Fig. 3. Since no such triangle can be drawn to encompass the entire horseshoe, spectral colours can never be simulated.

SATURATION

Colours near the horseshoe boundary have a strong undiluted quality, the strongest being the spectral colours. Colours nearer to the white at the approximate centre of the horseshoe are paler or 'pastel'. The distance from white of a colour on the diagram is called its 'saturation' which ranges from 0% (white itself) to 100% saturation on the border of the horseshoe - Fig. 4.

HUE

If we start at any 100% saturated colour and progressively desaturated it by adding white light, we travel from the boundary of the horseshoe along a straight line towards white. All colours along such a line are said to have the same hue and vary only in saturation. There is an infinity of possible hues - see Fig. 5. Note that a triangle of real primaries, as used in a colour television display, can simulate any hue but not at full saturation. Since 100% saturated colours are rare in nature the restriction is acceptable. Thus the question of how colour television can



Block diagram of PAL colour receiver.

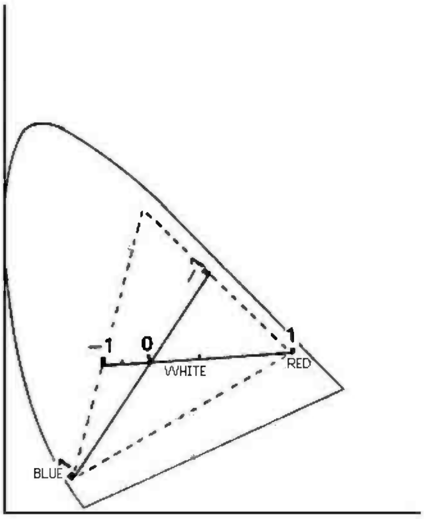


Fig. 6. Any colour position inside the triangle corresponds to a unique pair of values on these two axes.

reproduce a rainbow spectrum is answered - the hues are reproduced correctly but some colours may lack true saturation.

CHOICE OF COLOUR VARIABLES FOR TV

We shall see in Part 2 of the series that because of the need for the colour television signal to be suitable also for monochrome receivers, luminosity information is transmitted in the form of a monochrome television signal and two extra streams of information are cunningly added to the signal for recognition by colour receivers only. These two extra signals are two variables which define positions of colours on the chromaticity diagram. There could be many choices of pairs of variables. Hue and saturation are a possible pair since they uniquely define any colour. However it is undesirable to use variables capable of specifying colours which cannot be reproduced.

Another choice of variables with relevance to colour television, since they define only space inside the realizable colour triangle, are shown in Fig. 6. Here the red-hue line has been extended through white to hit the far (blue-green) side of the triangle, likewise the blue-hue line has been extended through white to yellow. The values placed along these axes initially represent the progressive desaturation of blue or red but then go negative on the 'far side' of white

ELECTRONICS -it's easy! PART12

Introducing emitter followers and DC amplifiers.

IN OUR GENERAL discussion of the ac amplifier we have shown how this common system component can be used to increase the amplitude of AC signals. The frequency range of a typical AC amplifier may extend from a few hertz to many megahertz, the upper limit being limited mainly by the performance of the active device (transistor etc) used.

The type of amplifier illustrated, in Fig.15 of the previous section, is only one of several different basic design concepts that we may use. Each different approach has particular advantages and disadvantages that suit it more to one application than another. For example a different approach must be used where the amplifier is to be loaded by a low impedance or where DC signals must be amplified.

We will now discuss the three basic amplifier configurations, their fundamental properties and their typical uses. This will then equip us with the information needed to understand basic DC amplifiers and, in addition, modern integrated circuit amplifiers.

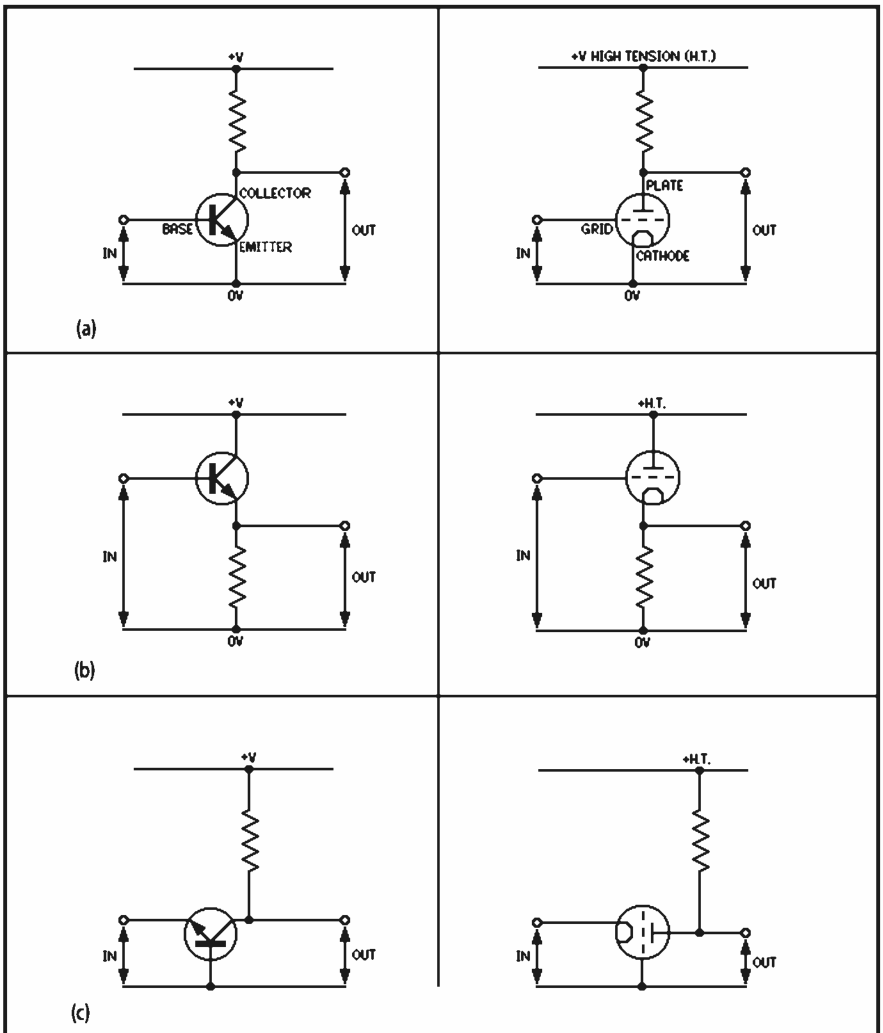


Fig.1. Basic configurations of transistor (left) and valve (right) amplifiers. (a) Grounded emitter, grounded grid. (b) Grounded collector more commonly called emitter follower, and grounded plate more commonly called cathode followers. (c) Grounded base and grounded grid.

In our previously described amplifier you will remember that we developed the circuit from a basic configuration of the transistor where the emitter is connected to the negative rail. This method of connection, naturally enough, is known as "grounded-emitter" and is illustrated in Fig.1a (together with the equivalent valve circuit). This, and the other methods of connection were first devised for use with valve circuitry and then conveniently passed on to transistor technology. There is one major distinction between the two amplifier elements - valves operate as voltage devices, transistors as current devices. In the 50's and early 60's, transistor technique was taught by using analogues with the then established and widely known valve practices. Today, valves play only a limited part in electronics, but we have included valve counterparts alongside the transistor circuits to assist those previously trained in valve technology and the newcomer too will be acquainted with components that are still used in some special applications.

THE EMITTER FOLLOWER

Another valuable configuration is that given in Fig. 1b the grounded collector circuit which is more commonly called an emitter follower.

In this case it is the collector that is connected directly to the supply rail, not the emitter. The term 'grounded' may appear incorrect but, when it is remembered that a perfect voltage supply has zero resistance, it can be seen that the collector is effectively connected directly to the ground line. As it is much a case of where the essential load resistor is placed it might be easier to remember that th is configuration places the load resistor in the emitter lead, not the collector lead. The transistor is wired into the circuit with the same polarities at each connection as for the grounded emitter.

In the development of a satisfactory grounded-emitter circuit we saw how the addition of an emitter resistor provided thermal stability. We also saw how this resistor reduced the DC gain of the circuit. This is because the collector current through the resistor produces a voltage drop which opposes the original drive voltage applied to the base-emitter circuit.

The emitter follower uses this effect to provide impedance buffering between two stages. The output voltage developed across the resistor is closely equal to (but not quite the same because of the voltage drop across the base-emitter junction) that applied to the input.

This may seem a futile process for the voltage level of the signal cannot be amplified. In fact, however, it is the signal current that is amplified. The emitter-follower, therefore complements the operation of the grounded-emitter circuit. It is invaluable as a means to raise the current level of signals without altering the voltage level.

Although current gain is very important in some applications (discussed later), in small signal situations we usually regard the emitter follower as an impedance - conversion stage. This will become more- obvious after we examine emitter-follower characteristics.

The voltage drop across the forward biased base-emitter junction is a constant (almost) 600 mV for a silicon transistor (400 mV for germanium). Thus the voltage at the emitter closely follows the signal at the base, but with a 600 mV lower mean DC level.

Hence the voltage gain of the emitter follower is always slightly less than unity.

$$\text{gain } A \approx \frac{Ze}{Ze + (\frac{1}{gm} + \frac{Zs}{\beta})}$$

Where
Ze = impedance in emitter

$\frac{1}{gm}$ = a factor dependent on resistances within the transistor but typically 50 ohms at 1 mA for small transistors (falls with increasing current).

Z_S = source impedance

β = transistor current gain.

Thus if an emitter resistor of 1k is used with a transistor having a β of 100 and the impedance of the source is 2k.

Voltage gain A=

$$\frac{1000}{1000 + \frac{(50 + 2000)}{100}} = \frac{1000}{1070} = 0.93$$

$$Zin \approx \beta\,(Ze + \frac{1}{gm})$$

Thus for our example
Zin = 100 (1000 + 50)

= 105 k

Output Impedance

$$Zout \approx \frac{Zs}{\beta} + \frac{1}{gm}$$

$$\frac{2000}{100} + {}'50$$

= 70 ohms

The actual output impedance is the value as calculated above in parallel with the emitter resistor. That is, in our case -

70//1000 = 65 ohms

Thus we can see that the input impedance of 105k will not appreciably load the 2k source and the full signal voltage (0.93 gain) appears at the emitter across an impedance of 65 ohms. Thus we see how the impedance conversion has taken place. By choosing the correct values this impedance may be adjusted to a desired value, e.g 50 ohms.

The emitter follower, therefore, can be used to connect a low input impedance stage to a preceding high-output impedance stage without introducing serious attenuation due to loading.

For example, if a stage with an output impedance of, say 10k is to drive a stage with 1k input as shown in Fig.2 a direct connection would load the first stage so much that its signal voltage output level would be reduced to roughly one tenth of its original magnitude. A single emitter-follower stage can be designed to have 100k input and 50 ohm output which will enable the original two stages to be joined with little attenuation of the signal level.

Figure 3 shows a typical circuit in which voltage gain is obtained by a grounded-emitter stage followed by buffering with an emitter follower.

The amount of impedance reduction

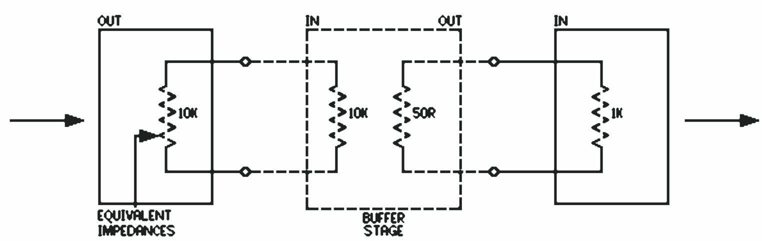


Fig. 2. The emitter follower, used as a buffer stage, allows two stages to be coupled without introducing loading effects.

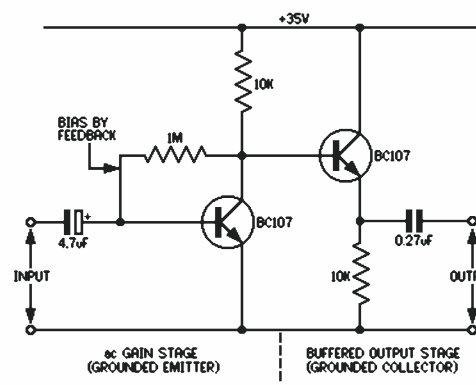


Fig. 3. A typical grounded emitter stage buffered by an emitter follower. Note the bias arrangement for the first stage and that base of the emitter follower is directly coupled.

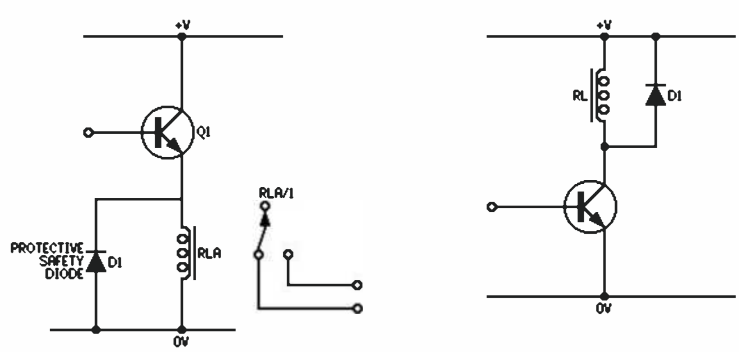


Fig. 4(a). In output stages the load becomes the resistance in the emitter of the follower circuit. (b). The alternative grounded emitter circuit. Note that diode D1 absorbs high voltages induced in the relay coil when the transistor turns off.

	GROUNDED BASE	GROUNDED EMITTER	GROUNDED COLLECTOR
Current Gain	<1(.98)	High (200)	High (200)
Voltage Gain	High	High	<1
Input Impedance	Low (40)	Medium (2k)	High (100k)
Output Impedance	(1 Megohm)	Medium (30k)	Low (1k)
Power Gain	(Medium (30dB)	High (40 dB)	Low (16 dB)
Cut-off Frequency	High	Low	depends on R_L
Voltage Phase Shift (L.F.)	Zero	180°	Zero

Fig. 5. Comparison table of characteristics for alternative connection modes. Note that these are typical values only.

attainable depends largely upon the B value of the transistor. Where greater than tenfold reduction is needed the designer can resort to cascading two or more emitter follower stages or use can be made of special semi-conducting active devices (eg the field-effect transistor) that have high input impedances.

When the buffer stage is also the final output stage, and is required to drive an actuator such as a loudspeaker or relay coil, the actuator itself may be used as the emitter resistor, being wired into circuit as shown n Fig.4. In this case there is no need to provide a separate resistor.

The emitter follower does not change the phase of the signal. This contrasts with the grounded emitter amplifier where a positive going signal becomes a negative going output. That is, AC signals are phase shifted by 180° or one half-cycle. The emitter-follower is a robust stage and is less likely to be damaged than the grounded emitter circuit. The ma;n point to watch is that the emitter load impedance (the resistance value added in parallel with the input resistance value of the next stage) is not so small that the collector current Ic exceeds the manufacturer's stated safe maximum value.

The input base connection of the emitter-follower stage is usually coupled directly to the output (collector) connection of the preceding stage. There is no need for thermal runaway compensation or for a bias network. The emitter-follower is a very simple stage but nevertheless a very important one.

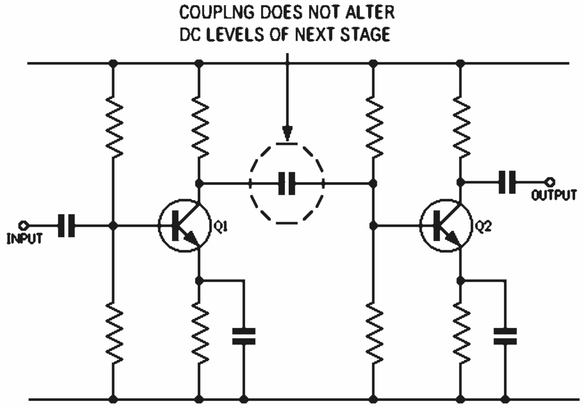


Fig. 6a Typical AC circuits coupled with capacitor.

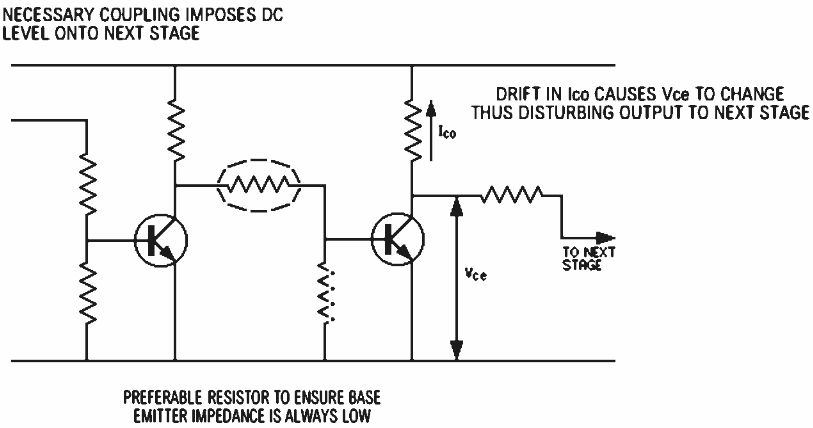


Fig. 6B. Simplest DC amplifier.

Fig. 6 (a) Coupling between AC stages by a capacitor does not affect levels of either stage. (b) Direct coupling between DC stages creates problems because of imposed DC levels.

GROUNDED BASE CONFIGURATION

Having grounded, firstly, the emitter then, secondly, the collector the next obvious stage design is to ground the base. The schematic of a grounded-base stage is given in Fig. 1c. This design is seldom used but there are circumstances where its peculiar characteristics render it useful. It can provide voltage gain roughly equivalent to the B of the transistor but it cannot provide more than unit current gain. Its usefulness arises from its ability to couple low-impedance input transducers microphone transformers for example - to normal grounded emitter gain stages with optimum power transfer. The input impedance of the grounded-base stage is in the region of tens of ohms and the output impedance is near a megohm.

The characteristics of the three configurations for a transistor are tabulated in Fig.5. Such a table can only be used as a guide, for the actual values of each circuit depend largely upon the B of the device and upon the passive components wired in to form the practical working stage - all remarks made apply to both p.n.p. and n.p.n. transistors alike; only the polarity of the supply needs to be changed.

THE COMPLEMENTARY TRANSISTOR

The foregoing explanations implicitly suggest that the emitter of a p.n.p. device must always be connected to the pos1t1ve polarity and that of a n-p-n to a negative polarity. This is usually the case in practice - but not an absolute rule.

Remembering that the transistor is a three-layer device we can see that it is, in principle, symmetrical. The p's of a p-n-p device could, in principle, be either the emitter or the collector, implying that it could be connected either way into a circuit. In practice, the junctions are made in such a way that operation is optimized for the connections stated by the manufacturer. It is, however, possible to procure special transistors that are made to exhibit similar characteristics for both possible connections of the collector and emitter, but one seldom meets the need for this in electronic circuits.

DC AMPLIFIERS

We have seen how it is necessary to add passive components to a basic active element to construct a practical ac amplifier. The same applies to constructing a practical DC amplifier.

To better understand what is required let us examine the different requirements of AC and DC amplifiers.

In the ac amplifier two different design conditions exist together, the bias and other steady state conditions and, the ac coupling which allows the signal to cause variations around these steady state conditions. This is necessary so that both polarities of the ac waveform may be amplified. Thus each stage in a chain of ac amplifiers is self-contained that is, the DC levels of one stage are not imposed on the next. This is illustrated in Fig. 6a.

If the signal to be amplified is a DC level (including also signals below 5 Hz) it is not possible to isolate the steady-state conditions of successive stages and some means of direct connection must be used.

Figure 6b illustrates a basic method of interconnecting DC amplifiers by means of a resistor. It is obvious that the DC level at the collector of O 1 will cause current flow into the base of 02 and a corresponding collector current in 02. This implies that with no signal to the base of 01 the output voltage from 02 will not be zero, and its level will depend on the conditions in the previous stage.

From this we see that the first important requirement is to carefully select resistor values such that the following stage is not driven into saturation. The series coupling resistor is thus chosen to limit base current into 02. It must not be too high, however, because the DC signal will be attenuated by the ratio of this resistor to the base-emitter resistance of the following transistor.

A further problem is that when the input to the base is zero, the collector output is not zero but at the supply voltage. So that even with no input to the first stage, the second may well be saturated.

Thus this particular approach, whilst capable of providing some DC amplification, is not very practical. Resistors must be chosen to suit actual betas of the transistors used as a change in gain means a change in output current and in bias to the next stage.

Assuming we managed to establish a workable set of values the next problem is that the values of the components and the gains of the transistors may (and do!) change with age and, more spectacularly, with temperature. Thus if the output DC voltage is somehow set so that it is zero with zero level input, it subsequently will drift in time and with temperature. If the overall gain is 100 000 (typical value) it does not require much drift at the first stage to fully saturate the last stage! (A 10V swing is produced by a tenth of a millivolt change).

Finally, to add to the problems to be faced by the designer we have not overcome the problem of amplifying both positive and negative polarity signals; the schematic arrangement of Fig. 6b can only handle negative signals. Positive signals merely bias the input stage into a totally non-conducting stage. An n.p.n. equivalent (of 6b) handles positive signals but not negative.

TURNING THE TRANSISTOR ELEMENT INTO A WORKING DC AMPLIFIER

A decade ago the electronic system builder had to design and build his own DC amplifiers Commercial units were available but were very expensive. The DC amplifier was regarded as a system block best avoided if possible! Numerous designs were investigated in an attempt to overcome the problems in satisfactory way but it was not until 1936 that the first successful high-gain DC amplifier was built (in Sweden) by Buchtal and Nielson. Since then many

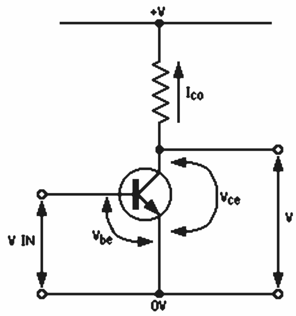


Fig. 7. Basic grounded-emitter stage of a DC amplifier is rarely satisfactory due to drift in V_{out} due to changes in leakage current I_{co}.

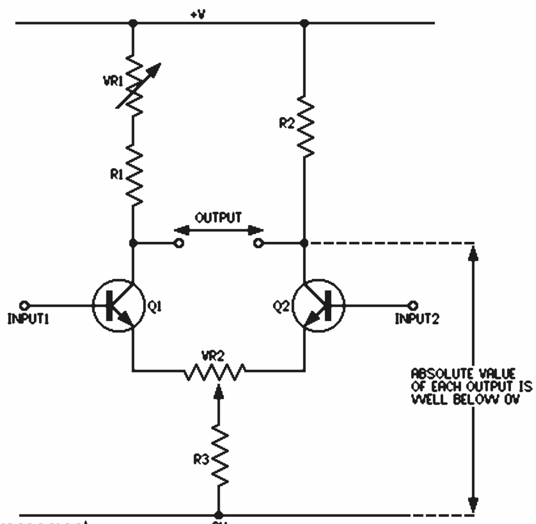


Fig. 8. Schematic of the differential pair arrangement which is used to reduce effects of thermal drift.

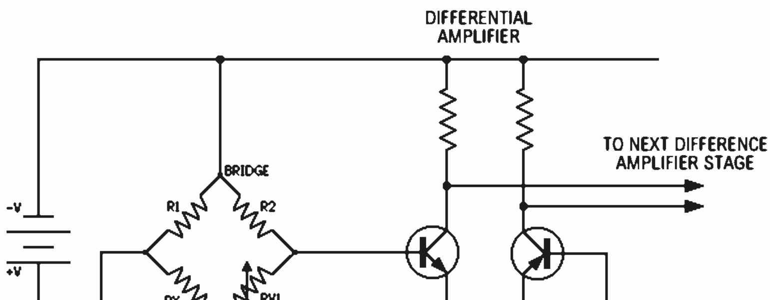


Fig. 9. Differential DC amplifiers are ideal for use with Wheatstone bridge arrangements and sensors of various kinds. The circuit provides high common-mode rejections. That it is rejects noise hum etc, and only amplifies the difference signal.

intriguing circuit 'tricks' have been devised to overcome the drift problem that is still encountered with this and subsequent designs.

Today the situation has, quite suddenly, been reversed and we more often than not use a DC amplifier to provide the relatively simple AC amplification than build a special-purpose AC amplifier.

This revolution has come about with the use of integrated circuit manufacturing methods whereby numerous elements - (typically, 20 transistors, half as many resistors and a capacitor or two) are formed into a DC amplifier that, now markets for 50p or less and, may be mounted in a space about 5 mm square.

The circuit requirements of a DC amplifier stage have not-been eased; in fact a modern amplifier in integrated form contains more elements than its earlier discrete predecessor. Now, a few highly specialised designers devise the IC circuit which, after extremely thorough testing, is made as a one piece package that the electronic-system designer then uses as a basic building block.

The low price of such amplifiers means that, despite their internal complexity they can be used as freely as transistors were a few years ago.

Before we discuss how to use these amplifiers, let us consider some basic circuit techniques that are used to create the general purpose DC amplifier.

THE DIFFERENTIAL PAIR

In the basic grounded emitter circuit shown in Fig.7 V out will be roughly {3 times V in. However an unwanted leakage current, termed Ico, also flows through the device and resistor and, produces voltage drops across them.

Thus the Vout value may alter even though Vi n remains the same. When several stages are cascaded, to provide a gain approaching a million, the temperature dependency of Ico is large enough to produce a considerable swing in output voltage. Obviously such a system is unworkable, more a thermometer than a usable DC amplifier!

One remedy is to control the temperature of the element and this was standard practice in early units. Today internal electronic compensation will overcome this problem except in the most stringent cases.

There is, however, a more powerful method of eliminating the temperature effect. It uses two transistors to form what is known as a differential pair - as shown in Fig. 8.

When used as a single input DC amplifier, input 1 (or 2) is connected to the bottom rail with the signal to be amplified being fed into the other input. (The emitter resistor provides further temperature compensation). When the working input is also connected to the bottom rail both transistors are connected in an identical manner. Thus the two collector resistances are .equal, and if the two transistors have similar leakage currents, the voltages developed at each collector will be closely identical and will 'track' each other with temperature changes.

The output is taken to be that between the two collector voltages, not from one of the collectors to ground. When the two inputs are identical (no difference input signal) the output will be zero. (If not, VR1 is trimmed to make it so.) If one input rises above the other in magnitude, the output between the collectors will swing accordingly, but with the opposite sense and larger amplitude.

In this way the differential pair handles bi-polar (positive or negative going) signal swings, and provides significant temperature compensation.

A further advantage of the differential method is that any noise (such as mains interference or hum) is common to both transistors and, therefore, does not appear at the output. This is called common-mode rejection.

A similar differential circuit can be constructed using a pair of emitter-followers. In this case current gain is obtained instead of voltage gain. To obtain more gain such a stage can be connected to the two inputs of a following differential pair. Note particularly that the output has no connection with the common lower rail and any attempt to make such a connection prevents correct operation of this compensating method.

In many cases where DC amplification is needed; the input already exists as two leads which cannot be connected to earth - Fig.9 shows the commonly encountered Wheatstone bridge used in measurement. A small change in RX causes the bridge to go out of balance providing either a negative or positive output signal to the differential amplifier. In practice RX might be a temperature-sensitive resistor (thermistor) a strain-sensitive resistance grid (strain/gauge) or a light dependent resistor (LDR), to name just a few uses of the bridge.

Thus it can be seen that the differential pair concept is invaluable in the creation of a workable de amplifier. In discrete designs the transistors must be carefully matched for best results. In IC designs however this close matching of both characteristics, and the temperature of the devices is almost automatically achieved.

THE COMPLEMENTARY PAIR

The differential pair can handle a bi-polar signal swing but has two major disadvantages. Both output leads must be isolated from ground and the method is wasteful of both power and transistors. For these reasons DC or AC power output stages (where power lost as heat is expensive)often use what is called a complementary-pair circuit - shown schematically in Fig.10.

Here the load is connected between the two joined emitters of p.n.p. and n.p.n. transistors and the 0 volts rail, and the two bases connected together. If the input 1 signal swings positive the upper transistor begins to conduct, increasing the positive voltage applied to the load, and the other transistor is

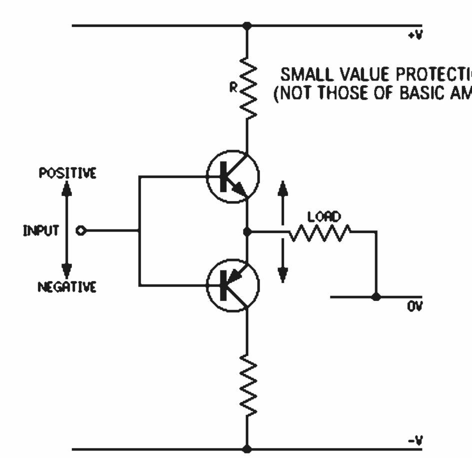


Fig.10. The complementary pair provides bipolar operation in a very efficient way.

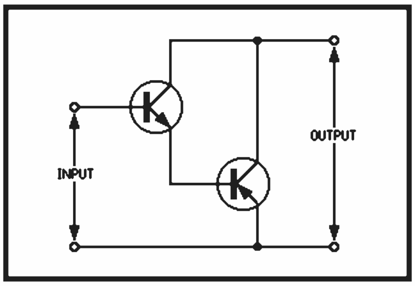


Fig. 11. Two transistors connected as a "Darlington pair" provide a super Transistor and perform better than two emitter followers cascaded.

biased into a safe 'off' state. In the reverse direction the opposite applies. As the complementary pair uses emitter followers it is inherently stable. However transients or other effects could possibly switch the off-state transistor to an on-state in which case the transistors would rapidly be destroyed. Addition of small value resistors in each collector helps to reduce this risk.

THE DARLINGTON PAIR

When the need arises for an amplifier with high input impedance the initial stage could be an emitter follower. If still higher input impedance is needed it is better to use the Darlington-pair circuit shown in Fig.11 than to cascade emitter followers. Although not immediately obvious, this circuit does consist of two cascaded emitter followers in which the emitter load for the first transistor is the base-emitter junction of the second. With the Darlington pair it is relatively easy to obtain input impedances of greater than 1 megohm. For still higher values the designer would normally use the field-effect transistor (FET). This will be explained later in the series.

Darlington pairs are, in effect, a super-transistor for the combined unit still has three terminals, has far greater input impedance and a typical combined gain of 30 000. The pair is available as a single packaged unit.

THE INTEGRATED CIRCUIT LINEAR AMPLIFIER

Having covered the main (but by no means all) circuit concepts used to build high performance DC amplifiers, we are better able to look a little closer at the IC operational amplifier. This circuit block is now used as the general purpose amplifier for both DC and AC analogue signals.

The ideal amplifier should be extremely stable to temperature changes, should not drift over long periods of time, should have relatively high input impedance, very low output impedance, wide tolerance to voltage supply variations, not be damaged by accidental short circuits of the output and be standardised in mounting methods and supply voltage.

Before IC devices were made, numerous manufacturers provided DC amplifiers in even more numerous packages and forms. This did not lead to the drastic price reductions realized by IC manufacturing, additionally their high cost did not guarantee that the units were as good as their makers claimed.

Today there are many makers of integrated circuit components: All offer DC amplifiers that provide a performance so good that we rarely even remember that DC amplifier design is very difficult. We just wire them in and forget them.

Figure 12 shows the basic circuit schematic of the very commonly used μA 709 operational amplifier. This unit requires the. addition of several components but is now a standard IC offered by numerous manufacturers.

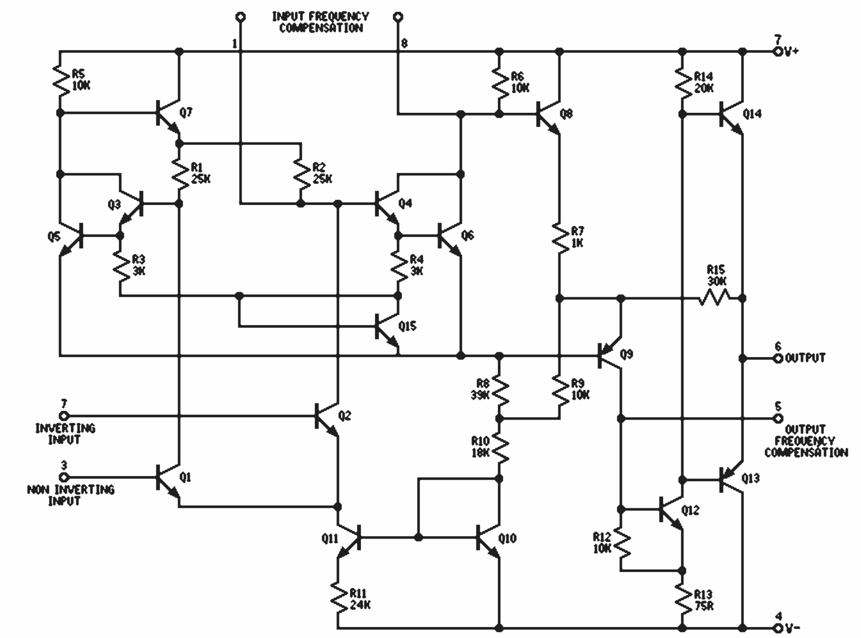


Fig. 12. Schematic diagram of the μA709 high performance, integrated circuit operational - amplifier as marketed by Fairchild. Can you pick the Darlington pair, complementary pair and a differential pair?

REFERENCES

Data

Semiconductor manufacturers are pleased to provide data sheets and application notes for their products. The electronic engineer uses these for design data and basic system ideas. Well known companies are:-

National Semiconductor, Fairchild, General Electric, Motorola, Philips, RCA, STC, Plessey, Sinclair, Texas Instruments, Hewlett Packard, Sprague, A.W.A.

Data is provided in several forms

(a) Books and binder catalogues that are expanded with time (not always a free service).

(b) Application notes which often run to 100 page unbound books.

(c) Individual data sheets giving vastly more data and detail than normal user needs (these may tend to confuse when first encountered).

For those who have a mathematical bent, and an urge to know the intricate whys and wherefores of amplifier design, an inexpensive useful text is the:-

"Transistor Manual" by General Electric, this is now in its 7th edition. It gives the theory of operation of transistors and plenty of generalised practice.

ELECTRONICS - in practice

OFTEN THE NEED arises to drive an output device, such as a relay, with a smaller input signal. The gain needed can easily be obtained with a single DC connected transistor stage which switches the power to the relay. This requires the transistor to operate in what is called switching mode (rather than linear amplification). Although switching circuits have not yet been covered this exercise is useful, helps to build more confidence in the use of transistor devices and illustrates more problems of DC circuitry.

The basic circuit is given in Fig.15. With the switch in the off position the transistor base current is at minimum and Vce rises to nearly 12V (the transistor 'resistance' changes to be very much greater than .the resistance of the coil of the relay). The coil is then de-energised. (The switch, in practice, could be replaced by any other device which provides sufficient voltage change to switch the transistor, e.g another transistor or LDR etc).

When the switch is put to the on position, base current flows and is limited by Rb. This is chosen to ensure that the transistor is fully conducting and, therefore, providing a very low resistance compared with the relay coil. The coil is then virtually connected across the supply and the relay operates.

A diode is connected across the relay to absorb the large voltage spi es that are induced across the relay as the current through it collapses when the transistor is turned off. Without it the transistor would be pulsed and probably destroyed.

The design steps are as follows:

(a) To fully energise the relay 12V/185 of current (65mA) must flow through the transistor.

(b) From data charts we select BC108 (or BC107, 109) as being capable of withstanding the 12V supply and the 65mA needed. The actual limits of the BC107 n.p.n. series are shown in Table 1.

(c) The minimum gain ((3) of a BC108 is around 100, so the base current of the on-state must be at least 65/100 = 0.65 mA. To be on the safe side double this, for it is essential that the transistor be properly saturated. A base current of, say, 2mA is, therefore, needed. Further delving into the data sheet values and curves establishes that this value of Ib is well within safe limits.

(d) Choose Rb to give 2 mA from a 12V supply which leads to a value of 6 k for which the nearest preferred value is 5.6 k.

These simple steps can be greatly elaborated upon by the trained expert

TABLE 1

	BC107	BC108	BC109
Vce max. Volts (base shunted to emitter)	50	30	30
Vce max. Volts (base lead open)	45	20	20
Icm (mA)	200	200	200
P total max (mW)	300	300	300
(maximum dissipated power hfe (B)	125-500	125-900	240-900
ft (max. useful frequency)	300MHz	300MHz	300MHz

but for general usage they are adequate.

The circuit, therefore, operates the 65mA reply coil with a control current of only 2mA - a considerable reduction. For further sensitivity another stage can be added as shown in Fig.16.

Now the design criteria is that the extra transistor provides 2mA when switched off -which also means it must pass about 4mA when on, for the collector resistor decides the flow into the following stage as well as into the transistor. The base current of 01 is, therefore, now 50µA or less. Note also that the phase is now changed - with the switch up the relay is 'off' instead of 'on' as in Fig.15.

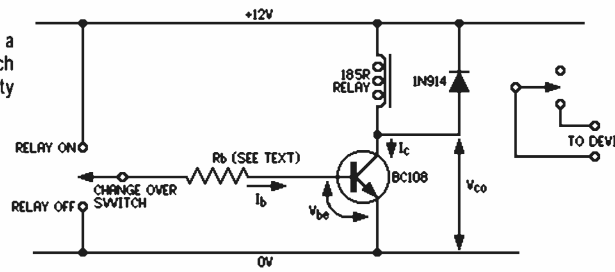
Switching circuits are the easiest DC circuits to design, for thermal effects are not so rampant. This is because the currents needed can be over-driven to ensure that changes in leakage and gain do not ·bring the transistor out of the 'off' or 'on' state.

It is good practice to clamp the base to earth when the transistor is in the off state. Should the base be left open circuit, thermal runaway may occur. This is because the leakage current, dependent on temperature, causes Vbe to rise, collector current to increase and further temperature rise to occur - thermal runaway.

In the two-stage switch Vce of the first transistor never quite goes to zero so a small base current is injected into the next stage. Thus it is by no means certain that the second transistor will turn off.

This can be overcome by using a small resistor or a forward-biased diode (which produces a 600mV voltage drop) in the emitter of the relay driver transistor. This raises the turn-off voltage at the base of 02 well above the saturation-voltage at the collector of the preceding transistor ensuring reliable turn-off of 02, and little chance of spurious tum-on due to transients.

Fig.15. The use of a transistor as a DC switch provides greater sensitivity for a relay.



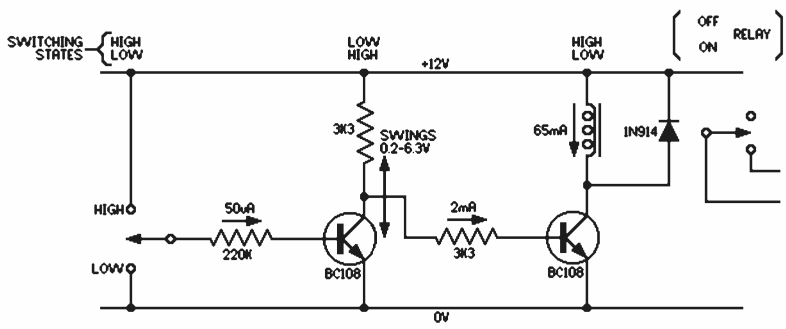


Fig.16. Two stages of DC amplification further increases the sensitivity, but, are more difficult to design. (See text).

New starter? - No, another retirement in the design section ----
---- Fine thing when you're finished at 27!

Electronics Tomorrow

by John Miller Kirkpatrick

LAST MONTH we mentioned the all powerful mighty computer that controls a complete business. Perhaps this at present is a little far-fetched, but the idea of a mini-computer in every home is fast becoming a reality. Mostek have recently announced a CPU chip which is possibly capable of controlling a lot of home functions. It is not primarily designed for that purpose but it could act as a house CPU or could be used for many other controlling applications that the designers have probably not yet thought of.

The MK5065 is an 8-bit micro· processor CPU (Central Processing Unit) chip in a 40-pin DIL package. It has a repertoire of 51 basic instructions with a capability of 81 instructions, all inputs and outputs are TTL compatible, it can address up to 32K of 8-bit memory and can control or be controlled by external 10 devices. Instructions and data are transmitted to the CPU on a bi-directional 8-bit bus. An 8-bit output bus is used along with the bi-directional bus to give simultaneous memory addresses for addressing up to 32K (K=1024) words where each word is 8-bits. Six control input signals provide control of the CPU and seven status outputs indicate the current status of the CPU.

The CPU chip has the following pin functions.

Output Bus 8-pins carrying parallel data from the chip.

Bi-direct Bus 8-pins carrying parallel data to and from the chip.

WAIT Input to halt processing until an external process is complete.

STEP Input to control CPU in single steps, a manual clock input.

INT1 Interrupt input to switch processing to a new sub-routine which takes precedence over the existing program.

INT2 As INT1, INT1 has precedence over INT2.

RESET Reset the whole CPU back to a cleared status, e.g. after power on.

FLAG Used to transfer to the CPU the status of a peripheral device.

CLOCK Main timing signal.

DATA STROBE To enable the data outputs.

STATUS STA To enable the status outputs.

WRITE CPU is writing to memory.

PESY CPU is writing to or receiving from a peripheral device.

BUSY The CPU is busy, actually executing an instruction.

LEV1 The CPU is active on level 1.

LEV2 The CPU is active on level 2.

DMA Used to instruct WAIT controller that the CPU is now waiting.

MAC Indicates that memory is being addressed at present.

Those of you who have played at all seriously with TTL (or any other) logic ICs will understand the importance or usefulness of most of the above 10 commands. Those of you who have not yet investigated logic ICs will probably be able to under· stand that the CPU cannot be inter-rupted during an i1nstruction, thus the WAIT,. BUSY, DMA, MAC, etc in-structions. The output status indicators are useful to enable the overall system to work as efficiently as possible. The three level operating modes are to enable interrupts and superior interrupts to take over com-mand of the CPU if necessary without necessarily destroying the main program routine.

The instruction set contains Store, Load, AND, EX OR, ADD, Subtract Compare, Point, Jump, Call, Return, Skip and 10 instructions.

The external memories may be RAM or ROM, each memory unit (page) is assumed to be 256 x 8-bit memory, it can hold up to 256 instructions or data words. Up to 256 instructions or data words. Up to 128 of these external memories can be added to the CPU chip thus making up a total of 32K words of storage. Up until a couple of years ago most commercial business computers were only 32K or 16K word machines, and these did accounts, stock control, etc for very big companies. Perhaps that gives you some idea of the capabilities of this chip in a normal commercial application.

Of course, the chip is very expensive but the cost of such a chip is high only because the manufacturers have to recover a lot of development money and as initial sales are not in vast quantities the recovery on each chip is high. There is no reason why this chip and others like it, including the RAMs and ROMs should not be in the price area of £10 each or even less. All that it needs is for sales to go into the millions area and the sale price per chip comes close to the cost of manufacturing the chip. Remember that the first calculator chips were well over £100 each and you needed two or three to make a very basic calculator. Within five years you may be able to buy CPU, ROM and RAM chips just as you can buy clock and calculator chips at present.

You may not be able to see the applications of one of these chips in your home, half the problem is that the necessary 10 devices are not yet available or perhaps even thought of. Imagine what you could do if you had one of these connected to - an electric typewriter, tape recorder, burglar alarm, cooker, 'fridge, central heating, house lighting, magnetic tape data cassette recorder, etc. You could program into it your diary, recipes, dictionary, TV program times, homework, Christmas card list, etc. Your friendly home computer could take telephone messages, telex messages (and even answer them!), identify visitors, cook your Sunday dinner, switch your lights, TV, heating on or off, wake you up to tea and toast and tell you a bedtime story to send you to sleep. All of this and even more all controlled from a small black box sitting in the loft.

This might all seem a bit ridiculous and futuristic to you but there are a lot of houses now being designed and even built with a data bus running alongside the mains cables. If your house has been built in the last couple of years have a close look at .the plans, you might only have to plug your CPU into the wall.

For further information on the MK5065 contact Distronic Ltd., 50 Burnt Mill, Harlow.

DX monitor

Compiled by Alan Thompson

Ave atque vale! If your memories of learning Latin are as misted by the passage of time, as are mine, it roughly translates as "Hi there - and, so long!". I am sorry to say that this will be the last regular "DX MONITOR" feature to appear in ETI as a change in my work day schedule means that leisure will now be considerably reduced and, inevitably, that means that time for DXing and associated activities has to be reduced. It is now well over 18 months since "DX MONITOR" first appeared in these pages and it. has been a great deal of fun writing this feature each month and a very satisfying experience to hear from many readers that they have enjoyed the various topics which have been covered month by month. Perhaps it will not be without some interest to devote part of this feature to describing some of the problems which exist in producing a DX feature in any magazine on general sale: the problems are not always appreciated by those who read the finished result and are critical of some aspects of what they read!

TIMESCALE

A couple of months ago I asked who it was that devised the now almost universal arrangement by which which appears monthly is dated for the month after that in which it appears -no-one came up with the answer and I am still in the dark! Commercial magazines - by that I mean the sort which appear on bookstalls on general sale, as distinct from the Club magazines to which one usually has to subscribe - take a not inconsiderable time from the moment when the editorial staff begin putting together an issue to the moment when all is finished and the copies start rolling off the presses on their way to booksellers all over the country. Because of this, copy for a DX feature has to be in the hands of the Editor several weeks before the reader sees it, and this is where the problems start. However closely one tailors the copy date to fall as near as possible to the press-date, there is still some-thing like 4 weeks (at least!) between the time when I - or any other DX feature compiler - put the cover back on the typewriter, and the date when you read the finished result. If DX were static then this would not matter at all: however, it is a live, fluid, ever changing hobby and it is just those changes which are of interest to the DXer. Within the confines of a time-scale one can do nothing but write of things as they are at the moment the feature is created and trust that nothing too drastic occurs in the field one is covering in the next 3 or 4 weeks. Sometime it comes off: other times, there are "clangers" which go on resounding and echoing - example? Well, do you recall that I once said that you ought to hear Radio Ghana on 4980kHz? If you were a "DX MONITOR" reader then, you may remember that in the period between my writing those words and their appearing in print someone at Ghana Broadcasting decided to switch the transmitter to 4824kHz. Next month, I duly reported the change - AND, of course (!), in the "gap" Radio Ghana moved back to 4980kHz. To echo Queen Victoria, "We were not amused!".

I'LL WRITE AND ASK ... "

Every month, quite a number of people say those words to themselves or to those with whom th are discussing some DX topic or other. Have you ever considered what it would be like to be on the receiving end of those letters? *Of course,* every letter is a pleasure to receive (even if it is critical!) but, please, stop and give a moment's thought to the addressee. Apart from the fact that it is just common courtesy to enclose reply postage, there is a limit to the amount of time that one can devote to answering letters. Short and simple queries are no real trouble but it is asking just a bit much to set out a foolscap page full of technical queries on the subject of aerial design and performance and to expect a reply: the information is all contained in various reference works and any good reference library ought to have a copy of the R.S.G.B. "Radio Communication Handbook", perusal of which will lead you to a number of other books. If your reference library still clings to a copy printed 20 years ago then start agitating for the radio section to be updated!

The other kind of letter which doesn't get a very good reception is the one which says something like this: 'I'd like to buy a receiver which will enable me to hear all the stations you mentioned in your January feature. What should I buy?". Being possessed of a mischievous streak I often feel tempted to recommend the latest all-solid state Communication receiver in the £1,000-plus bracket, but, more sensibly, what sort of reply should one give? Without a crystal ball, one has no idea of the depth of the pocket of the writer: the moment of technical expertise he possesses (because the more complicated the receiver, the more it becomes like playing a grand piano than a bar-room upright of yesteryear!), nor, indeed, has one the least idea of whether it is to be operated with a wire strung round the living-room or with an aerial array which would do credit to a professional monitoring station. All those factors are relevant so, please, give some facts in your letter if you want the reply to be of some use to you.

SURPRISE! SURPRISE?

The annual "Handbooks" of the I.B.A. and the B.B.C. are mines of information about the broadcasting systems of the United Kingdom, and the "BBC Handbook 1975" has recently appeared, complete with all the usual data, service area maps, an attractive colour section and lots more besides its 370 pages are well worth the cover price of £1.00. to anyone interested in the workings of the Corporation. Some figures on the development of External Broadcasting throughout the world, covering the period 1950 to 1973, certainly lend substance to the claim of the "old. timer" that DXing was more pleasant *25* years ago. The figures show that over the above period the total program hours per week broadcast by both the United States and the U.S.S.R. have jumped by about 400%, whilst the B.B.C.'s own output has shown only an increase of around 17% in the same period. One could develop this theme at length but all the figures are summarised on page 71 of the "BBC Handbook 1975" and they will bear a great deal of study if you are interested in the ups and downs of world external broadcasting over the last quarter of a century, or so.

"Much of the information in the previous section about technical and program developments in international broadcasting was obtained by the Monitoring Service in its day-to-day work. Such is the interest in these matters, especially in broadcasting organisations and among DXers (radio 'hams'), that the Service recently started a new weekly publication entitled *World Broadcasting Information"* so states the "Handbook". Ignoring the fact that DXers and radio 'hams' are not inter-changeable terms (and the fact that a lot of licensed amateur radio operators take the greatest objection to being called 'hams'), it is worth, I think, adding a personal recommendation of *World Broadcasting Information* and the detailed broadcast station schedules which accompany it. It provides the most accurate, contemporaneous, source of data about radio stations and subscription details can be obtained from Head of the Monitoring Service, Caversham Park, Reading RG4 8TZ.

FINALE

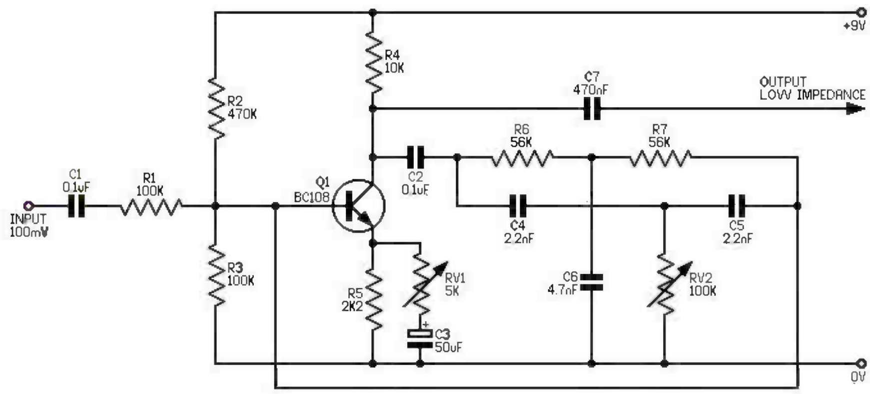
And that, I think, is as good a time as any to say "Cheerio" to you all. As I said earlier it's been a lot of fun writing this feature for the last year or two and I have enjoyed, very much, the correspondences which have been started in that time and, even, the 'phone calls at odd times of night asking whether I can identify this-or-that station. (Gee! Some of you must have been mighty persistent to discover my telephone number.).

I hope that in the months ahead I shall appear in the pages of ETI, now and again, with some general features which, as yet, are still just in the planning stage - we shall see what happens. But for how, as I was taught to say as a very small boy, "Thanks for having me", and my 'thanks too to all those who have written me, from time to time, and to the members of the editorial staff who have had the exasperating task of converting my copy into a finished article, and who have been so patient on the many occasions when I've pressed for some late change in the finished feature, which must have caused them more than a little annoyance.

Good luck in 1975 and the years ahead in all you undertake and, to everyone, everywhere, 73 de ABT.

tech-tips

SIMPLE WAA WAA CIRCUIT



This circuit can be incorporated in guitar. amplifiers, or electronic organs.

A phase shift RC oscillator makes up the basic circuit, C4, C5, C6 and R6, R7, RV2 make up the components of the bridge that determine the operating frequency. Negative feedback is obtained by feeding, part of the signal back to the base via C2.

The waa-waa effect is achieved as certain frequencies are amplified more than others.

The transistor used is not critical however it should have a gain of more than 150. An NPN type such as the BC108 or BC109 is suitable.

The values of C4, C5, C6 are chosen so as to emphasise waa-waa effect on the higher audio frequencies. This gives the sound its brilliance. These values can be changed quite freely till the specific desired effect is achieved.

When adjusting the unit initially RV1 is turned to its minimum value. RV2 is now adjusted to and fro till a point is found at which ah audible whistle appears indicating oscillation.

RV1 is then adjusted till the oscillation just disappears. RV2 is turned over its whole range and if at any point oscillation occurs again, RV1 is again advanced till it ceases.

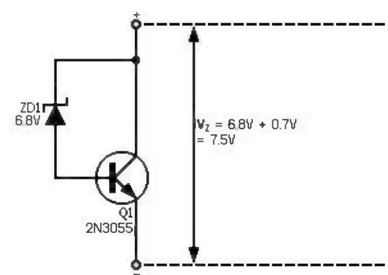
It should tie possible to set RV2 to any value over its range of adjustment without any oscillation being apparent, this should also be achieved with the minimum possible value of RV1. The unit is now ready for operation.

INCREASING POWER RATING OF ZENER DIODES

There are occasions when a higher power Zener diode is required and one is not readily available. Here is a circuit which with the aid of a power transistor can increase the power rating of any Zener diode.

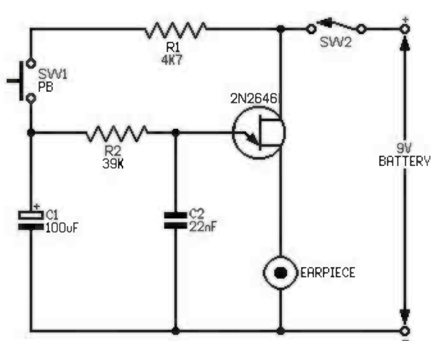
By simply shunting the base-collector junction of the transistor by a low power Zener and if the gain of the transistor at the operating current exceeds 30, then across the collector-emitter terminals the device will behave as a Zener diode.

If the original diode is a 250mW device then the power dissipation of the system will be 30 x 250mW= 7.5 watts. It should be noted that the Zener voltage thus obtained will be 0.7V higher than the diode rating.



Thus if originally a 6.8V diode was used then the new voltage will be 6.8V + 0.7V = 7.5V. Thus for a power of 7.5W, the maximum permissible current will be 7.5W/7.5 V = 1A.

TOY SIREN



This circuit can be built small enough to be fitted inside a toy.

With a little manual skill on the part of the operator it can tie made to sound like the sirens on such vehicles as fire trucks ambulances etc. The transducer used is an ear-piece which will give a scaled down sound in the proximity of the toy, without being annoyingly loud.

The circuit consists of a relaxation oscillator utilising one unijunction transistor. (2N2646, MU10, TIS43) R2 and C2 determine the frequency of the tone.

On pushing the button SW1 the capacitor C1 charges up and the potential at the junction of R2 and C2 rises thus causing an upswing in the frequency of oscillation; if one now releases the pushbutton the charge on C2 will drop slowly with a proportional reduction in the frequency of oscillation.

Manual operation of the button at intervals of approximately 2 sec will give a siren sound.

FINISHING FRONT PANELS

The finish on aluminium panel can be improved by etching them in a caustic soda solution. To get the best effect:

1) Do all marking out on the back of the panel.

2) Drill holes two ways - small pilot hole from front to back. This minimizes the problem of getting rid of the 'flash' which arises round the holes while drilling. Removing flash often leaves scratches, and it is better that these be on the back of the panel than the front.

3) Rub the front of the panel with medium grade emery cloth to rid it of all unwanted marks and scratches. The

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 be preferably typed. Circuits must not be subject to copyright. Items for consideration should be sent to the editor, Electronics Today International, 36 Ebury Street, London SW 1W 0LW.

emery should be rubbed only in one direction for the final rubbing. This leaves the aluminium with a bright Matt finish. From this point on, avoid touching the front of the panel.

4) Attach a length of thin plastic string or tubing to the panel by tying it through one of the panel holes.

5) Prepare a caustic etching solution. Put about 30 grams of caustic soda in a glass or plastic dish. The plastic throw-away food containers are ideal. Carefully pour on about 300 ml of hot water. 1oz. of caustic soda in half a pint of water, if that's any easier for you. The strength of the solution is in no way critical. Now, by means of the plastic string, lower the panel into the solution, leaving one end of the string hanging out of the dish. It will fizz fiercely and the solution will get hotter - but all is well.

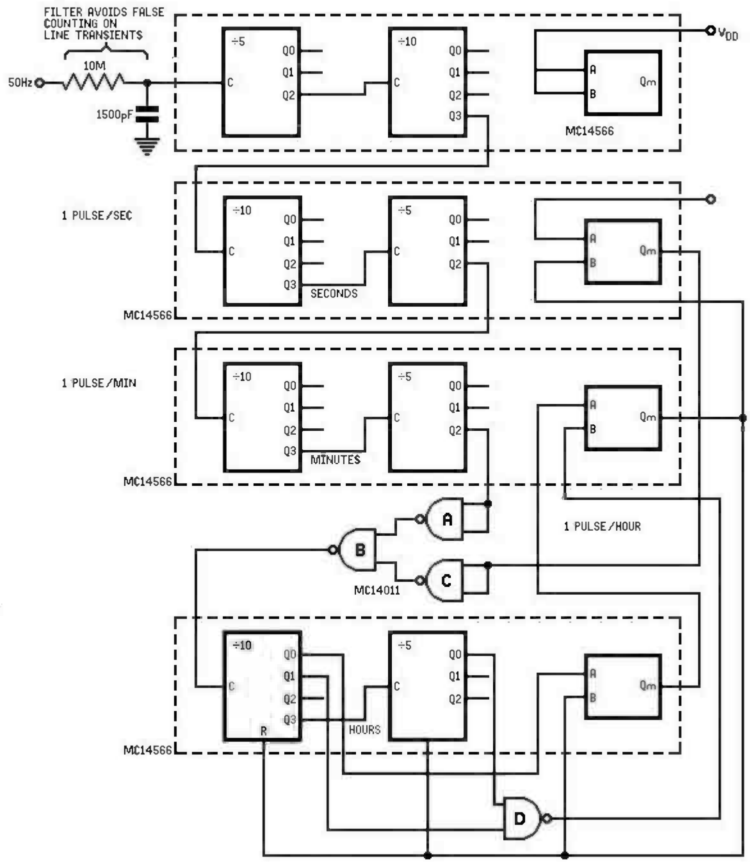
6) About 3 minutes later remove the panel, rinse it under a cold water tap, and wipe it clean. Rinse it again thoroughly, and if it looks O.K. - dull Matt all over, it's finished. Hang it to dry.

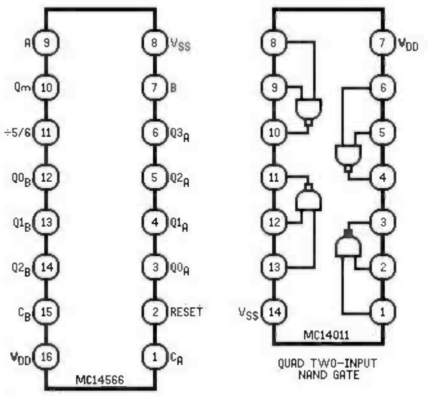
A panel finished this way has a satin chrome look to it, and does not retain finger marks the way untreated aluminium does.

CMOS CLOCK

A new, and unique, addition has been made to Motorola's rapidly expanding family of CMOS logic circuits. It is the MC14566 time base generator which consists of two pulse shapers, a divide-by-ten ripple counter, a divide-by-5 (or 6) ripple counter and a monostable multivibrator on a single chip. A single MC14566 can be connected to divide by 50 or 60 (÷5 and ÷10 or ÷6 and ÷10) to produce one output pulse per second when fed with a 50 or 60Hz input. In addition, a binary coded decimal output indicating tenths-of-seconds is available. A second MC14566 can be connected in cascade with the first (arranged to divide-by-ten and then by six) to provide one output pulse per minute and a BCD output of up to 59 seconds. A third cascaded MC14566 will then provide a minute's BCD output and one pulse per hour.

Although the devices can be used to construct electronic digital clocks - as shown in the circuit diagram - their main application will be to provide timing signals to industrial process control, data-logging and computing



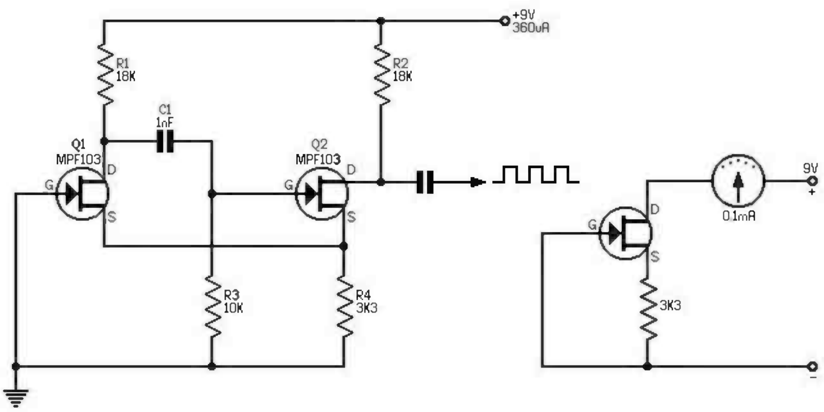


V_{DD} = +3V TO 18V
V_{SS} = 0V
CONNECT PIN 11 TO V_{SS} TO DIVIDE BY SIX AND TO V_{DD} TO DIVIDE BY FIVE
ALL UNUSED RESET PINS MUST BE CONNECTED TO V_{SS}

equipment from 50 or 60Hz line supplies. Available in plastic package (suffix P) or a ceramic package (suffix L), the MC14566 has Zener diode protection fitted to all inputs and is available for operation over the extended industrial temperature range (-40 to 85 degrees C) or the full military temperature range (-55 to 125 degrees C). As with all members of the Motorola CMOS family the power supply voltage can be from 3 to 18V, the noise immunity is typically 45% of VDD and an input capacity of 5pF is standard for all inputs. Quiescent power dissipation at 5V supply voltage is 25nW, rising to about 1.5mW at a clock frequency of 1MHz when working into a 15pF load. Normally, when used as a timer, power consumption would be less than this since the clock frequency would be either 50 or 60Hz. Maximum operating frequency is typically 4.2MHz at VDD = 15V.

tech-tips

FET SQUARE WAVE GENERATOR



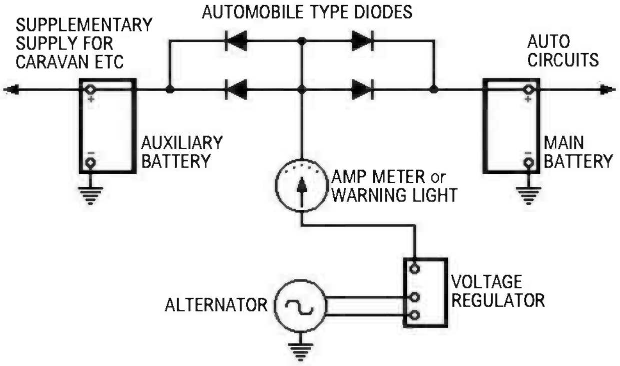
Field effect transistors lend themselves readily for use in astable multivibrator circuits.
The output square wave yields an amplitude close to the power supply voltage, and battery drain is low.
In this circuit the battery supply is 9V. Drain is a minimal 360μA. The waveform shows very good symmetry and this is achieved by matching the FETs by means of the circuit (b); transistors are matched up for equal drain currents.
Frequency of operation is set by R3 and C1. The values in the circuit give a frequency in the region of 15kHz.

AUXILIARY BATTERY ADAPTOR

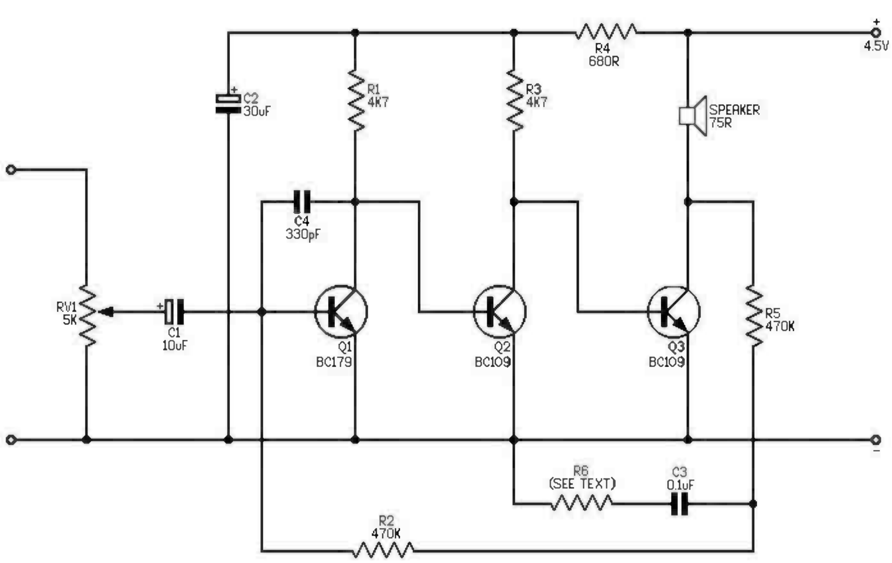
When towing a caravan. or using the automobile battery supply for other heavier duty purposes the drain on the battery may be excessive.

Here is a method of hooking up an auxiliary battery to the auto's charging circuit without upsetting the existing battery, and limiting discharge to external circuitry, to the auxiliary unit only.

The four isolating diodes are of the automobile type as used in alternators, being capable of carrying up to 25A they should be mounted on heatsinks.

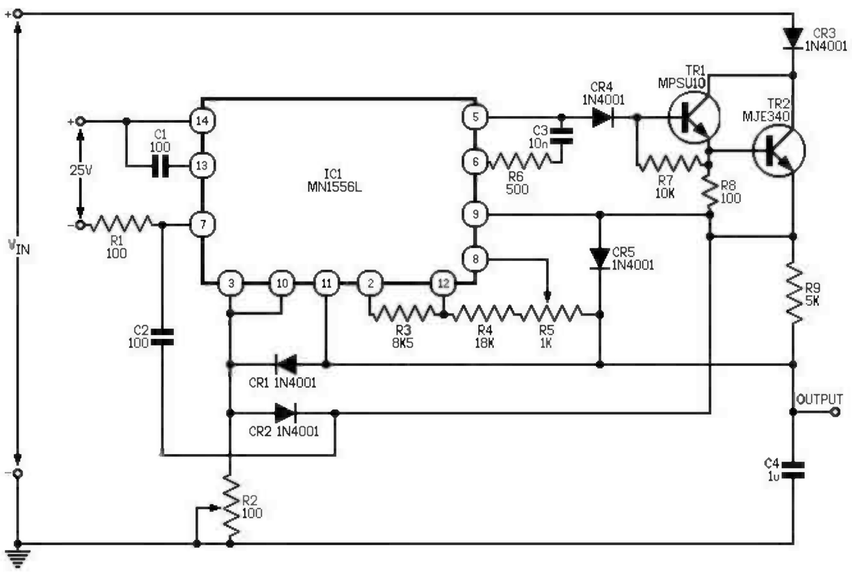


ECONOMY AMPLIFIER



When power output, harmonic, distortion, frequency response are not the absolute parameters for an amplifier, such as in the case of small personal portable radios, operation of an amplifier in class 'A' does have a number of advantages.
The circuit shown uses only three transistors, does not require an output transformer, and gives an output of between 100 -200mW for a battery supply of only 4.5V.
RV1 provides volume control and couples into the amplifier through C1. The following three stages are directly coupled.
01 base bias is established by resistors R2 and R5. R1 - Q1 act as a bias potential divider for Q2 base and similarly R3 - Q2 bias base of Q3.
R2 and R5 also form part of an overall negative feedback loop improving frequency response and reducing distortion.
A compromise between gain and quality results in a choice of values for R6 and C3. C3 is a decoupling capacitor and R6 is adjusted by trial and error. (Minimum value should be 22k).

HIGH VOLTAGE CONSTANT CURRENT SUPPLY



WHEN a constant current source is required and the various advantages offered by the use of IC's are to be exploited, an input voltage limit of 40 or, possibly, 50V is normally necessary if the IC's are not to be damaged.

Neil Wellenstein, an applications engineer working in Motorola's Phoenix, Arizona, laboratories, discovered a means of obtaining a variable constant current supply with input voltages as high as 750V using a standard regulator IC. In fact, the input voltage is limited only by the breakdown voltage of the series pass transistors employed.

The IC used. by Wellenstein was the Motorola MC1566L which has the ability to "float" on its own output voltage. However, when used conventionally, a voltage sensitive error occurs in the constant current mode and this is large enough to prevent the device from being used as a precision constant current source. Normally the constant current feature of the MC1566L would only be used to provide short circuit protection when the device is employed as a voltage regulator. The magnitude of the current error is small enough to be of no consequence in this application.

The MC1566 contains a current sensing and a voltage sensing amplifier which "float" on the output voltage arid which are supplied from an on-chip regulator. The on-chip regulator receives its input from an auxiliary 25V supply external to the chip. When used conventionally a constant 1mA flows from pin 3 through a resistor to ground to establish the reference voltage for the voltage sensing amplifier. The error voltage appears between pins 8 and 9. When the device goes into the current limit mode (short circuit conditions) part of the 1mA output from pin 6 can flow through a diode to pin 9 thereby upsetting the error voltage and producing a voltage sensitive output current error.

Wellenstein discovered by reversing the roles of the voltage and the current sensitive amplifiers, he could eliminate this problem altogether. The net effect is that any portion of the reference current that appears in the load must pass through the current sensing resistor (R9) which cannot be bypassed as was previously the case. The maximum input voltage to the circuit is limited by the series-pass transistor. In the case of the MJE340 shown, the maximum input voltage is 300V. The circuit provides a constant current output which is adjustable from 200µA to 100mA; above 10mA take care not to exceed the ratings of the MJE340. At both the 200µA and the 1mA settings, output impedance exceeds 20 Megohms.

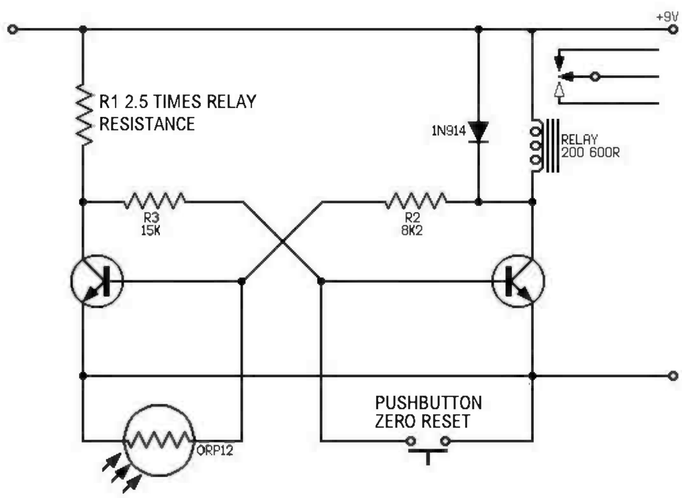


PHOTO ELECTRIC RELAY

There are many applications where photoelectric detection is used to switch a circuit on or off.

This simple circuit is a bistable multivibrator. The base resistor of Q1 is a photo-resistor type ORP12. When not illuminated resistance is high, Q1 conducts and Q2 is off. As the illumination on the OPR12 is increased the resistance drops till Q1 cuts off and Q2 turns hard energising the relay coil.

The system is reset by the pushbutton. The diode across the relay coil can be any low power silicon type. It is for protecting Q2 from any spikes generated across the coil when de-energised.

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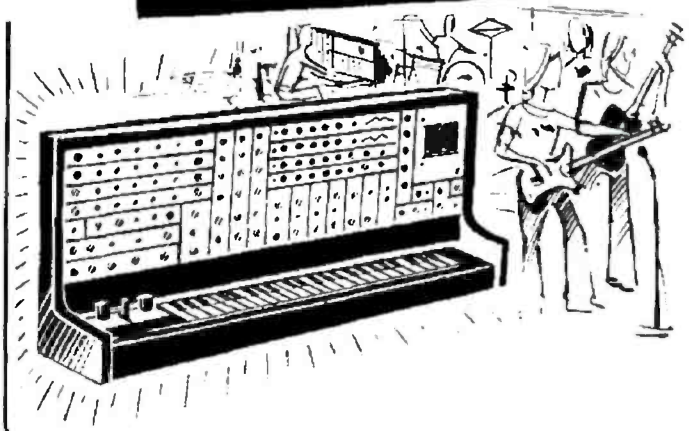

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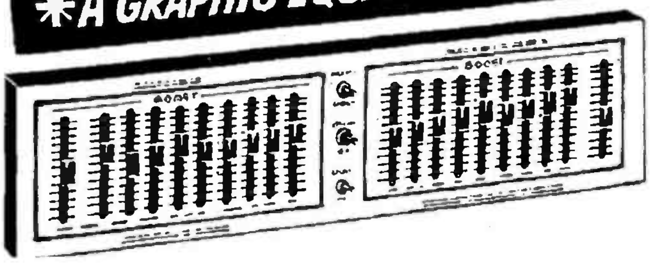

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