electronics today international

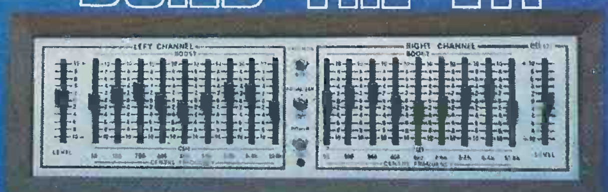
JANUARY 1975

25p

TWO OFFERS INSIDE

SURVEY OF ELECTRONIC KITS

BUILD THE ETI GRAPHIC EQUALISER



MATRIX TV

RADIO ASTRONOMY

MOTOR SPEED CONTROL

RUMBLE FILTER PROJECT

YAMAHA AMP REVIEW

HI-FI ... CONSTRUCTION ... COMMUNICATIONS ... DEVELOPMENTS

electronics today international

JANUARY 1975 Vol. 4. No. 1.

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projects

product tests

news & information

Cover: A selection of kits available on the U.K. market – details of these and many more in our Kits Survey starting on page 35.

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DETAILS OF THE ETI TOP PROJECTS BOOK ON PAGE 59

Now-two fascinating ways to enjoy saving money!

NEW! Sinclair Scientific kit £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.

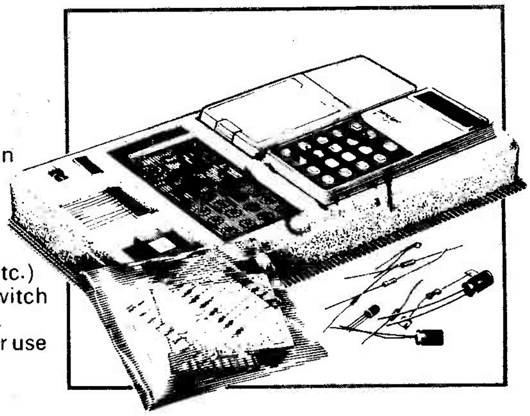
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our Service Department will back you throughout if you've any queries or problems.

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}

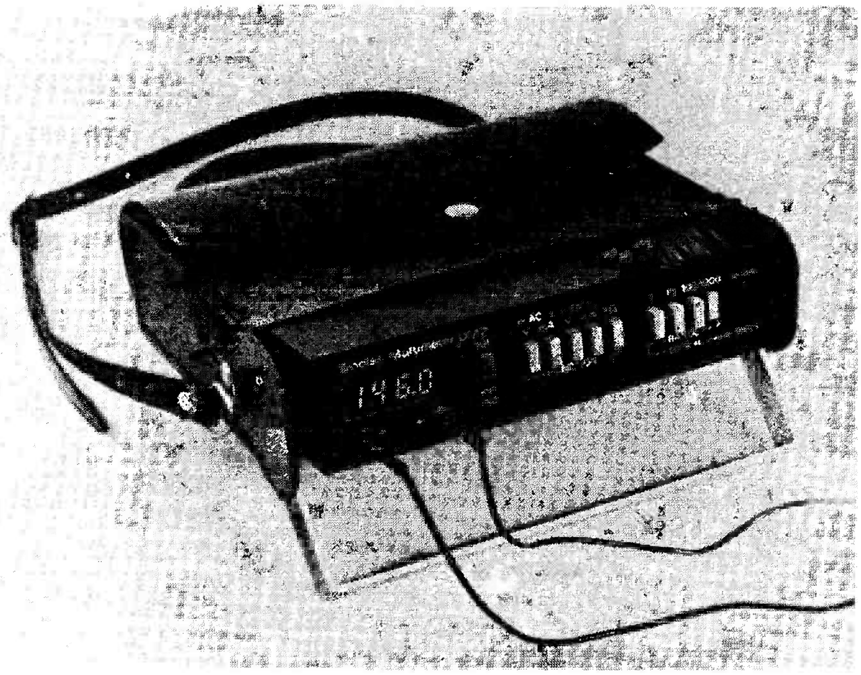
● **Reverse Polish logic**
Post-fixed operators allow chain calculations of unlimited length – eliminate need for an = button.

● **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.

news digest

NEW DIGITAL MULTIMETER FROM SINCLAIR



Replacing the DM1, one of the first digital multimeters, Sinclair have introduced the DM2, a much improved model for £59 plus VAT.

The designers have carefully thought out the needs of the user. Multimeters are dropped; we know they shouldn't be but that's life so they have gone for a thick aluminium case, not plastic. The unit is powered by an integral PP9 battery for portable use (60 hours life) but an external mains power supply is also available. For normal overloads, built-in protection is provided but for gross overload there is fuse protection.

Input impedance, even on low voltage ranges is 10MΩ. The actual ranges can be seen clearly on the photograph. Basic accuracy is 0.4% - very much better than even excellent analogue meters.

The display is large, made up from 0.3" 7-segment displays. Designed around a custom-designed MOS I.C., the DM2 utilises dual scope integration and features high operational repeatability and reliability.

A chain of high stability resistors are used in perference to presets: this improves stability and reduces setting-up costs. Optional extras are a carrying case(£5.00 + VAT) and mains converter (£1.85 + VAT). The DM2 weighs 1kg and measures 9" x 6" x 2" plus handle.

Sinclair Radionics, St. Ives, Huntingdon, Cambridgeshire.

PERSONAL ALARM SYSTEM

All Americans may soon carry a wristwatch-sized personal security alarm!

The US Law Enforcement Assistance Administration has commissioned the Aerospace Corporation to launch a massive field test next year of a prototype system that may eventually become nation-wide.

The system is based on thick-film hybrid UHF modulated transmitters which may eventually be built into standard electronic watches.

To generate an alarm, the wearer presses two buttons simultaneously. This causes an internal shift register to generate a digital code which in turn frequency modulates the transmitter.

The alarm signal is then picked up by the nearest of a vast number of local receivers which retransmits the signal together with data identifying the transmitter's locationm to a central processing computer in the local police headquarters.

In the forthcoming field trials, some 5000 alarm units will be used.

SCHOOLS' LINK TO INDUSTRY

We received an interesting newsletter from the organisers of the "Link Scheme" They are a service for school teachers complimentary to that of the National Centre for School Technology.
Help is offered regarding technical data, component distributors or technical advice, by means of a "Hot Line" phone number. The scheme's newsletter prints comments on recent issues of electronics magazines and provides additional information for school teachers. Also there is an evaluation of magazine projects which have been built up by grammar school pupils. Their scheme has a contact man who will be arranging to visit schools to see what assistance a contact in industry can be to a school teacher.

If you are an interested teacher we suggest you get more details from Peter Noakes at the University of Essex Department of Engineering and Science, Wivenhoe Park, Colchester, CO4 3SQ.

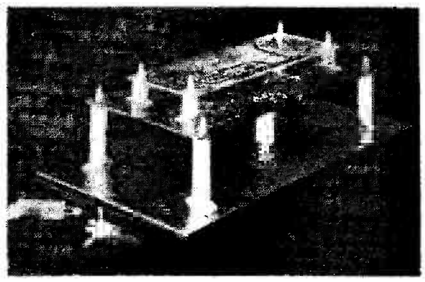
200 MILLION DEGREES!

An important advance in work on nuclear fusion is reported by scientists at the University of Texas, Austin. Dr. William E. Drummond, director of the university's fusion research centre, says that a temperature of more than 200 million degrees Centigrade has been attained for some 50 micro-seconds in the centre's Tokamak-type unit by turbulent heating of the plasma, a new technique developed at Texas and in the U.K.

PCB MOUNTING PILLARS

The Ilex pillars are designed to insulate printed circuit boards from the chassis and at the same time to support them. One PCB can be stacked on another (either vertically or horizontally).

Now the experimenter can easily mount a PCB to a chassis, a PCB to a PCB, or a screen to a PCB using Ilex, completely dispensing with nuts or screws.



The pillars are made in moulded nylon, and have a rigid girder-shaped supporting section, a spring-in fastening at the top and at the base constant bending springs together with a push-in clip (giving a wide thickness tolerance which ensures an equally tight fit to any thickness from 1/32" to 1/8"). A firm grip by the Ilex into the upper board can be obtained with a 4 mm hole, and because it is insulating, it can quite safely be close to the conductors. At the base a 4.8 mm hole is needed.

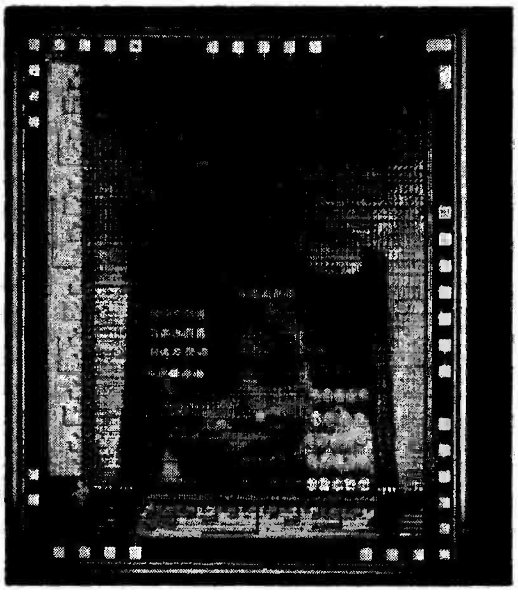
Ilex come in heights of ¼", ½", ¾", 1" and 1½". The half inch size costs 3p each for 10 off, dropping to 1.2p each in lots of 10,000 off. From West Hyde Developments Limited, Ryefield Crescent, Northwood Hills, Middlesex, HA6 1NN.

STATIC 4k MEMORY

For some time now, efforts have been made to increase the integration density of static memories. In the Siemens Research Laboratories a static MOS memory has been produced accommodating 4000 bits on 14.7mm^2.

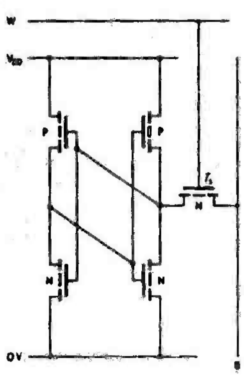
The memory is an integrated circuit in aluminium gate ESFI technology. This step forward was made possible by integrating the switching elements on an insulating substrate and employing a non-crossing conductor layout between the transistors and resistors in a memory cell.

An initial breakthrough on the way towards static ESFI MOS memory cells (ESFI = epitaxial silicon film on insulators) of high packing density was the development of a complementary MOS cell with five transistors and an area of 4000μm^2. The second measure was to combine two complementary transistors and two load transistors in one cell in a non-crossing layout to obtain a flip-flop. In this way, the cell area was reduced to 2000μm^2. The final step was to replace the select transistor by a diode and to use the power supply lines. It was thus possible to reduce the memory cell area again to 1500μm^2. This is even less than the area required by MOS memories and bipolar memory cells.

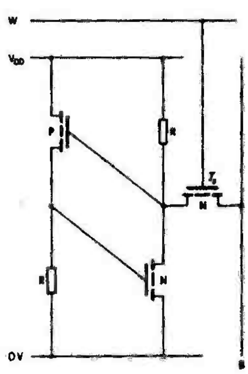


The chip measuring 4.2mm x 3.5mm contains the actual memory matrix, the word line decoder (on the left), the bit line decoder (at the bottom) and the read-out circuit (bottom left-hand corner).

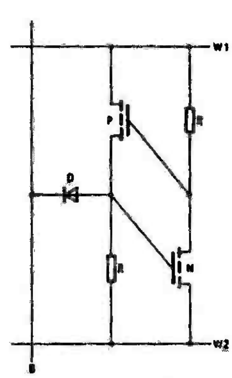
Such memory cells have already been integrated in a configuration with 4096 bits. The chip area is then 14.7mm^2: the actual memory matrix, the word and bit line decoders and the read-out circuit are accommodated in an area measuring 4.2mm x 3.5mm. The results of tests allow us to predict an access time of around 120nS and a cycle time of about 170nS for the production module. The power dissipation is 100mW.



4000μm^2 (6.4 mil^2): *circuit of a conventional flip-flop memory cell with two p-channel and two n-channel transistors and a select transistor T_S in ESFI MOS technology.*



2000μm^2 (3.2 mil^2): *circuit of the new memory cell made in the Siemens Research Laboratories. One of the p-channel and one of the n-channel resistors was replaced by a high-valued resistor R. The size of this flip-flop in non-crossing conductor layout has been halved.*



1500μm^2 (2.4 mil^2): *This further reduction in area has been obtained by replacing the select transistor T_S by diode D.*

Supply Voltage: V_{DD}
word lines: W & W_1 & W_2
bit lines: B
chassis ground: 0 V

QUAD OP-AMP: LM324

SDS Components Ltd have available an interesting quad op-amp which is unusual in that the input common mode voltage range includes ground even when the amplifier is operated from a single supply rail. In addition, also under single-rail supply conditions, the output voltage swing includes ground. The device is the Signetics LM324. The current drain (800μA) is essentially independent of supply voltage over the range 3 to 30V or ±1.5 to ±15V. Power consumption works out at about 1mW per op-amp when a 5V supply is used.

The devices feature internal frequency and temperature compensation, and each op-amp has a unity gain bandwidth of 1MHz, a common mode rejection ratio (d.c.) of 85dB and a power supply rejection ratio of 100dB. Open loop gain at d.c. is 100dB while coupling between amplifiers is −120dB.

Differential input voltages equal in value to the power supply voltage can be applied without fear of damage. Bias current and input offset voltage and current are all very low at 45nA, 2mV and 5nA respectively. The input bias current is temperature compensated. At the 100 up rate, the cost is £1 (25p per dual-in-line package). Designed for operation over the industrial temperature range of 0 to 70°C, the LM324 is a general-purpose quad operational amplifier of good performance for use in industrial, automtove and other similar applications.

SDS Components Ltd, Hilsea Trading Estate, Portsmouth, Hants, PO3 5JW.

PUSHBUTTON POTENTIOMETER

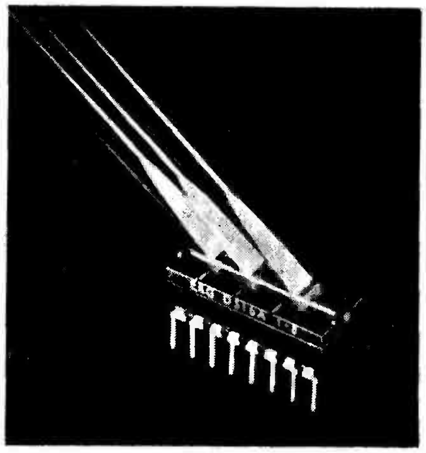
Bourns new Model 3680 KNOBPOT Digital Potentiometer combines a precision incremental decade potentiometer with an easy-to-read digital display, and fast, pushbutton resistance selection all in one integral package, with snap-in-mounting.

This device is ideal for use where Panel designs involve data entry or set-point controls. Bourns' unique design combines precision laser-trimmed cermet resistor technology with a pushbutton detent action. Resolution of the output is 1 in 1000 discrete steps, and repeatability of ±0.1%. Each decade has a rated life of 100,000 operations. The specification gives a power rating of 2W, a standard resistance range of 3-decade units (5KΩ to 1MΩ), and a resistance tolerance of ±1.0%.

Bourns (Trimpot) Ltd., Hodford House, High Street, Hounslow, Middlesex TW3 1TE.

DIL PCB SWITCH

Ten new types of dual-in-line PCB programming switches are now available. Contact arrangements include 1 pole 8 way and 4 independent changeover contacts with bbm action. The gold on nickel contact surfaces give in excess of 20,000 switching



steps at the full rated load of 30VDC 250mA. Applications include BCD setting, select on test, range attenuation and cross point switching.

From ERG Limited, Luton Road, Dunstable, Beds.

GRAVITY WAVE DATA TRANSMISSIONS?

Future communications systems could well utilize modulated gravity waves propogating directly through the centre of the earth — according to a report given recently to the British Association by Dr. Drever of the Dept of Natural Philosphy, Glasgow University.

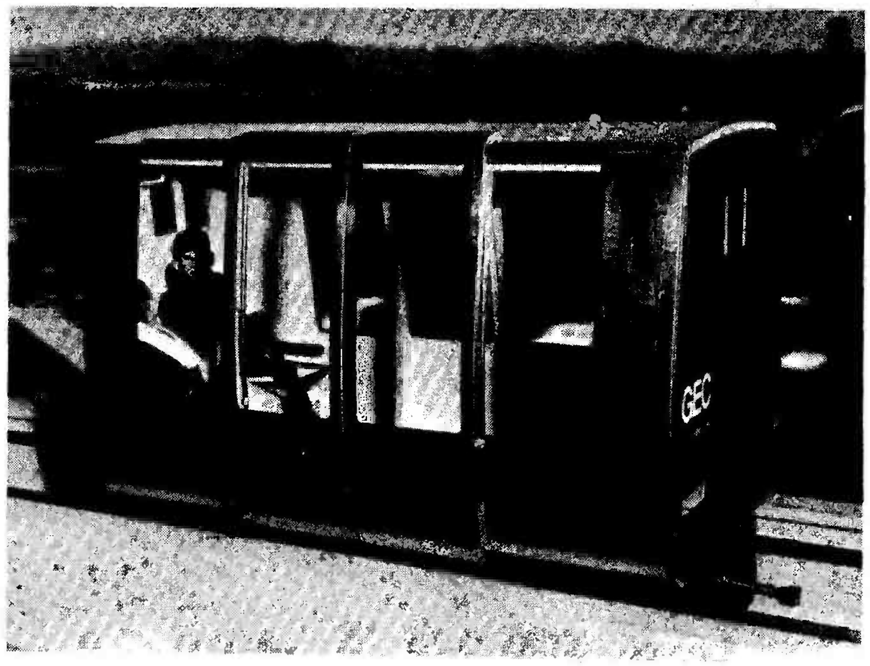
The notion is very much on the border-line between physics and science fiction as great controversy still continues as to whether gravity waves exist or not, however modern theory increasingly supports the idea of energy waves flowing across the universe in the way that light energy flows from the gigantic energetic disturbances in stars and galaxies.

MAGNETIC-ELECTRIC INTERCONVERSION

Philips Research Laboratories in Eindhoven have developed a composite piezo-magnetic/piezo-electric material that inter-converts magnetic and electrical fields.

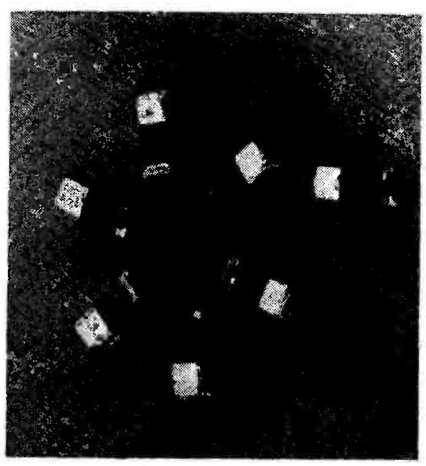
The actual material is composed of a molten eutectic mixture of barium titanate and cobalt ferrite which is solidified uni-directionally.

Conversion is brought about by mechanical deformation hence optimum efficiency occurs at the mechanical resonant frequency.



The photo shows a model of the GEC-Marconi Minitram which was produced as a result of work on a competitive contract for the Transport and Road Research Laboratory to define the development necessary for a proposed system in Sheffield. The work included the design of the vehicle itself, the track on which it would run and the control system for its operation.

There is of course nothing new in magnetic and electrical inter-conversion. It is achieved for instance in a solenoid. What is unique about Philips' new material is that conversion takes place without a flow of current.



They might look like date stamps but in fact they are new aluminium electrolytic capacitors.

They are made by AEG-Telefunken and coded EFT. The capacitors feature low dissipation, low impedance and good temperature characteristics. Intended for AC operation without polarized voltage DC, these components are especially suitable for the audio-frequency load in dividing networks of loudspeaker-cabinets. They come in ratings from 2.2μF to 100μF and voltages of 40V and 63V DC as well as 15V and 23V AC.

ELECTRONIC BALANCE

This first product from Shinko Denshi of Tokyo launched on the British market is the Digipet top-loading automatic electronic weighing machine with digital display. This is a compact precision weighing machine with measuring ranges of 0-19.99gm and 0-199.9gm; the required range is set automatically to provide an accuracy of two decimal places for weights under 20gm and one decimal place for objects over 20gm. Overload is set at 250gm.

The elctromagnetic weighing mechanism automatically resets to zero within 0.15 sec and the digital meter can be switched to give a read-out within either 0.5 or 1.5 sec. Facilities are provided for automatic tare compensation, and BCD, TTL-compatible digital outputs or 5-V analogue outputs are provided for recorders, printers, comparators and computers. Supplied by Transducers (CEL) Limited, Trafford Road, Reading, R61 8JH.

Continued on page 70.

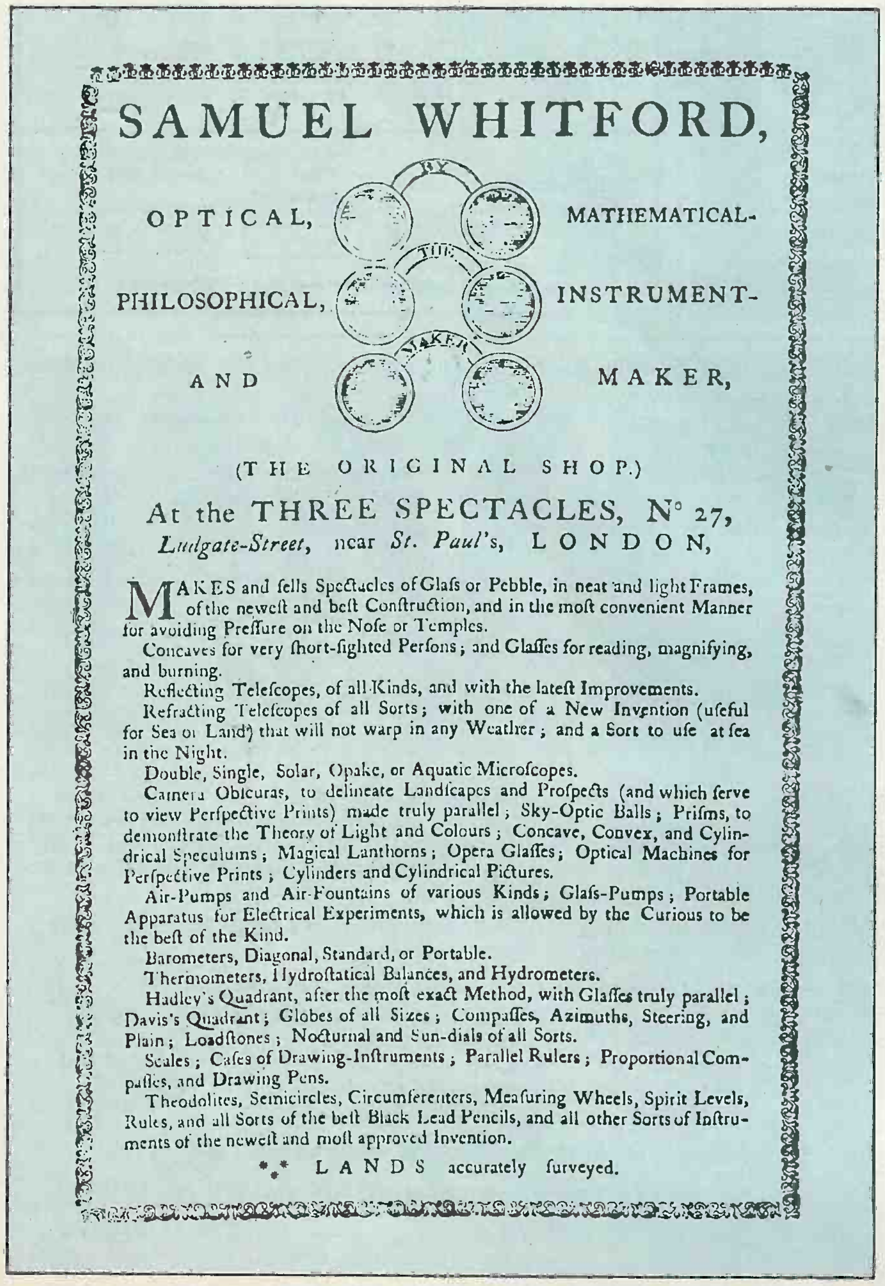
MATRIX TV - a solid-state picture transmission system

by Dr. Sydenham

WHEN MAN learned of ways to produce an optical image — probably when he found that a pin-hole in a screen produced a reduced size picture — he took a great step forward in both understanding and enjoying life.

In 1859 Dionysius Lardner of University College, London wrote in his encyclopaedic "Museum of Science and Art"

"The image of visible objects produced by reflection from smooth or polished surfaces, natural and artificial, and by looking through transparent media, bounded by surfaces having certain curved shapes, play a part so important in the effects of vision, that it must be regarded as highly interesting to explain the optical principles upon which the production of such images depends, so far at least as may be necessary to render intelligible the natural appearances and effects which are familiar to every eye, and innumerable contrivances, from which we derive essential benefit, either in repairing defects of vision, or extending the range of that sense to objects removed beyond its natural limits, either because of their minuteness or remoteness or in fine in producing phenomena affording at once amusement and instruction."



SAMUEL WHITFORD,

OPTICAL, MATHEMATICAL-

PHILOSOPHICAL, INSTRUMENT-

AND MAKER,

(THE ORIGINAL SHOP.)

At the THREE SPECTACLES, N° 27, *Ludgate-Street*, near *St. Paul's*, LONDON,

MAKES and ſells Spectacles of Glaſs or Pebble, in neat and light Frames, of the neweſt and beſt Conſtruction, and in the moſt convenient Manner for avoiding Preſſure on the Noſe or Temples.

Concaves for very ſhort-ſighted Perſons; and Glaſſes for reading, magnifying, and burning.

Reflecting Teleſcopes, of all Kinds, and with the lateſt Improvements.

Refracting Teleſcopes of all Sorts; with one of a New Invention (uſeful for Sea or Land) that will not warp in any Weather; and a Sort to uſe at ſea in the Night.

Double, Single, Solar, Opake, or Aquatic Microſcopes.

Camera Obſcuras, to delineate Landſcapes and Proſpects (and which ſerve to view Perſpective Prints) made truly parallel; Sky-Optic Balls; Priſms, to demonſtrate the Theory of Light and Colours; Concave, Convex, and Cylindrical Speculums; Magical Lanthorns; Opera Glaſſes; Optical Machines for Perſpective Prints; Cylinders and Cylindrical Pictures.

Air-Pumps and Air-Fountains of various Kinds; Glaſs-Pumps; Portable Apparatus for Electrical Experiments, which is allowed by the Curious to be the beſt of the Kind.

Barometers, Diagonal, Standard, or Portable.

Thermometers, Hydroſtatical Balances, and Hydrometers.

Hadley's Quadrant, after the moſt exact Method, with Glaſſes truly parallel; Davis's Quadrant; Globes of all Sizes; Compaſſes, Azimuths, Steering, and Plain; Loadſtones; Nocturnal and Sun-dials of all Sorts.

Scales; Caſes of Drawing-Inſtruments; Parallel Rulers; Proportional Compaſſes, and Drawing Pens.

Theodolites, Semicircles, Circumferenters, Meaſuring Wheels, Spirit Levels, Rules, and all Sorts of the beſt Black Lead Pencils, and all other Sorts of Inſtruments of the neweſt and moſt approved Invention.

LANDS accurately ſurveyed.

Fig. 1. Trade card of Samuel Whitford shows evidence of early links between optical and electrical crafts.

All manner of devices were indeed devised. The microscope, the telescope, the camera obscura, the camera lucida and the magic lantern have been handed down to us.

The science of optical imaging was well developed by the start of the 19th century. For many a decade before this, firms had been proudly advertising their optical wares and expertise in handsheets such as that shown in Fig. 1.

Optical instrument-makers excelled at the crafting of mechanical contrivances so it was natural for them also to take on the manufacture of the then emerging electrical machines.

There were very few of these to begin with — Whitford's sheet mentions "portable apparatus for electrical experiments". But by the mid-19th century, the electrical "curiosities" had expanded in number from simple electrostatic devices to include magnetic ones as well. The feeble oil-lamp powered magic lantern gave way to arc-lamp versions — like that of Mr. Dubosc of Paris (illustrated in Fig. 2).

A new science, that of electro-optics, came into being. But it could hot advance much in the 19th century, for hardware capable of converting light into electrical signals was not developed until the 1880's. If an experimenter wished to relay or record images before this time then they had to be copied and conveyed by hand. If several people wished to view the same image they had to take turns, use elementary photographs or manage with a multiple instrument such as Nachet's multiple microscope (shown in Fig. 3.)

In 1895 Becquerel observed that certain substances used as electrolytes in a primary battery cell generated differing voltages if the two plates them to scan an area, or a matrix of such photo cells is used.

The first photo cells were bulky so early inventors of two-dimensional image transducing systems were obliged to use mechanical scanning to effectively move the photo cell across the image.

Nipkow devised his spinning disc method of television in 1884; with it successive elements of the picture were viewed one at a time in a sequential pattern.

His work was further developed by Baird, in the 1920's — who pioneered our present-day television systems.

The Nipkow disc, however, was incapable of producing really acceptable picture definition, it was soon replaced by thermionic camera tubes in which an electron beam is systematically deflected across a photo-sensitive target on which the image is formed.

Zworykin's "Iconoscope", one of the earliest camera tubes, used a photo sensitive area of fine mica flakes — called the mosaic. These minute cells formed small capacitors that became charged to a level decided by the intensity of the radiation falling on them. The many "cells" were interrogated at regular time intervals by an electron beam scanned across them, monitoring the change in beam current occurring at each cell as they discharged.

As the cells were not being read out continuously it was possible to integrate (or average-out) the charge produced over a period of time, thereby increasing the sensitivity to light. This process is now known as charge-integration.

Today's television picture-tubes are still similar to the Iconoscope, the differences being in simplification of

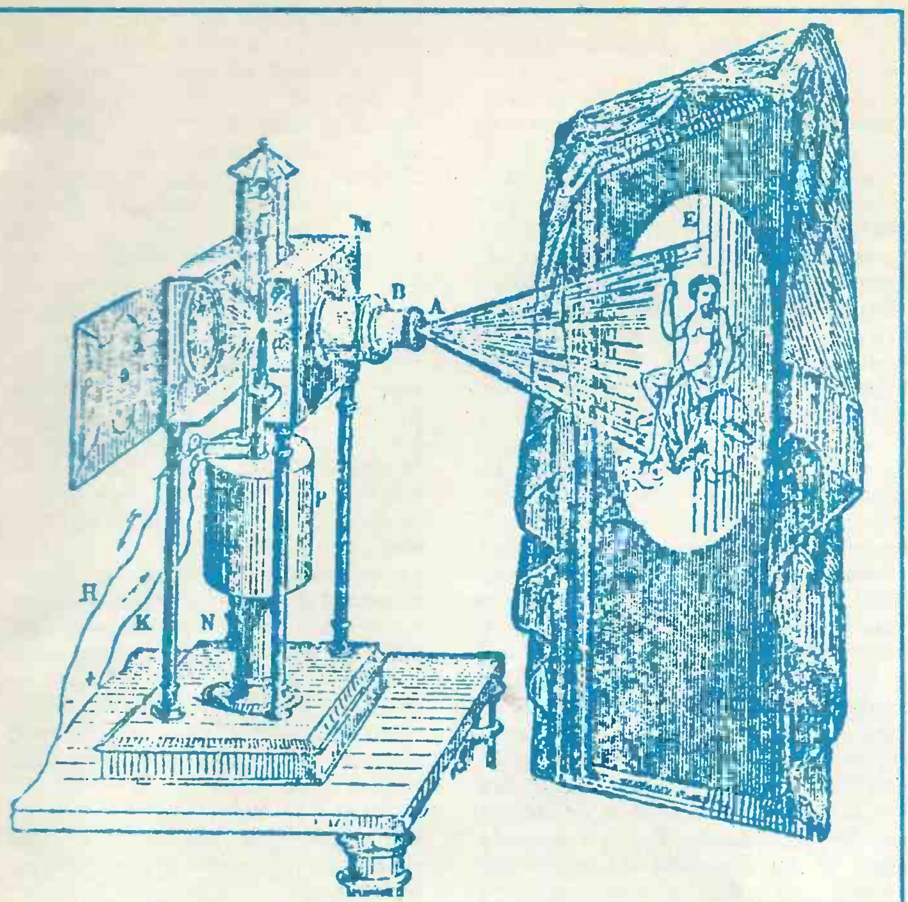


Fig. 2. This magic lantern, made about 1855, uses electrics and optics. In those days electric photo diodes did not exist: opto-electronics was a simple discipline.

were exposed to different light intensities.

A little later, in 1887, Arrherrius found that the resistance of silver halides increases with increasing light level.

In 1905 a photo-electric theory of vision was published and photo-detectors (of cumbersome form) became a more or less routine component available to designers.

By 1920 one could purchase a potassium-hydride photocell complete with a thermionic valve amplifier. Glazebrook, in his 'Dictionary of Applied Physics' (1922) remarked on this package —

> *"Used in this way the photo-electric cell may well prove its usefulness not only in photometry but in signalling without wires and as a means of scientific investigation."*

He was so right*

He also said he was pleased to see that such an obscure phenomenon was finding increasing use of technical importance.

Single-cell detectors were continually improved, and far greater sensitivity was achieved by devices such as the photo multiplier. A solid-state photo-diode was eventually developed which was not only small but retained a good measure of detectivity.

Single-cell detectors, however, can only measure and transduce the intensity of radiation occurring in a single-point area. They cannot produce an electrical equivalent signal of two-dimensional images unless some mechanical system is used to enable

**(A future issue of ETI will feature modern electro-optic communication links.)*

Fig. 3. Before closed-circuit television was invented, multiple viewing had to be under-taken with devices such as Nachet's multiple microscope.

MATRIX TV

the mica mosaic to give us the relatively inexpensive Vidicon and its derivatives and sometimes to make use of secondary emission which enhances sensitivity in tubes such as the image-orthicon.

Thermionic picture tubes have long provided adequate resolution and linearity for most purposes, and production costs have been reduced to the point where amateur video recording is an increasingly popular hobby.

Nevertheless, thermionic tubes are bulky and thirsty for power compared with the potential capability of the latest solid-state integrated circuit technology. The days of thermionic picture tubes are numbered. Solid-state detection will undoubtedly replace them in the not too distant future — indeed in a few special cases this has already happened.

MATRIX SOLID-STATE DETECTORS

Early photo detectors needed several square centimetres of radiation to produce a useable signal change. Consequently a multiple array used to transduce line or plane optical information was rather large in size. Scanning was much easier to implement in a reasonable space.

Selenium was found to be a photo-electric substance. Willoughby Smith made resistors of it (in 1873) only to find its ohmic value varied with light intensity — thus adding another important transducer effect to the growing list!

The existence of relatively sensitive selenium detectors enabled Ruhmer to study the practicality of matrix array techniques which were connected to a similar array of lights with paralleled wires. In the period 1901-1912 he tried many ways of producing television by such means. He failed miserably. Selenium cells have a quite long time-constant (many milliseconds) so they were unable to follow transients of moving images.

Experimenters tried to reduce wiring connections by scanning the cells using mechanical switches. A scheme was proposed that needed a 32-contact wiper switch rotating at 960 rpm; it was dropped because it would also demand lamps that could be flashed at 640 000 times a second "which was manifestly impossible" says the author of the report.

In 1929, a popular-science technical writer (Ellison Hawks), summed up the situation by these remarks:— "Although there are immense difficulties, however, one would like to suggest that the method should not be finally discarded for it is the only one so far suggested by which the whole of the picture can be transmitted at one time".

When semiconductor technology exploded in the 'fifties and 'sixties it became possible to make highly reliable and inexpensive solid-state photo-diodes that were of only pinhead size. Eventually the problems of placing a large number of these side by side to form a matrix were overcome and we saw the successful development of lines of detector elements using large-scale integrated circuit production methods.

Some of the "immense difficulties" have been overcome, some still remain.

It is now about ten years since satisfactory integrated detector arrays were first made. Line arrays have been used in military optical missile trackers, and in a few industrial applications. Their widespread use was, however, restricted by cost and by the lack of an adequate density of photo-diodes. Today the diodes can be formed 75 μm apart (less than half the size of a full stop on this page) with a 64 by 64 array being comparatively easy to accomplish.

Such achievement may well seem surprising but the resolution needed for many purposes is already routinely obtained with the 625 line television system — about 3 000 000 picture elements in the picture area.

The massive IBM array still does not compete on a size basis with a good vidicon tube!

To illustrate the technology used, we now take a look at some manufacturing methods and circuit techniques.

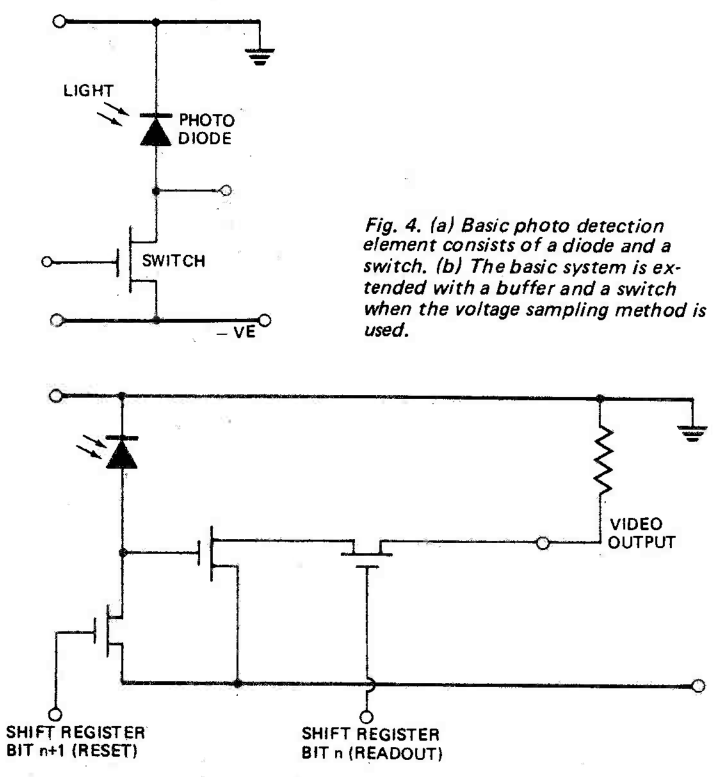


Fig. 4. (a) Basic photo detection element consists of a diode and a switch. (b) The basic system is extended with a buffer and a switch when the voltage sampling method is used.

THE MATRIX

Basically light-detecting photo-diodes are paired with semiconducting solid-state switches — shown diagrammatically in Fig. 4a. They are made by sequentially depositing metal conducting and semiconducting films on a supporting insulator substrate. This technique gives the designer a high degree of confidence as the majority of devices made in an array will work as expected. It also enables a variety of components — both active and passive to be produced by the same basic process of depositing films through carefully made screening masks.

The most generally used mode of operation for the photo diode is that of charge-integration.

Using the self-capacitance of the diode, (which is created by the separated metal films), the diode is first charged up with an externally applied voltage source. The associated switch is used firstly to connect the diode to the source — and then to isolate it by effectively opening one connection of the photo diode. Charge in the diode then commences to leak away due to electron leakage within the diode structure and, more dominantly, by electron carriers that are formed by the photons falling on the photo-diode. The charge loss is then measured, as will be explained later.

The amounts of energy involved are minute. The voltage across the diode decays through 2.5 V (that is, the charge is lost and, therefore, so is the voltage) in an integration period of 10 ms when the incident light level falling on the diode is 0.1 W/m^2. This process, due to the tiny area of the diode, involves only 1-10 pC of charge (pC — pico coulombs; the charge of a single electron is roughly 10^7 pC and 1 C flowing per second is a current of one ampere). Direct sunlight provides a radiation intensity of around 100 W/m^2. The energy involved to "drive" the detector through the 2.5 V swing is of the order of 10^{-10} W!

Having devised a scheme to charge the diode and isolate it ready for radiation detection, the next state is to measure the loss of charge. This can be achieved by measuring the voltage across the diode, in which case a second MOS switch is used to connect the external circuit to the diode. A third MOS component is used to buffer the photo-diode from the load imposed by the sampling switches. This is necessary for without it, the sampling switch will present too low a resistance to the diode, leaking charge before the correct voltage level can be decided.

This method of measurement is known as voltage sampling. It is portrayed diagrammatically in Fig. 4b. The sampling rate for this mode of readout is around 200-500 kHz and it suffers from a somewhat large noise level.

An alternative way to interrogate the diode is by what is known as the recharge-sampling mode. In this the criteria of light-level used is that related to the amount of recharge needed to fully re-establish the voltage across the diode, (Fig. 5). This method needs only the first-mentioned charging switch at the diode location, thus reducing the number of elements needed in the full detector component, but it does require more analogue voltages. But having added this extra circuitry, it then becomes possible to read at 5 MHz multiplexing rates — and the noise level is much less than with the above described voltage sampling.

The actual manufacturing method used to make an element of the array is typified by the drawing of one such element that is given in Fig. 6. Simplicity of contacts and junctions is had at the expense of adding more electronic components elsewhere in the data processing. When the array is made as a single line only it is possible to pack the photo-detecting elements at one third of the spacing, that is at only 25 μm centres.

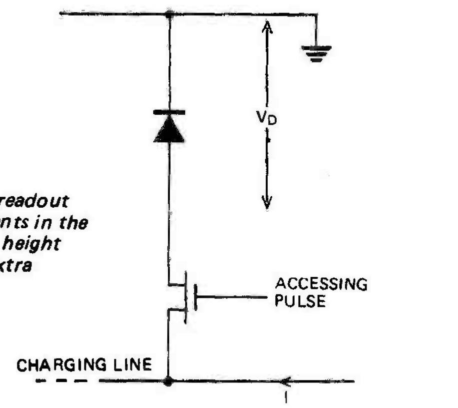
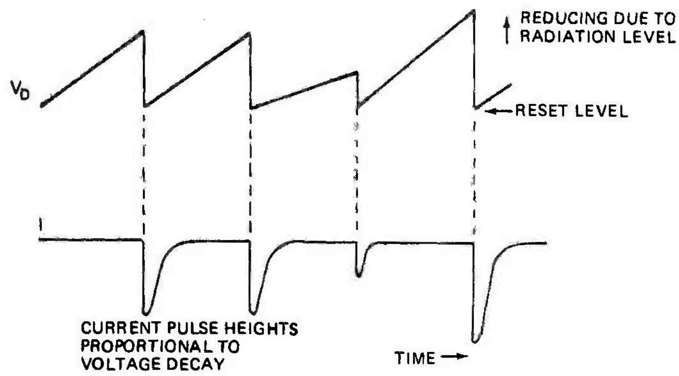


Fig. 5. Recharge-sampling readout requires no extra components in the array but produces a pulse height current signal that needs extra processing.



OBTAINING ACCESS TO THE DIODES OF THE ARRAY

Each element has its input and output "terminals" permanently connected to X and Y conducting lines — made with deposited metal film strips.

The arrangement used for the faster recharge-sampling processing method is shown in Fig. 7. The ends of each X and Y line are connected such that each can be connected to a single common line as needed, this happening sequentially. This is achieved by using a continuously operating pulse generator that 'clocks' a solid-state scanning switch — the register — along in steps. This causes a string of charge pulses to appear on the output line ready for height processing.

Special consideration has to be given to driving these lines, for several effects, such as large line capacitance, tend to limit the useable scan rate unless used in special ways. IPL, for example, have developed a system whereby the flyback time is eliminated thus utilizing the total time more efficiently.

The shift register scanning switches for the X and Y drives, are also formed on the same chip, placing them around the edges. Figure 7 shows an enlarged view of the top of the 64 x 64 IC which includes both the photo-diode array with its recharge switches and the shift registers. (Most users of such a chip would not wish to have to build

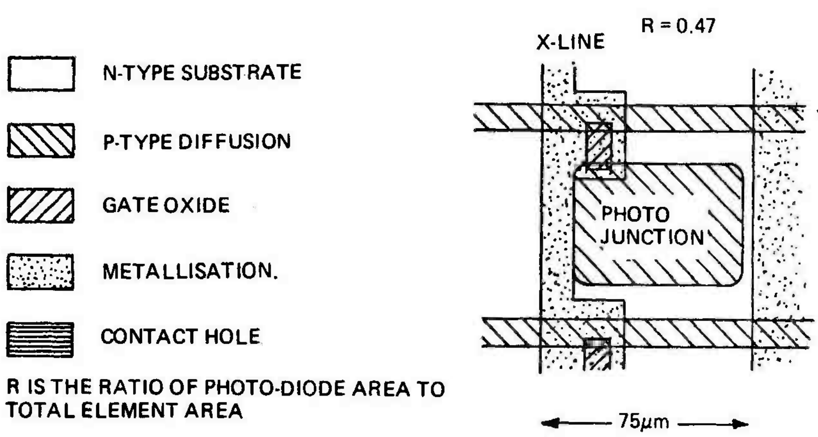
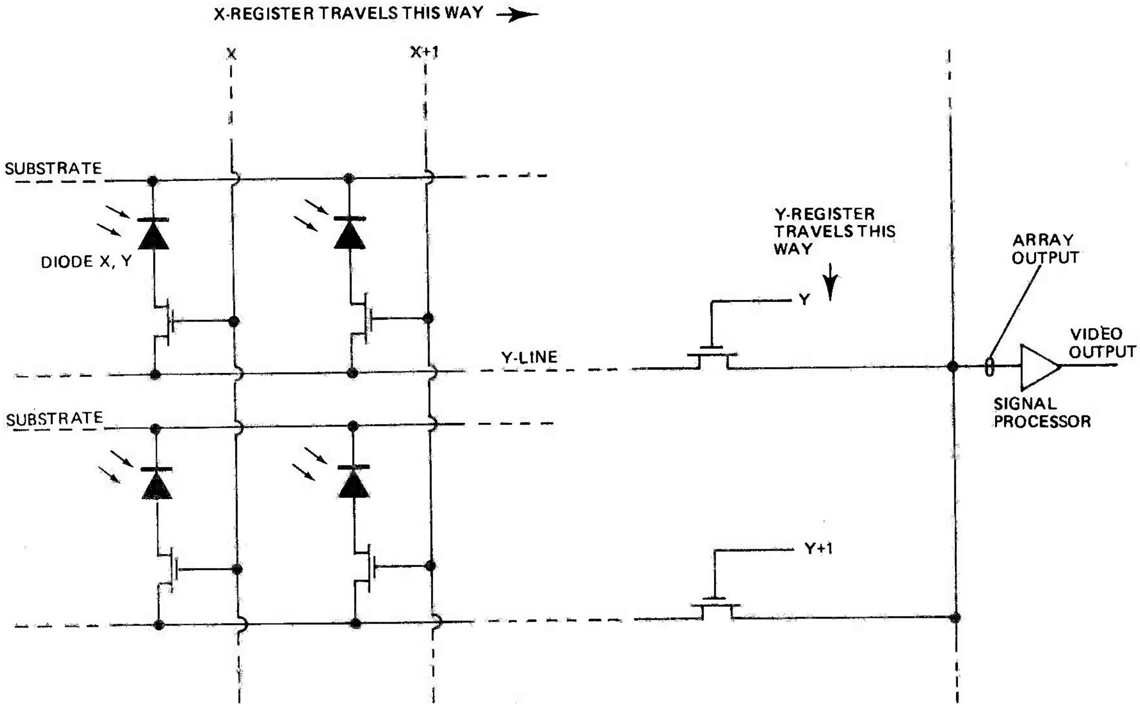


Fig. 6. Photo-diode and switch is manufactured by appropriate diffusion and metallisation on a substrate.

Fig. 7. Typical section of a two-dimensional array using recharge-sampling.



their own processing circuits, so a complete system is offered shown in Fig. 9. In this are housed the clock pulse generator, signal processing circuits and a means to physically mount the appropriate optical element to produce the right size image.)

After preamplification, the recharge pulses appearing on the output line are integrated (rather than peak detected) and applied to a circuit that samples them and holds their level for outputing. as a closely analogue-varying signal.

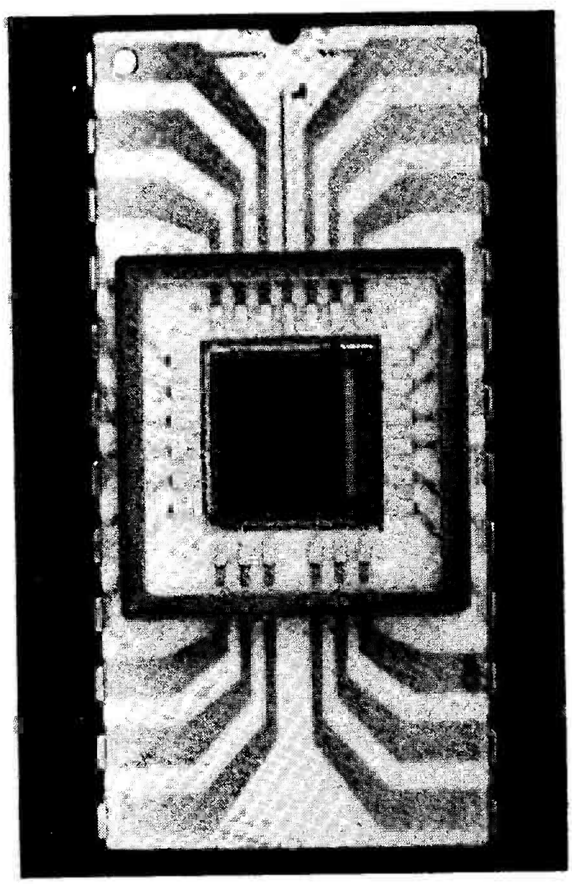
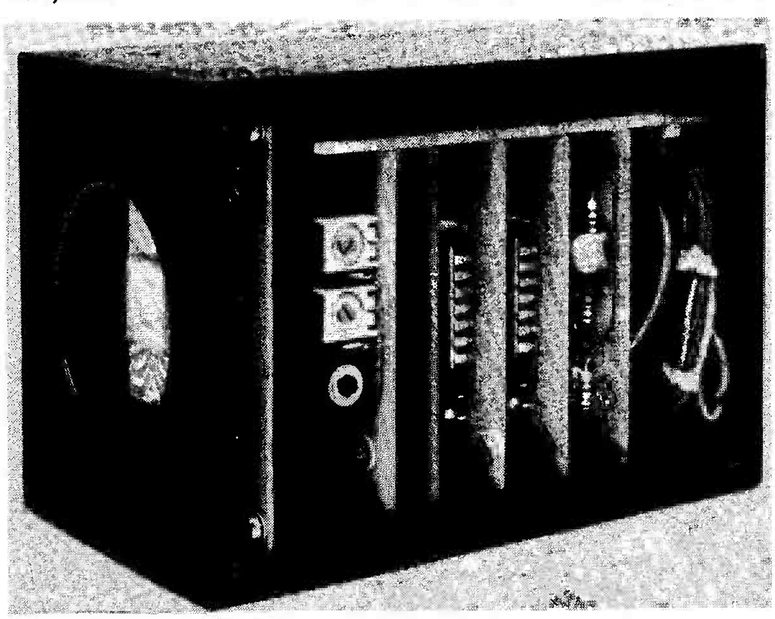


Fig. 8. Integrated Photomatrix Ltd.'s 64 x 64 photo-diode array. The central chip is barely 6 mm square.

Fig. 9. At present the processing circuits of the complete matrix camera require more room than the array (lower centre) but this is largely due to the need to custom build this part of the system.



APPLICATIONS OF MATRIX ARRAYS

Arrays containing only 4096 picture points ("pixels" is a term sometimes used) cannot compete with vidicon television picture tubes on a resolution basis.

Neverthless, there are many applications where an array is superior and/or where the full resolution capability of the thermionic camera tube is not required.

Flaw detection – unwanted pin holes in, say, tape or films can be easily detected using a single photo detector to look for light coming through from a source mounted below. This basic method, however, is limited by non-uniformity of the background

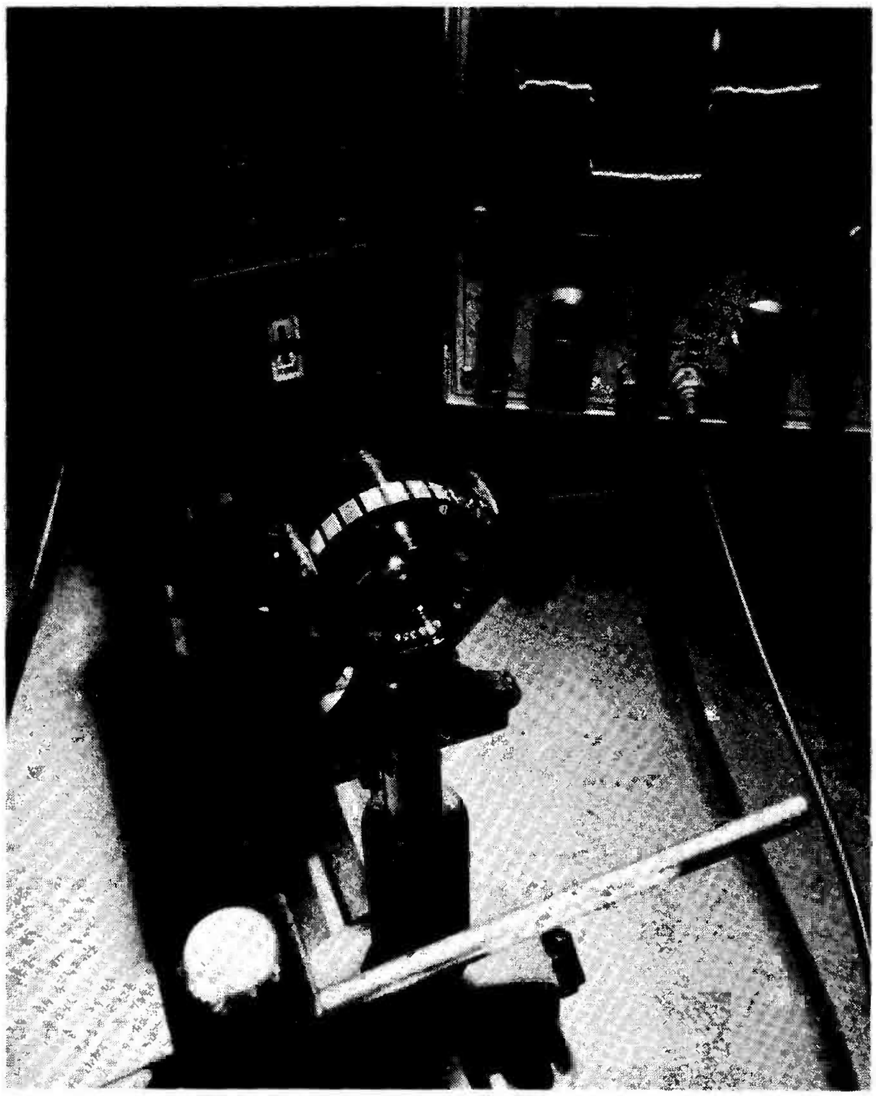


Fig. 10. In this demonstration a linear array is used to produce an electrical signal which has pulse-width proportional to the diameter of the rod seen in the foreground.

illumination coming through the tape or film and cannot provide information about flaw distribution. In looking for small flaws in a wide area the area is actually directed up into smaller fields — that of each element in the array — to increase the signal to background ratio and to define the location of flaws. For this purpose a linear array of 100 photo-diodes is adequate. The actual size of the film and the detector array matter little as the appropriate power lenses will provide the magnification needed. The possibilities for using the data obtained are numerous and depend only on the needs of the task.

Gauging size — if the width and range to be gauged lies within the full range of a linear array, the array can be used to measure rod size without physical contact and at great speed. Figure 10 demonstrates this principle. Back lighting passing the rod throws a shadow on the linear array. This, in turn, produces the gauging signal seen on the CRO screen. As the diodes resolve measurements in discrete dimensionally stable increments, these arrays can provide greater accuracy and long-term stability than a vidicon method.

If the measurement task is one needing only width change monitoring it is better to use two separate arrays set apart as shown in Fig. 11. This technique increases the relative resolution obtained, and by this method it is possible to monitor the width of sheets, stripes and even railway lines. The block schematic of a hot rod gauging system using two arrays is given in Fig. 12.

Optical character recognition and data digitizing — linear arrays for scanning documents, such as cheques, have been in use for several years. Current developments involve automatic post-code recognition and for the processing of football-pools entry forms.

Linear arrays have been used in an instrument for measuring pipe straightness. This device consists of a flexible tube containing two fixed-end units. Mounted in one fixed unit is a fine light source that radiates across the flexible section to the other side which houses a linear array. The unit is blown by compressed air down the pipe to be tested, bending as the pipe bends. If and when the unit bends, the light scans across the array, thus yielding straightness data.

Television — this is an extension of one-dimensional array methods to two dimensions. Arrays with only 64 x 64 elements, although somewhat limited, are capable of many useful tasks.

Obvious applications include blood count and cell analysis, more complex character recognition situations and area gauging. There is also a large potential market for the arrays as sensors for reading cost and inventory labels in the so-called "point-of-scale" checkout systems recently introduced into some supermarkets.
Here the label on the item is "read" as the checkout girl scans it with a special head. The data is then used to prepare the total cost and to inform the computing storage about the latest stock totals.

To demonstrate the capabilities of their self-scanned matrix array, IPL have developed a complete C.C.T.V. system based on the 64 x 64 array

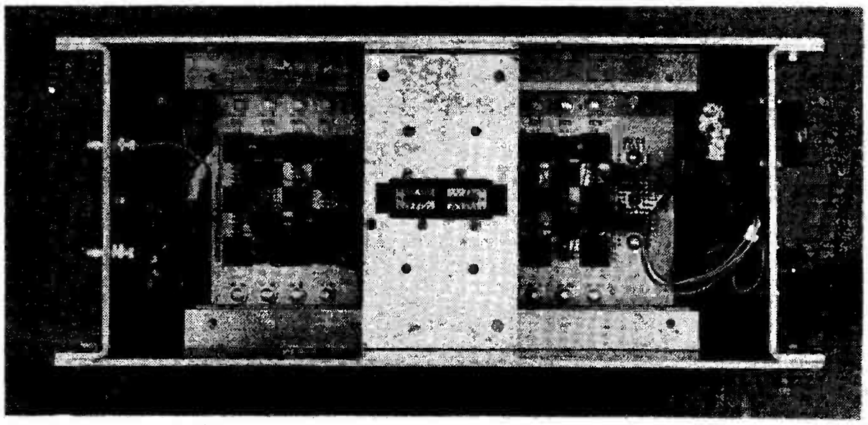


Fig. 11. Width gauging using two linear arrays.

element. Figure 13 shows the system using a cathode-ray tube to reconstruct the image.

It is clear that the basic technology exists for designers seriously to consider matrix television techniques.

As integrated circuit manufacture advances toward finer detail and more extensive LSI systems resolution will be improved and price reduced. Currently, it is more difficult to find applications that *need* the fast rate of data obtainable than with its procurement.

We have come a long way since electricity and optics first came together in the instrument makers workshops.

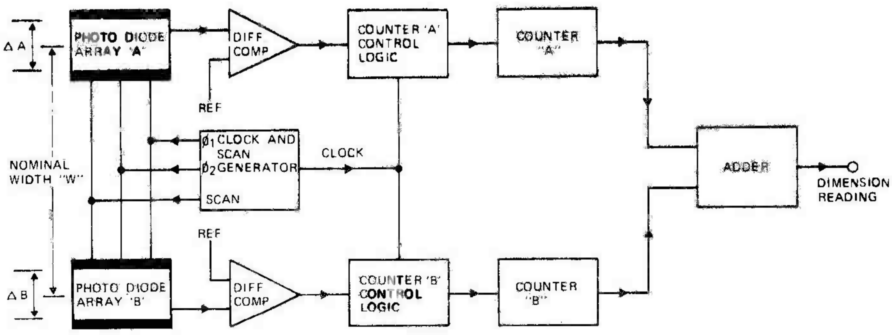
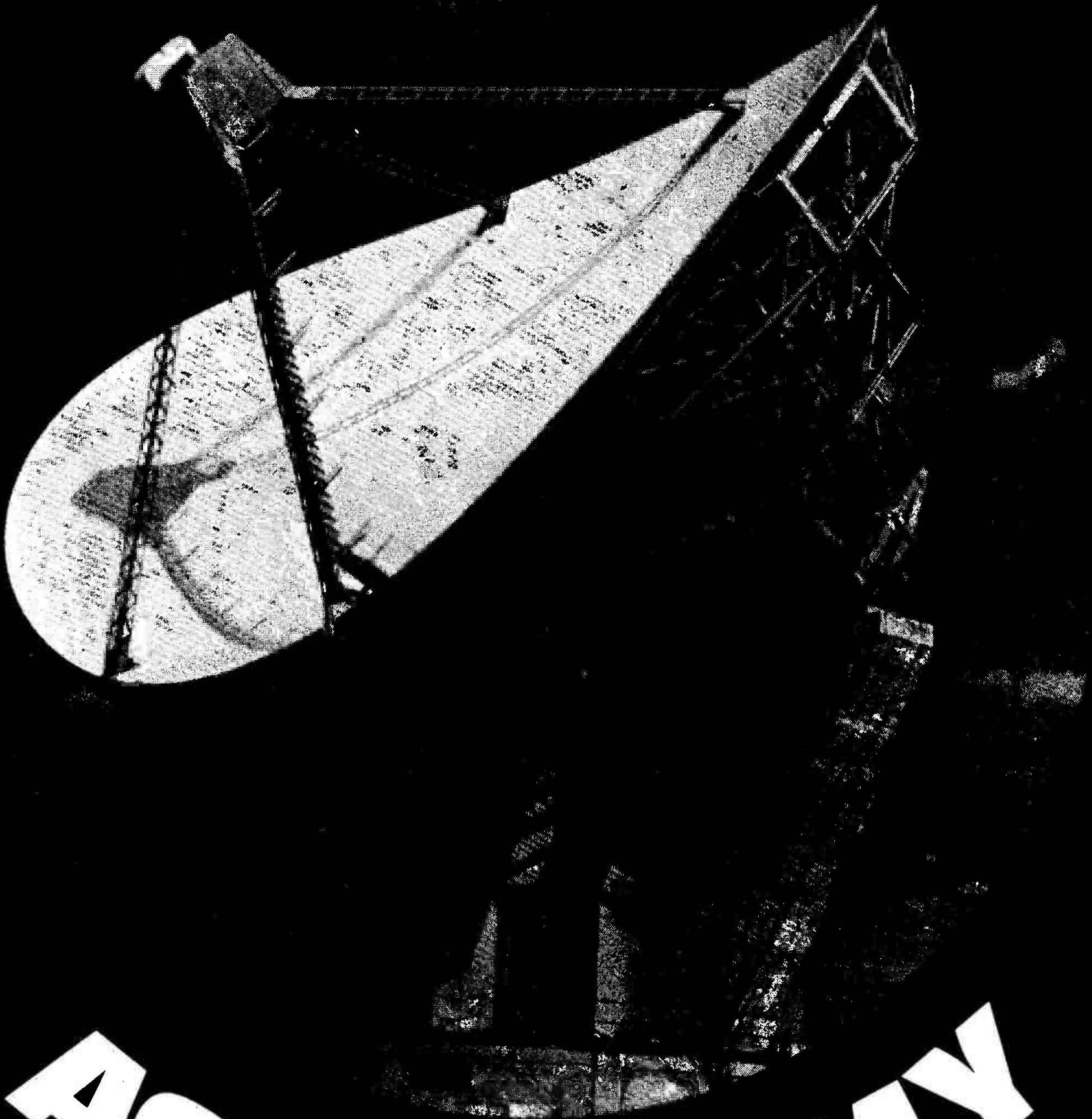


Fig. 12. Block schematic showing how two arrays are combined electronically to provide width variations.

Fig. 13. Although not primarily intended to rival conventional C.C.T.V. (at this stage of development) a useable picture can be formed with a 64 x 64 array. The reconstruction is made on a C.R. Tube.

RADIO

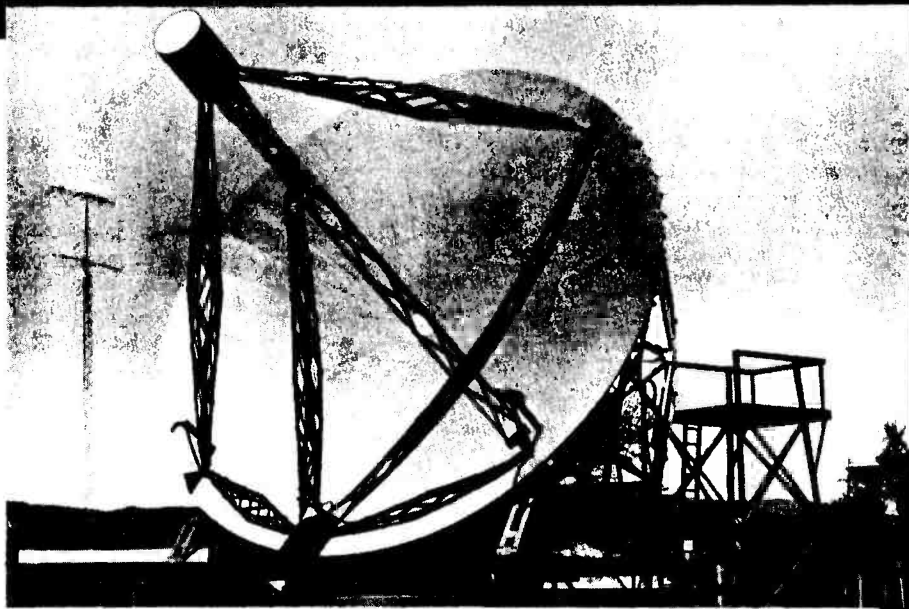


ASTRONOMY

By C. Bruce Sibley

During recent years, our concept of the Universe and of our own place in it has been turned completely upside-down by the discoveries of the radio astronomer. Radio signals radiated by our Sun and Planets; from the debris of exploding stars and fast moving galaxies; from vast clouds of gaseous material; and lastly, from the most distant objects of all - the Quasars and Pulsars, have presented mankind with a valuable tool to probe the innermost secrets of energy, time and space.

Radio Astronomers have taken over the helm in charting the maps of the heavens. Their investigations have probed deeply into our own galaxy, the Milky Way, revealing that our own Sun with its tiny system of nine planets travels some 180 x 10^{15} miles from the galaxy's centre - we live at the edge of the Milky Way, an enormous spiral system of stars, planets and moons - we are a mere dot amongst millions of millions.



Grote Reber's home-made dish antenna - years ahead of its time.

COSMIC RADIO EMISSION was first discovered in 1932 by a young American radio engineer, Karl Jansky, an employee of Bell Telephone Laboratories, USA. Jansky has been assigned to investigate the sources of radio static which disrupt short-wave radio traffic. Some of the static appeared to have no earthly origin and further observations suggested that the 'noise' was coming from outer space - from the centre of the Milky Way to be exact! Although Jansky published his discovery in the Proceedings I.R.E. (now I.E.E.E., USA), scientists paid little attention. Radio was a young science and there was much to do by way of improving telecommunications without diverting effort elsewhere.

However, one man did take note of Jansky's report and became highly intrigued by the thought of tuning into radio signals from the depths of galactic space. This was Grote Reber who spent nearly 11 years (1934-1945) recording and plotting the 'noises' of space. He can truly lay claim of the title of 'first' radio astronomer.

Reber's equipment was years ahead of its time, anticipating most of Radar and Microwave techniques used in the Second World War. He designed and constructed all of his equipment, including a 30ft dish antenna - the first radio telescope! He experimented with various new radio valves and modified them to meet his requirements in the quest for perfecting very low noise amplifiers; the noise from space was exceedingly weak and Reber quickly realised that extremely low noise techniques were necessary. He published several papers and articles on his findings in the Proc. I.R.E. (now I.E.E.E. (USA)), giving details of his equipment. His early maps plotting the noise distribution of space parallels the work done in later years by others.

During the war, the radar networks of both sides began to experience severe forms of interference. Experts spent a great deal of time eliminating the possible causes of this annoying 'snow storm' on the radar screens. Both sides had learnt various games of subterfuge, like dropping long and short pieces of metallic strip from attacking aircraft and confusing the radar plotters as to how many raiders were actually approaching the target areas. However, investigations soon showed that another source was responsible the interference was coming from the Sun!

From time to time, the Sun becomes extremely active; about every 11 years. At these cyclic moments, the solar surface becomes pock-marked with markings called 'sun-spots'. Sunspots are areas of intense nuclear activity and also giant whirlpools of magnetic force. The reaction between these two agencies releases enormous amounts of radiant energy in the form of 'ionized' particles and a wide spectrum of electro-magnetic radiation. The latter form of radiation reaches the vicinity of the Earth in 8 minutes, travelling at the speed of light. Meantime the 'ionized' portion of the ejected solar radiation takes much longer to travel the 93 million miles distance between the Sun and the Earth - between 24 and 36 hours - travelling at speeds of between 1077 and 718 miles per second.

When this solar radiation hits the earth's upper atmosphere and magnetic field, enormous ionic storms occur and the entire 'ionosphere' becomes disturbed and short-wave radio transmissions become much weakened and distorted. Simultaneously with the commencement of these 'storms', radio receivers detect a considerable increase in noise level, heralded on radar screens as 'snow' patterns and as hissing in the loudspeaker.

After the war, scientists returned to peaceful research and many turned their attention to radio astronomy. The huge advances made in the field of telecommunications and electronics were now channelled to meet the needs of radio astronomy. Wartime equipment was quickly converted into low noise receivers, various antennas (including several 'captured' German microwave dishes) were re-assembled and pointed skywards. Britain and Australia led the way in this new enterprise with Holland and the USA close behind. Today, most advanced nations participate in this field of research and the science has sprouted a veritable mountain of data leading down many corridors of scientific investigation; even biology has been influenced by the discoveries of radio astronomers!

THROUGH THE WINDOW

The power intensity of cosmic radio noise is extremely weak, one value for a very distant source quotes 0.000,000,000,000,001 watt! Thus radio telescopes and their receiving equipment must push the current engineering techniques to their absolute perimeter of performance. Radio telescopes vary in size depending on the task required of them. Small aerials a few feet across will usually serve the requirements involving the reception of solar radio noise - with one or two important exceptions. Larger telescopes are usually constructed for the task of probing deep into galactic space. Some telescopes are built to stand on supporting structures that can tilt or rotate the antenna into any required direction, like the 250 foot dish at Jodrell Bank, UK. Alternatively the size of the collecting bowl may prohibit motorised movement such as the huge 1000 foot dish at Arecibo, Puerto Rico. This telescope is sculptured from the ground itself; surrounding mountain tops act as part of the pillar supports for the enormous gantry that hangs at the point of focus 500 feet above the centre of the reflector. This gantry is the site of the 'pick-up' antenna (or transmitting antenna when used for sending Radar signals to the planets). The entire structure scans the sky by using the rotation of the earth.

Other radio telescopes consist of miles of dipole antennas supported on short poles and switched into circuit as required.

One important advantage that radio astronomy exercises over optical astronomy lies in its ability to operate regardless of weather conditions.

The atmosphere is a complicated mixture of gases and varying amounts of water vapour. These constituents combine together and act as a powerful screen to all life on the earth - without this protection all plants and animals would die of intense solar irradiation. Equally miraculously the atmosphere does permit 'necessary' radiation to pass through a series of 'natural' windows. Ordinary sunlight, heat rays, some weak Ultra-Violet light and radio waves find access to the ground through these atmospheric windows. Astronomers utilise these windows to study the radiation beyond.

THE CAUSES OF COSMIC RADIO NOISE

Cosmic radio noise is generated by a variety of strange phenomena, many of these are as yet not fully understood, but noise is produced by interstellar gases, free electrons and magnetism, thermal processes, atmospheric forces and gravitational forces.

GAS NOISES

Throughout the Universe there exist copious quantities of gaseous debris, the fragments of cosmic collisions and explosions. Much of this debris consists of fine clouds of hydrogen which, as a result of changes within the energy level of individual atoms, radiates a precise radio signal at 1420. 4057MHz. Astronomers can use the 'radio fingerprint' to track these clouds and their speed of travel throughout the Universe.

The Dutch astronomer, Van De Hulst, suggested the existence of a Hydrogen 'line-emission', in 1943, but it was not until 1951 that his prediction was proved correct! Since then, several 'emission-lines' have been observed among which molecules of Hydroxyl, Ammonia, Water, and Formaldehyde have featured - each a constituent of the basic building blocks of life itself.

FREE ELECTRON NOISE

Free electrons (escapees from nuclear reactions), travel at various speeds throughout space. In the course of these wanderings they encounter several areas of strong magnetic influence. When electrons travel along lines of magnetic force they move in a spiral motion. As they spiral around and around they emit radiation over a wide band of frequencies, much of this in the radio spectrum. Receivers on earth are able to detect this radio noise and thus examine not only the probable electron density of a particular area under observation, but also establish other factors such as the level of magnetic intensity, temperature, and distance, etc, etc. Noise from spiraling free electrons is called *synchrotron* radiation after the selfsame effect logged in the earth-bound laboratories of nuclear research. Atom smashers produce similar results!

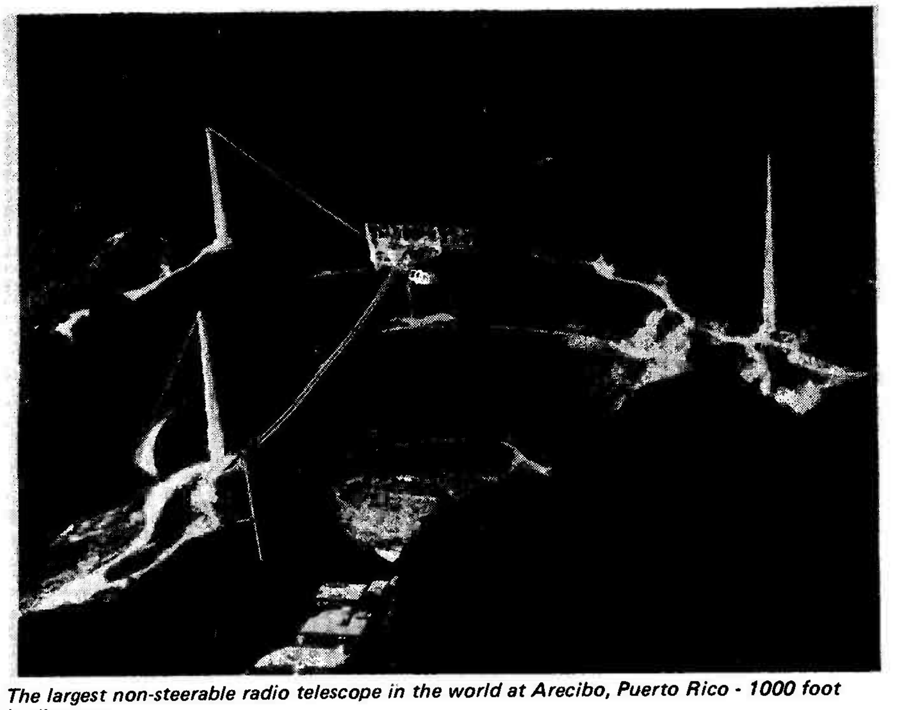
THERMALLY GENERATED RADIO NOISE

Like other stars, our Sun 'burns' nuclear energy. The temperature of this seemingly eternal furnace reaches unimaginable heights - perhaps more than a million degrees inside its fiery atmosphere. The 'stripped' nuclear particles of this atmosphere whirl about in frenzied motion generating huge amounts of dangerous radiation and prodigious radio noise. The amount and spectrum range of star's radiation depends directly on its evolutionary state. A less active body will generate correspondingly less noise. Our Sun generates a considerable amount of radiation and radio noise which tends to increase dramatically in level every 11 years, called the 'sun-spot' cycle. At these times, the last peak was 1968/69, very high radio noise levels were recorded throughout the radio spectrum. Most experts believe that there are longer cyclic variations in solar activity and that the 11 year one is only part of the story. All the planets of the solar system 'bathe' in the 'solar-wind', it blows continuously across interplanetary space enveloping all in its path.

The planets themselves exhibit a personal temperature regardless of solar absorbed heat. Bodies radiate their own temperature data by means of 'infra-red' radiation. This radiation lies at the top of the radio wavelength spectrum. Measurement of the 'noise temperature' of any radiating object (including icebergs) can be accomplished using specially designed equipment. Volcanic 'hot-spots' can be detected by these methods.

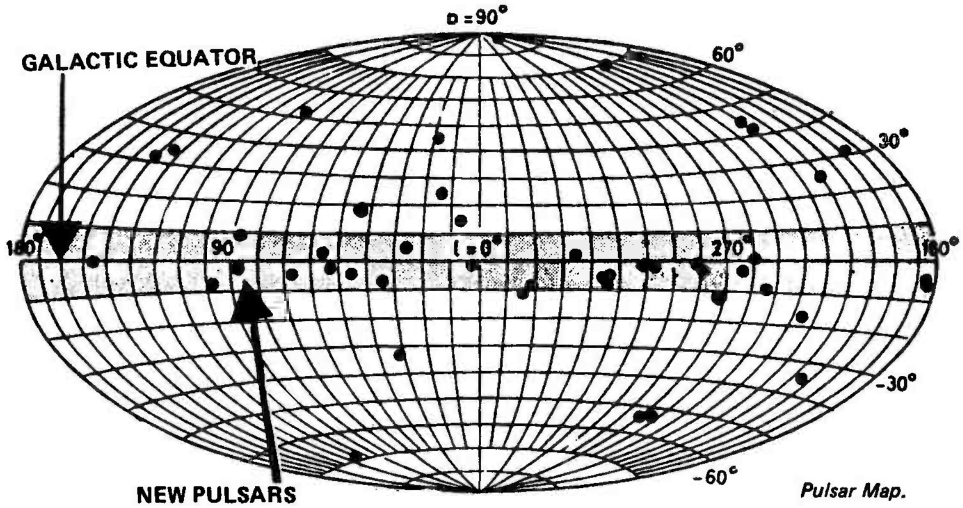
NOISE FROM ATMOSPHERIC SOURCES

Radio scanning of the Moon and



The largest non-steerable radio telescope in the world at Arecibo, Puerto Rico - 1000 foot in diameter.

planets has revealed self-generated 'thermal' noise. But in one particular instance another type of noise making phenomenon has been discovered. When the early radio astronomers turned their attention to the huge planet of Jupiter they were amazed to discover that Jupiter was generating powerful pulses of radio noise around 22MHz. This noise consists of short sharp bursts of static, rather similar in character to that of terrestrial storm static. Hence one of the theories put forward to explain this strange Jovian noise relies heavily on the concept of Jovian thunderstorms, though of course the magnitude of such storms would be considerably larger in relation with the size of Jupiter. Another theory points at the idea of Jupiter's radiation belts interacting with the planets magnetic field and producing noise. Lastly, there is another hypothesis that the red spot, a feature plainly seen on the surface of Jupiter, triggers the discharge of naturally generated electricity residing in the atmosphere. We may be witnessing the very same events that began life upon Earth.

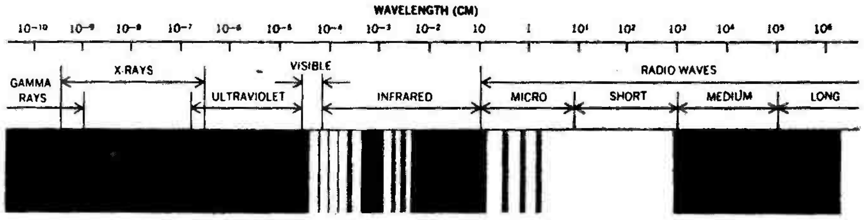


Pulsar Map.

NOISE GENERATED BY GRAVITATIONAL COLLAPSE

Pulsars are thought to be the product of stars of a particular type and in a unique gravitational state. The term 'gravitational collaspe' really explains itself - a body collapsing under its own gravitational force. With Pulsars we have a situation that tests our concept of normal experience - when a body gets smaller and smaller, and the material within gets packed more tightly together, curious and entirely new rules of physics begin to reveal themselves. Strange and quite bizarre things occur. One of these new and difficult to understand phenomena takes the form of pulsed radio noise - but quite fantastic and beyond the normal everyday measurement of radio astronomers. The radio pulse emitted by collapsing stars (called neutron stars) takes the form of precision pulses and not only that, their radiating power is enormous.

If we take the evolution of a neutron star to its logical conclusion, we finally reach a point where *no* radiation escapes because the force of gravitation is so great - we get a 'black hole' in space - our pulsar stops sending and collapses into "something" we can only speculate about!

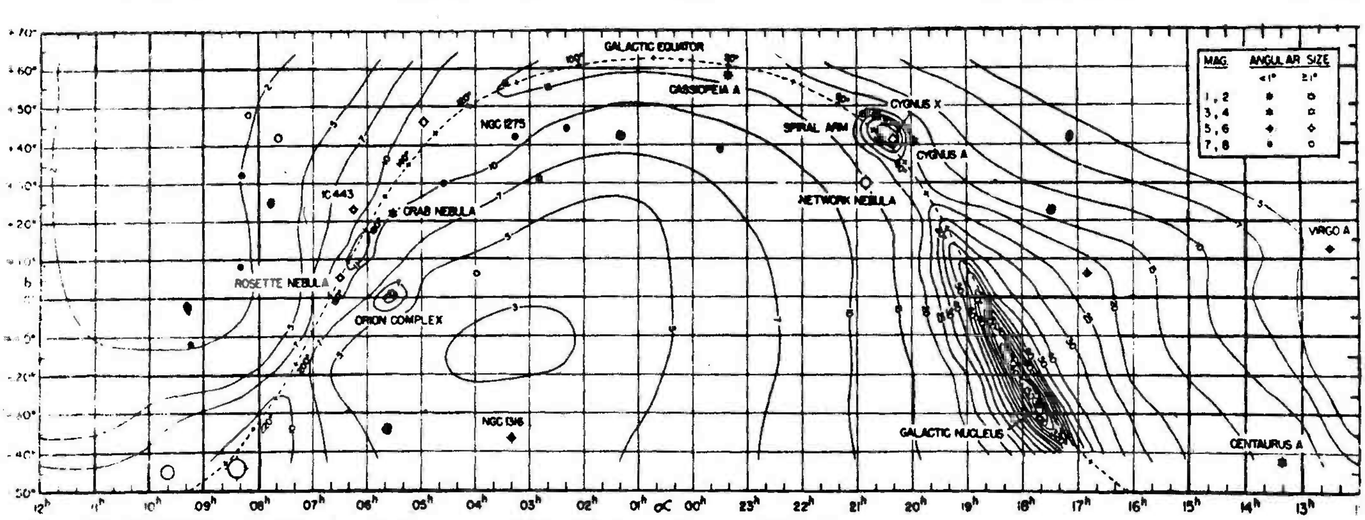


The Earth's Atmospheric 'Windows' (white), and absorption (black strips).

RESOLVING POWER - SEEING CLEARLY

Next time you go for a walk at night, look up at that nearby office block. Notice that you are so close to the windows that you can perceive the light streaming from each and every window. Your eyes are capable of 'resolving' this image. Now get into your car and travel to some distant point where you can again observe the same building. The further and further away you travel from the block the harder it will become for your eyes to perceive the individual points of light. Finally you will be at such a distance from the image that all the illuminated windows merge as one splash of light.

This is a simple demonstration of what is termed 'resolving power'. Most of us are familiar with the inability of resolving distant objects - though we know that what we see cannot be!



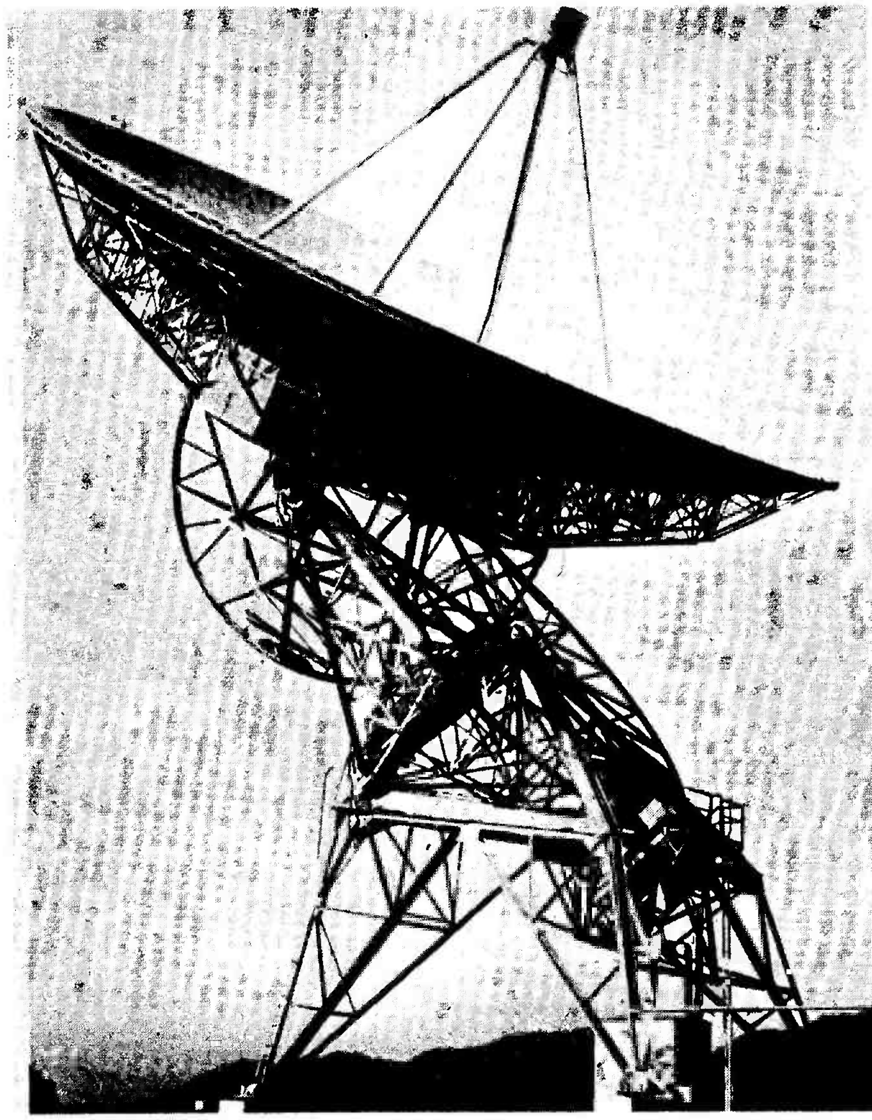
Map of 'radio brightness' of the sky. Point sources of identified stars shown as black dots.

Railway tracks, street lamps, roads, houses, trees, telegraph poles 'do not' merge as one at a distance.

But in astronomy we have no first hand experience of what is 'out there' we have no celestial tape measure to confirm that this or that object is really as we see it. The very distant point of starlight may belong to one, two, three, or more stars. Unless we can achieve high telescopic resolution we shall never know the answer to this conundrum.

Bigger and better telescopes ere being built all the time but there are 'physical' limits to their size and precisional movement. It is doubtful if any optical telescope larger than 300 inches will be built on the surface of this planet unless some new and dramatic change in optical telescope design takes place. But with radio telescopes there is considerable room for improvement and advanced sophistication. The 1000 foot bowl of Arecibo has already been mentioned but we need not be hamstrung by the limit on physical size and mobility. We can circumnavigate this by building several Jodrell Bank sized telescopes and siting them in specific places all over the globe. In conjunction with these installations we link each radio telescope with its neighbour via a computer. The entire system is monitored by an atomic clock so that individual observations can be 'tagged' by time signals having accuracies of the order of one billionth of one second. By pre-programming each telescope to one specific area of the sky and matching their sum observations with the clock and analysing the result by computer, resolving powers of a few millisecond of Arc diameter are obtained!

We call this new system of observation, 'long baseline interferometry'. One day they may have such a system existing between the Earth and Moon!



The 85 foot radio telescope at the U.S. National Radio Astronomy Observatory at Green Bank, West Virginia. Through the lens of this giant telescope American astronomers made the first observations of the surface of the planet Venus.

NEW DISCOVERIES

During the last decade the science of radio astronomy has been shaken to its young foundations by the discovery of hitherto unsuspected objects - the Quasar and Pulsar. Most recently of all, other even more fascinating objects have been 'discovered' - black holes!

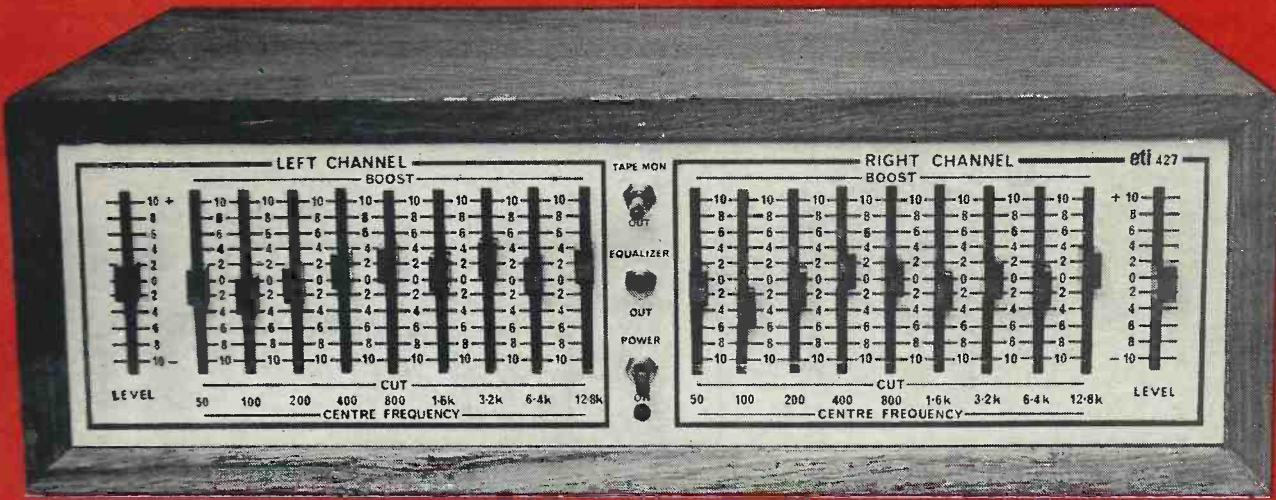
The Quasar, a distant yet fantastically powerful radiating source, has presented several conundrums to science. Their 'doppler shifts', a means of measuring speed and direction of travel, indicated that Quasars were imensely distant objects, yet other evidence pertaining to the signal strength indicated the opposite and that they were relatively close to us.

The Pulsar, another object yet equally powerful as a radiating source, confounded everybody at first by its inconceivable precision. Pulsars transmit pulses of radio energy just like earthbound radar transmitters. The 'ticking' rate varies from one Pulsar to another, but all exhibit astounding precision. One Pulsar stays switched on for a precise 1.33730113 seconds! Another delivers four pulses per second - 'on' time = .0601967 sec and 'off' time = .253071 sec.

As explained in the early section covering the sources of radio noise, gravitational collapse is the mechanism thought responsible for these almost unbelievable 'natural' objects. When they were first discovered it was thought that they were the product of some advance inhabitants of the Universe, they still seem like something to do with space travel and navigation rather than the objects most scientists would have us believe!

From the Pulsar we conclude our discussion pausing just for a few moments to consider the newest and strangest of all phenomena - the 'black hole'. Astronomers are still arguing about its true nature or even in its existence! If, as stated earlier in this article, Pulsars can collapse down to absolute nothingness then surely there will just be a hole. Just like that proverbial oozelem bird that 'disappeared' after flying around in ever decreasing circles! However, other experts argue that should gravity collapse to this degree, *all* radiation, including 'light' and 'radio' would fail to escape from its grip and we should be quite unaware of its existence in the first place! The arguments and searching for 'real' black holes continues.

Several interesting ideas regarding time and space have evolved as a consequence of the 'black-hole' debate. Time itself will become changed by the huge force of compacted gravity, and, if one could survive the journey through the 'hole' where would one be on the other side? ●



eti PROJECT 427

GRAPHIC EQUALIZER

A unit that compensates for speaker and room deficiences.

MANY audiophiles are discovering the advantages of graphic equalizers in domestic as well as professional sound systems. Unfortunately the costs of such units have prevented them becoming as popular as warranted by the many advantages they offer.

The advantages of an equalizer are not generally well known but are as follows.

Firstly an equalizer allows the listener to correct deficiencies in the linearity of either his speaker system alone, or the combination of his speaker system and his living room.

As we have pointed out many times in the past, even the best speakers available cannot give correct reproduction in an inadequate room. It is a sad fact that very few rooms are ideal, and most of us put up with resonances and dips, sadly convinced that this is something we have to live with.

Whilst the octave equalizer will not completely overcome such problems, it is possible to minimize some non-linearities of the combined speaker/room system.

In a concert hall it is also possible to use the unit to put a notch at the frequency where microphone feedback occurs, thus allowing higher power levels to be used.

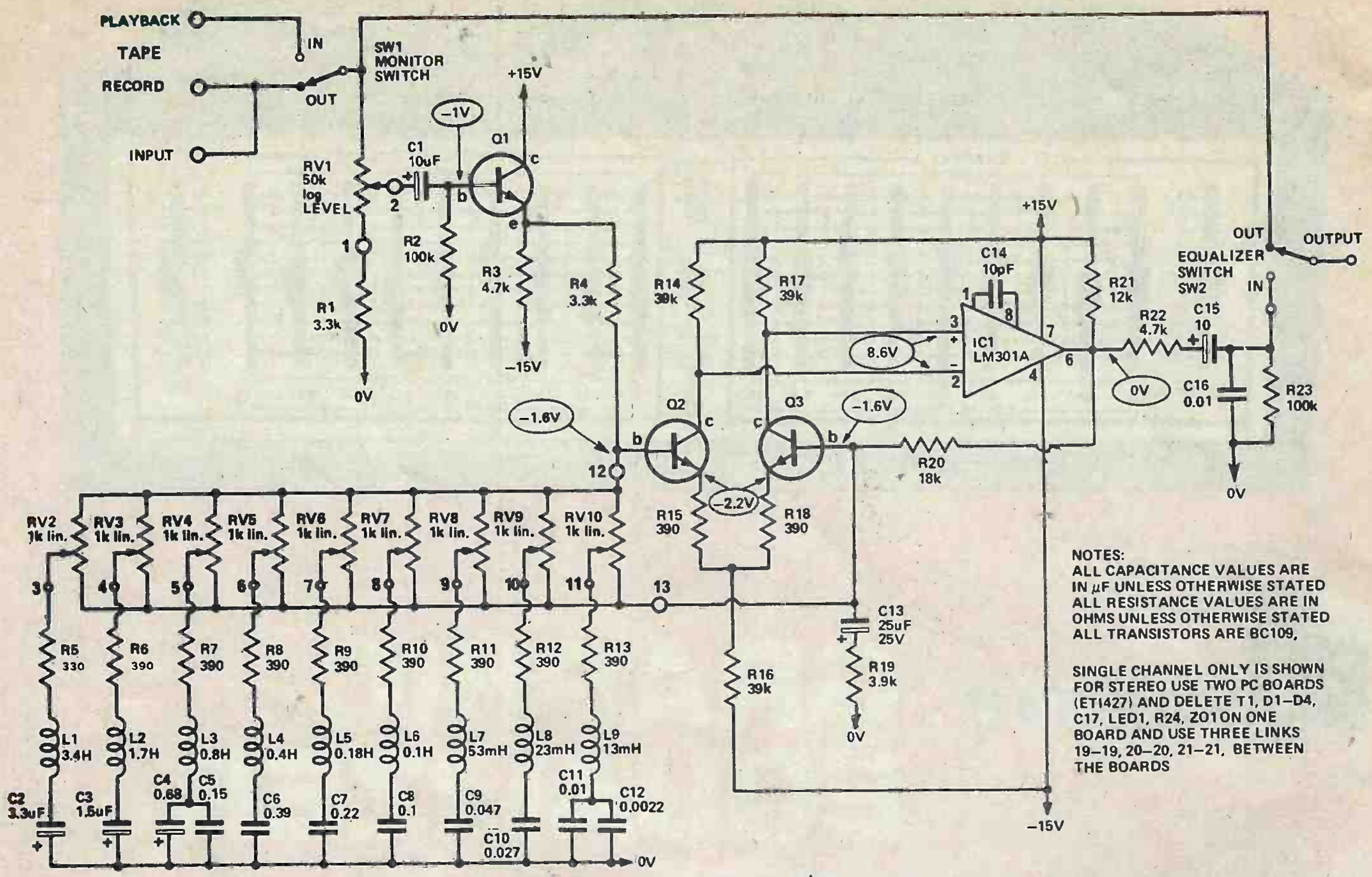
Thirdly, for the serious audiophile, an equalizer is an exceedingly valuable tool in evaluating the deficiences in a particular system. One adjusts the equalizer to provide a uniform response, the settings of the potentiometer knobs then graphically display the areas where the speaker etc is deficient.

There is a snag, however, one must have an educated ear in order to properly equalize a system to a flat response. It is not much use equalizing to your own preference of peaky bass etc in order to evaluate a speaker.

Ideally, a graphic equalizer should

MEASURED PERFORMANCE (of Prototype)

Frequency Response				
Equalizer out			Flat	
Equalizer in	10 Hz – 10 kHz		±½ dB	
and all controls at zero	1.5 Hz – 30 kHz		+ ½ – 3 dB	
Range Of Control				
Individual filters			±13 dB	
Level control			+ 14 – 9 dB	
Maximum Output Signal at < 1% distortion			> 6 volts	
Maximum Input Voltage			3 volts	
Distortion				
at 2 volts out, controls flat		100 Hz < 0.1%	1 kHz < 0.1%	6.3 kHz < 0.1%
Signal to Noise Ratio at 2 volts out (unweighted)			69 dB	
Input Impedance			50 k	
Output Impedance			4.7 k	



▲ *Fig. 1. Circuit diagram of one channel of the equalizer.*

GRAPHIC EQUALIZER

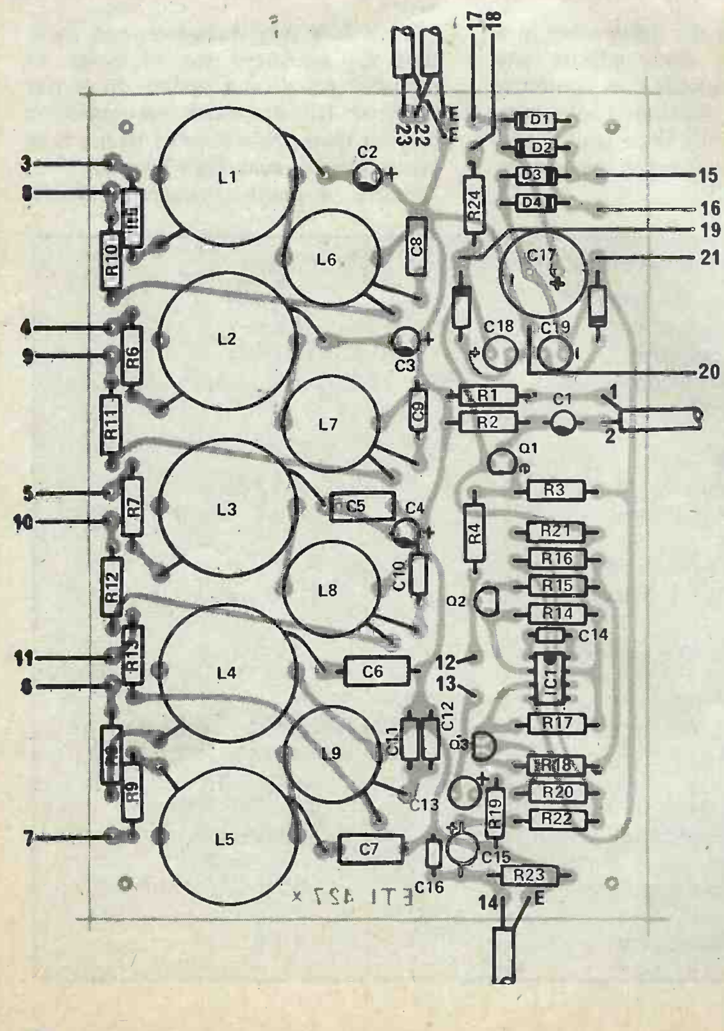


Fig. 2. Component overlay of the equalizer (one channel only)

have filter at 1/3 octave intervals, but except for sound studios and wealthy pop groups, the expense and size of such units are too much for most people.

Recently some excellent commercial units have become available with filters spaced at octave intervals. These are relatively inexpensive and cater for the needs of most professionals and domestic users. Such a unit is the Soundcraftsmen 2012 which we hope to review in the next issue.

The Electronics Today Equalizer has been designed to provide nine filters spaced at octave intervals in each of two channels. It is simple to construct and should be available inexpensively in kit form in the near future.

HOW IT WORKS ETI 427

This equalizer is basically similar to those used in the ETI Synthesizer and master mixer projects with the exception that it has nine filter sections per channel.

The equalizer stage is a little unusual in that the filter networks are arranged to vary the negative feedback path around the amplifier. If we consider one filter section alone, with all others disconnected, the impedance of the LCR network will be 390 ohms at the resonant frequency of the network. At either side of resonance the impedance will rise (with a slope dependant on the Q of the network which is 2.5) due to the uncancelled reactance. This will be inductive above resonance and capacitive below resonance. We can therefore represent the equalizer stage by the equivalent circuit below.

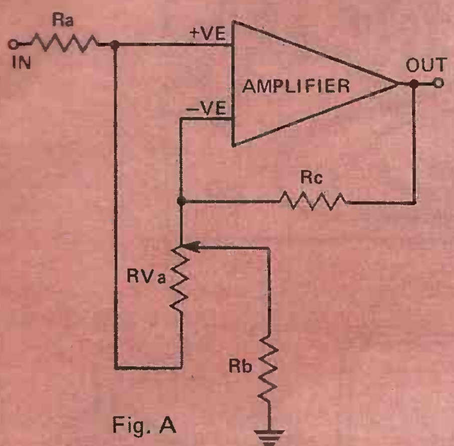


Fig. A

It must be emphasized that this equivalent circuit represents the condition with one filter only, at its resonant frequency. Additionally letters have been used to designate resistors to avoid confusion with components in the actual circuit.

With the slider of the potentiometer at the top end (Fig. A) we have 390 ohms to the OV line from the negative input of the amplifier, and 1 k between the two inputs of the amplifier. The amplifier, due to the feedback applied, will keep the potential between the two inputs at zero. Thus there is no current through RVA. The voltage on the positive input to the amplifier is therefore the same as the input voltage since there is no current through, or voltage drop across resistor RA.

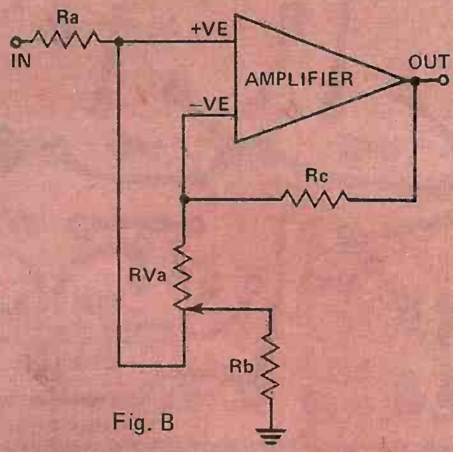


Fig. B

The output of the amplifier in this case is approximately the input signal times (3300 + 390)/390 giving a gain of 19 dB. If the slider is at the other end of the potentiometer, (Fig. B), the signal appearing at the positive input, and thus also the negative input, is about 0.11 (390/(3300 + 390) of the input. There will still be no current in the potentiometer and in RC, thus the output will be 0.11 of the input. That is, the gain will be -19 dB.

If the wiper is midway, both the input signal and the feedback signal are attenuated equally, and the stage will have unity gain.

With all filter sections in circuit the maximum cut and boost available is reduced, but ±14 dB is still available.

Reverting back now to the actual circuit, the amplifier consists of IC1, Q2 and Q3. The transistors help to reduce the effect of the noise in the IC and add gain at the high-frequency end. This additional gain is required because the negative feedback, due to the potentiometer between the two inputs, causes high-frequency roll off. This does not affect operation of the unit provided the open-loop gain is above 60 dB over the entire audio range. An overall closed-loop gain of about 15 dB is

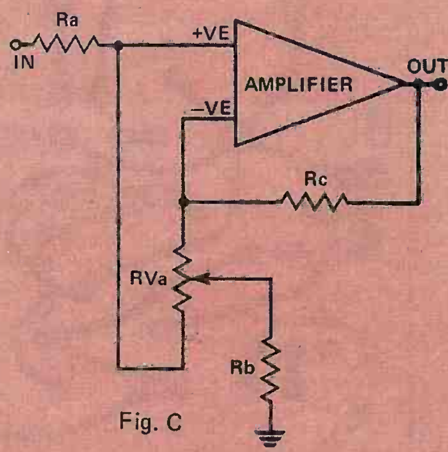


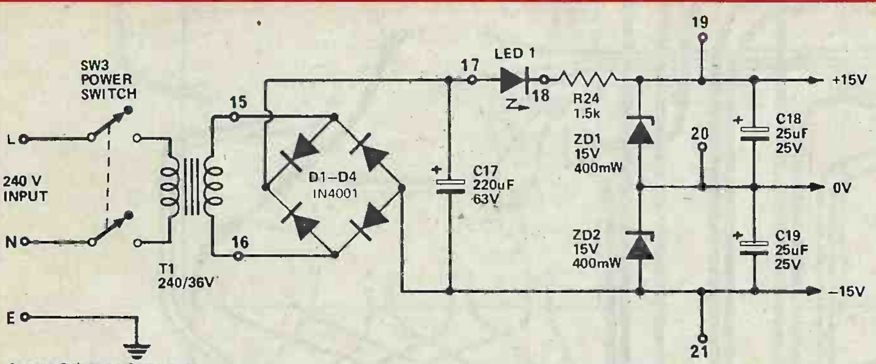
Fig. C

maintained by R20/R19 with the filter potentiometer at mid position.

The output of the amplifier is decoupled to the output of the unit via C15, and C16/R22 provide a cutoff above 30 kHz.

The input signal is buffered by Q1 because the equalizer stage requires a low impedance signal source for correct operation. Potentiometer RV1 provides level control with 0 to -23 dB range which, combined with the equalizer characteristic, results in an overall level range of + 14 to -9 dB.

The power supply used is a simple, full-wave bridge filtered by C17. Plus and minus supplies are derived by means of two 15 volt zeners in series fed via R24. The front-panel power indicator is an LED connected in series with the dropping resistor R24.



Circuit diagram of the equalizer power supply.

CONSTRUCTION

All components, with the exception of the transformer and the slide potentiometers, are mounted on two printed circuit boards — one for each channel. Whilst the layout is not critical, any alternative construction method could be used, we strongly recommend the use of printed-circuit boards to ease construction and eliminate a possible source of faults.

The components should be assembled to the boards with the aid of the overlay Fig. 2. Carefully check polarities of ICs, capacitors and transistors, etc, before soldering in place. Attach lengths of wire and Coax of adequate length to the board before mounting in position by means of 13mm spacers.

Due to the close spacing used for the slide potentiometers it is necessary to mount the 9.6 mm spacers, to the potentiometer support-bars, before mounting the potentiometers. Use 6.4 mm long countersunk screws for this purpose.

The potentiometer assembly, and all other external components, (switches etc) can now be assembled to the chassis and the unit wired as shown in the interconnection diagram.

The circuits used have very high gains and it is necessary to take precautions

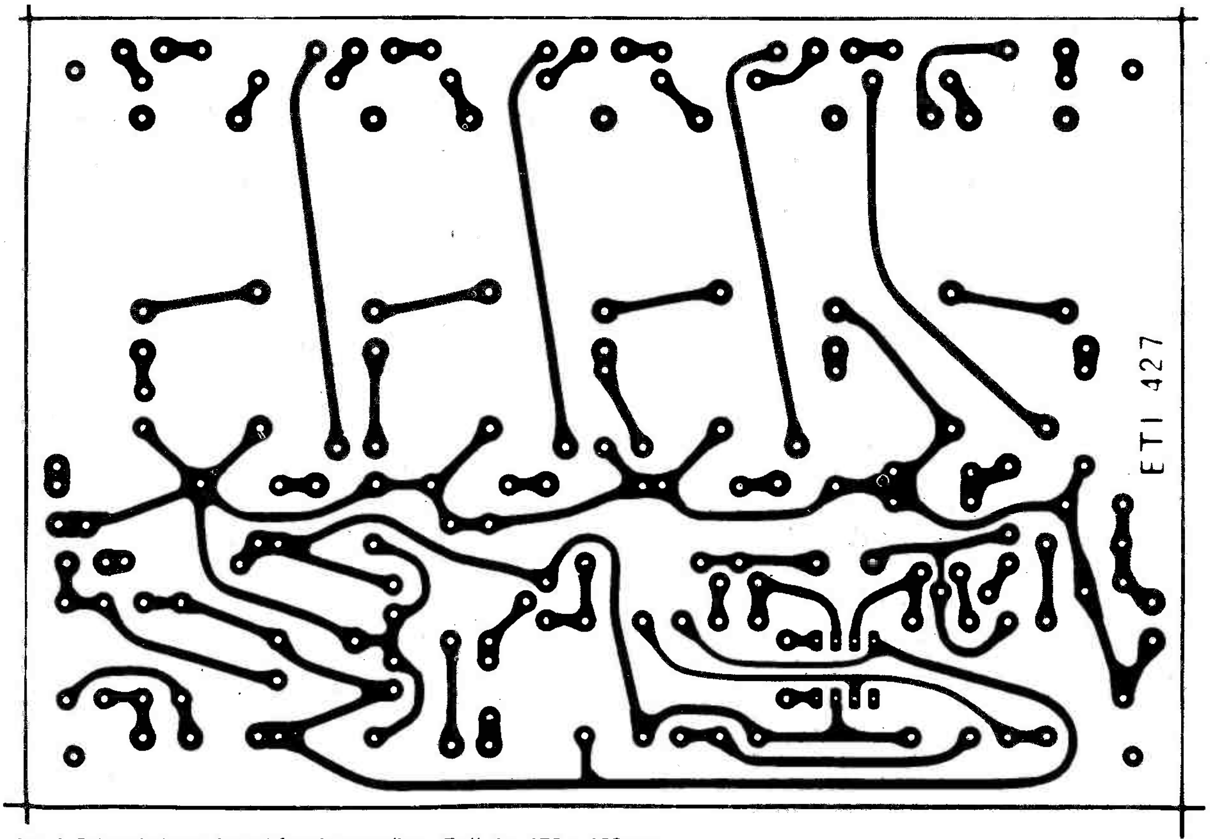


Fig. 4. Printed circuit board for the equalizer. Full size 152 x 103 mm.

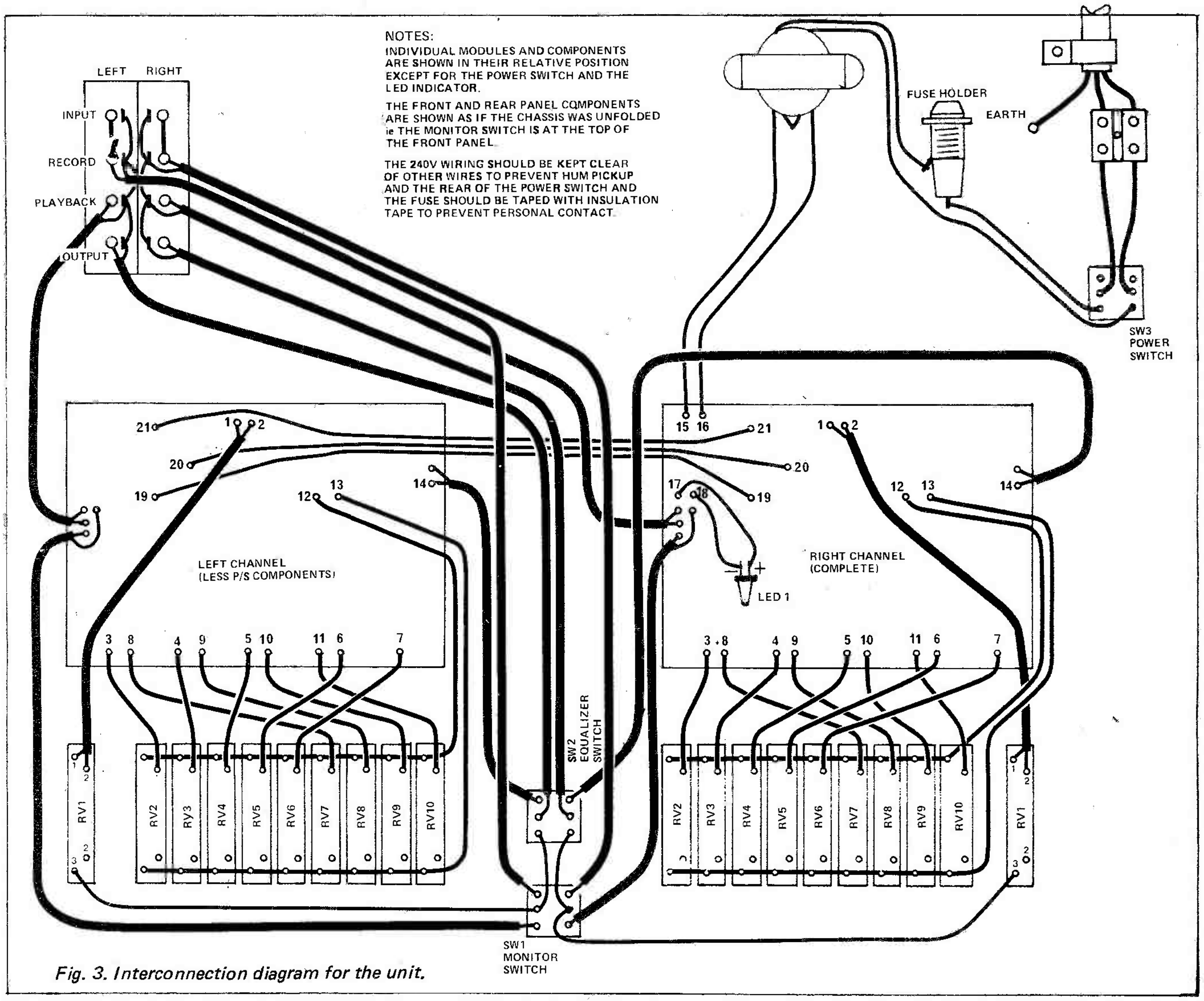


Fig. 3. Interconnection diagram for the unit.

against mains hum-pickup. The transformer should be mounted in the position shown, and the 240 volt wiring, to the front power switch, should be run down the right-hand side of the chassis and along the front, in front of the potentiometer support brackets. If hum pickup does occur, it may be necessary to mount the transformer inside a metal box to shield it.

Due to tolerances of resistors variations in V_{be} of Q2 and Q3 etc, the steady-state output of IC11 may be anywhere within plus or minus one volt of zero.

Hence it is desirable to determine the polarity of the steady state voltage at pin 6 of IC1 in order to determine which way round C15 should be inserted. If the output is positive insert as shown in Fig. 1. Alternatively C15 should be a non-polarized type.

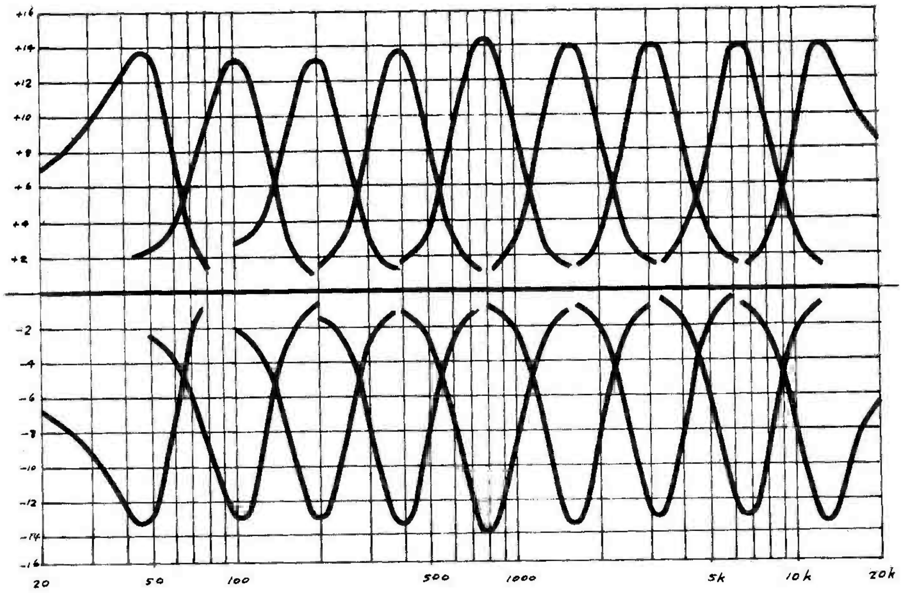


Fig. 5. Individual filter responses for the unit. Boost at top and cut at bottom.

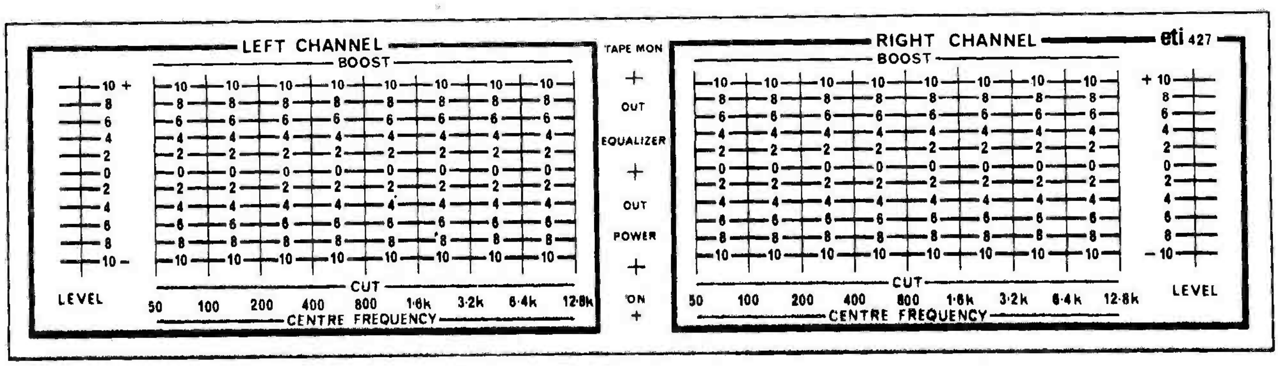
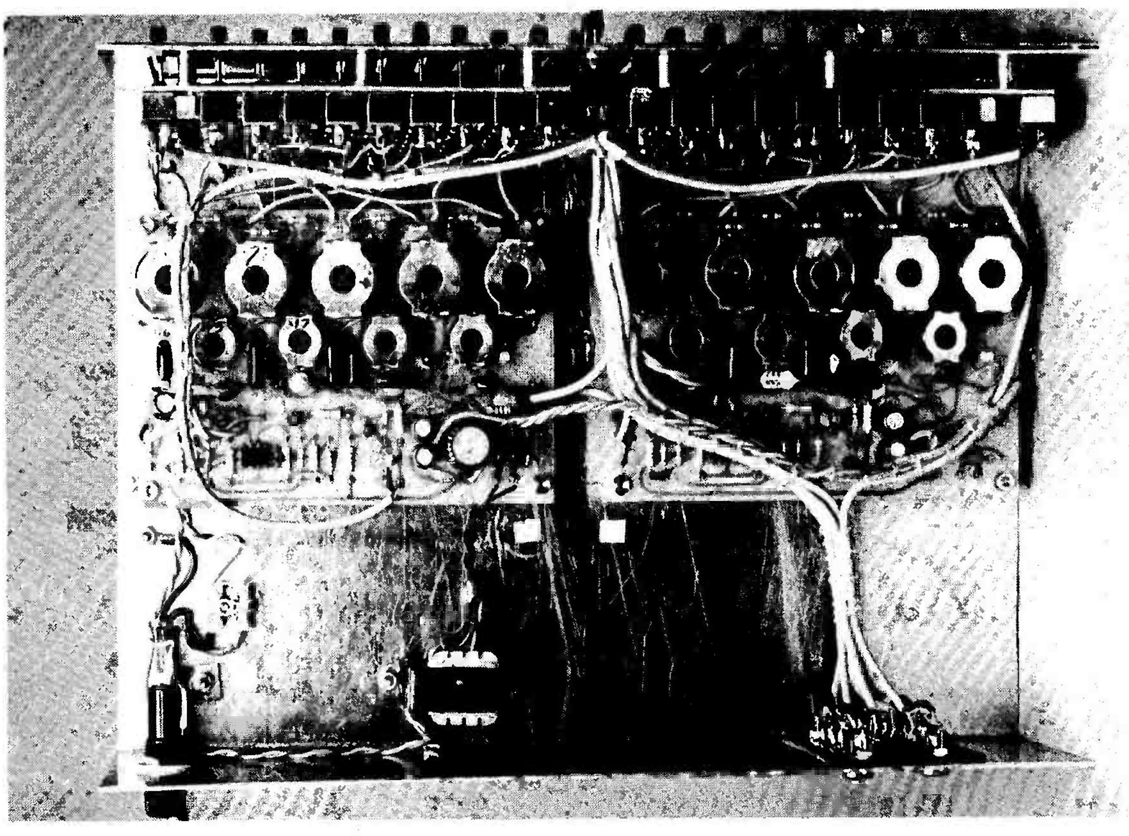


Fig. 6. Front panel artwork for the equalizer. Full size 336 x 88 mm.



Internal layout of the equalizer.

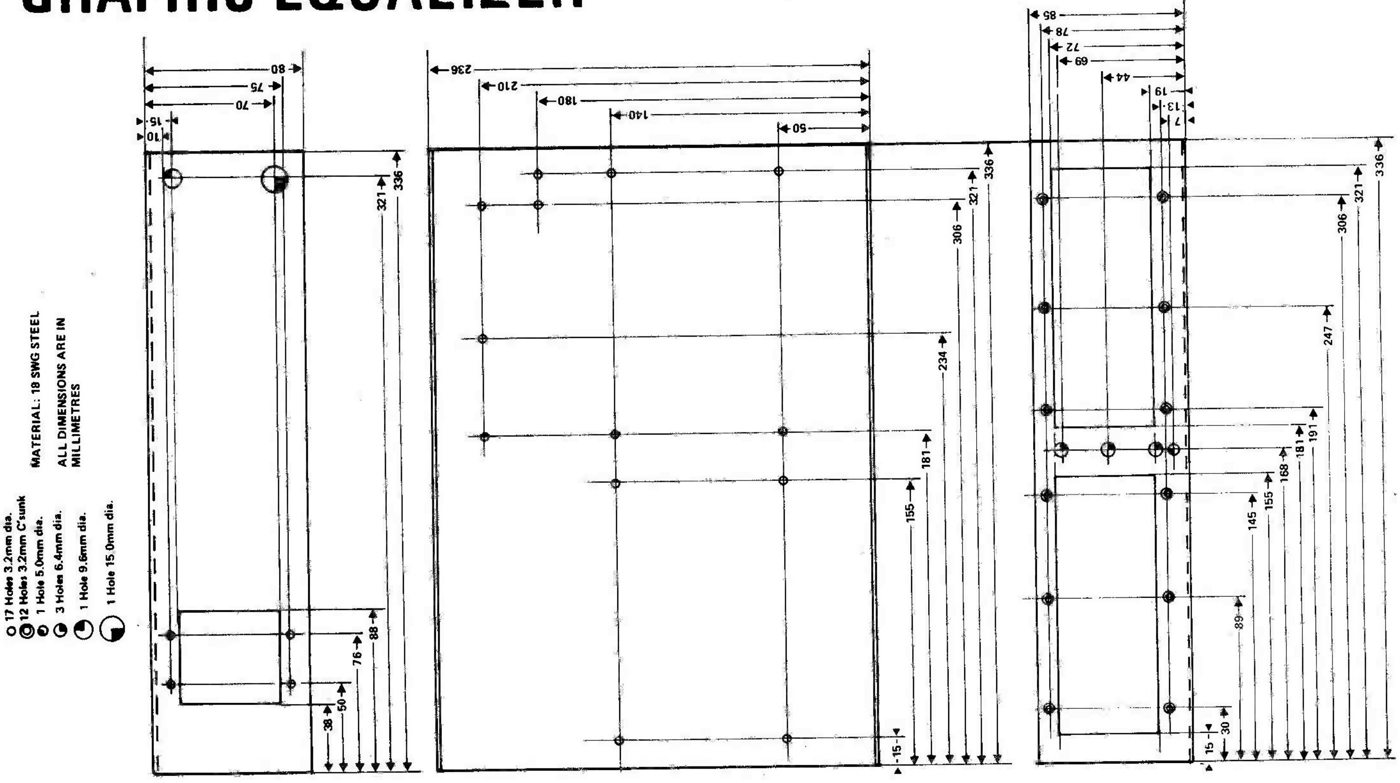


Fig. 7 Detail of the chassis.

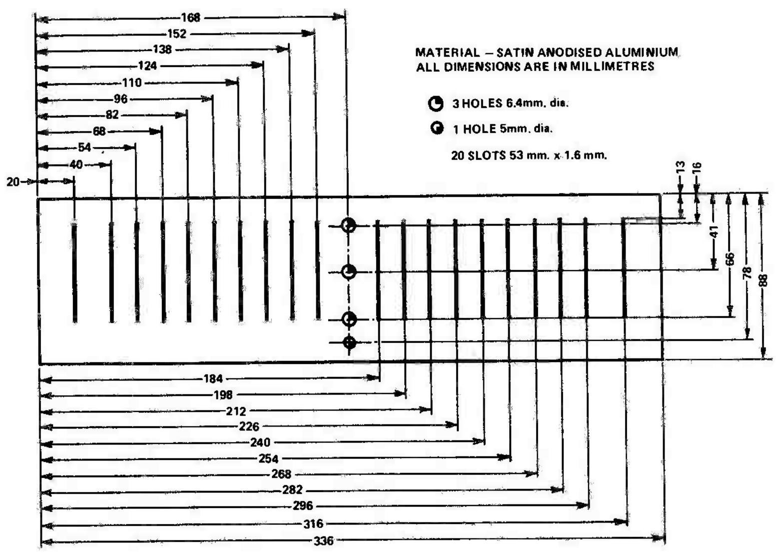


Fig. 8 Metalwork details of the front panel.

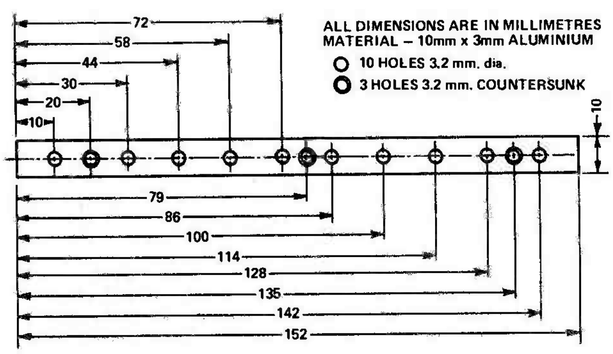


Fig. 9 Drilling details for potentiometer support brackets.

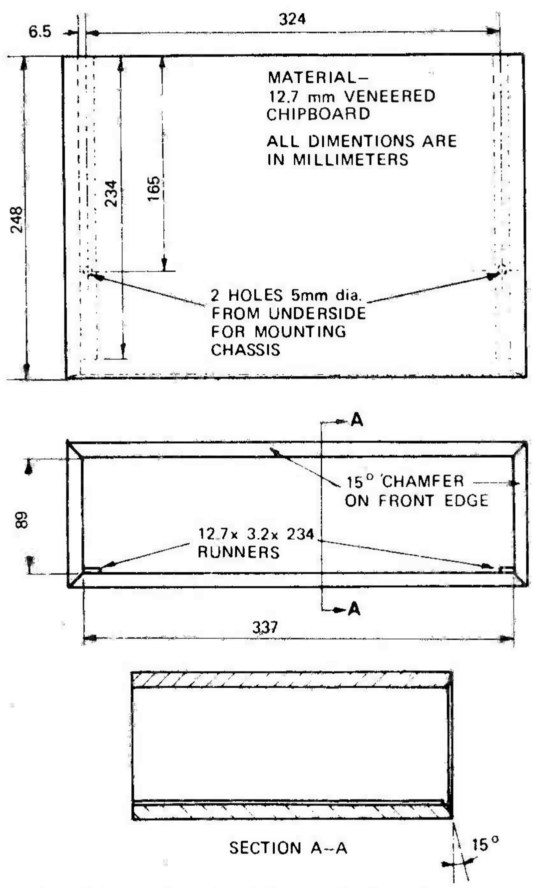


Fig. 10. Constructional details of the cabinet.

PARTS LIST – ETI 427

R5	Resistor	330	½W	5%
R6	"	390	½W	5%
R7,8,9	"	390	½W	5%
R10,11,12	"	390	½W	5%
R13,15,18	"	390	½W	5%
R24	"	1.5k	½W	5%
R1,4	"	3.3k	½W	5%
R19	"	3.9k	½W	5%
R3,22	"	4.7k	½W	5%
R21	"	12k	½W	5%
R20	"	27k	½W	5%
R14,16,17	"	39k	½W	5%
R2,23	"	100k	½W	5%

RV1 Potentiometer 1k lin 45mm slide
RV2-10 Potentiometer 1k lin 45mm slide

C17	Capacitor	220µF	63V electrolytic
C13,18,19	Capacitor	25µF	25V electrolytic
C1,15	Capacitor	10µF	16V electrolytic
C2	"	3.3µF	10V tag. tant.
C3	"	1.5µF	25V " "
C4	"	0.68µF	25V " "
C6	"	0.39µF	polyester
C7	"	0.22µF	"
C5	"	0.15µF	"
C8	"	0.1µF	"
C9	"	0.047µF	"
C10	"	0.027µF	"
C11	"	0.01µF	"
C12	"	0.0022µF	"
C16	"	0.001µF	"
C14	"	10pF	ceramic

L1-L9 Chokes see table 1.
Q1,2,3 Transistor BC109 or similar
D1,2,3,4 Diodes IN4001 or similar
ZD1,2 Zener Diode 15V, 400mW
LED 1 light emitting Diode
IC1 Integrated Circuit LM301A
PC Board ETI 427
For stereo operation double the above components except R24, C17, LED 1, ZD1, ZD2, D1-D4 where only one is required.
Transformer 240V — 36V @ 30mA min.
SW1,2,3 switch DPDT miniature toggle
4-way phono socket, 2 off
Chassis to Fig. 6.
Front panel to Fig. 7 and 8.
20 off knobs for slide pots.
4 pot support rails (Fig. 9)
12 threaded spacers 9.6mm long
8 plain spacers 12.7mm long
24 screws, countersunk head, 6.5mm long to suit spacers
3 core flex and plug
Cable clamp, grommet, terminal block.

TABLE 1
COIL WINDING DETAILS

Coil	Ind.	Turns	Wire	Core	Bobbin	Clip
L1	3.4H	707	40 swg	ITT-C26-4300	BD26	MS26*
2	1.7H	500	40 swg	"	"	"
L3	0.8H	895	38 swg	Mullard LA4543	DT2534	DT2406**
L4	0.4H	632	38 swg	"	"	"
L5	0.18H	424	38 swg	"	"	"
L6	100mH	500	38 swg	Mullard LA4345	DT2470	DT2396**
L7	53mH	364	38 swg	"	"	"
L8	23mH	240	38 swg	"	"	"
L9	13mH	180	38 swg		"	"

* The MS26 clip is not currently available but will be in February 1975; a nylon screw and nut may be used to hold the core together.

** 2 required.

The pot cores and capacitors are being stocked for this project by Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex. Maplin are planning to market a complete kit (less woodwork) of this project in the near future with a selling price of under £50. Arrangements have not been completed at the time of going to press but details from Maplin on receipt of an s.a.e.

●

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If you have no trouble obtaining ETI from your newsagent, that's the obvious place to get it. However five out of the last six issues have been sell-outs and early analysis of the reader questionnaire has shown that one in three readers has trouble in buying ETI.

If you are one of those having trouble, why not take out a subscription? Normally you receive your copy a few days before our official publication. Note also that although the cover price of ETI is now 25p, we have not raised our subscription rates for the time being.

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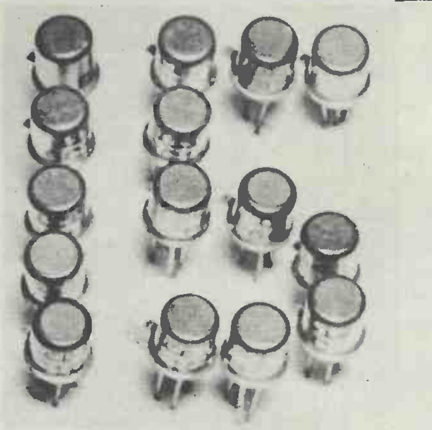
JANUARY 1975 . . . .

ETI OFFERS

transistors



This, as most readers will know, is the most universal transistor!

MAX RATINGS:

V_{CBO}	.... 30V
V_{CEO}	.... 25V
V_{EBO}	.... 25V
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H_{FE}	.... ⩾380
F_T	.... 250MHz
P_{TOT}	.... 300mW

BC108C

Metal can TO18 silicon planar expitaxial construction

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what to look for in February's eti

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FEBRUARY 1975 ISSUE
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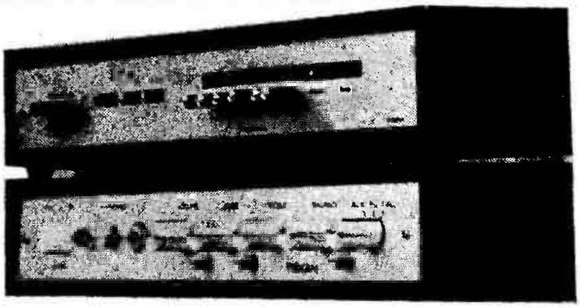
The features mentioned here are, at the time of this issue going to press, in an advanced state of preparation. However, circumstances, including highly topical developments may affect the final contents.



KITS

INTRODUCTION

Kits for the amateur constructor have gone through various phases in the last few years. In the mid-1960's most of the kits available were based on surplus equipment and components: frankly many of the kits were poor. Now the situation has changed considerably. Instructions and component quality is vastly better and there have probably never before been as many kits as now.

Originally kits were introduced to save money and many still show a worthwhile saving over the ready-built models. On the other hand many people opt for a kit mainly for satisfaction of having built it for themselves: indeed in some cases the kit costs more than a commercially built model.

Many companies now produce "modules". It is difficult to draw the line where kits and modules start. We have included modules where we consider that they constitute a kit but not when the module is really a built unit only requiring a few wires.

In this survey we have tried to give a bit more information that is normally available such as service charges and building time. We have also included details of many less well-known kits available from smaller companies.

Under the main headings we have included all of the kits that we could find (except one company who would not give us information) but in the Miscellaneous and Test Gear sections the number of kits make it impossible to deal with all but a few.

Almost always a complete kit costs less then the individual components: additionally very attractive, often professional looking, cases are available.

All the companies we have included will service units which have been built up and fail to work. We have also given details of kits which are suitable for the beginner.

GUIDE EXPLANATION

Prices shown include VAT at 8% and postage except where goods are not available mail order, these are marked with an asterisk. Some prices include optional extras, such as cases. Prices are correct at the time of going to press but it may be necessary to check before ordering.

Time is the average in hours (indicated by the makers) for an average constructor.

Beginners indicates that the makers consider the kit suitable for beginners though many feel that ability to solder is essential.

Built indicates that complete guaranteed models of the kit are available from the same supplier.

Service Charge. All companies have a servicing facility and all, except for Josty, reserve the right to charge. Some companies have a basic charge but this does not mean they will always make it or that this is a maximum. In many cases replacement components are extra and charged at cost. Josty guarantee unconditionally no service charge. Heathkit charges vary but are never higher than 10% of the kit's cost. A "V" in this column indicates that charges depend on the work necessary. Most companies (not all) make no charge if a faulty component is to blame.

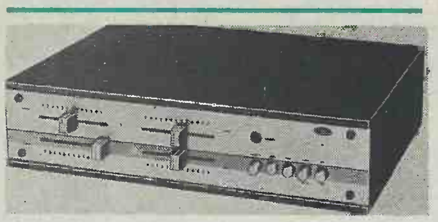
Overseas. Some companies are not prepared to despatch orders overseas. Of those that do, virtually all charge extra postage but are less VAT making some prices cheaper, other dearer.

Literature. Leaflets are available for many of the kits. Josty, Heathkit, Tandy and Amtron have detailed catalogues which contain full details (Amtron have a 10p charge for this). A large stamped, self-addressed envelope should be sent when requesting leaflets etc.

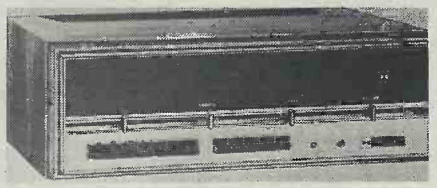
Size. Dimensions of the completed unit to nearest ¼".

Suppliers are listed at the end; the number refers to the company from whom details are available. Tandy kits are *not* available mail order; Josty kits are available mail order but only from certain retailers (these are given in their catalogue).

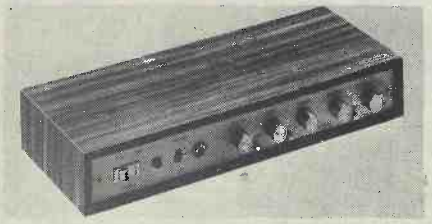
ETI KITS REVIEW



Amtron Shown above is the UK185 with 20W per channel and 0.5% distortion. Frequency response is 20Hz-20kHz ±1dB with three inputs. 15 transistors are used in the circuit. The UK187, shown on the cover, is also 20 r.m.s. per channel and has a similar specification, the main difference being a 'Quadrik' feature which gives a 4-channel effect. The UK110/A is a very simple amplifier without power supply and case but can be run from 12V.



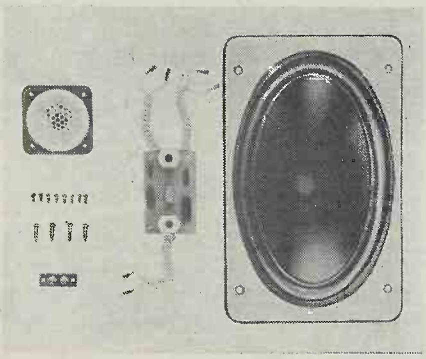
Heathkit do several stereo amplifiers, the one shown is the AA-29 producing about 35W per channel. The spec puts this into the true Hi-Fi category. The AA1214 gives 15W in each channel, has a good spec though not as high as the AA-29.



Henelec Texan Now a well established design, 20W per channel and with an excellent specification. Very slim line construction and originally designed by Texas engineers.

Harverson Despite the name this gives 14W r.m.s. per channel (nice that some people are conservative). Has very good specification. Price here includes power supply and cabinet which are available separately.

Josty 310 is made up from four individual kits which require a cabinet to house them. Specification is said to be good and output of the system is 10W per channel.



Helme XL Range includes five models, one is shown above. No soldering is necessary in most cases. Cabinets have to be built from your own resources but instructions and diagrams are provided.

Baker Major Module is provided as speakers with a simple crossover, handling power is 20W. Baffle board is provided.

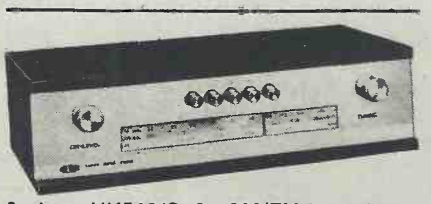
STEREO AMPLIFIERS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Amtron UK110/A	12.73	3	√	X	V	X	C	7x3½x2	5W p.c. Needs case. 12V operation.	1
Amtron UK185	56.64	20	√	X	1.00	√	C	14½x10 x3¼	20W p.c.	1
Amtron UK187	74.64	24	√	X	1.00	√	C	18½x10 x3¼	50W p.c. Synthetic Quad facility.	1
Harverson 10+10	21.60	10	X	√	5.00	√	X	12x8x 2¾	Testmeter essential	14
Heathkit AA-1214	49.70	10	√	√	V	–	C			15
Heathkit AA-29	113.50	24	√	X	V	–	C	5¼x16¾ x14½		15
Henelec Texan	33.93	6	X	√	2.00	√	√	14½x6x2		17
Josty 310	47.23*	4	√	√	–	√	C	–	Uses GP310, NT310 and 2xAF310 kits.	20

LOUDSPEAKERS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Baker Major Module	10.95	½	√	√	V	√	√	19x12½	Requires cabinet.	2
Helme XL Range	c 15–50	–	√	√	V	√	√	–	Various kits. Need cabinets (also available as kits).	16
R & TV Components 950	21.00	–	√	X	–	X	X	–	5 speakers and crossover. Requires cabinet.	22
Heathkit AS-9515	14.05	2	√	√	V	–	C	7x12x6	15W	15
AS-9520	3460	2	√	√	V	–	C	12x20x 10	20W	
AS-9530	54.00	2	√	√	V	–	C	16x26x 12	30W	
AS-9560	81.00	2	√	√	V	–	C	32x16x 12	60W	

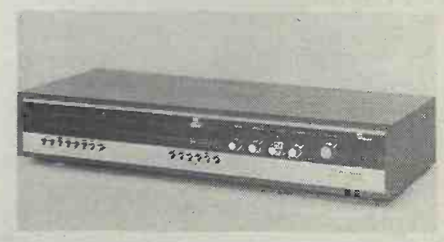
AM/FM TUNERS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Amtron UK540/C	21.28	8	√	X	1.00	√	C	12x3¼ x5¾	Not stereo. Inc. cabinet.	1
Heathkit AJ1214	51.90	7	√	√	V		C			15
Heathkit AR2000	105.90	25	√	X	V		C	24½x4½ x11	Cabinet extra.	15

Heathkit have four speakers covering 15W-60W. These come complete with cabinets.

R & TV Components have a set of five speakers with crossover which will handle 45W.



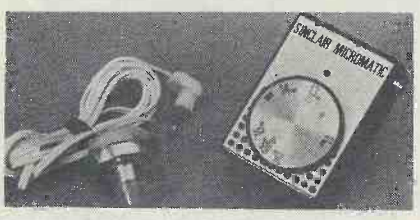
Amtron UK540/C. An AM/FM tuner (no amplifier). Inexpensive but does not have a decoder.



Heathkit AR2000 has LW/MW/SW and FM with a stereo amplifier giving 18W per channel. Spec lifts this into the Hi-Fi category. Alternative attractive cabinets are available for £10.80. A less expensive AM/FM tuner-amplifier from the same company is the AR1214 giving 15W r.m.s. Tuner has MW and FM bands. Cabinet included.

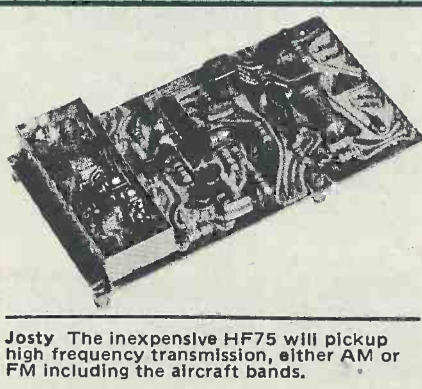
FM TUNERS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Heathkit AJ 29	124.20	18	√	X	V	–	C	5¼x16¾ x14½		15
Heathkit AJ1510	314.00	30	X	X	V	–	C	6x16½x 14¾	Inc. cabinet. Reviewed in ETI Oct. 74.	15
Henelec Stereo FM Mk III	23.13	5	X	√	2.00	√	√	7¾x6x2	Reviewed ETI June 74.	17
FM Varicap Stereo Tuner	28.50	2	√	√	V	√	√	8¾x2¾x 6½	Reviewed ETI June 74.	10
Josty HF325	28.44*	2	√	√	–	√	C	–	No cabinet. Part module.	20
Nelson Jones	32.21	7	X	X	V	√	√	6¾x15½ 2¾	Price Inc. Lowest cost decoder.	18
Hart FM3	31.16	3	√	X	1.00	√	√	4½x1½x 10	Uses modules. Inc. Case.	13
Integrex Low-cost Stereo Tuner	29.00	3	√	X	V	√	√	6¾x15½ x2¾	Inter-station mute.	18

MISCELLANEOUS RADIOS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Sinclair Micromatic	2.68	1	√	√	V	√	V	1¾x1¼x ½	Ultra miniature, earphone only.	23
Heathkit Tiger FM	10.20	5	√	X	V		C	11x6½x 3¾		15
Heathkit 4-Band SW717	33.50	8	√	X	V		C	5½x14½ x8		15
Heathkit 6-Band GR78	96.15	16	√	X	V		C	6¼x11½ x9		15
Amtron UK525/C	12.71	4	√	X	1.00	√	C	6¼x5¼x 2½	120–160MHz	1
Amtron UK 546 AM/FM	6.65	4	√	X	1.00	√	C	3x4x1¾	25–200MHz	1
Amtron UK515	7.92	4	√	X	1.00	√	C	6x3x1½	MW Radio	1
Amtron UK500	29.01	15	√	X	1.00	√	C	16x3¼x 5¾	AM/FM Receiver	1
Josty HF75	3.95*	1	√	√	–	√	C	–		20
Codar Multiband-6	17.33	5	√	X	2.00	√	√	11x5x 4¾		5
Johnson's CV2 Globe King	5.00	2	√	√	1.50	√	√	4x4x2	80–180MHz	19
HAC DX One-Valve	4.50	2	√	X	1.50	√	√	6x6x4	S.W. tuner	12
HAC K Mark 2	8.50	2	√	X	1.50	√	√	6x6x4	S.W. tuner	12
Globe Patrol	15.49*	3	√	X	V	–	C	5x9x4	4 Bands	24



Sinclair Micromatic. Perhaps the most common introduction to kit building. Has been around for years but remains a favourite. TRF, reflex, two transistor circuit using two mercury batteries.

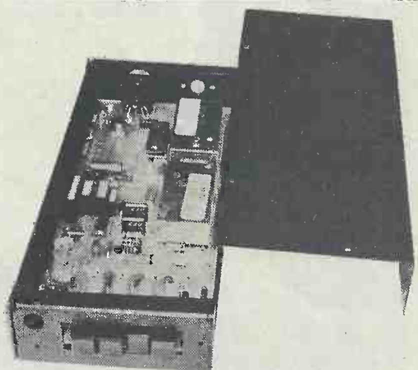
H.A.C. have two kits, one using a valve but is a tried, tested design. Ideal beginners kits.



Josty The inexpensive HF75 will pickup high frequency transmission, either AM or FM including the aircraft bands.

Heathkit have two, very high spec FM tuners. The AJ29 is of fairly conventional design but the AJ1510 is an incredible unit with digital tuning and a fabulous number of facilities. The AJ29 is illustrated above.

Henelec Stereo FM Mk III uses slider pot to control the varicap tuning. 9 transistors, 9 diodes and decoder i.c. are used. No test equipment is required. Can be modified to cover aircraft bands.



Hart produce an unusually shaped push-button tuner using prealigned modules. This is designed to be adjacent to record player plinth.

Electrospares FM varicap stereo tuner has five push-buttons and uses pre-aligned r.f. and i.f. modules. Incorporates PLL decoder. Attractive cabinet included.

Josty HF325 uses prealigned tuner which can operate from 12—55V, designed to connect to their HF330 stereo decoder (£11.40).

Integrex produce two FM tuners, the Nelson-Jones which got a good review in June's ETI albeit a fairly complex kit. They have since brought out a simpler, slightly cheaper model which uses prealigned modules.

Amtron have a variety of receivers and tuners covering most bands, including some unusual features. Those interested are referred to their catalogue.

Codar The Multiband-6 comes from a company who normally produce ready-built receivers. It is a TRF covering 550kHz—30MHz. Uses four coils and modules. SSB facility. Loudspeaker not supplied. Uses PP6 battery.

Heathkit have a wide range of receivers ranging from portable sets such as the Tiger FM up to multiband receivers of professional quality. The SW717 covers 550kHz to 30 MHz with a large dial. The GR78 has additional long wave and better bandspread. Runs off rechargeable batteries.

Johnson's market a triple purpose VHF kit covering 8 —180MHz, it can be used as a converter, tuner feeder or as a receiver with headphones.

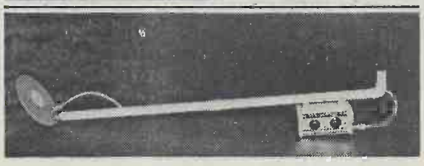
Tandy Globe Patrol. A simple receiver covering 540kHz—30MHz. Built-in speaker and comes with 'where to listen' guide. Battery powered.

ETI KITS REVIEW

Heathkit have a push-button car radio kit in their range suitable for 12V +ve or —ve chassis models. Medium and long wave coverage.

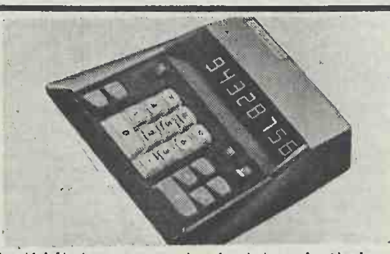
R & TV Components produce the inexpensive Tourist in two models, the Mk I which is cheaper but requires quite a bit of work but the Mk II is suitable for beginners as no soldering is required! The company tell us that there are considerable delays at present on the Mk II.

Heathkit have two induction balance metal locators in their range, the GD348 is shown. This has speaker output and a meter. The GD48 is an older model, still available, at a lower price.

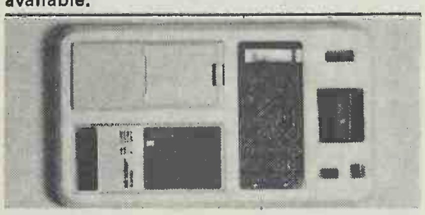


Minikits market the Treasure Tracer Mk III with speaker output and using the BFO principle. This comes with a prebuilt search head.

Amtron produce the electronics section for a metal locator operating using the BFO principle. A handle is all that is required.



Heathkit have several calculators in their range, the one illustrated is the desktop IC2108 which is mains operated with large displays. Rechargeable models are also available.



Sinclair calculator kits are well known and ETI has given details in the past of both the Cambridge and Scientific (the Scientific kit is illustrated). At £19.95 this is by far the cheapest scientific calculator available.

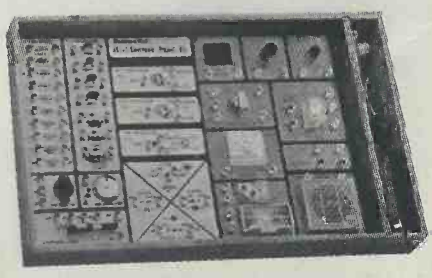
CAR RADIOS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Heathkit CR9502	20.55	5	√	X	V		C	7x6x2	Push-button	15
Tourist I	7.15	7	X	X	2.50	X	√	7x4¾x2	Push-button	22
Tourist II	8.25	2	√	X	2.50	X	√	7x4¾x2	As Tourist I but no soldering. (long deliveries at present)	22

METAL LOCATORS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Amtron UK 780	13.09	2	√	X	1.00		C		Handle not included	1
Heathkit GD 348	48.60		√	X	V		C	–	Induction Balance	15
Heathkit GD 48	37.80		√	X	V		√	–	Induction Balance	15
Treasure Tracer Mk III	11.03		√	√	V	√	√	–	BFO	21

CALCULATORS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Heathkit IC 2006	39.95	8	√	X	V		C		Other models available	15
Heathkit IC 2108	43.20	8	√	X	V		C	7x2¼x 9¾	Desk top model.	15
Sinclair Cambridge	14.95	2	√	√	2.50	√	ads	4½x2x¾		23
Sinclair Scientific	19.95	2	√	√	2.50	√	ads	4½x2x¾	Details in Oct. 74 ETI.	23

MULTIPLE BUILDING MODULES	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Electroni-kit	8.80 to 33.95	–	√	–	–	√	√	–	Several versions	9
Tandy	8.99 to 17.95 *	–	√	–	–	X	C	–	Several versions	24

Electroni-Kit have a wide range of building modules for the absolute beginner, the simplest of these will make up 16 projects whilst the largest enables 150 circuits to be built. There are 'add-on' kits also available. Each comes with a very extensive manual describing each circuit.



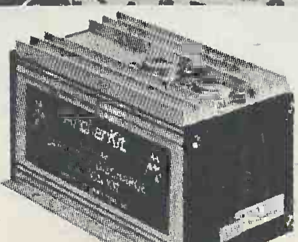
Tandy stores market four starters modules which are a base-board with spring clips. All that is necessary is to connect hook-up wires to the points specified. The simplest makes up 20 circuits whilst the dearest has 100 ideas. These come complete with an educational manual.

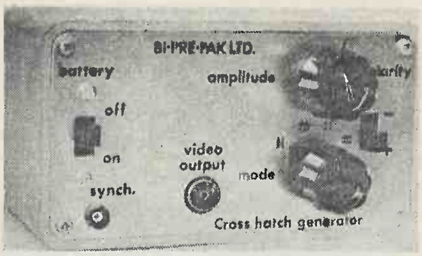
TEST GEAR	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Cross-Hatch Generator	8.71	4	√	√	1.77	√	√	5¼x3x3	Leads 54p extra	3
A.F. Signal Generator UK437	23.20	8	√	X	1.00	√	C			1
Digital Frequency Meter IB-1101	91.80	15	√	√	V		C	3½x8¼x 9	1Hz—100MHz, 5-digit.	15
Chart Recorder IR-18M	100.45	20	√	√	V		C	15x6x9¼	Paper rolls £2.20 each	15
5MHz General Scope IO-102	84.25	12	√	√	V		C	12¾x9¼ x16¼		15

The Amtron and Heathkit catalogues both contain an extensive range of test equipment. Readers interested primarily in test equipment are referred to these. Both these catalogues and the one from Josty contain details of numerous power supplies.

DIGITAL CLOCKS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Digitronic II	32.12	2	√	√	50p	√	√	5¼x4¼x 2¾		4
Heathkit GC 1005	34.55	6	√	—	V		C	7x2½x4¾	Alarm clock.	15
Amtron UK820GB	36.24	15	√	X	£1	√	C		Shows seconds.	1

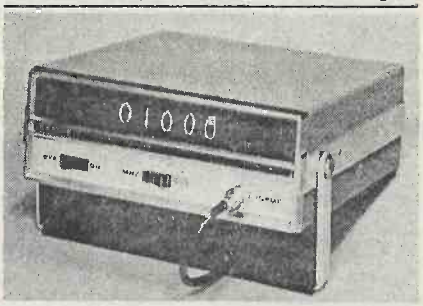
ELECTRONIC IGNITION	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Amtron UK875	14.47	3	√	X	1.00	√	C	4x2¾x 2¾	—ve earth.	1
Bi-Pre-Pak	6.73	6	X	X	1.87	√	√	5½x4x3	ETI Design, +, —ve earth.	3
Dabar Scorpio	12.72	4	√	√	2.16	√	√	7¼x4¾x 2¼	6/12V, +, —ve earth.	7
Electrospares Scorpio	11.50	4	√	√	V	√	√	4¾x3½x 2¼	6/12V, +, —ve earth.	10
Heathkit CP 1060	25.95	2	√	X	V	—	C	3¼x3¾x 6	—ve earth.	15
Sparkrite Mk2	10.93	2	√	√	2.20	√	√	6x4x3	+, —ve earth.	8
Tandy	28.95*	3	√	X	2.50	X	C	5½x3x3½	—ve, earth.	24



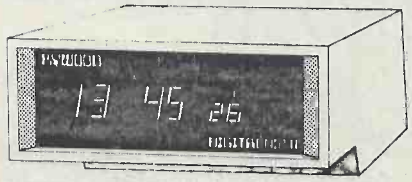


Bi-Pre-Pak sell a Cross-Hatch generator which enables a colour TV set to be properly converged. This is cheap enough to fit permanently into the back of your TV.

Amtron's UK437 shown on the cover and is an A.F. Signal generator covering 15Hz—22kHz in three ranges. It has distortion of 1% and a maximum output of 2V. Amtron's range in the test gear field is extensive and reference should be made to their catalogue.

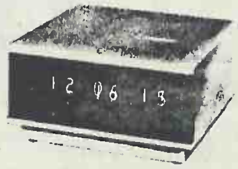


Heathkit have a very wide range of test gear in their catalogue. We show their IO-103 Scope and the IR-18M chart recorder on the cover. The range in the test gear is huge - several oscilloscopes and digital frequency meters for a start. This varies in cost from true professional to amateur market.



Bywood's Digitronic II is a kit available in various versions from a company who specialise in digital clocks. A recent ETI offer on these proved very popular. The Digitronic II is shown on the cover.

Heathkit's GC1005 is one of the company's most popular products and is featured on the cover their catalogue. It has an alarm facility. Another model - the GC1092A at £50.80 is now available with a variety of extra features including reserve battery operation.



Amtron also have a digital clock in their range which uses 15 TTL I.c.s.

Bi-Pre-Pak's electronic ignition is based on the ETI design of September 1973. This is suitable for positive or negative chassis operation and incorporates a burglar foiling devices.

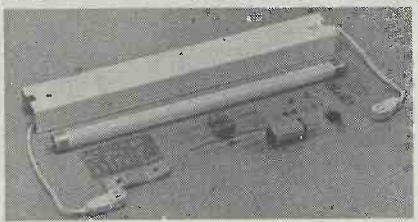
ETI KITS REVIEW

TELEVISIONS	PRICE	TIME	BEGINNERS	BUILT	SERVICE CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPPLIER
Forgestone 400	About £200	70	X	X	V	√	√	Depends c.r.t.	Price depends on screen size. Colour.	11
Heathkit GR9900	68.00	12	√	X	V		C	16½x10½ x9	240V/12V B & W.	15

Forgestone have the only DIY colour TV kit on the market; this is available with several screen sizes. Details were given in November 1974 ETI.

Heathkit market a 12in. B & W TV for the U.K. UHF bands which can be mains or 12V battery operated.

MISCELLANEOUS	PRICE	TIME	BEGINNERS	BUILT	SPECIAL CHARGE	OVERSEAS	LITERATURE	SIZE	NOTES	SUPLIER
Fluorescent Light	3.19	½	√	√	85p	√	√	12x1½ x2	Diffuser 59p each.	8
Nova Lighting Display	26.34	3	√	√	V	√	√	24x12 x1¾		6
Microtrol Radio Control	88.60		X	√	V	√	√	–	Complete system.	25
Stereo Headphones	13.49*	3	√	X	V	X	C	–		24
Noise Reduction Unit UK127	8.76	4	√	X	1.00	√	C	4x3x1½		1
Lie Detector	7.95*	3	√	X	V	X	C	–		24
Guitar Preamplifier UK835	5.62	2	√	X	1.00	√	C	4x3x1½		1
AM/FM Aerial Preamp UK230	3.59	2	√	X	1.00	√	C	3x2x1¾	VHF/UHF (UK285)	1
Aerial Preamp HF380	6.51*	2	√	X	–	√	C	–		20
Capacitive Burglar Alarm UK790	8.94	3	√	X	1.00	√	C	4x3x1½		1
Ultrasonic Alarm UK815	26.08	20	√	X	1.00	√	C	6½x2x 5½		1
Heathkit Informer GD-39	28.10	12	√	X	V		C	2½x10¼ x7½	Ultrasonic	15
200W Light Dimmer UK640	8.84	2	√	X	1.00	√	C	3x2½x 1½		1
400W Light Dimmer AT56	5.60*	2	√	X	–	√	C	–	2.2kW version available.	20
Psychadelic Light Control AT65	17.85*	2	√	X	–	√	C	–		20
Digital Thermometer ID-1390E	38.90	12	√	X	V		C	2½x7x5		15
Stereo 21	20.55	4	√	X	£2.50	X	X	–	No soldering.	22



E.D.A.'s Fluorescent light is a simple unit which runs from a 12V battery and produces 8W.

Cosmic's Nova Light Display is a slim unit which needs no direct connection to the sound source; a mike is used.

Teleradio's Microtol Radio control equipment is sophisticated and controls up to five functions.

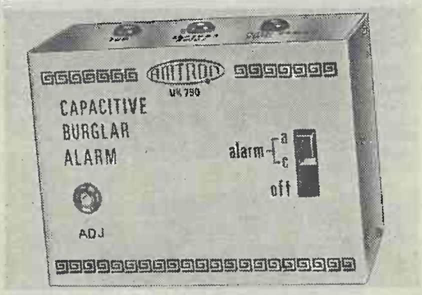
Tandy market a pair of stereo headphones in kit form which incorporate a volume control for each ear. 8-24 ohms.

Tandy's Lie Detector relies on changes in skin resistance under tension which alters an audio tone.

Amtron's Noise Reduction unit alters the pass-band dependent on input level thus being more effective than a scratch control.

Amtron's Guitar Preamplifier has low output impedance and is suitable for most guitar magnetic pickups. Gives 32dB gain.

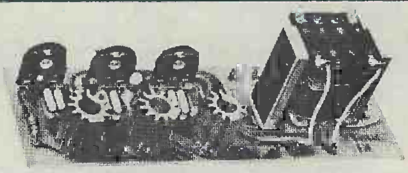
Aerial Preamplifiers are available from Josty and Amtron. Details of frequency coverage and gain are in the catalogues.



Amtron market a number of burglar alarm units which use a variety of trigger systems. The UK790, a capacitive type, switches when a body comes near it.

Heathkit's Informer Ultrasonic Intrusion Alarm is built into book form. It has a built-in 30 sec delay. A suitable alarm bell is available for £7.55.

Light Dimmers covering 200W to 2.2kW are sold by Josty and Amtron.



Josty's Psychadelic Light Control 400W in each of three frequency channels. Lights, case etc. are not included.

R & TV Components have a very inexpensive stereo system which gives a very decent sound if not Hi-Fi. Glue is all that is required.

Heathkit's Digital Thermometer has the appearance of a digital clock and gives either Fahrenheit or Centigrade readings in the range —30° to +50°C. Monitors both inside and outside temperature.

INDEX TO KIT COMPANIES

1. Amtron (U.K.) Ltd.,
4-7 Castle Street,
Hastings,
Sussex.

2. Baker Loudspeaker Co.
Bensham Manor Passage,
Thornton Heath,
Surrey.

3. Bi-Pre-Pak Ltd.,
222-224 West Road,
Westcliff-on-Sea,
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4. Bywood Electronics,
181 Ebberns Road,
Hemel Hempstead,
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5. Codar,
Valcon Works, Burrell Buildings,
Churchill Industrial Estate,
Lancing, Sussex.

6. Cosmic Electronics,
62 Ongar Road,
Brentwood,
Essex.

7. Dabar,
98 Lichfield Street,
Walsall,
Staffs, WS1 1UZ.

8. Electronic Design Associates,
82 Bath Street,
Walsall,
Staffs, WS1 3DE.

9 Electroni-Kit,
498 St. John's Street,
London E.C.1.

10. Electrospares,
288 Ecclesall Road,
Sheffield.

11. Forgestone Colour Developments Ltd,
Ketteringham,
Wymondham,
Norfolk.

12. H.A.C. Shortwave Products,
P.O. Box 16,
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Sussex, RH19 3SN.

13. Hart Electronics,
Penylan Mill,
Oswestry,
Salop.

14. Harverson Surplus Co. Ltd.,
170 High Street,
Merton,
London S.W.19.

15. Heath (Gloucester) Ltd.,
Gloucester GL2 6EE.

16. Helme Audio Products Ltd,
Summerbridge,
Harrogate,
Yorks.

17. Henry's Radio Ltd.,
303 Edgware Road,
London W2 1BW.

18. Integrex Ltd.,
P.O. Box 45,
Derby,
DE1 1TW.

19. Johnson's Radio,
Shaw Street,
Worcester,
WR1 3QQ.

20. Josty Kit (U.K.) Ltd.,
P.O. Box 68,
Middlesbrough,
Cleveland,
TS1 5DQ.

21. Minikits Electronics,
35d Langley Drive,
London E11 2LN.

22. Radio & TV Components (Acton) Ltd.
21 High Street,
Acton,
London W3 6NG.

23. Sinclair Radionics,
St. Ives,
Hunts.

24. Tandy Corporation,
Bilston Road,
Wednesbury,
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WS10 7JN.

25. Teleradio,
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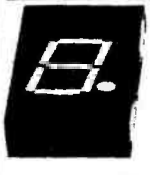

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The MHI clock kit is partnered by the MHI display kit, a set of four or six LED displays plus a PCB. This PCB interfaces directly to the clock PCB. The four main units (clock PCB, display PCB, switch matrix, transformer) may be mounted up to 15" apart from each other for use where there is not room for the whole unit behind the display board.

The additional components required to complete the unit are standard components available through most component outlets.

CLOCK KITS –

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MHI-5025/S	£11.35
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DISPLAY KITS –

MHI-D707/4	£ 7.60
MHI-D707/6	£11.00
MHI-D747/4	£10.25
MHI-D747/6	£15.15

All prices on this advert exclude VAT.

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CLOCK CHIPS:

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MK50250	6 digit alarm chip with alarm tone out-put, Standard basic alarm facilities.	£ 7.60*
CT7001	Time, Date & Alarm on one 6 digit chip. The Alarm can be used in 3 modes including a time switch. Clock-Radio & Snooze features. 7 seg outputs, 50/60Hz or 100.8kHz input frequency.	£ 9.80*
CT7002	As CT7001 but with BCD outputs not 7 seg.	£ 9.80
TMS3952	Stopwatch chip, most reqd. stopwatch functions 6 digits (hhmmss or mmssss), 300kHz input. 7 seg output. Special price.	£10.50
HEEC2	8 digit (HhMmSsss), stop/start/reset, 50Hz/60Hz/100kHz input, BCD output hard-wired alarm with repeat (snooze). Can also be used as 8 digit decade counter.	£ 8.50
CT6002	CMOS chip for Liquid-crystal displays, 12Hr, 1Hz colon, input 32768Hz or 65536Hz. Runs on 1.5V hearing aid battery for a year.	£19.54
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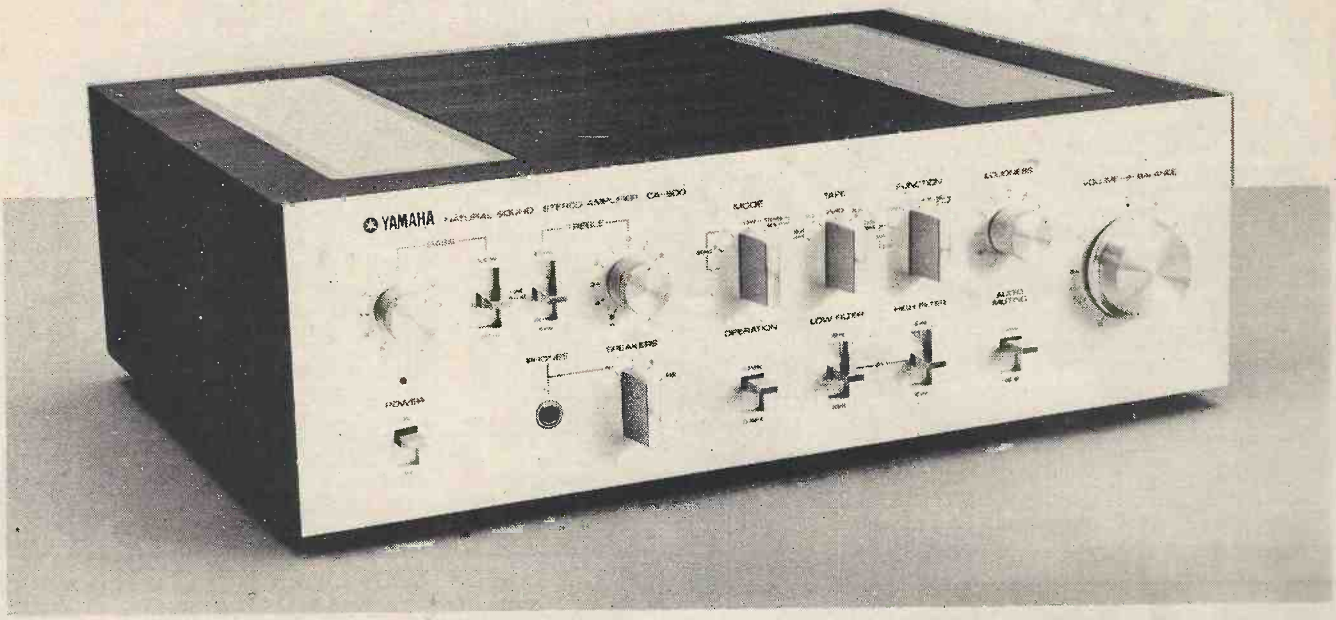
YAMAHA CA800 AMPLIFIER



Yamaha's CA-800 switchable class A/class B amplifier reviewed.

A SMALL but vocal number of hi-fi enthusiasts insist that for truly distortion-free amplification, nothing but Class A operation will suffice.

Even the best of Class B amplifiers, they insist, is an electronic abomination.

Until now this argument has been difficult to evaluate. Whilst some Class A amplifiers are audibly better than their Class B counterparts, the difference may well be due to things other than the operating mode of the output stages!

Now, Yamaha have produced a high-class amplifier with an output stage that can be switched to either Class A or Class B operation.

The amplifier, Yamaha's CA-800 — has a number of other unusual features as well. Like Leak's old Varislope units, the CA-800 features variable-slope cut-off frequencies for bass and treble filters. It also has a variable loudness control that operates independently of the main volume control.

A very wide range of facilities is provided. There is a bass attenuator with a cut-off frequency selectable at either 500 Hz or 250 Hz — together with a central 'defeat' position; a treble filter with cut-off frequencies of 2.5 kHz and 5 kHz; a low frequency filter (70 Hz and 20 Hz) and a high frequency filter (12 kHz and 6 kHz).

Also provided is a switch for selecting Class A or Class B operation, and the aforementioned loudness control which provides a set of contours for true compensation for the physiological response of the ear.

The rear panel of the amplifier has all necessary inputs together with a preamplifier out and main amplifier input sockets with an electrical coupler switch; two microphone sockets; and a switch for selecting impedances of 100 kΩ, 50 kΩ, or 30 kΩ on phono 1 input.

With one or two minor exceptions, the amplifier is constructed to truly professional standards. For example, each of the audio sockets on the rear panel, with the exception of the speaker outputs, is terminated on a printed circuit card which is itself connected to the preamplifier cards via gold-plated plug-in sockets. The

> **Most power amplifiers have output stages that operate in what is usually called 'Class B'.**
>
> **In this mode of operation, two power transistors are connected so that as one 'pushes' the other 'pulls'.**
>
> **A positive going signal, for example, will cause one transistor to conduct and the other to turn off.**
>
> **Class B is an efficient mode of operation and quite high power outputs can be achieved econmically, but so-called 'cross-over' distortion will be generated unless the circuit is very carefully designed.**
>
> **Despite this 'disadvantage', several modern Class B operation amplifiers have very low distortion indeed.**
>
> **Class A amplifiers have an output stage arranged so that, with normal input levels, the output transistors are never driven into either cut-off or saturation.**
>
> **In theory, the output waveform is identical to the input waveform. Distortion is very low indeed but the output stage's efficiency is very low. Because of this it is not practicable to build high power output Class A amplifiers.**

SUMMARY: The Yamaha CA800 amplifier offers a performance which is generally better than most other amplifiers regardless of price. It is designed for the purist who is seeking the ultimate, but that the ultimate is "CLASS A" output operation is something that has yet to be proven!

preamplifier cards themselves are fully shielded from the rest of the unit by well designed steel covers to reduce magnetic and electrostatic induction. The function selectors extend through from the front panel to switches which are incorporated within this shielded cover. All of the circuitry mounted behind the front panel is also shielded in either individual sub-shields or partial shields around individual switches and terminations.

In keeping with the latest technique in amplifier layout, the main amplifier cards and their associated heat sinks are constructed as complete modules with direct connection between the printed circuits and the power transistors.

It was interesting to note that the leads running close to the heat sinks are individually protected with glass insulation spaghetti to preclude the possibility of melting or shorting wires. The printed circuit cards are all individually coated on the rear faces to prevent corrosion, electrolysis and fungus, problems which plagued many earlier and cheaper pieces of Japanese equipment.

One of the few details that precludes this amplifier from being a fully professional unit is the use of phenolic resin based cards in lieu of the more often used epoxy glass cards found in true professional equipment.

The amplifier design incorporates a number of highly desirable features including a relay operated protection circuit to switch off speakers in the event of a substantial dc level appearing at the speaker terminals. There is also a fully-electronic protection circuit to protect the output amplifier and its silicon power transistors against short-circuiting or unusually low speaker load impedances. In addition, each output amplifier card incorporates two fast acting fuses to provide a third stage of protection.

The amplifier is constructed on a strong steel chassis within a very well made and adequately ventilated veneered plywood cabinet. The unit is readily capable of being rack mounted should this be desired although its frontal dimensions are 50 mm short of the standard 482 mm (19") rack mounting.

HOW IT PERFORMED

Evaluating the electrical performance proved to be particularly interesting, for excellent though Yamaha's claimed specifications are — the unit is in most respects even better!

In the Class B mode for example, the amplifier is capable of producing a true 60 watts into both channels at 8Ω impedance with a distortion level lower than the manufacturer claims for 50 watts. Likewise, the performance at 12.5 watts in the Class A mode is better than Yamaha's claim for 10 watts (both channels driven into 8Ω).

It is of course the matter of distortion, its measurement, and its subjective evaluation, which makes this amplifier different from all others, for Yamaha have provided the facility for being able to select Class A or Class B operation at the flick of a switch.

Amplifiers, whether Class A or Class B generally produce more distortion at low power levels than at levels closer to their maximum power output.

A 60 watt Class B amplifier for example may generate four or five times as much distortion at five watts output than at 50 watts output.

Class A amplifiers have similar characteristics, but to a lesser extent — so that a 10 watt unit (quite large for Class A operation) will be working closer to its lowest distortion point at the same five watt level.

At least that's what all the text books say — but to some extent Yamaha appear to have hoisted themselves by their own petard, because the CA-800 working in Class B produces so little distortion anyway that further reduction by switching to Class A seems to be of only academic interest. Certainly it can be *measured*, but after many hours of very careful listening at all sound levels we could not *hear* any difference.

Yamaha claim that the very low level of residual distortion at low listening levels (in Class B) *can* be heard. It could well be, but it must be by perfectionists whose hearing is a great deal more sensitive than ours!

Continued on next page.

YAMAHA CA800 STEREO AMPLIFIER

Power Output (at 1kHz)	CLASS B	60W (rms) into 8Ω both channels driven		
	CLASS A	12.5W (rms) into 8Ω both channels driven		
Frequency Response at rated output		20Hz to 20kHz ±1dB		
" " at 10W output		20Hz to 20kHz ±1dB		
" " at 1W output		20Hz to 20kHz ±1dB		
Channel Separation at Rated Output		100Hz	−37.5dB	1kHz −38.0dB
Hum & Noise re Rated Power				
Volume control at maximum gain		−70dB (Lin.)	−87dB (A)	
Volume control at minimum gain		−68dB (Lin.)	−87dB (A)	
Input Sensitivity for Rated Output		CLASS A	CLASS B	
Aux. 1		50mV	100mV	
Aux. 2		50mV	100mV	
Tuner		50mV	100mV	
Phono 1			2.8mV	
Phono 2			2.8V	
Main Amp.		400mV	900mV	
Total Harmonic Distortion (at 60W output and 12.5W output respectively with both channels driven)		CLASSB (60W + 60W)	CLASS A (12.5W + 12.5W)	
100Hz		<0.01%	<0.01%	
1kHz		<0.01%	<0.01%	
6.3kHz		0.45%	0.02%	
Intermodulation Distortion		less than 0.05%		
Tone Controls		Filters		
Bass	50Hz	250Hz +15dB −13dB	500Hz +17dB −14dB	
Treble	10kHz	5kHz +6.5dB −7.5dB	2.5kHz +10.5dB −10.0dB	
Loudness Control (at constant volume control setting)				
Loudness control at 10		50Hz	+13dB	
		10kHz	+5.5dB	
Dimensions	436mm x 144mm x 323mm			
Weight	13.5kg			
Price	£210.25			

MEASURED PERFORMANCE

The measurable distortion of the amplifier is as low as any we have ever measured. In fact it presented us with a number of interesting problems in electrical measurement to be certain that our measurements were of amplifier distortion itself rather than distortion from our test oscillator.

The distortion products at maximum output were generally in the range −67 dB to −80 dB, re 0 dB at maximum output in the Class B mode, and in the range −74 dB to −80 dB re 0 dB at maximum output in the Class A mode.

Before embarking upon subjective tests we doubted our ability to be able to discriminate between distortion products 60 dB down on the fundamental component (less than 0.1%). After completing our tests we are *convinced* that we cannot hear such low distortion.

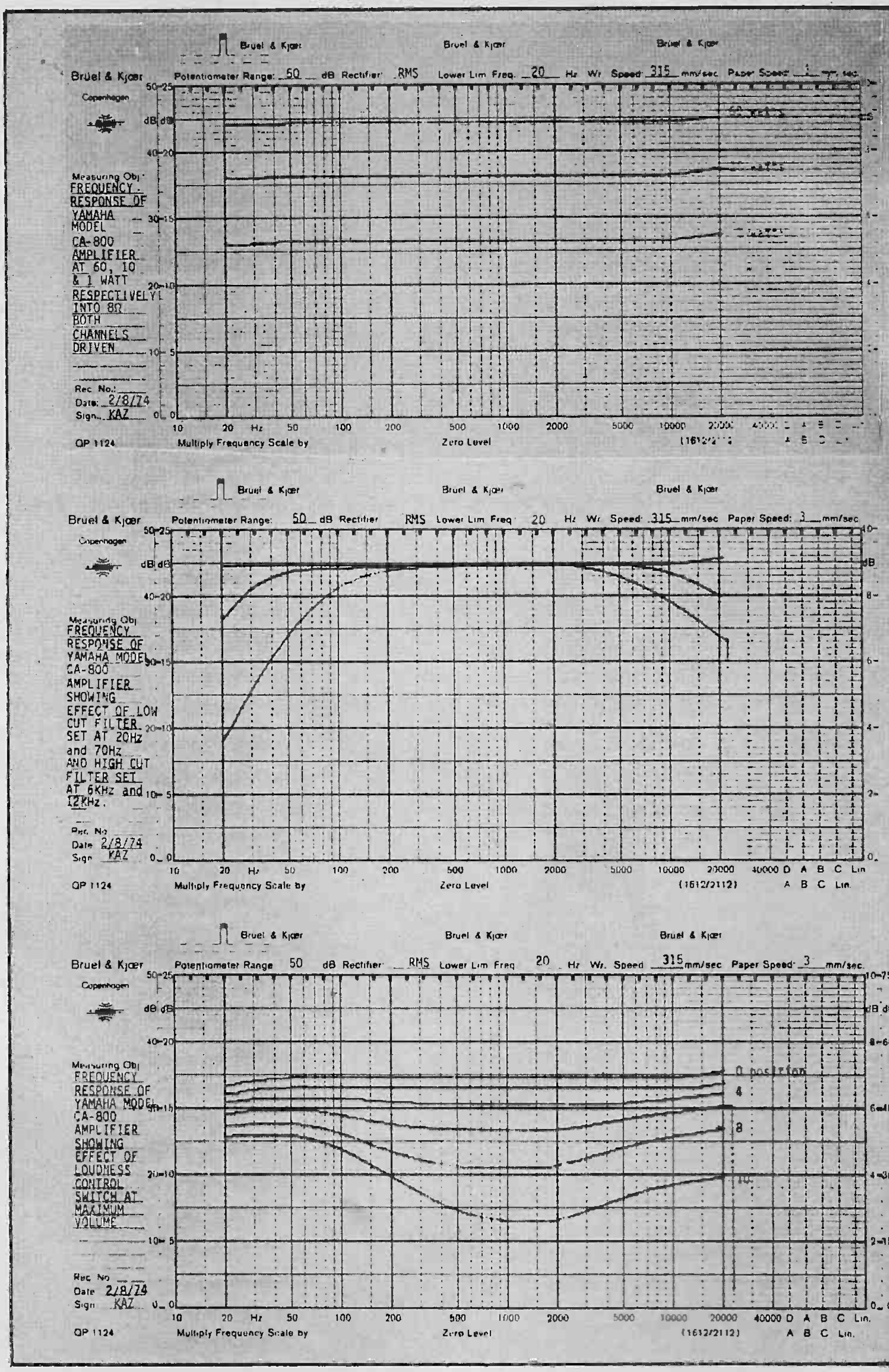
Is then the facility to switch to Class A operation a necessary or desirable feature – or is it just a gimmick?

Certainly its inclusion enables purists to decide for themselves whether or not Class A operation is worthwhile. A further advantage is that if you *can* still detect some distortion when switched to Class A, then you can be virtually certain that it's not coming from the amplifier! But our frank opinion is that for most people, the facility is an interesting gimmick. But, had Yamaha not incorporated such a superb Class B output stage, it would have been a different matter – as we said they've hoisted themselves by their own petard!

One very worthwhile and technically valid feature is the inclusion of a loudness control which is meant to be used as the preferred means of adjusting listening level. Whilst not unique to Yamaha, this feature is very desirable. Loudness controls are based on the psycho-acoustic fact that as sound levels decrease, high and low frequency components are heard at subjectively lower levels than mid-range sounds. Eventually, at very low sound levels, bass appears to drop out altogether.

Many amplifiers have 'loudness' controls that compensate for this phenomenon to some extent. Yamaha's method, used in the CA-800, is far more complex. The subjective effect is that the overall sound at all levels has the same apparent frequency response as at the higher levels.

The control is used by firstly setting the loudness knob to a 'flat' position. Then the volume control is set to the loudest volume that would normally be used. From then on, volume is adjusted solely with the loudness control – not with the main volume potentiometer.



As there are some hi-fi purists to whom loudness compensation is anathema, the volume control may be used normally – with loudness compensation switched out.

The tone controls and associated switch are well designed and the use of two "break" frequencies follows a growing trend. The choice of frequencies and the resultant response curves are not as different as might be expected, and a lower "break" frequency than 250 Hz and a higher break frequency than 5000 Hz may well have been advantageous.

One fault became apparent during testing. With the amplifier set to maximum treble boost, and with the volume control set to maximum gain for response curve testing, we found it possible to introduce very high frequency (above audibility) instability in the output circuitry, and the amplifier could be induced into oscillation. This worried us, but it may well be that this was an isolated fault in this unit. In every other respect, however, the features of the amplifier were exemplary and it offered a superb performance. ●

ELECTRONIC SPEED CONTROL FOR MOTORS

How various types of motor can be controlled in speed using semiconductor devices, Applications Department, Motorola, Phoenix.

SPEED CONTROL of motors in domestic appliances has been technically possible for a long time, but only recently has it become a good proposition economically.

Such diverse items as blenders, furnace blowers, clothes dryers, and food mixers can now use electronic controls. In this article, we review some of the common circuits being used today, and also describe some of the new circuits.

By far the easiest to control electronically are universal (or series-wound ac-dc) motors. Their characteristics and construction allow the use of a simple circuit to provide an electrical feedback so that speed is held relatively constant under varying load conditions.

Permanent-magnet motors are also easy to control. Perhaps surprisingly, the speed of several forms of induction motors may also be successfully controlled by electronic means – if these motors have a suitable load.

How AC power control

The most common method of electronic ac power control is called phase control.

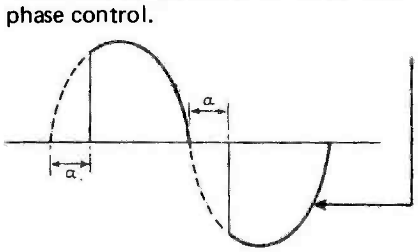


Fig.1. Illustrating the basic principles of phase control. The portion of the waveform applied to the load is shown shaded.

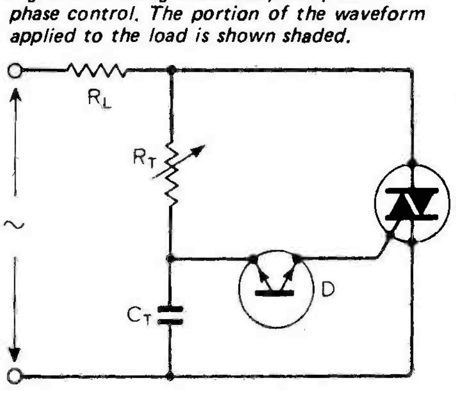


Fig.2. The simplest possible circuit for phase control. The load is represented by resistor R_L.

Figure 1 illustrates this concept. During the first portion of each half-cycle of the ac sine wave, an electronic switch is opened to block current flow. At some specific phase angle, *a*, this switch is closed to allow the full line voltage to be applied to the load for the remainder of that half-cycle. Varying *a* will control the portion of the total sine wave that is applied to the load (shaded area), and thereby regulate the power flow to the load.

The simplest circuit for accomplishing phase control is shown in Fig. 2. The electronic switch in this case is a triac *(Q)* which can be turned ON by a small current pulse to its gate. The triac turns OFF automatically when the current through it passes through zero.

In the circuit shown capacitor C_T is charged during each half-cycle by the current flowing through resistor R_T and the load. The fact that the load is in series with R_T during this portion of the cycle is of little consequence since the resistance of R_T is many times greater than that of the load. When the voltage across C_T reaches the breakdown voltage of the trigger diode (D), the energy stored in capacitor C_T is released. This energy produces a current pulse in the trigger diode, which flows through the gate of the triac and turns it ON. Since both the trigger diode and the triac are bidirectional devices, the values of R_T and C_T will determine the phase angle at which the triac will be triggered in both the positive and negative half-cycles of the ac sine wave.

The wave form of the voltage across the capacitor for two typical control conditions ($a = 90°$ and $150°$) is shown in Fig. 3. If a silicon controlled rectifier is used in this circuit in place of the triac, only one half-cycle of the wave form will be controlled. The other half-cycle will be blocked, resulting in a pulsing dc output whose average value can be varied by adjusting R_T.

Characteristics of semiconductor switches

The silicon controlled rectifier (SCR) was the first of several thyristors developed for controlling electric power efficiently. It blocks current flow in both directions as long as no gate signal is applied and the applied voltage is below the rated breakover voltage. Exceeding the breakover voltage in the forward direction (with anode more positive than cathode) will cause the SCR to switch to its ON condition, in which the voltage from anode to cathode is approximately 1 V (and the current is limited only by the external circuitry). When the forward current is interrupted, the SCR recovers its blocking character.

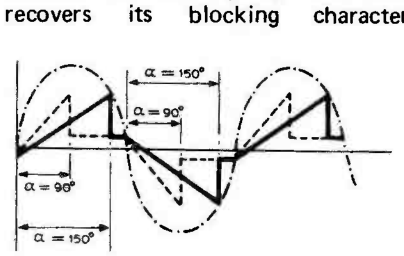


Fig.3. Waveforms across the capacitor at two different phase angles. The applied sine wave is shown dotted.

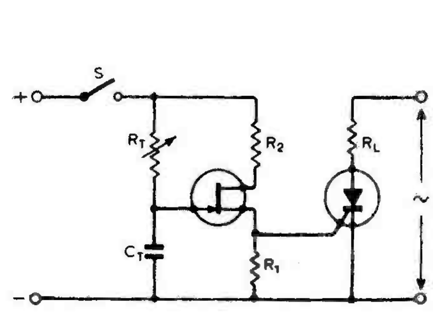


Fig.4. A typical phase control circuit using a unijunction transistor firing circuit.

Exceeding the reverse breakdown voltage of an SCR will destroy the device, most often causing a permanent short circuit.

Current flowing into the gate of an SCR will also cause it to turn ON when forward voltage is applied. Since the SCR is a regenerative device (that is, it remains in the ON condition as long as anode current is flowing), only a current pulse at the gate is necessary to effect switching. Thus, in the previously described circuits, a properly timed current pulse into the gate of an SCR can control average power flow to a load.

The triac is a bidirectional SCR. It is designed for use with alternating current, and functions the same way in both directions of applied voltage (as an SCR does in the forward direction). Its gate characteristics are different from that of an SCR in that gate current of either polarity will cause the triac to turn ON, with either polarity of applied anode voltage.

The trigger diode is a device designed specifically to provide current pulses to trigger SCR or triacs. In use, it acts much like a triac without a gate. That is, it will block current flow in either direction as long as the applied voltage is below the breakover voltage, which is generally between 16 and 36 V, depending on the device type. When the breakover voltage is exceeded, the device turns ON. In this state, the current is limited by the external circuitry, and the voltage drop across the diode is about 10 to 15 V. The trigger diode is most commonly used in circuits similar to the one shown in Fig. 2.

The unijunction transistor (UJT) is a three-terminal trigger device in which the characteristics of the emitter and base 1 are very much like those of the trigger diode. However, its breakover voltage can be controlled by the power supply voltage applied between base 1 and base 2. Since the UJT is a unidirectional device, unlike the bidirectional trigger diode, it requires a source of direct current for the interbase voltage as well as for the timing-circuit components, R_T and C_T. Figure 4 shows a UJT in a typical control circuit.

Because the breakover voltage of the UJT emitter is controlled by the interbase voltage, the unijunction transistor can be used for the timing circuit with a much lower source voltage than can be trigger diode, whose breakover voltage is controlled by the parameters of its structural materials. As a result, the UJT is quite popular for use with electronic control systems utilizing feedback.

In many applications it is desirable to vary motor speed in proportion to the magnitude of a change in a physical condition, such as a change in temperature. A furnace blower responding to the air temperature of a house is one example. Similarly, a control device can light a lamp in response to the fading twilight. Control of these circuits can be effected by resistors that change in value in response to a change in temperature or light intensity. A typical circuit using such a variable resistor is shown in Fig. 5. If motor speed is the quantity to be controlled, R_S may be a fixed resistor, and a direct-current tachometer generator may be inserted as shown. Only a few additional components are necessary to turn these elementary circuits into working modules.

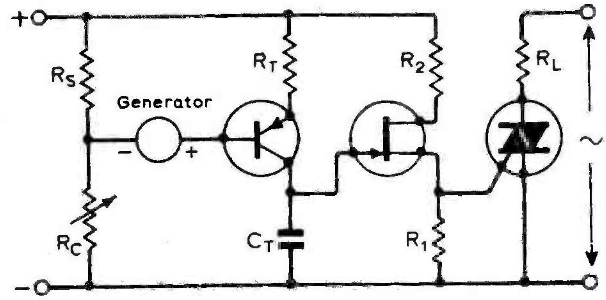


Fig. 5 Motor speed control with a unijunction transistor using feedback.

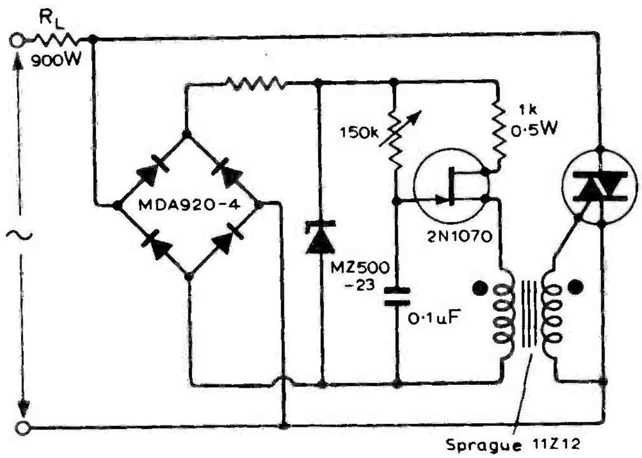


Fig. 6 Simple full-wave trigger circuit for a 900 W resistive load.

Figure 6 shows a simple full-wave trigger circuit for controlling a 900 W load. The additional components required are a full-wave bridge, a resistor, and a Zener diode, which make up the dc power supply, and a pulse transformer which provides the isolation between the UJT circuit and the power line, necessitated by the bridge rectifier. The feedback circuitry shown in Fig. 5 could also be added to this circuit.

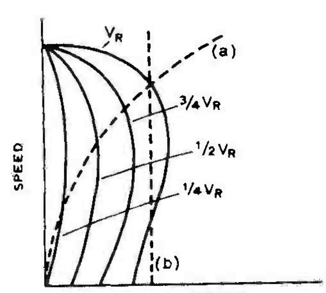


Fig. 7 Characteristics of a shaded pole motor at several voltages. V_R is the full rated voltage, (a) indicates a typical fan load and (b) shows a constant torque load.

Control of induction motors

Shaded-pole motors driving low-starting-torque loads such as fans and blowers may readily be controlled using any of the previously described full-wave circuits. One needs only to substitute the winding of the shaded-pole motor for the load resistor shown in the circuit diagrams.

Constant-torque loads or high-starting-torque loads are difficult, if not impossible, to control using the voltage controls described here. Figure 7 shows the effect of varying voltage on the speed-torque curve of a typical shaded-pole motor. A typical fan-load curve and a constant-torque-load curve have been superimposed upon this graph. It is not difficult to see that the torque developed by the motor is

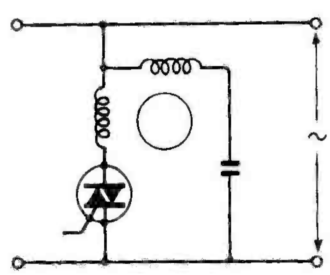


Fig. 8 Connection diagram for permanent split capacitor motors.

ELECTRONIC SPEED CONTROL FOR MOTORS

equal to the load torque at two different points on the constant-torque-load curve, giving two points of equilibrium and thus an ambiguity to the speed control. The equilibrium point at the lower speed is a condition of high motor current because of low counter emf and would result in burnout of the motor winding if the motor were left in this condition for any length of time. By contrast, the fan speed-torque curve crosses each of the motor speed-torque curves at only one point, therefore causing no ambiguities. In addition, the low-speed point is one of low voltage well within the motor winding's current-carrying capabilities.

Permanent-split-capacitor motors can also be controlled by any of these circuits, but more effective control is achieved if the motor is connected as shown in Fig. 8. Here only the main winding is controlled and the capacitor winding is continuously connected to the entire ac line voltage. This connection maintains the phase shift between the windings, which is lost if the capacitor phase is also controlled. Figure 9(a) shows the effect of voltage on the speed-torque characteristics of this motor and a superimposed fan-load curve.

Not all induction motors of either the shaded-pole or the permanent-split-capacitor types can be controlled effectively using these techniques, even with the proper loads.

Motors designed for the highest efficiences and, therefore, low slip also have a very low starting torque and may, under certain conditions, have a speed-torque characteristic that could be crossed twice by a specific fan-load speed-torque characteristic.

Figure 9(b) shows motor torque-speed characteristic curves upon which has been superimposed the curve of a fan with high starting torque. It is therefore desirable to use a motor whose squirrel-cage rotor is designed for medium-to-high impedance levels and, therefore, has a high starting torque. The slight loss in efficiency of such a motor at full rated speed and load is a small price to pay for the advantage of speed control.

A unique circuit for use with capacitor-start motors in explosive or highly corrosive atmospheres, in which the arcing or the corrosion of switch contacts is severe and undesirable, is shown in Fig. 10. Resistor R_1 is connected in series with the main running winding and is of such a resistance that the voltage drop under normal full-load conditions is approximately 0.2 V peak. Since starting currents on these motors are quite high, this peak voltage drop will exceed 1 V during starting conditions, triggering the triac, which will cause current to flow in the capacitor winding. When full speed is reached, the voltage across the main winding will decrease to about 0.2 V, which is insufficient to trigger the triac — thus the capacitor winding will no longer be energized. Resistor $R2$ and capacitor C_2 form a dv/dt suppression network; this prevents the triac from turning on due to line transients and inductive switching transients.

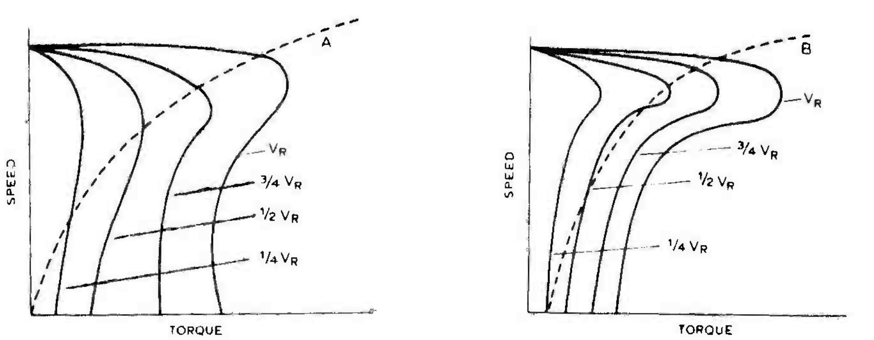


Fig. 9 Speed-torque curves for (A) high starting torque and (B) high efficiency permanent split capacitor motors at several voltages. The dotted line indicates a typical fan load and V_R is the full rated voltage.

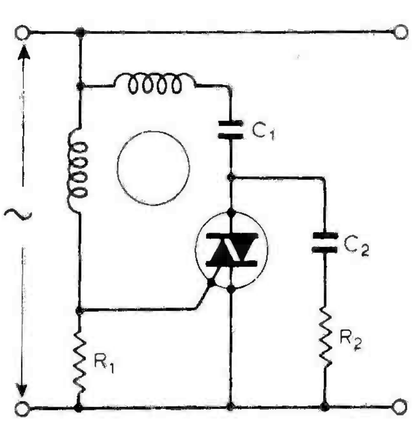


Fig. 10 Circuit diagram for a capacitor start motor.

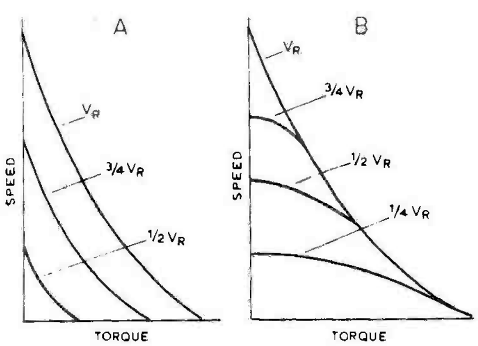


Fig. 11 Speed control, with (A), and without (B). feedback, compared.

Control of universal motors

Any of the half-wave or full-wave controls described previously can be used to control universal motors. Non feed-back, manual controls, such as those shown in Fig. 2, are simple and inexpensive, but they provide very little torque at low speeds. A comparison of typical speed torque curves using a control of this type with those of feedback control is shown in Fig. 11.

These motors have some unique characteristics which allow their speed to be controlled very easily and efficiently with a feedback circuit such as that shown in Fig.12. This circuit provides phase-controlled half-wave power to the motor: that is, on the negative half-cycle, the SCR blocks current flow in the negative direction causing the motor to be driven by a pulsating direct current whose amplitude is dependent on the phase control of the SCR.

The theory of operation of this control circuit is not at all difficult to understand. Assuming that the motor has been running, the voltage at point A in the circuit diagram (Fig.12) must be larger than the forward drop of diode D_1, the gate-to-cathode drop of the SCR, and the emf generated by the residual (magneto-motive force) in the motor, to get sufficient current flow to trigger the SCR.

The waveform at point A(V_A,) for one positive half-cycle is shown in Fig.13, along with the voltage levels of the SCR gate (V_{scr}), the diode drop (V_D), and the motor-generated emf (V_M). The phase angle (a) at which the SCR would trigger is shown by the vertical dotted line. Should the motor for any reason speed up so that the generated motor voltage would increase, the trigger point would move upwards and to the right along the curve so that the SCR would trigger later in the half-cycle and thus provide less power to the motor, causing it to slow down again.

Similarly, if the motor speed decreased, the trigger point would move to the left and down the curve, causing the triac to trigger earlier in the half-cycle providing more power to the motor, thereby speeding it up.

Resistors R_1, R_2 and R_3, along with diode D_2 and capacitor C_1 form the ramp-generator section of the circuit, as shown in the diagram in Fig.12. Capacitor C_1 is charged by the voltage divider R_1, $R2$ and R_3 during the positive half-cycle. Diode D_2 prevents negative current flow during the negative half-cycle, therefore C_1 discharges through only R_2 and R_3 during that half-cycle. Adjustment of R_3 controls the amount by which C_1 discharges during the negative half-cycle. Because the resistance of R_1 is very much larger than the ac impedance of capacitor C_1, the voltage waveform on C_1 approaches that of a perfect cosine wave with a dc component. As potentiometer R_2 is varied, both the dc and the ac voltages are divided, giving a family of curves as shown in Fig.14.

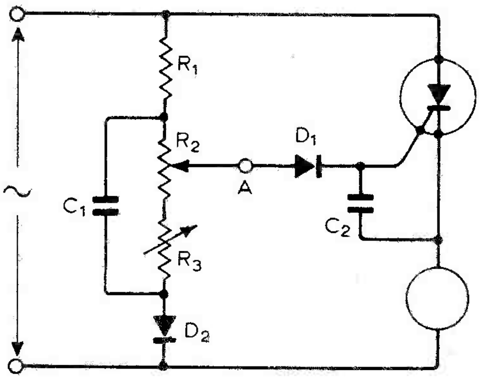


Fig. 12 Speed control scheme for universal motors.

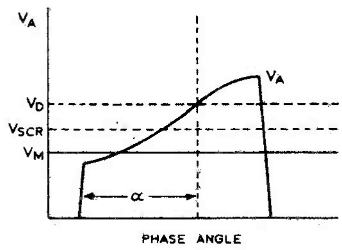


Fig. 13. Waveform for one positive half cycle in the circuit shown in Fig. 12.

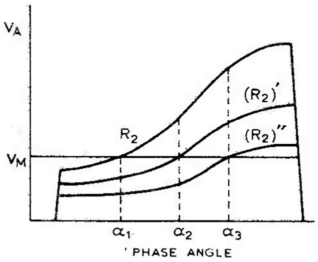


Fig. 14. Voltage waveform at point A (Fig. 12) for three different settings of R_2.

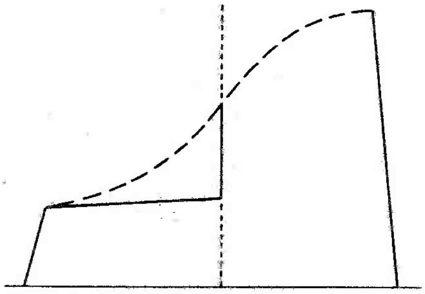


Fig. 15 When resistor R1 (Fig. 12) is too large, this voltage waveform appears at point. A. The dotted line is the unloaded waveform and the unbroken line is the actual waveform.

The gain of the system, that is, the ratio of the change of effective SCR output voltage to the change in generator emf is considerably greater at low speed settings than it is at high speed settings. This high gain coupled with a motor with a very low residual emf will cause a condition sometimes known as cycle skipping. In this mode of operation, the motor speed is controlled by skipping entire cycles or groups of cycles, then triggering one or two cycles early in the period to compensate for the loss in speed. Loading the motor would eliminate this condition; however, the undesirable sound and vibration of the motor necessitate that this condition be eliminated. This can be done in two ways.

The first method is used if the motor design is fixed and cannot be changed. In this case, the impedance level of the voltage divider R_1, R_2 and R_3 can be lowered so that C_1 will charge more rapidly, thus increasing the slope of the ramp and lowering the system gain. The second method, which will provide an overall benefit in improved circuit performance, involves a redesign of the motor so that the residual emf becomes greater. In general, this means using a lower grade of magnetic steel for the laminations. As a matter of fact, some people have found that ordinary cold-rolled steel used as rotor laminations makes a motor ideally suited for this type of electronic control.

Another common problem encountered with this circuit is that of thermal runaway. With the speed control set at low or medium speed, at high ambient temperatures the speed may increase uncontrollably to its maximum value. This phenomenon is caused by an excessive impedance in the voltage divider chain for the SCR being triggered. If the voltage-divider current is too low, current will flow into the gate of the SCR without turning it on, causing the waveform at point A to be as shown in Fig.15. The flat portion of the waveform in the early part of the half-cycle is caused by the SCR gate current loading the voltage divider before the SCR is triggered. After the SCR is triggered, diode D_1 is back-biased and a load is no longer on the voltage divider so that it jumps up to its unloaded voltage. As the ambient temperature increases, the SCR becomes more sensitive, thereby requiring less gate current to trigger, and is triggered earlier in the half-cycles. This early triggering causes increased current in the SCR thereby heating the junction still further and increasing the sensitivity of the SCR until maximum speed has been reached.

The solutions to this problem are the use of the most sensitive SCR practical and a voltage divider network of sufficiently low impedance. As a rough rule of thumb, the average current through the voltage divider during the positive half-cycle should be approximately three times the current necessary to trigger the lowest sensitivity (highest gate current) SCR being used.

In addition to the type of steel used in the motor laminations, consideration should also be given to the design of motors used in this half-wave speed control. Since the

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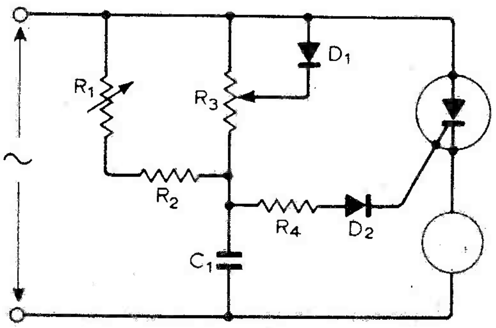


Fig. 16 Speed control of permanent magnet d.c. motors.

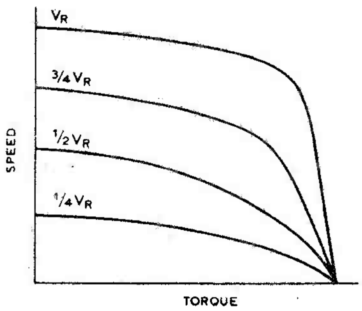
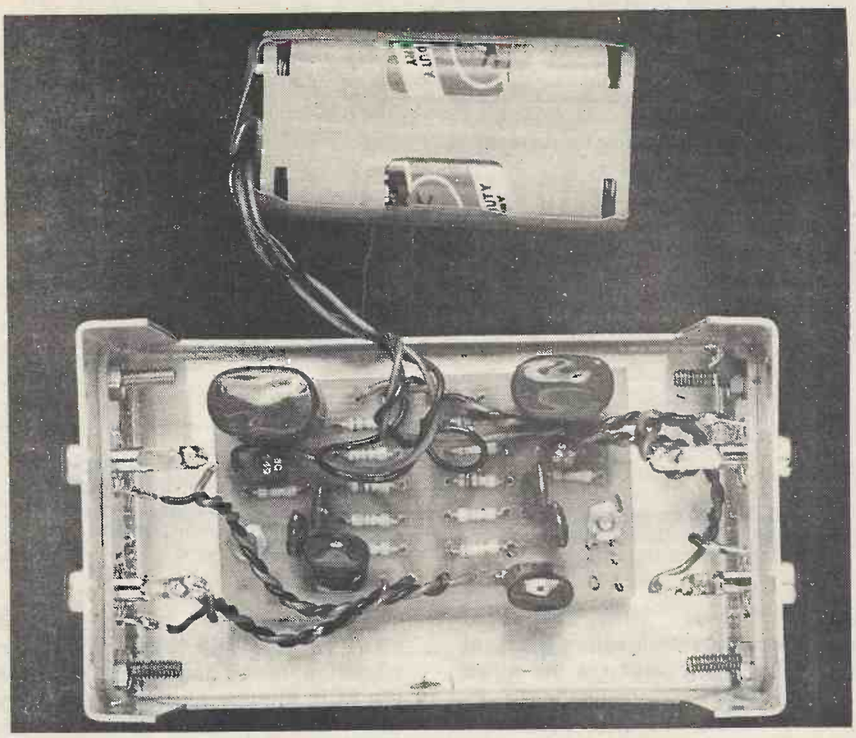


Fig. 17 Speed-torque characteristic of permanent magnet motors at various applied voltages.

STEREO RUMBLE FILTER

ETI PROJECT



This internal view shows how the rumble filter is assembled.

Active filter design improves clarity of bass reproduction.

IN BYGONE DAYS rumble filters were very popular because even the best of turntables, used then, generated considerable vibration due to bearing and motor deficiences. These vibrations, mechanically transmitted to the pickup cartridge, resulted in an audible output. Hence high-pass filters were often incorporated in amplifiers to reduce this objectionable rumbling sound to an acceptable level, and as bass response seldom extended below 50 Hz, a simple RC filter with 6 dB per octave roll-off below 50 Hz was considered adequate.

Modern turntables have far smoother bearing and drive arrangements than their early counterparts — and for this reason many amplifier manufacturers no longer include a rumble filter facility.

Those that do are rarely satisfactory. Their slope is generally inadequate and the main effect of switching them in is to roll off the low-frequency response to the detriment of programme content.

At first sight it would seem better to exclude the rumble filter altogether and just make sure that our turntables do not generate any appreciable rumble.

Surprisingly perhaps, a rumble filter is still very much required and if designed correctly, can make an appreciable improvement to reproduction — even when used with turntables that generate no rumble at all!

The reason why will be clearly apparent if you take the front grille

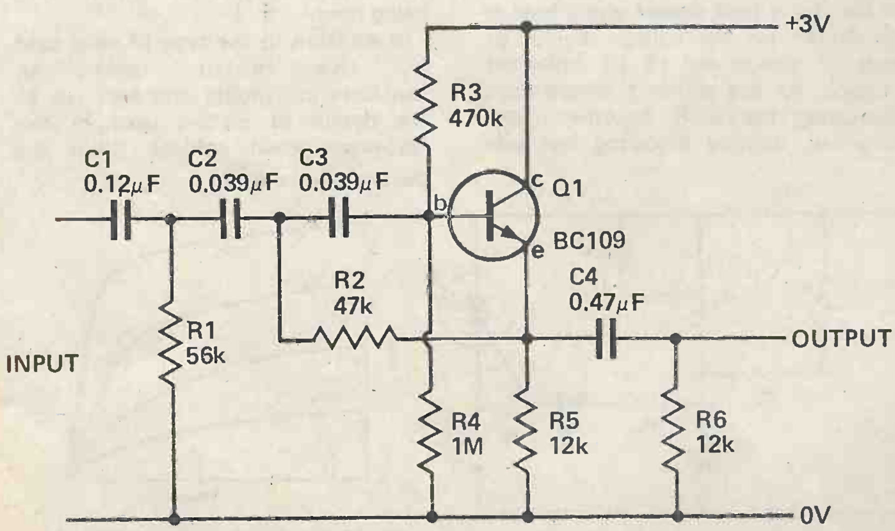


Fig. 1. Circuit diagram of the rumble filter. Two required for stereo.

HOW IT WORKS

The filter consists of three separate sections:—

1. A passive RC filter consisting of R1 and C1.
2. An active filter comprising C2, 3, R2, 3, 4 & 5 and Q1.
3. A passive filter comprising C4 and R6.

The active filter (from input of C2 to output to C4) is a standard design with the exception that values have been selected to give a peak in the response at the cut-off frequency. The maximum lift is about 2 dB and this characteristic, combined with those of the two RC filters, gives a sharp knee to the roll-off. The composite filter has a lift of 0.2 dB before turning over sharply.

Thus low frequency response is maintained substantially flat down to 50 Hz and is only 2 dB down at 40 Hz. Thereafter the response drops very rapidly and is in excess of 30 dB off one of your speakers and — with the phono-cartridge tracing a section of record that has no recorded content (or very low level content) — turn the volume control up fairly high. You will almost certainly find that the cone of the bass driver is making wild excursions to and fro, probably at frequencies between 5 Hz and 15 Hz.

So it's sub-audible — why then does it matter?

Well it really does — and we'll explain just why later in this article — but first let us consider just where this 5 Hz — 15 Hz content comes from.

Firstly, modern turntables and arms have mechanical resonances lying within the 5-15 Hz region. Secondly, stereo cartridges are sensitive in the vertical as well as horizontal planes and will respond to uneveness in record or turntable surfaces. They will also respond to a defect in the record surface known as pressing rumble.

In addition the noise finds its way onto the record during the actual recording process. This recorded noise is due to LF noise and rumble sometimes being induced in the recording lathe by seismic disturbances, and by vibration in drive gears and cutting head carriage rails.

Lastly vibration of a low frequency nature, due to people walking past the turntable or vehicles passing by outside, may well excite the turntable and arm resonances even though the turntable is reasonably well sprung.

WHY SUB-AUDIBLE NOISE MATTERS

This very low-frequency noise is responsible for a remarkable amount of intermodulation distortion which generally makes the bass sound muddy. In extreme cases it may cause the reproduction to sound as if speaker cone break-up is occurring. The reasons for this are as follows.

Preamplifier stages usually have two or three transistors around which large negative feedback is applied for equalization and/or tone control. At sub-audio frequencies these feedback networks are not generally effective. Thus the LF signals may well receive considerably more amplification in the preamplifier than would normally be expected. Secondly although the magnitude of the LF signal may not itself be sufficient to overload the preamplifier, the combined LF and music signals may well cause the preamplifier to clip. Even if clipping does not occur the LF signal will cause intermodulation distortion despite the fact that the LF signal is inaudible!

Most modern power amplifiers are quite capable of amplifying this noise signal, presenting it to the loudspeaker at a surprisingly high power level. The speaker itself has very little acoustic loading at these low frequencies and the cone will thus move considerably and may even be driven beyond its linear excursion region. Even if not actually overdriven, the presence of such large cone excursions will produce a high level of intermodulation distortion.

Whilst elimination of factors causing the noise is by far the best procedure, a lot of these factors are completely beyond the control of the average hi-fi owner. Hence a rumble filter would seem to be the obvious answer. But, we do not want to sacrifice any low frequency response and we want signals in the offending 5-15 Hz region to be attenuated as far as possible — two apparently conflicting requirements. In addition, as LF noise cannot be allowed to enter the equalization stages of the preamplifier,

PARTS LIST

R1	Resistor	56k	¼W	5%
R2	"	47k	"	"
R3	"	470k	"	"
R4	"	1M	"	"
R5,6	"	12k	"	"
C1	Capacitor	0.12μF		polyester
C2,3	"	0.39μF		"
C4	"	0.47μF		"
Q1	Transistor	BC109 or similar		

* for stereo 2 off each of the above parts are needed.

PC Board
2 dual phono sockets
2 dual battery holders or one 4 way holder.
4 1.5V batteries.
2 8mm long spacers
1 small aluminium box.

SPECIFICATION

Input Impedance (rises below 50 Hz)	47k
Output Impedance	< 5k
Input voltage (maximum)	250mV
Cut-off Frequency (—3dB)	36 Hz
Cut-off Slope (maximum)	24dB/octave
Attenuation at 10 Hz	37 dB
Gain at 1 KHz	—0.2 dB.

down below 15 Hz where most LF noise occurs.

Current drain of the two filters is only 100 μA and the batteries will last their normal shelf life of about 12 months, thus no power switch is required. Batteries should be replaced annually.

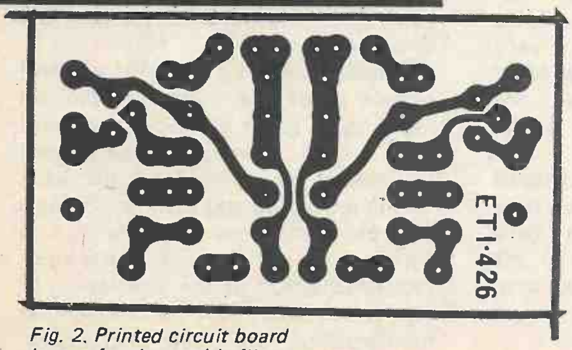
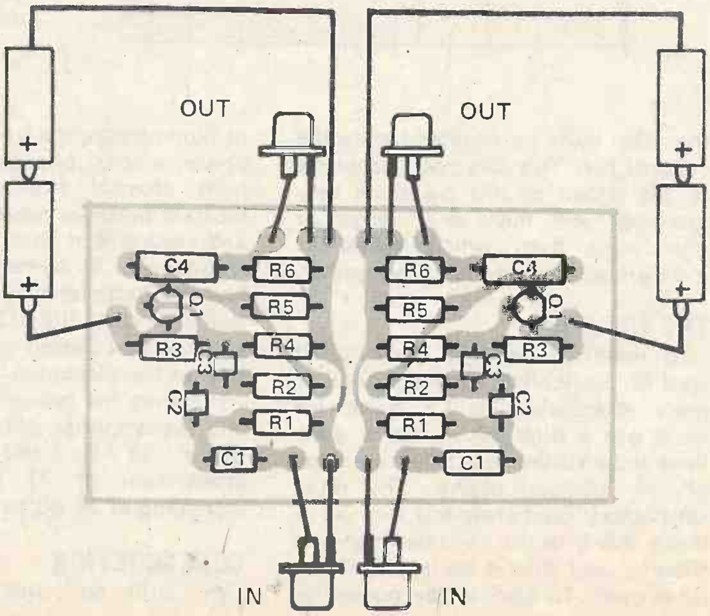


Fig. 2. Printed circuit board layout for the rumble filter 40mm x 70mm.



STEREO RUMBLE FILTER

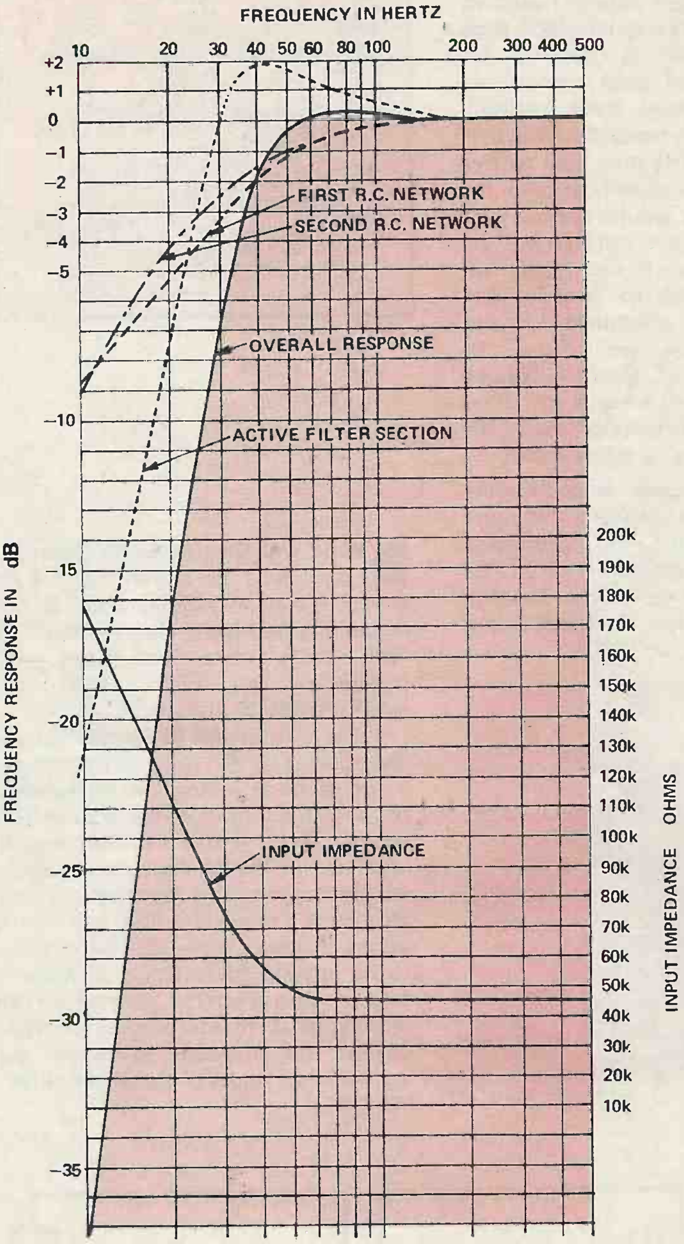
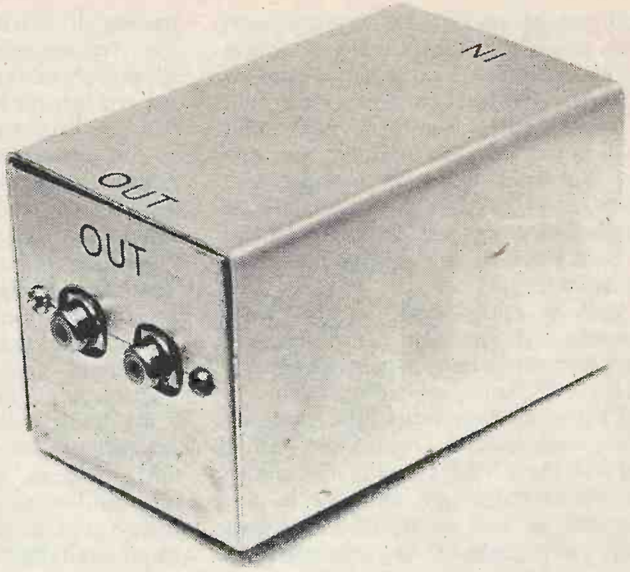


Fig. 4. Characteristics of the rumble filter.



the filter must be situated before the preamplifier. This also poses problems as the signals at this point are very low-level, and there is a danger of introducing hum which would be merely replacing one fault by another.

THE SOLUTION

To maintain response down to at least 50 Hz, whilst obtaining 30 dB or more attenuation to LF noise, we must use a filter which has a sharp knee and an ultimate attenuation slope of 24 dB per octave. The most satisfactory (and cheapest) method of doing this is to use an active high-pass filter — and this is the approach we have used. To obviate the possibility of hum-pickup, the unit uses a battery power supply, one each for left and right channel filters. The use of separate batteries prevents earth loops and ensures that channel separation is maintained. As current drain is very low the batteries may be expected to last their shelf life (12 months or so) and for that reason an on/off switch has not been included.

The unit fits between the turntable and the amplifier, cuts any frequency below 35 Hz and has a total attenuation of 37 dB at 10 Hz increasing at 24 dB/octave below that.

CONSTRUCTION

We built our unit onto a small printed circuit board, but layout is not critical and other alternative methods, such as matrix or Veroboard, may be used successfully.

The signal levels involved are extremely small (about 100 μV at 50 Hz) and for this reason a metal box is a must if hum pickup is to be minimized. And, as said before, two separate battery supplies should be used in order to avoid earth loops. We used a conventional four-way battery holder to hold the two sets of batteries. These holders normally connect all four batteries in series. However it is a simple matter to snip the connection between the two sets of two cells.

The phono sockets for both input and output should be insulated from the metal case. When connecting the unit we found minimum hum was introduced by earthing the turntable to the metal box and then, by taking a separate earth from the metal box to the amplifier. However experimentation in the positioning of earths may well show that some other configuration is best for your particular setup. ●

The largest selection

BRAND NEW FULLY GUARANTEED DEVICES

Type	Price
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	0.28
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	0.53
AD142	0.53
AD143	0.42
AD149	0.55
AD161	0.39
AD162	0.39

Type	Price
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
ASY58	0.28
ASY73	0.28
ASZ21	0.44
BC107	0.14
BC108	0.14
BC109	0.15
BC113	0.11
BC114	0.17
BC115	0.17
BC116	0.17
BC117	0.20
BC118	0.11
BC119	0.33
BC120	0.88
BC125	0.13
BC126	0.20
BC132	0.13
BC134	0.20
BC135	0.13
BC136	0.17
BC137	0.17
BC139	0.44
BC140	0.33
BC141	0.33
BC142	0.33
BC143	0.33
BC145	0.50
BC147	0.11
BC148	0.11
BC149	0.13

Type	Price
BC150	0.20
BC151	0.22
BC152	0.19
BC153	0.31
BC154	0.33
BC157	0.20
BC158	0.13
BC159	0.13
BC160	0.50
BC161	0.55
BC167	0.13
BC168	0.13
BC169	0.13
BC170	0.13
BC171	0.16
BC172	0.16
BC173	0.16
BC174	0.16
BC175	0.24
BC177	0.21
BC178	0.21
BC179	0.21
BC180	0.27
BC181	0.27
BC182	0.16
BC182L	0.16
BC183	0.16
BC183L	0.16
BC184	0.22
BC184L	0.22
BC186	0.31
BC187	0.31
BC207	0.12
BC208	0.12
BC209	0.13
BC212L	0.14
BC213L	0.14
BC214L	0.18
BC225	0.28
BC226	0.39
BC301	0.30
BC302	0.27
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	0.28
BD115	0.68
BD116	0.88
BD121	0.66
BD123	0.72
BD124	0.76

Type	Price
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	£1.05
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	0.50
BF123	0.55
BF125	0.50
BF127	0.55
BF152	0.61
BF153	0.50
BF154	0.50
BF155	0.77
BF156	0.53
BF157	0.61
BF158	0.61
BF159	0.66
BF160	0.44
BF162	0.44
BF163	0.44
BF164	0.44
BF165	0.44
BF167	0.24
BF173	0.28
BF176	0.39
BF177	0.39
BF178	0.33
BF179	0.33
BF180	0.33
BF181	0.33

Type	Price
BF182	0.44
BF183	0.44
BF184	0.28
BF185	0.33
BF187	0.30
BF188	0.44
BF194	0.13
BF195	0.13
BF196	0.16
BF197	0.16
BF200	0.50
BF222	£1.05
BF257	0.50
BF258	0.66
BF259	0.94
BF262	0.61
BF263	0.61
BF270	0.39
BF271	0.33
BF272	0.88
BF273	0.39
BF274	0.39
BFW10	0.66
BFX29	0.30
BFX84	0.24
BFX85	0.33
BFX86	0.24
BFX87	0.27
BFX88	0.24
BFY50	0.22
BFY51	0.22
BFY52	0.22
BFY53	0.19
BSX19	0.17
BSX20	0.17
BSY25	0.17
BSY26	0.17
BSY27	0.17
BSY28	0.17
BSY29	0.17
BSY38	0.20
BSY39	0.20
BSY40	0.31
BSY41	0.31
BSY95	0.14
BSY95A	0.14
BU105	£2.20
C111E	0.55
C400	0.33
C407	0.28
C424	0.28
C425	0.55
C426	0.39
C428	0.22
C441	0.33
C442	0.33
C444	0.39
C450	0.24
MAT100	0.21
MAT101	0.22
MAT120	0.21
MAT121	0.22

Type	Price
MJE2955	0.95
MJE3055	0.62
MJE3440	0.55
MPF102	0.46
MPF104	0.41
MPF105	0.41
OC19	0.39
OC20	0.70
OC22	0.52
OC23	0.54
OC24	0.62
OC25	0.42
OC26	0.32
OC28	0.55
OC29	0.55
OC35	0.46
OC36	0.55
OC41	0.22
OC42	0.27
OC44	0.17
OC45	0.14
OC70	0.11
OC71	0.11
OC72	0.16
OC74	0.16
OC75	0.17
OC76	0.17
OC77	0.28
OC81	0.17
OC81D	0.17
OC82	0.17
OC82D	0.17
OC83	0.22
OC139	0.22
OC140	0.22
OC169	0.28
OC170	0.28
OC171	0.28
OC200	0.28
OC201	0.31
OC202	0.31
OC203	0.28
OC204	0.28
OC205	0.39
OC309	0.44
OCP71	0.48
ORP12	0.48
ORP60	0.44
ORP61	0.44
P20	0.55
P346A	0.22
P397	0.46
ST140	0.14
ST141	0.19
TIS43	0.34
UT46	0.30
ZN414	£1.20
2G301	0.21
2G302	0.21
2G303	0.21
2G304	0.27
2G306	0.44

Type	Price
2G308	0.39
2G309	0.39
2G339	0.22
2G339A	0.18
2G344	0.20
2G345	0.18
2G371	0.18
2G371B	0.13
2G373	0.19
2G374	0.19
2G377	0.33
2G378	0.18
2G381	0.18
2G382	0.18
2G401	0.33
2G414	0.33
2G417	0.28
2N388	0.39
2N388A	0.61
2N404	0.22
2N404A	0.31
2N524	0.46
2N527	0.54
2N598	0.46
2N599	0.50
2N696	0.14
2N697	0.15
2N698	0.27
2N699	0.39
2N706	0.09
2N706A	0.10
2N708	0.13
2N711	0.33
2N717	0.39
2N718	0.27
2N718A	0.55
2N726	0.31
2N727	0.31
2N743	0.22
2N744	0.22
2N914	0.16
2N918	0.33
2N929	0.23
2N930	0.23
2N1131	0.22
2N1132	0.24
2N1302	0.16
2N1303	0.16
2N1304	0.19
2N1305	0.19
2N1306	0.23
2N1307	0.23
2N1308	0.26
2N1309	0.26
2N1613	0.22
2N1711	0.22
2N1889	0.35
2N1890	0.50
2N1893	0.41
2N2147	0.79
2N2148	0.63
2N2160	0.66

Type	Price
2N2192	0.39
2N2193	0.39
2N2194	0.39
2N2217	0.24
2N2218	0.22
2N2219	0.22
2N2220	0.24
2N2221	0.22
2N2222	0.22
2N2368	0.19
2N2369	0.16
2N2369A	0.16
2N2411	0.27
2N2412	0.27
2N2646	0.52
2N2711	0.23
2N2712	0.23
2N2714	0.23
2N2904	0.19
2N2904A	0.23
2N2905	0.23
2N2905A	0.23
2N2906	0.17
2N2906A	0.20
2N2907	0.22
2N2907A	0.24
2N2923	0.16
2N2924	0.16
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
2N3053	0.19
2N3054	0.51
2N3055	0.55

Type	Price
2N3391	0.16
2N3391A	0.18
2N3392	0.16
2N3393	0.16
2N3394	0.16
2N3395	0.19
2N3402	0.23
2N3403	0.23
2N3404	0.31
2N3405	0.46
2N3414	0.17
2N3415	0.17
2N3416	0.31
2N3417	0.31
2N3525	0.83
2N3614	0.74
2N3615	0.82
2N3616	0.82
2N3644	0.10
2N3702	0.13
2N3703	0.13
2N3704	0.14
2N3705	0.13
2N3706	0.13
2N3707	0.14
2N3708	0.09
2N3709	0.10
2N3710	0.10
2N3711	0.10
2N3819	0.31
2N3820	0.55
2N3821	0.39
2N3823	0.31
2N3903	0.31
2N3904	0.33
2N3905	0.31
2N3906	0.30
2N4058	0.13
2N4059	0.11

Type	Price
2N4060	0.13
2N4061	0.13
2N4062	0.13
2N4284	0.19
2N4285	0.19
2N4286	0.19
2N4287	0.19
2N4288	0.19
2N4289	0.19
2N4290	0.19
2N4291	0.19
2N4292	0.19
2N4293	0.19
2N5172	0.13
2N5294	0.60
2N5457	0.35
2N5458	0.35
2N5459	0.44
2N6221	0.75
2S301	0.55
2S302A	0.46
2S302	0.46
2S303	0.62
2S304	0.77
2S305	0.86
2S306	0.86
2S307	0.86
2S321	0.62
2S322	0.46
2S322A	0.46
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 AND RECTIFIERS

Type	Price	Type	Price	Type	Price
AA119	0.09	BY128	0.17	OA10	0.15
AA120	0.09	BY130	0.18	OA47	0.08
AA129	0.09	BY133	0.23	OA70	0.08
AAY30	0.10	BY164	0.55	OA79	0.08
AAZ13	0.11	BYX38/30	0.46	OA81	0.08
BA100	0.11	BYZ10	0.39	OA85	0.10
BA116	0.23	BYZ11	0.33	OA90	0.07
BA126	0.24	BYZ12	0.33	OA91	0.07
BA148	0.16	BYZ13	0.28	OA95	0.08
BA154	0.13	BYZ16	0.44	OA200	0.07
BA155	0.16	BYZ17	0.39	OA202	0.08
BA156	0.15	BYZ18	0.39	SD10	0.06
BA173	0.16	BYZ19	0.31	SD19	0.06
BY100	0.17	CG62		1N34	0.08
BY101	0.13	(OA91Eq)	0.06	1N34A	0.08
BY105	0.19	CG651 (OA70–		1N914	0.06
BY114	0.13	79)	0.07	1N916	0.06
BY124	0.13	OA5	0.39	1N4148	0.06
BY126	0.16	OA5 short		1S021	0.11
BY127	0.17	leads	0.23	1S951	0.07

LINEAR I.C's—FULL SPEC.

Type No.	Price 1	25	100 +
72702	0.50	0.48	0.45
72709	0.35	0.33	0.30
72709P	0.33	0.31	0.29
72710	0.45	0.43	0.40
72741	0.40	0.38	0.35
72741C	0.45	0.43	0.40
72741P	0.38	0.36	0.34
72748P	0.38	0.36	0.34
SL201C	0.59	0.45	0.40
SL701C	0.50	0.45	0.40
SL702C	0.50	0.45	0.40
TAA263	0.80	0.70	0.60
TAA293	£1.00	0.95	0.90
TAA350A	£1.85	£1.80	£1.70
μA703C	0.28	0.26	0.24
μA709C	0.35	0.33	0.30
μA711	0.45	0.43	0.40
TBA800	£1.50	—	—

NUMERICAL INDICATOR TUBES

CD66	£1·87
GR116	£1·70
3015F Minitron	£1·50
MAN 3M. L.E.D. 7-segment 0·127"	£1·90

All indicators 0·9 + Decimal point.
All side viewing. Full data for all types available on request.

ZN414 . . . . £1·20 each
I.C. Radio Rec. incl. full cir. data.

TRIPLE 66-bit DYNAMIC SHIFT REGISTER EDSR 3166

Comprises three 66-bit 2 O dynamic shift registers with independent inputs and outputs. TTL compatibility and buffered clock lines to reduce the capacitive load presented at the clock pins. A boot-strapped buffer ensures a full logic swing at the output.
£2·50 each

DTL 930 SERIES LOGIC I.C's

Type	Price 1	25	100 +
BP930	0.15	0.14	0.13
BP932	0.16	0.15	0.14
BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	0.30	0.28	0.25
BP946	0.15	0.14	0.13
BP948	0.30	0.28	0.25
BP951	0.70	0.65	0.60
BP962	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
BP9094	0.45	0.43	0.40
BP9097	0.45	0.43	0.40
BP9099	0.45	0.43	0.40

Devices may be mixed to qualify for quantity price. Larger quantity price on application. (DTL 930 Series only).

VOLTAGE REGULATORS

TO.3 Plastic 1·5 Amps

μA.7805/L129 5V (Equiv. to MVR5V)	£1·76
μA.7812/L130 12V (Equiv. to MVR12V)	£1·76
μA.7815/L131 15V (Equiv. to MVR15V)	£1·76

DUAL-IN-LINE SOCKETS

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

TYPE No.	1-24	25-99	100up.
TSO 14 pin type	33p	30p	27p
TSO 16	38p	35p	32p
LOW COST No.			
BPS 14	16p	14p	12p
BPS 16	17p	15p	13p
BPS 8 spin type	15p	13p	11p

ALL PRICES INCLUDE VAT.

74 Series T.T.L. I.C's

BI-PAK STILL LOWEST IN PRICE. FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

Type	Quantities 1	25	100 +
7400	0.18	0.17	0.16
7401	0.18	0.17	0.16
7402	0.18	0.17	0.16
7403	0.18	0.17	0.16
7404	0.18	0.17	0.16
7405	0.18	0.17	0.16
7406	0.39	0.34	0.31
7407	0.39	0.34	0.31
7408	0.25	0.24	0.23
7409	0.25	0.24	0.23
7410	0.18	0.17	0.16
7411	0.28	0.27	0.26
7412	0.30	0.29	0.28
7413	0.32	0.31	0.30
7416	0.40	0.39	0.38
7417	0.40	0.39	0.38
7420	0.18	0.17	0.16
7422	0.30	0.29	0.28
7423	0.40	0.39	0.38
7425	0.40	0.39	0.38
7426	0.40	0.38	0.36
7427	0.40	0.38	0.36
7428	0.45	0.42	0.40
7430	0.18	0.17	0.16
7432	0.40	0.38	0.36
7433	0.42	0.40	0.38
7437	0.45	0.42	0.40
7438	0.45	0.42	0.40
7440	0.18	0.17	0.16
7441	0.74	0.71	0.64
7442	0.74	0.71	0.64
7443	£1.20	£1.15	£1.10
7444	£1.20	£1.15	£1.10
7445	£1.98	£1.95	£1.90
7446	£1.20	£1.15	£1.10
7447	£1.10	£1.07	£1.05

Type	Quantities 1	25	100 +
7448	£1.10	£1.07	£1.05
7450	0.18	0.17	0.16
7451	0.18	0.17	0.16
7453	0.18	0.17	0.16
7454	0.18	0.17	0.16
7460	0.18	0.17	0.16
7470	0.32	0.29	0.27
7472	0.32	0.29	0.27
7473	0.41	0.39	0.35
7474	0.41	0.39	0.35
7475	0.60	0.58	0.56
7476	0.44	0.43	0.42
7480	0.74	0.71	0.64
7481	£1.30	£1.25	£1.20
7482	0.90	0.85	0.80
7483	£1.20	£1.15	£1.05
7484	£1.10	£1.05	£1.00
7485	£2.00	£1.90	£1.80
7486	0.35	0.34	0.33
7489	£4.00	£3.75	£3.50
7490	0.74	0.71	0.64
7491	£1.10	£1.05	£1.00
7492	0.74	0.71	0.64
7493	0.74	0.71	0.64
7494	0.85	0.82	0.75
7495	0.85	0.82	0.75
7496	0.96	0.93	0.86
74100	£1.50	£1.45	£1.40
74104	0.70	0.68	0.66
74105	0.70	0.68	0.66
74107	0.44	0.42	0.40
74110	0.60	0.55	0.50
74111	0.95	0.92	0.90
74118	£1.10	£1.05	£1.00
74119	£1.50	£1.40	£1.30
74121	0.50	0.48	0.45

Type	Quantities 1	25	100 +
74122	0.88	0.86	0.84
74123	£1.58	£1.54	£1.50
74141	0.85	0.82	0.79
74145	£1.58	£1.54	£1.50
74150	£2.50	£2.40	£2.30
74151	£1.10	£1.05	£1.00
74153	£1.20	£1.10	£1.00
74154	£1.98	£1.90	£1.75
74155	£1.20	£1.15	£1.10
74156	£1.20	£1.15	£1.10
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33µF	16V	6½p	1000µF	16V	20p
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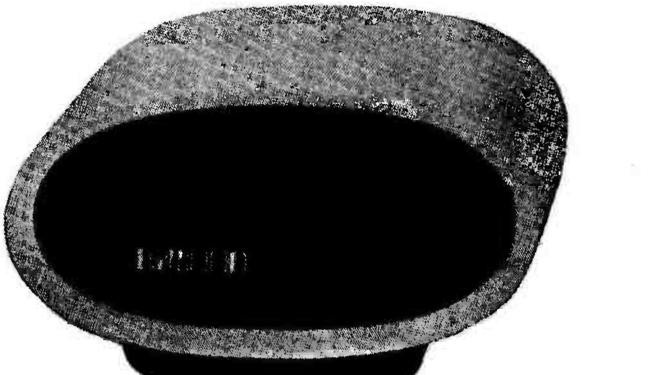

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ELECTRONIC SPEED CONTROL FOR MOTORS

Continued from page 51.

maximum rms voltage available to the motor under half-wave conditions is less than for full-wave, the motor should be designed for use under these conditions to obtain maximum speed.

CONTROL OF PERMANENT MAGNET MOTORS

As a result of recent developments in ceramic permanent-magnet materials that can be easily moulded into complex shapes at low cost, the permanent-magnet motor has become increasingly attractive as an appliance component. Electronic control of this type of motor can be easily achieved using techniques similar to those just described for the universal motor. Figure 16 is a circuit diagram of a control system to control permanent-magnet motors presently being used in blenders. Potentiometer R_3 and diode D_1 form a dc charging path for capacitor C_1; variable resistor R_1 and resistor R_2 form an ac charging path which creates the ramp voltage on the capacitor. Resistor R_4 and diode D_2 serve to isolate the motor control circuit from the ramp generator during the positive and negative half-cycles, respectively.

A small amount of cycle skipping can be experienced at low speeds using this control, but not enough to necessitate further development work. Since the voltage generated during off time is very high, the thermal runaway problem does not appear at all.

HEATER CONTROL AND TIMERS

The circuit shown in Fig.2 or 3 could well be made to control heaters in domestic appliances without any modifications.

If the capacitor C_T in Fig.3 is made very large a timer results. The time delay is set by the value of C_T and the variable resistor R_T. ●

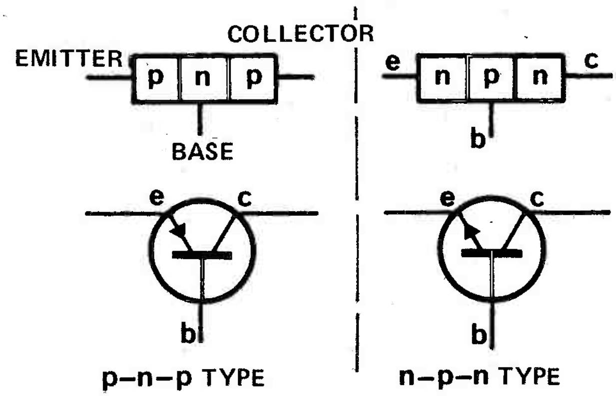
We must emphasis that this article is not intended as a constructional one and component values cannot be supplied. However a number of practical circuits covering speed control are scheduled for the magazine in two months.

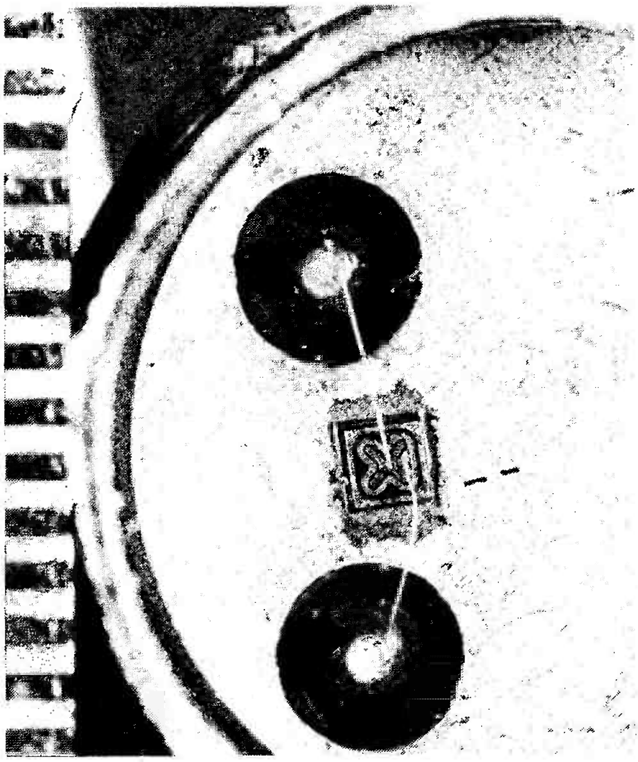
ELECTRONICS —it's easy!

PART 11b

This month we continue our discussion of Amplification by looking at the basics of the transistor amplifier.

Fig.9. The basic structure and symbols for the two elementary transistor types.





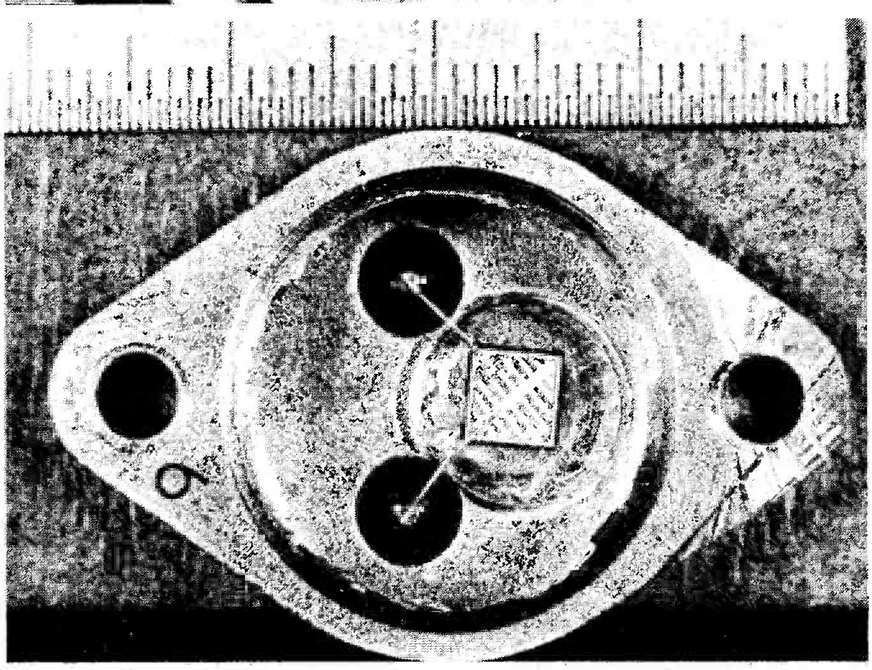


Fig.10. The actual transistor chip is indeed tiny — as these enlargements show. The scales at left half millimetre divisions. The smaller chip is a high-frequency small-signal transistor, mounted in a TO5 case, the other a power transistor mounted in a TO3 case.

THE TRANSISTOR

Transistors are made from two basic materials — germanium or silicon. These two materials are known as semiconductors because they are neither good insulators, nor good conductors. That is, they are somewhere in between.

Germanium was used for early transistors, but has largely (although not entirely) been replaced by silicon in modern devices. Although there are some important differences between transistors constructed from these two materials, the basic theory, as follows, is the same.

The basic pure material is modified by adding a controlled amount of impurities called dopants, to form two new materials, one (called P type) having a deficiency of electrons and one (called N type) having a surplus of electrons.

If two pieces of these differently doped materials are intimately joined we have what is called a PN junction. Such a junction of P and N materials will conduct current more readily in one direction than in the other — it is in fact a rectifier, or in other words, a semiconductor diode.

Current flow occurs when the P type material is made more positive than the N type material. The physics involved in this phenomenon are complex, but of little interest at this stage. We are only interested in the fact that it happens.

To make a transistor we add a third layer of material to form a three-layer sandwich in either NPN or PNP format. We refer to the transistors in this way – as a silicon NPN or PNP type etc. The symbols for the two types are shown in Fig.9. Each terminal is given the name as shown, the base being the centre connection, the emitter the one marked by an arrow and the collector unmarked. Note particularly that the direction of the emitter arrow denotes whether the transistor is a PNP or NPN type also that the symbol is the same for both germanium and silicon devices.

In actual manufacturing processes the three layers are formed by selectively growing N and P crystal layers, or by diffusing P and N impurities into the opposite sides of a pure, silicon or germanium crystal.

The actual transistor chip may be extremely small, often pin-head size and is generally a tiny fraction of the total packaged volume of the device. This is illustrated in Fig.10 which shows the inner construction of different types of transistor. From this we see that although small, a conventionally packaged transistor wastes a relatively enormous amount of space. Integrated circuits, where both active and passive components are made and connected by layering and diffusion processes, are logical developments from transistor technology – it is just as easy to fit 20 or 100 transistors in a T05 case as it is to fit one.

The main problems in integration are in limiting power dissipation within a given chip or case, and in fabricating resistors and capacitors.

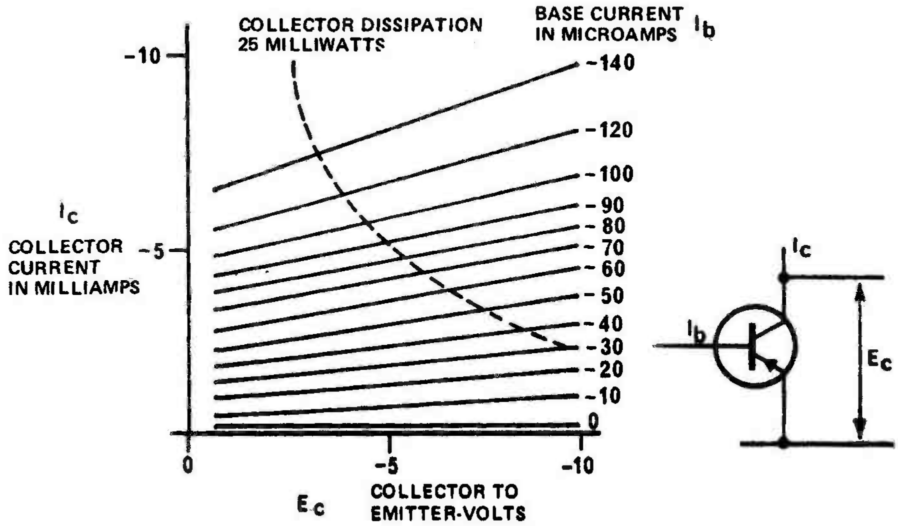
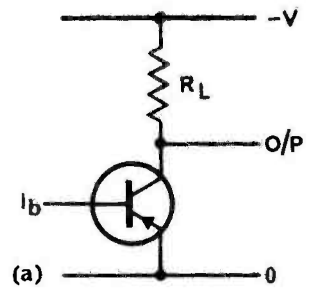
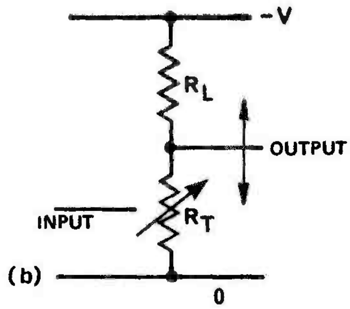
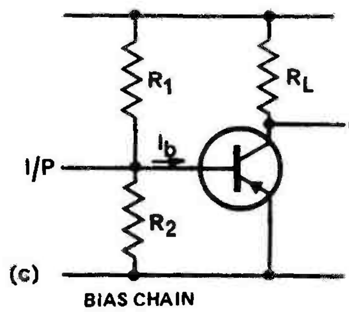


Fig.11. Typical characteristic curves for a small signal PNP-transistor.







$\frac{R_1}{R_2} \approx 4$ $\frac{R_1}{R_L} \approx 10$

Fig.12(a). To use a transistor as an amplifier we first need to insert a load resistor RL. (b) The load resistor together with the resistance of the transistor become a voltage divider. (c) To amplify ac signals we must use a bias current to offset the operating point.

SYMBOLS

As we go further in electronics we must use shorthand methods of expressing things – otherwise explanations tend to become unwieldy. For example, in our discussion of transistor parameters we will be considering the currents, voltages and impedances etc. associated with each lead of the device. To avoid having to write for example, "current in the collector lead" we simply write I_C. The main symbol I tells us we are concerned with current and the subscript 'C' tells us that it is the collector lead we are talking about.

Thus E_b = base voltage
E_c = collector voltage
I_b = base current
E_{ce} = voltage between collector and emitter.

Now that we have established our shorthand we are in a position to examine the practical characteristics of transistors.

CHARACTERISTIC CURVES

Let us examine what happens if we hold the collector-to-emitter voltage, E_{ce}, constant at -5 volts and then vary the base current, I_b from 50 to 60μA we find that we have a corresponding I_c change of 500μA (0.5 mA). Thus we have a gain, β of 500/10 = 50.

Note that corresponding changes in I_b at other points (e.g. 90 to 100μA) do not result in the same gain. In fact, there is non-linearity at extremes of I_b which would result in distortion of the signal.

In practice it is not necessary to perform these calculations, the manufacturer tells us the gain in his data sheet. This is referred to as β or Hfe (don't worry about interpretation of this latter symbol) and is the ratio of the change in collector current resulting from a small change in base current.

That is $\beta = \frac{\Delta I_c}{\Delta I_b}$ (Δ means small change in)

Values of β range from 5 or so for early transistors to several hundred, or even thousands in modern components. Manufacturing tolerances don't allow all transistors of any type to have the same β' and the manufacturer usually specifies the limits within which the device current-gain will fall.

For example the BC108 featured in this month's offer is specified as having Hfe (β) greater than 125 but less than 900 at 1_C=2mA and Vce= 5 volts.

Referring back to Fig.11, we find a dotted line across the curves which represents the maximum permissible

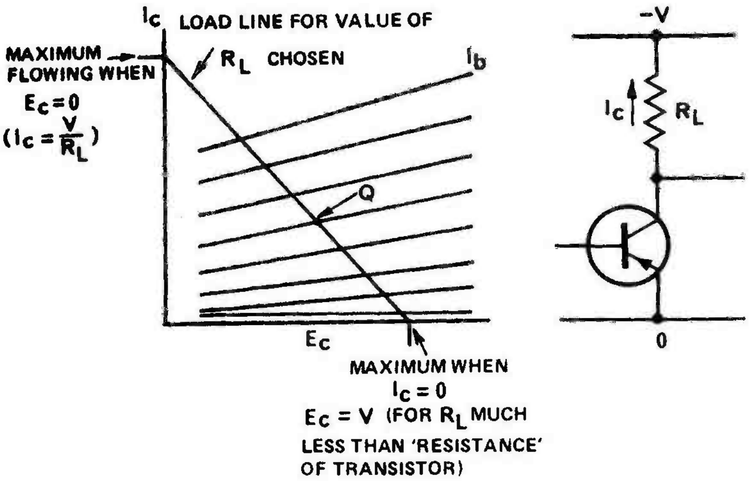


Fig. 13. Output impedance of the stage is equal to the value of R_L. R_L is generally chosen to be about one-tenth of the input impedance of the following stage provided that $(\frac{V}{2})^2 R$ does not exceed the rated device dissipation. The load line is then drawn and operating point Q determined as detailed in the text.

power dissipation for the device. This is determined by the maximum heat that can be dissipated without the chip being destroyed, unless the device is cooled by a heat sink or with forced air circulation.

For example if the transistor of Fig.11 has an E_{ce} of 5 V, then the collector current must not exceed 5 mA if the dissipation is to be less than 25 mW. Thus the user must check his design to ensure that under worst case conditions (component tolerances, power supply voltage etc.) this dissipation is not exceeded. The device must never be operated at any point above and to the right of the dissipation curve.

Thus we see that much information can be extracted from the characteristic curves.

THE BASIC AC AMPLIFIER

Used alone, the transistor cannot amplify ac waveforms. The two main limitations are its inherent rectifying action and an effect known as thermal runaway. In addition we must devise a way of taking an output from the transistor.

The transistor may be considered as a resistor whose value is varied by the input base current. Hence, if we place a resistor in series with the collector lead of the transistor, we will have a voltage divider as shown in Fig. 12. The collector current, as it changes in response to changes in base current, will produce an output voltage across the series resistor. This series resistor is called the 'load' resistor and is denoted by the symbol R_L.

Note that to drive more current into the base we must raise E_b towards the collector supply voltage. The resulting increase in I_C will cause the voltage at the collector, E_C, to fall. Thus the output voltage will be the inverse of the input. In other words, the transistor connected in this fashion, changes the phase of the input voltage by 180°.

BIASING

If a sine wave were to be applied to the base of the transistor in Fig. 12a, the negative half cycles would be clipped off – the waveform would be rectified as previously explained. We can overcome this by applying a dc 'bias' current to the base such that the input signal either adds or subtracts from this current but *never* drives the base current to zero.

Hence the collector current will also be biased away from zero and will follow the variations in base current. In practical circuits it is not feasible to have a separate battery or power supply to provide bias, so it is usually derived from the collector supply. The most common method is by using a voltage divider as illustrated in Fig. 12c.

Biasing can also be illustrated using characteristic curves. For any chosen R_L value, there will be corresponding pairs of I_C and E_C values – Ohms law again. This means for any value of R_L we can draw a line – called the load line – across the characteristic curve as in Fig. 13. The importance of this curve is that the input signal, I_b moves up and down this line. If we do not add a bias current to I_b we would be operating at the bottom end, where $I_b = 0$, and only negative swings of I_b would be amplified. By adding a *quiescent* bias current we put the mean operating point at a place midway (this is called the Q point) along the load line and both half cycles of our input signal will be amplified linearly.

The degree of distortion is decided by the extent to which the input signal varies I_b up and down about the Q-point. Small signal changes will be undistorted but not large ones. One cause of this is that the gain I_c/I_b will change at the limits.

Secondly, if the input signal increases still further, the peaks of the sine wave will be clipped, at one end by the base current reaching zero, and at the other by the collector voltage being driven to zero (this latter condition is called saturation). Hence it can readily be seen, from the characteristic curves and load line, what maximum input signal can be applied without distortion occurring.

Note that the load line must always lie below the maximum power dissipation curve.

THERMAL RUNAWAY

As well as the currents I_b and I_c that are designed to flow in the transistor there is leakage current through the normally reverse-biased, collector-base junction. Some of this current will flow through the base-emitter junction (actually all of it if the base is not connected) appearing as a normal signal. The apparent signal current will be amplified causing an I_c of βI_b.

Now here is the danger – the leakage current is proportional to temperature. So the increased I_c heats the transistor, the leakage current increases, I_c increases still further – and the process may continue until the transistor destroys itself.

The actual process is more involved than we have described but the explanation suffices for our purposes.

With silicon transistors leakage current is very small and of little importance but silicon has another temperature effect that produces similar, although not as serious, thermal runaway. This is that the E_{be}

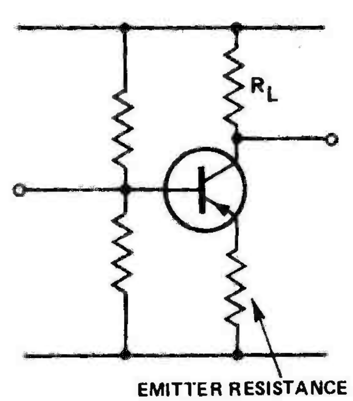


Fig.14. The amplifier is stabilized against the effects of thermal runaway by adding an emitter resistor.

of a silicon transistor, required for a certain collector current, falls with temperature. Hence with a fixed input voltage the resultant I_c causes a rise in temperature, which causes a decrease in E_{be} required, and hence a further rise in I_c – result thermal runaway.

Silicon transistors can be used over a much wider range than can germanium but thermal runaway must be compensated for with both types.

Fortunately this potentially damaging effect is easily overcome, in both cases, by adding a resistor into the emitter path as shown in Fig. 14. Its effect is as follows.

As the collector current rises (due to leakage current) the voltage dropped across the emitter resistor, Re, increases thus reducing the base-emitter voltage V_{be}. This reduces the base current, and almost restores the collector current to its original value. Mathematics tells us the ideal conditions to achieve stability and show that an emitter resistance roughly one sixth of the collector load resistance is about right. The bias chain values must be readjusted for this and again there are complex mathematical expressions for optimizing the values. In practice a good choice is that the chain has values in the same ratio as the collector chain but about ten times larger.

BYPASSING

Having overcome thermal runaway conditions we now find the amplifier is nicely stable but lacks gain. This is because the same collector current flows through the emitter resistor as through the load resistor. Hence the gain can only be equal to the ratio of R_L to R_e, that is, in our case 6. And this is completely independant of β. We can restore our gain by adding one more component— a capacitor across R_e.

Thermal effects occur slowly by comparison with ac signals (10 Hz and above) so a capacitor connected across the emitter resistor will act as a low impedance to ac signals (thus restoring ac gain) but as a non-existant component to dc. Hence we get the best of both worlds – thermal runaway is eliminated and ac gain is maintained. The capacitor is chosen such that its reactance is about one tenth the value of R_e at the lowest frequency of interest. ●

Further reading:
"Understanding Solid State Electronics" Texas Instruments Ltd. Manton Lane, Bedford.

ELECTRONICS – in practice

THE CIRCUIT of a typical ac amplifier, for audio frequencies, is given in Fig. 15. The input signal is coupled in via a capacitor that provides dc isolation between the preceding stage and the bias network.

As the capacitor needs to be fairly large (X_c less than one tenth the resistance from base to ground at lowest frequency) it is usually an electrolytic. An electrolytic may be used as long as the positive terminal is connected to the most positive dc potential.

The circuit uses the transistors in this month's offer and may be put to work (and tested) by adding the components as shown in Fig. 16.

In effect we now have a light intensity meter which can be used to monitor the modulated content of the radiation from a fluorescent-light tube. Note that it does not measure the steady-state light radiation.

The light dependant resistor, type ORP12, provides a small amplitude 100 Hz signal when excited by the light from a fluorescent tube. The amplifier increases the signal amplitude by about forty times. The output from the amplifier may then be half-wave rectified to provide a dc output proportional to the level of the 100 Hz light signal. This may be measured by a normal multimeter, or alternatively, the ac signal may be fed directly to high impedance headphones. You will then hear the 100 Hz tone from the light radiation.

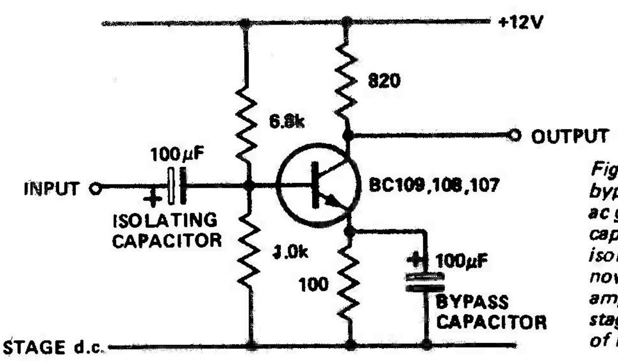


Fig.15. The addition of a bypass capacitor restores ac gain and an input capacitor provides isolation for the input. We now have a complete ac amplifier. Two or more stages can be used in series of more gain is required.

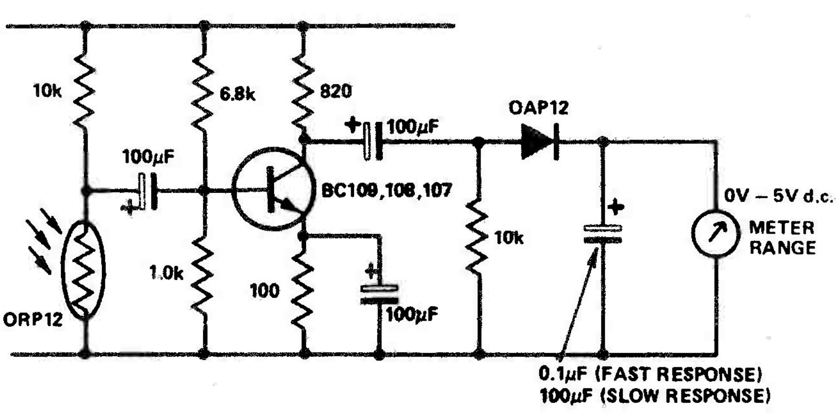


Fig.16. The modulated light output from a fluorescent lamp may be amplified and measured by adding just a few more components. This also provides a simple test of correct amplifier operation.

Electronics Tomorrow

by John Miller-Kirkpatrick

PETROL PRICES UP! Food Prices Up! Cigarette Prices Up! Electronics Prices Down!

Has it ever occured to you that whereas most products in this country, in fact in the world, have suffered from price inflation, products connected with the electronics industry tend to go down in price. Such things as television sets, HiFi sets, calculators, clocks, etc. all tend to go down in price regardless of the rate of inflation. This is quite possibly because most of the raw materials used in the electronics industry are cheap and reasonably plentiful. Even those materials which are expensive or rare (such as are used in semiconductor manufacture) are used in such small quantities per finished unit that the cost per unit is relatively small. If the material cost is low then the only inflationary costs involved are power and labour, thus the price of such components is based substantially on the actual manufacturing costs. Thus to keep prices down the manufacturer must use less of the expensive materials and at the same time automate as much as possible. The LSI integrated circuit has meant that more functions can be packed onto a small silicone chip and therefore fewer of those functions need to be made up from discrete components on a PCB, this cuts the component cost, PCB cost, assembly cost and testing costs.

As the finished PCB becomes simpler to assemble and contains fewer and fewer components other than ICs so the economics of automated assembly become more feasable. Machinery already exists for automatically assembling PCBs from ICs and discretes, other machines can automatically make the ICs from the raw materials, yet other machines can produce and/or purify these raw materials. From shovelling in the basic materials at one end (which could be done automatically) to producing the finished PCB at the other end, the whole process can be done automatically and controlled by a computer. This same computer can also test the finished PCBs and automatically reject or perhaps repair any that are below spec.

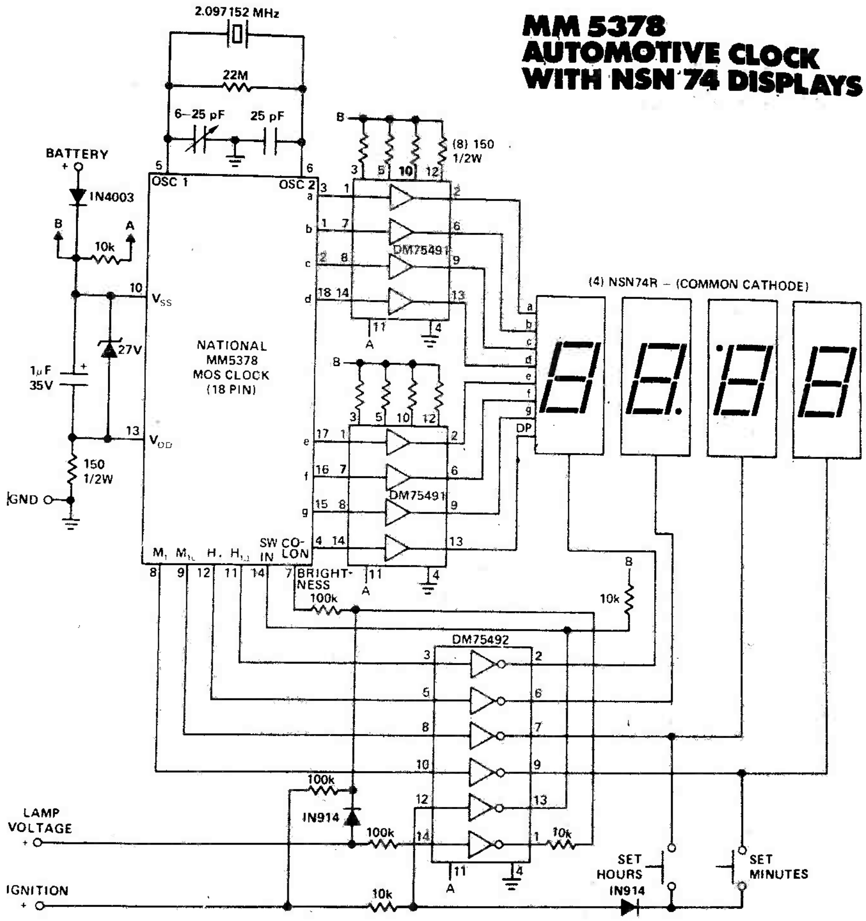
Of course, the human brain is still used in the original design and layout of the ICs and PCBs - or is it? Computer Aided Design is now used for optimum design in most ICs and some of the more complex PCBs. The computer uses pre-written programs and sub-routines to route the tracks of the various parts of the IC and to calculate the amount of material required to give the resistance or capacitance needed. Similarly, the computer can help out with the theoretical circuit design by simulating the circuit under any conditions and changing theoretical values for other values. By using massive subroutines the computer can call in complete IC functions in one go, ie it could call up the equivalent of a 7490 decade counter rather than incorporating one built from basic principles. The computer can also be taught to build in much larger units into its circuits design, the designer could call for a ten decade count module or a clock module or a 256 bit RAM, all of these units can be simulated by computer programs and built into the PCB or IC being designed.

At some stage in the operation the human designer has to tell the computer to incorporate, so the system is not completely automated yet. The computer cannot 'think' for itself - or can it? Most large computers now are capable of scheduling their own workload and deciding which programs or sub-routines it requires at any one time. The computer also usually writes its own programs, the human programmer in fact programs in a language more like English or mathematical notation and the computer converts from these high-level language programs into its own machine language instructions by using another program called a compiler. The computer can also modify these programs if it thinks that the programmer has made a mistake, or if the computer knows of a better way to approach the problem. When the program is being executed the machine can still alter the program to make the most efficient use of the core, disk or tape storage available. The programs could be models of a system the designer is testing and the computer will write its own program by trial and error until the absolute optimum is developed.

Our computer is now capable of designing a program to design a set of ICs and PCBs, another program to control the machine that will assemble the PCBs, another program for a minicomputer to test the finished units. There is no reason why the machine could not also pack the units for despatch to customers, debit the customers account, produce invoices and statements, print "solicitor's letters" for overdue payments, etc. At the other end of the business the computer could turn out designs for, let us say, calculators, list the components required either make them or send out orders for them, it could write letters to all existing customers about its new calculators, schedule incoming orders against production, etc. Most of these functions can and are being done by computers now in various companies. If all of these functions could be controlled by one computer then that computer could do its own design, ordering, scheduling, marketing and sales. All you do is to sit back and press a 'start' button and collect the profits - if the computer decides to pay you! Impossible? - No. The cost of such an exercise could be too high even to contemplate but there are some companies who could afford to extend their existing system until it became like our system. The only hope we have is that the computer is going to break down or need servicing at some time. But wait a minute, our computer is electronic and is in the electronics business, could it? - no, its not possible, it couldn't diagnose its own faults, design replacements and then design a machine to install those replacements. – Could it?

N.B. The above should be read very late at night after a heavy meal

MM 5378 AUTOMOTIVE CLOCK WITH NSN 74 DISPLAYS



of cheese and perhaps just a little wine. Pleasant dreams!

AND NOW FOR SOMETHING COMPLETELY (?) DIFFERENT

National Semiconductors (UK) Ltd have just released a new list of digital clock chips. These chips are extensions of their existing range of chips and some of them we have mentioned in this column before. The first commercial clock chip available and readily obtainable in this country was the NS MM5311, the 5311 family was then extended to the 5312, 5313 and 5314 chips and the MM5314 is still (but only just) the cheapest 6-digit clock chip on the market. This family has now been extended to include the MM5309 and the MM5315, these are basically the MM5311 and MM5313 with a reset to zero function added - now we might see some decent digital stopwatch designs incorporating these chips.

The MM5370 and MM5371 alarm chips with passive interface to high-voltage displays are now available. These chips were mentioned in ETI some months ago (it was even news to some NS people!) and so we will not repeat details here again. Suffice to say that they are definately now available, I have even seen one working, but for some obscure reason with a Phosphor-diode display not a Gas-discharge display.

One of the very new families is the MM5375. This is basically one chip which can be mask programmed (ie before production) to give several options of use for its second count register, and such things as 50/60Hz, or Timer functions in the second 12/24 Hour, Alarm tone or switch, etc. Already NS have 6 versions of this chip with various options, it seems a shame that they could not design the chip so that some of the options such as the 50/60Hz could not be selected at operation time rather than at production time. I assume that the lack of these options is due to the fact that the clock chip has only 18 pins, presumably to save on space and cost. I would refer the NS designers to *Electronics Tomorrow* in the August 1974 edition of ETI.

Another of the NS 18 pin chips is the MM5378 'Auto' (car) clock chip. This runs from a quartz crystal at 2,097152MHz, with a minimum of additional components and gives a digital clock system suitable for use in cars, boats, etc. In the diagram it can be seen with a circuit to drive LEDs but it would also direct drive Phosphor-diode type displays, thus cutting the component count even further. The MM5378 functions are basic four digit clock in 12 hour mode with flashing colon and brightness control, another chip with the same spec but with circuitry for driving Gas-discharge type displays is the MM5379. The only problem with the 5379 is where do you get 200V necessary for the display in a car environment, surely NS could have put an inverter driver onto the chip at very little extra cost?

Having written this much of this column I decided to ring NS and check the prices of the MM5375 and MM5378, they're not as cheap as one would expect for 18 pin chips. The one-off prices of the MM5375 are £9.00 and the MM5378 at £8.40, I expected them both to be in the £5 area. *National Semiconductors (UK) Ltd, The Precinct, Broxbourne, Herts.*●

BACK NUMBERS

Back numbers are available for 30p each plus 10p postage on one, 15p for two or more.

We are unable to supply the following:

April, May 1972
February, November 1973
March, September 1974

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Many popular constructional features in the issues no longer available are in the Top Projects Book available for 75p + 10p postage.

Orders should be sent to:
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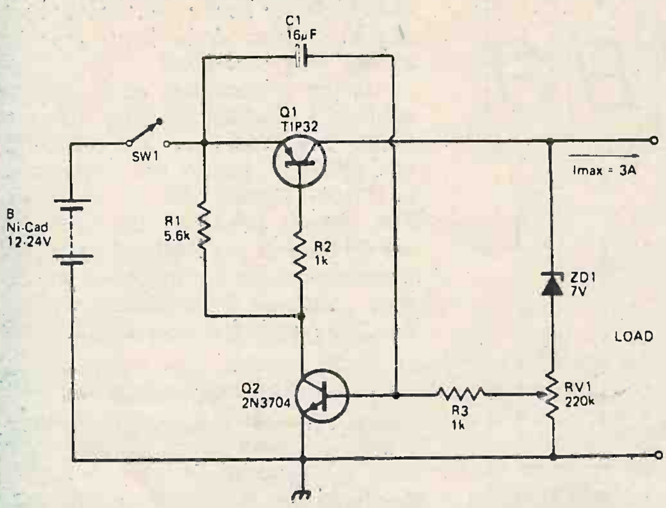
Electronics Today International, 36 Ebury Street, London SW1W OLW.

tech-tips

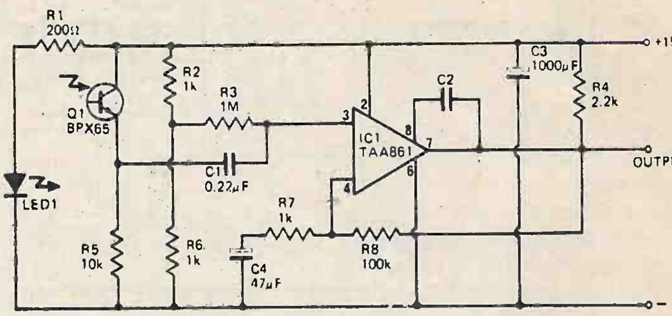
NI-CAD DISCHARGE LIMITER



Nickel-cadmium batteries should never be completely discharged as this leads to shortened life. The circuit shown may be used to disconnect the battery from the load when ever output voltage falls below a preset level.

In operation C1 charges through R1 and turns on Q2, the collector current of which flows through R2, turning Q1 on. Thus the battery is connected to the load. When the output voltage falls below a point set by RV1, Q2 turns off, Q1 turns off and further discharge of the battery is prevented.

OPTICAL PULSE CONDITIONER

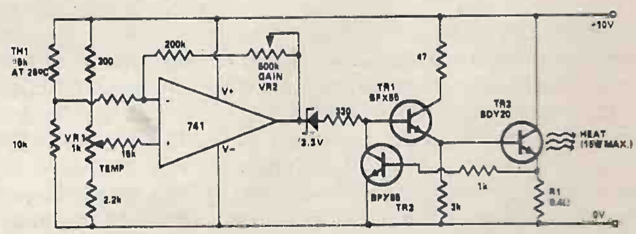


This circuit generates a fast rise time pulse each time the illumination of the BPX65 photo transistor by the LED is broken by a small object or rotating disc segment etc.

The operational amplifier, Siemens type TAA861, amplifies the signal from the photo-transistor and generates the fast rise time pulse the duration of which is determined by the value of C2: 5 microseconds when C2 = 47 pF, 1 microsecond for C2 equal to 16 pF and 0.4 microsecond when C2 equals 5 pF. The amplitude of the output pulse is 200 millivolt.

The circuit is thus ideal for generating pulses for an electronic counter. The maximum separation between the LED and the photo-transistor is around 20 mm.

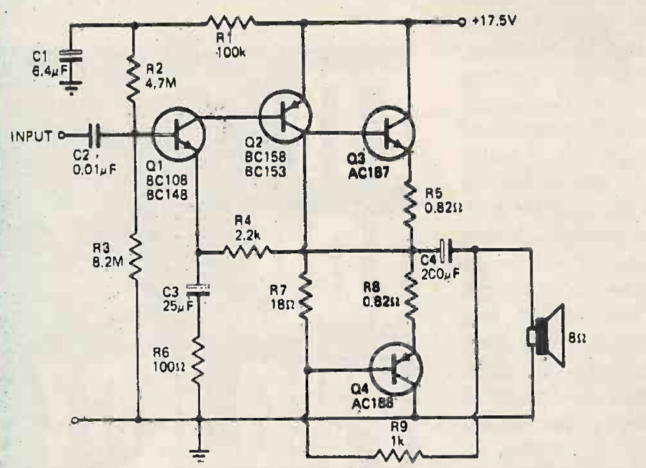
A SIMPLE TEMPERATURE-CONTROL SYSTEM



In electronics the need often arises to stabilise the temperature of critical sections of circuitry, such as master oscillators, log converters, and reference supplies. This circuit will control the temperature of a small mass of metal, such as a heat sink onto which critical components can be mounted, simply and efficiently.

The difference between a reference voltage set up on the temperature setting control VR1, and a voltage derived via thermistor TH1, is amplified by the op-amp, gain being set via VR2. This output voltage is applied to heater transistor TR2 via current amplifier TR1. ZD1 is essential for voltage-shifting since without it even the negative saturation voltage of the 741 would leave TR2 turned on. The current flowing in TR2 is limited to 1.5Amp by TR3, which shunts current from TR1 base if the voltage developed across R1 exceeds 0.6V. This arrangement leaves most of the supply voltage across TR2 and hence it is the only component dissipating significant heat.

AUDIO AMPLIFIER



A high input impedance of 1.1 megohm is made possible in this amplifier by keeping the collector current of Q1 low, and by using a high level of ac and dc feedback. The input sensitivity is adjusted by altering the value of R3.

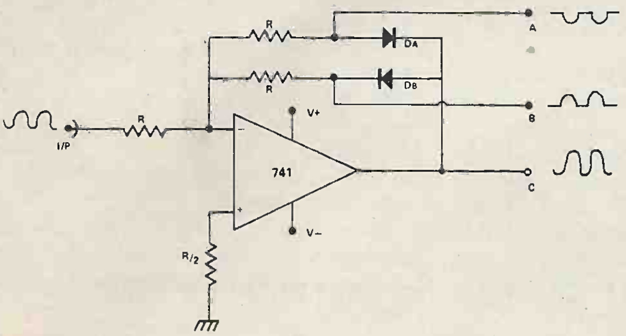
The quiescent current of the output stage is 2.5 mA and is stabilised by resistors R5 and R8. With a 17.5 volt supply the amplifier will deliver 2.5 watts across 8 ohms with a distortion of less than 1% at 1 kHz.

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

TR2 is bolted to the mass of metal to be temperature-stabilised, and TH1 mounted as close to its flange as possible, using silicon grease for good thermal contact. The less thermal time-lag between them, the higher the gain that can be used without instability, and hence the lower the steady-state error of the system. Instability can be easily checked for by monitoring the op-amp output; if this is stable at the non-saturated value, then the system is probably operating correctly. TH1 must be the type of thermistor that has a small head of sensitive material at the extreme end of the glass encapsulation; other types have too much thermal inertia.

The prototype held a small (3°C/W) heatsink within ½°C for temperature settings between 30°C and 70°C, when shielded from draughts. The unit must be powered from a 10V PSU having good voltage regulation, to attain this performance.

A DOUBLE PRECISION-RECTIFIER CIRCUIT



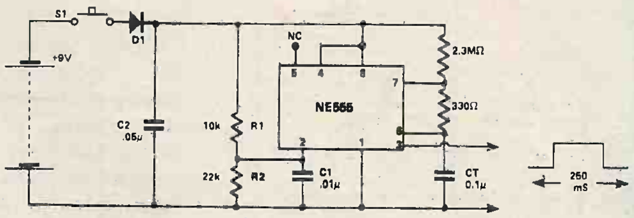
This circuit separates the positive and negative halves of an input waveform, and presents them (both phase-inverted) at separate output terminals. When the input swings positive, terminal A swings negative by an equal amount, terminal B remaining at zero voltage due to the reverse-biasing of D_B and the virtual-earth action of the op-amp. For negative inputs, terminal B swings positive by an equal amount, terminal A remaining at zero due to the reverse-biasing of D_A.

The insertion of a resistance of value R/2 in series with the non-inverting input gives partial cancellation of drift due to input offset-current changes. A suitable general-purpose value for R is 10K; note that the input-impedance is always R due to virtual-earth action.

A waveform appears at terminal C (at low impedance) that is the inverted input waveform with the addition of two diode-voltage-drops, in such a way that the central part of the waveform is "stretched". If the input is an audio source resulting distortion provides an interesting electronic music effect.

The circuit is particularily useful because positive and negative of a waveform can be operated on separately, and then combined in a simple virtual-earth mixer. For example, using two single-polarity log converters on the two outputs would provide bipolar logarithmic conversion upon recombination.

A SELF-TRIGGERING TIMING CIRCUIT

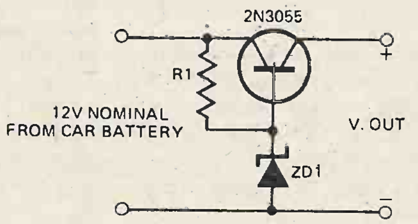


This circuit demonstrates a method of triggering a single time-period from a 555 timer supply by applying power to the circuit, thus eliminating the need for two switches or a two-pole push switch. The original application required that a single 250mSec pulse be produced when a push-button was operated, and the method shown allows the timer circuitry to be switched on and triggered simultaneously by a single MAKE contact. This also economises on battery power as there is no stand-by period.

A 555 timer triggers when the voltage on Pin 2 falls below $1/3V_{cc}$. When S_1 is closed Pin 2 remains briefly below $1/3V_{cc}$ due to the finite time C_1 takes to charge via R_1, and then climbs to $2/3V_{cc}$. Meanwhile the 555 has triggered and the time-period has begun. When S_1 is released, after the end of the period, C_1 discharges through R_2 and the circuit is ready for re-triggering in less than a millisecond. C_2 is essential to prevent supply-line transients resetting the 555 as soon as it triggers, and D_1 provides reverse-polarity protection.

Timing components (C_t and associated resistors) are shown with values for 250mSec pulses, though a wide range of different values can be used.

12V–9, 7.5, or 6V CONVERTER (AUTOMOBILE)



OUTPUT VOLTAGE	9	7.5	6
R1 (½ WATT)	180Ω	270Ω	330Ω
ZENER DIODE (250 mW)	10V	8V1	6V6

Many transistorised items such as radio, cassettes and other electrical items operate on batteries. Usually these are in the 6–12V range and sockets are provided for external power supply.

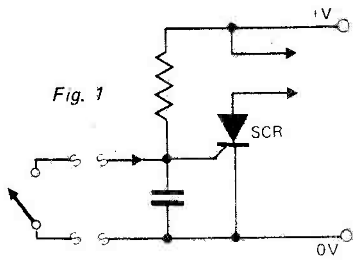
This circuit enables these devices to be operated from a car's electrical supply.

The table gives values for resistors and specified diode types for different voltage. Should more than one voltage be required a switching arrangement could be incorporated. For high currents the transistor should be mounted on a heatsink.

tech-tips

HOW NOT TO DESIGN YOUR OWN BURGLAR ALARM

Fig. 1



Innumerable designs have been published for simple burglar alarms based on variations of the circuit shown in Fig. 1. In these circuits an SCR is normally prevented from triggering by the external guard circuit — which is supposed to short the SCR gate to cathode.

These circuits are fine if the external leads are only a few inches long — but completely hopeless for most alarm applications where the external circuit may extend to hundreds of feet.

Never ever hang an 'aerial' onto the gate of an SCR. If you do, that SCR will be triggered by every electrical disturbance for miles. Thunderstorms, arc welders, contactors, fluorescent light starters, power drills — everything and anything is liable to trigger the SCR into conduction — and thus cause false alarms.

Many of these circuits show a capacitor or resistor connected from cathode to gate — this the project explains — is to prevent false triggering.

It doesn't.

The problem may be completely overcome by adding a capacitor, a unijunction and a few resistors as shown in Fig. 2. This circuit is virtually false-alarm proof. As long as the external loop is closed, the capacitor is shorted out. There is no way in the world that the UJT can oscillate — and until it does, that SCR is firmly held off.

Another advantage of the revised circuit is that, by suitably selecting C1/R1, a time delay may be built into the triggering circuit. This delay should preferably be half a second to one second. It is very worthwhile incorporating as it will prevent false alarms due to an external alarm switch momentarily vibrating open due perhaps to sudden wind gusts physically disturbing a structure.

A further problem with the circuit (Fig. 1) is that the SCR may also be tirggered by signals picked up in the SCR anode leads to the alarm bell.

This can be overcome by using the SCR to trigger a relay. If a second pair of contacts are available then these should be used to self-latch the relay thus further ensuring that the alarm will stay latched on (the SCR is of course self-latching).

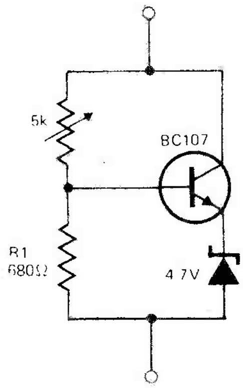
With transistor alarm circuits, another problem may arise if a circuit such as that shown in Fig. 3 is used.

Here the external triggering circuit is part of the bias circuit for Q1. Normally the closed external circuit will cause Q1 to be biased on via R1.

This circuit works well if fairly low value resistors are used for R1 and R2. However if R1 exceeds 75 k or so, problems may arise. What happens is that moisture across the external switches or leads can create a high resistance 'short' across the alarm circuit. This 'short' will appear to the alarm input as a closed switch and will prevent the alarm functioning if external triggering switches are opened.

So keep the values of those bias resistors down low. About 47 k for R1 and 4.7 k for R2 is about right.

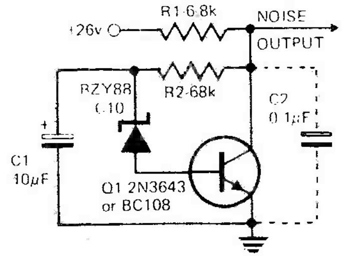
A VARIABLE ZENER DIODE



The circuit shown behaves like a Zener diode over a large range of voltages. The current passing through the voltage divider R1 — R2 is substantially larger than the transistor base current and is in the region of 8 mA. The stabilising voltage is adjustable over the range 5 — 45 V by changing the value of R2. The total current drawn by the circuit is variable over the range 15 mA to 50 mA. This value is determined by the maximum dissipation of the Zener diode. In the case of a 250 mW device this is of the order of 50 mA.

When stabilising higher voltages or operating at higher currents it is necessary to fit a small heatsink to the transistor.

WHITE AND PINK NOISE GENERATOR



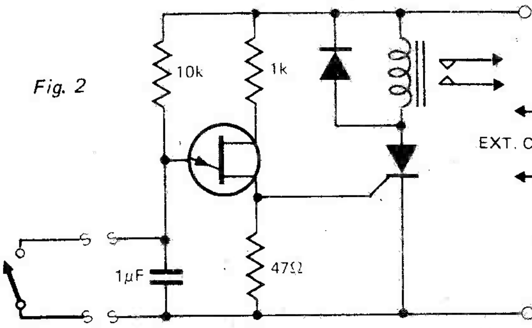
A basic noise generator can be built using one transistor and a Zener diode.

The 10 volt Zener acts as the noise source and also stabilizes the transistor operating point. Adding capacitor C2 will change the output from 'white' noise to 'pink' noise.

Output level for components specified will be about 15 V for white noise and about 14.5 V for pink noise.

The transistor should be a BC 108 or 2N3643 — other similar transistors will do.

Fig. 2



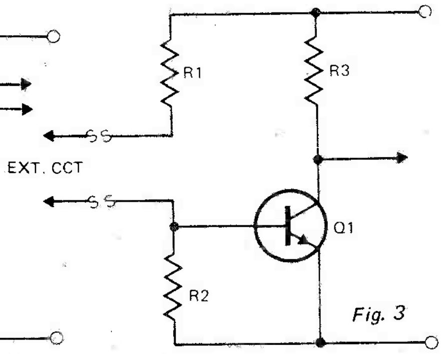


Fig. 3

DX MONITOR

Compiled by Alan Thompson

One of my favourite relaxations (apart from DXing, of course!) is tussling with a crossword: fellow addicts will know that this leads to the acquisition of strange, and frequently useless, pieces of information gleaned whilst searching through dictionaries for "A South American invertebrate (9 letters)" which appears to start with a Z and ends with PNF. Hunting for some such word, my eye chanced on the definition of "to monitor" in the "Penguin English Dictionary" - "(to) listen to and report on foreign broadcasts; check accuracy of wavelength". What a succinct definition that is of monitoring in the DX usage of the word.

In various parts of the world there are professional monitoring stations belonging to various governments and their agencies whose job is to listen to foreign broadcasts and check the content of their programmes and the frequencies on which they are transmitted. As one might expect such installations tend to be complex and to be provided with a huge quantity of extremely expensive, and sophisticated, technical equipment. However; good, accurate, detailed monitoring is within the scope of any DXer however simple his equipment provided that he possesses the mental stamina which it certainly calls for, and has the sort of mind one finds in the crossword addict - a mind which likes raking small clues, looking at them from all angles and arriving at the answer by a process of elimination and a study of the probabilities.

Essentially, so far as the hobby-DXer is concered, there are two quite distinct kinds of monitoring, or, perhaps, three if you make a distinction between two aspects of the first type. The first, and simplest, is the monitoring of fairly easy-to-hear stations either just for the sake of sending off a Reception Report and getting a QSL in return, or - and this is the aspect you can split off into a sub-category - the monitoring of a particular station, day after day, as an official monitor for that radio station. The vast majority of major radio stations around the world are interested in knowing how their signals are being heard and casual (one-off) reports are of only limited use to them. What they seek is a succession of reports, compiled over a longish period of one day or for the same period over say 14 days, which pin-point for them a variation in quality of their signals over the period concerned. If this kind of work interests you it is worth writing to the Chief Engineer of the station concerned offering your services and asking which frequencies and services they would like you to send reports on. Very often, small gifts - things like calendars, picture books, LPs and other souvenirs - will come your way in return for a long series of reports, and you will, if nothing else, gain a great deal of insight into the programming pattern of the station concerned, the "slanting" of its programmes, a better understanding of the problems of frequency planning and propagation, and the satisfaction of being of assistance to the people on the transmitting end of the programmes you enjoy (or, quite possibly, hate: many people *do* monitor stations whose programmes they hate hoping that their comments will lead to changes for the better!).

SLEUTHING!

Monitoring of the kind I've just described can be arduous enough if it entails listening to repetitious programming at around 0600, day after day. It's not at all bad in the cool of a Summer's morning but it can be sheer hell dragging yourself out of bed when the thermometer is at −10°C and it's dark, dank Winter morning. Still, there are such things as time switches . . . and tape recorders!

"Sleuthing" is my name for the second kind of monitoring and about the only use for a time switch in this regard is that it can a) turn on the radio gear 30 minutes before you arrive on the scene, and b) provide - given the necessary equipment and electro-mechanical facility - a hot cup of tea to start you on your way. More seriously, this kind of monitoring is one of the arts of DXing and you can do it whether you have the latest £1000+ receiver or just a decent transistorised short-wave portable. Your results will be quite different but that isn't the idea of the exercise which is to take a particular part of the broadcast-band spectrum and monitor it, day after day, for the signals it will disgorge. If you like problems this is just the exercise for you, because it will get steadily more difficult as the days progress and you identify more and more stations and find yourself left with a handful which call for all the crossword addict's ingenuity to unravel their identity.

If you feel like trying this kind of monitoring a suitable place to begin is with the 49, 41 or 31 metre bands and a reasonable time slot would be 1800-2100 in the evening. The first piece of advice is to give yourself something reasonable and not bite off a great deal more than even the expert would find it difficult to chew: so, confine yourself to a range like 9500-9750kHz or 6000-6250kHz.

Certain times of year are better than others for this sort of exercise as stations using the international short-wave bands change frequency at 0100 G.M.T. on the first Sundays in March, May, September and November. Consequently, the periods from the beginning of March-end April and early September-end October are rather short for ones first essays into this field. The present frequency period, officially known as D(1974), is with us until 0100 on 2 March 1975 so now is a good time to get started, as the chopping-and-changing of frequencies which always takes place in the first few weeks of a frequency period will be over by the time you read this.

For preference - but it is by no means essential! - one should have a copy of the current "World Radio-TV Handbook", a copy of the current "Tentative High Frequency Broadcasting Schedule" (published by the I.T.U.), and as many station schedules as you can get hold of. However, since that means some £10-worth of books let's assume that they are not available and that one is starting right from scratch. The first fact to be absorbed is that international SW stations operate at 5kHz intervals and that frequencies are shared by various broadcasters in the course of a day - indeed, many "sharings" of a particular frequency is now the rule. Given those facts, it is now all a question of listening and recording one's results in usable form!

KEEPING THE BOOKS

It's worthwhile devoting some time to setting-up the exercise before actually getting down to listening. If you have some form of bandspread on your receiver a graph of bandspread setting against frequency is almost a must as it saves a lot of time later. No bandspread? Well, it makes things rather more difficult but not impossible - you have to start by logging stations whose frequencies you know (from announcements or their schedules) and "fill in the gaps". How you record the information is entirely a matter for you: some people like to use sheets of card rules in a grid of quarter-hours along the top and frequencies (at 5kHz intervals: see above) down the left-hand side. Others - and this is my own favourite method - get hold of a pack of 5" x 3" index cards and use one for each 5kHz channel (i.e. one for, say, 9500kHz: another for 9505, one for 9510, and so on).

The first essay into band monitoring may make the thing seem fairly easy. In a couple of hours, over a chosen band of say 250kHz - which means 51 channels 5kHz apart - it isn't too difficult to record something like 20 or 30 separate stations with accuracy. The next foray will fill in a good number of the gaps, or let you complete the 'scan' which was left uncompleted on the previous occasion. Slowly, things will start to get a lot harder! What are those two stations fighting it out on, say, 9625kHz? What *is* that confounded interval signal? That station wasn't there last time and what language is it using? And so it goes on! Gradually you will build up a, virtually, complete picture of what is happening on your chosen piece of band over a few hours of the day and, I have no doubt, you'll manage to add a few interesting stations to your log over the course of a frequency season.

EDXC BAND SURVEYS

If you find yourself "grabbed" by this kind of DXing - which is one of the more esoteric aspects of the art! - then, maybe, you would like to take part in some of the European DX Council's Band Surveys which are held from time to time. Monitors with the necessary devotion to this kind of exercise are hard to find and if you would like to take part in future EDXC surveys please write to me and I will pass your letters along to the coordinator for those exercises, the results of which are of great interest and value to serious BC-band DXers. Please write to me, marking your letters "Band Surveys", at 16 Ena Avenue, Neath, West Glamorgan SA11 3AD. I am afraid that I am unable to assist with individual queries on "unidentifieds" but general letters about DXing will be replied to if you enclose a self-addressed and stamped envelope. ●

CCTV INSPECTION

This CCTV system is used at the Ferranti factory in Wythenshawe to help check the complex printed circuit boards used in Argus computers. The method avoids the risk of eye-strain inherent in purely optical methods.

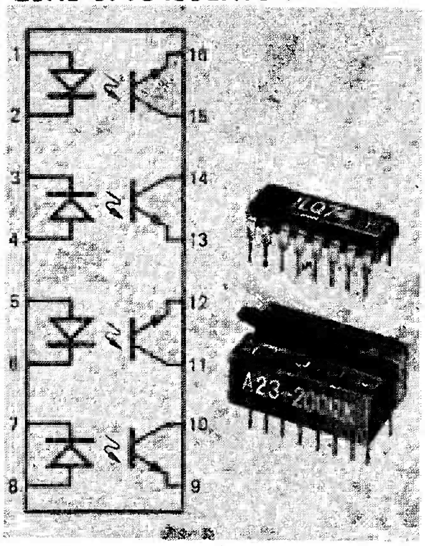
Ferranti stack their PCB's in several layers to achieve the required packing density, and so that through-connections can be made, tight dimensional tolerances have to be applied during manufacture. Precise checking of the boards can only be carried out using a magnified image. A miniature TV camera scans a photographic negative which is used in the manufacturing process. The beam is accurately positioned so that any out-of-tolarance dimensions can be detected by an operator watching the screen. The magnification obtained by this method is up to fourteen times.

8-TRACK STEREO CARTRIDGE RECORDER

JVC have a new 8-track cartridge recorder numbered ED1230. The 16 transistors and 9 diodes give a frequency response of 70-12,000Hz (+3dB) and a S/N ratio above 50dB at 1kHz. An AGC circuit controls the tape head recording current to ensure that all signals are recorded at the optimum level for maximum S/N ratio, and minimum distortion. JVC's paralled head-shift mechanism keeps the 3-in-1 head in intimate contact with the tape no matter which programme is playing, to reduce distortion still further, keep cross-talk below 60dB and channel separation over 40dB at 1kHz. The precision tape transport system keeps wow and flutter down to 0.2% (rms).

The player starts as soon as a cartridge is slotted in, programme changing and recording are effected by means of push buttons, and a third push button provides a 2-way programming facility. This will automatically eject the cartridge after all 4 programmes have played once, or just play continuously. RRSP is £67.90 inc. VAT.

QUAD OPTO ISOLATOR



The first ever quad opto coupler is now available from Jermyn Industries. The coupler is made by Litronix one of the leading manufacturers of opto-electronic devices in Europe, and is designated ILQ74. The coupler is compatible with most medium speed logic families and each channel has a typical isolation resistance of 100,000,000 ohms and a minimum breakdown voltage of 1500V. The device is housed in a sixteen pin dual-in-line package. The cost's £2.87 for one off and £1.65 for 1,000 off quantities.

SOLAR POWERED WATCH

Production is now said to have begun on the light-powered Ragen Synchronar watch.

A feature of the LED digital watch is its 100-year calendar, which is pre-programmed to allow for monthly aberrations and leap years to the year 2100.

An average exposure to sunlight of 10-15 minutes per day is claimed to be adequate to charge the watch.

PLUG-IN WHITE NOISE GENERATOR

Growing interest in the effect of artificially created background noise on office envirnoments has prompted the Milbank Electronics Group Limited, to introduce a simple, white noise generator for use with their professional amplifiers. The EQA16 has been developed as a two-tier, three device, plug-in equaliser circuit which can be adjusted to produce white, pink, green or blue noise.

Although, in some offices, noise must be reduced to assist communication and privacy and to alleviate annoyance, trials have shown that, in other areas, the introduction of artificially created background white noise can effectively reduce fatique and increase over-all efficiency.

The price of the EQA16 is £12.72 and the unit is available from Milbank Electronics Group, Bellbrook Estate, Uckfield, Sussex.

ERRATA

Projects Book page 95. The phone number of Marco Trading is WHIXHALL 464, STD CODE 094872, and not as printed.

LM380 Projects December issue page 32 and 34.

In Fig. 2 and Fig. 5 the pin on the IC marked '13' should be pin 14. All other drawings have correct pin markings. Also in Fig. 2 the symbols for the batteries are the wrong way round but the polarities are marked correctly.

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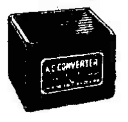

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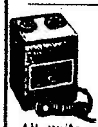

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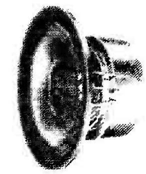

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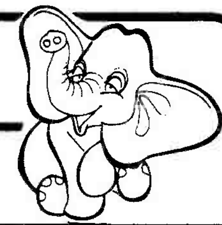

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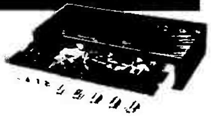

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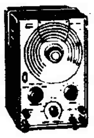

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104	9 volt	1 watt	£3.10
304	9 volt	3 watt	£3.95
555	12 volt	3 watt	£4.10
555ST	12 volt	1½ x 1½ watt	£5.95
E1208	12 volt	5 watt	£5.10
608	24 volt	10 watt	£4.95
410	28 volt	10 watt	£4.95
620	45 volt	30 watt	£9.95
Z40	30/35 volt	15 watt	£5.45
Z60	45/50 volt	25 watt	£6.95
SA6817	24 volt	6 + 6 watt	£10.20

Amplifiers with controls

E1210	12 volt 2½ + 2½ watts 8 ohms	£8.25
RE500	Mains 5 watts 4–16 ohms	£6.30
SAC14	Mains 7 + 7 watts 8 ohms	£11.75
SAC30	Mains 15 + 15 watts 8 ohms	£14.95
CA038	9 volt 1½ + 1½ watts 8 ohms	£6.95
CA068	12 volt 3 + 3 watts 8 ohms	£10.50

FM Modules

Mullard LP 1186 FM tuner (front end) with data 10.7MHz o/p	£4.85
Mullard LP 1185 10.7MHz IF unit	£4.50
Gorler Permability FM tuner (front end) 10.7MHz o/p	£4.20

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FM 5231 (tu 2) 6 volt FM tuner	£7.95
TU3 12 volt version (FM use with decoder)	£7.95
SD4912 Stereo Decoder for Tu 3.12 volt	£7.95
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A1018 9 volt FM tuner in cabinet	£13.95
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1062 12 volt stereo decoder. General purpose	£6.50

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Sinclair	Stereo 60 Preamplifier.	£6.75
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E1310	Stereo 3–30mV mal cart 9 volt	£4.75
FF3	Stereo 3mV tape head 9 volt	£4.95
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EQ25	Mono 3–250mV Tape/cart/flat. 9 volt	£1.95

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P1076 3/4½/6/7½/9/12 volt ½ amp	£4.20
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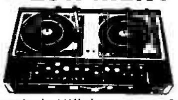

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AF139	0.41	MAT121	0.25	2N1132	0.24
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BC109	0.14	OA81	0.18	2N3054	0.48
BC109C	0.16	OA200	0.08	2N3055	0.45
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BC147	0.10	OC28	0.66	2N3442	1.39
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BC169C	0.15	OC44	0.20	2N3702	0.11
BC182	0.12	OC45	0.20	2N3714	1.41
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BCY55	2.64	OC77	0.54	2N3790	2.10
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BCY72	0.12	OC140	1.14	2N3903	0.15
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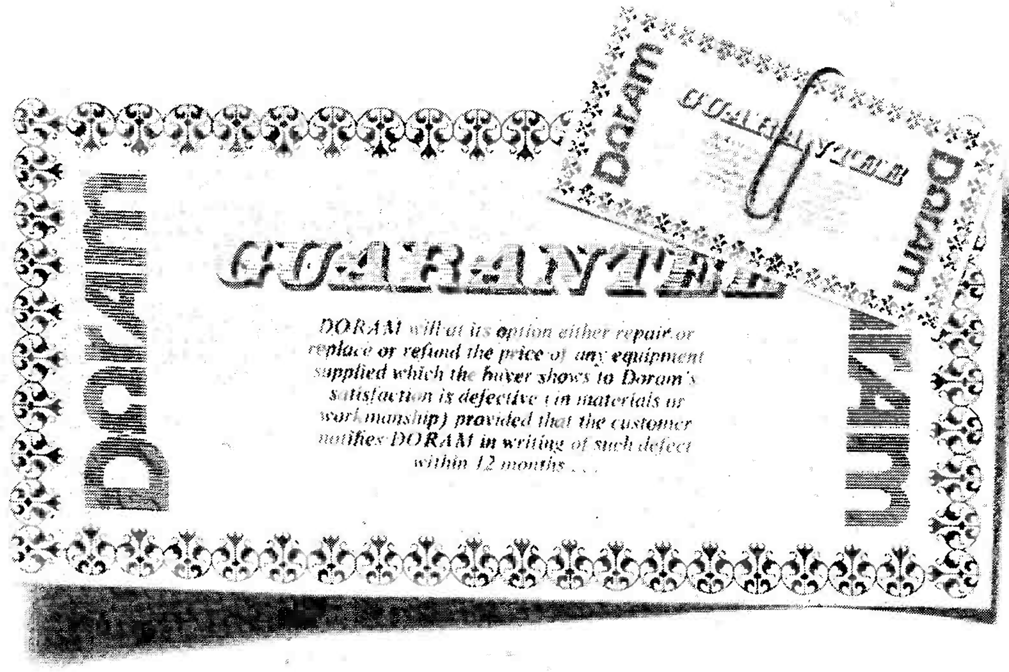

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